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Systematic review

THE EFFECTS OF AQUATIC ACTIVITIES ON PHYSICAL FITNESS AND AQUATIC SKILLS IN CHILDREN WITH AUTISM SPECTRUM DISORDERS: A SYSTEMATIC REVIEW

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Abstract. *Autism spectrum disorder is a complex brain development disorder characterized by restrictive and repetitive behaviors and a significant impairment of one's ability to interact with other people and engage in verbal or nonverbal communication, as well as in play. One form of physical activity which can be used with success in people with autism is aquatic activity. The objective of this systematic review study is to collect and analyze studies of the effects of aquatic activity on improving physical fitness and aquatic skills in children with autism. Based on an analysis of electronic databases and the inclusion criteria set, 13 studies were included in the analysis. The following conclusions are proposed based on their analysis: In terms of influence on aquatic skills, aquatic programs at least 10 weeks in duration can effect improvement in aquatic skills in children with autism, by means of learning methods well-used with autistic children, such as the Constant time delay procedure, Most to least prompting procedure, and assistance from siblings and peers. Regarding physical fitness improvements following aquatic activity, it is difficult to draw conclusions based on the results obtained in only three studies. Recommendations for future research include the application of aquatic programs with a higher weekly frequency, as well as the use of heart rate monitors during aerobic exercise in order to control heart rate training zones.*

Key words: *swimming, learning methods, Autism, effects*

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INTRODUCTION

Autism spectrum disorder (ASD) is a complex brain development disorder characterized by restrictive and repetitive behaviors and a significant impairment of one's ability to interact with other people and engage in verbal or nonverbal communication, as well as in play (American Psychiatric Association, 2013). According to the Autism and Developmental Disabilities Monitoring (ADDM) Network, a group of programs funded and tasked by the Center for Disease Control (CDC) to estimate the number of children with ASD in the United States, 1 in 68 children are identified as having of ASD (ADDM, 2014). Boys are 5 times more likely than girls to be identified with ASD.

Recent research suggests children with ASD have a tendency for sedentary behavior that in turn results in higher levels of obesity and lower levels of fitness. To be specific, physical activity levels of children with ASD were lower compared to children without disabilities (Borremans, Rintala, & McCubbin, 2013; MacDonald, Esposito, & Ulrich, 2011; Potvin, Snider, Prelock, Kehayia, & Wood-Dauphinee, 2013; Solish, Perry, & Minnes, 2010. As a result of limited physical activity children with ASD are twice as likely as children without disabilities to be overweight and obese (Phillips, et al., 2014).

One cause of insufficient physical activity in children with ASD is a lack of knowledge by physical activity providers regarding how to organize and administer physical exercise appropriately, in view of the specificity of acquisition of motor skills by these children (MacDonald et al., 2011). The objective of applying exercise programs in people with disabilities, including people with ASD, should therefore be to minimize the secondary effects such as hypertension, obesity, high blood pressure, diabetes, etc. By taking part in physical activity, people in this demographic maintain their functional independence (Joyce-Petrovich, & Menna, 1984), as well as exercising their fundamental right to leisure and enjoyment and improving their quality of life (Pan & Frey, 2006). In order to maintain a high level of health, it is important to enable children with ASD to achieve a higher level of physical fitness through those forms of physical activity that are suitable to and comfortable for them (Todd & Reid, 2006).

Adapted aquatics is physical activity in water performed by so-called special populations, such as: people with disabilities, people with chronic diseases, the elderly, the overweight, and so on. One form of physical activity that can be used with success in people with autism is precisely aquatic activity (Hall, 2013; Lee & Porretta, 2013). Through early stimulation in water, children with disability can experience multiple benefits from participating in aquatic programs: physical (Becker, 2004), social-emotional (Stein & Motta, 1992) and cognitive-intellectual (Stan, 2012).

In order to gain scientific corroboration, theoretical hypotheses regarding the positive effects of aquatic activity application on levels of physical fitness and aquatic skills acquisition in children with autism require the application of appropriate experimental programs. Following that, and based on a systematic analysis of published scientific studies, the requisite conclusions can be put forward. It was therefore the objective of this systematic review study to collect and analyze studies conducted on the effects of aquatic activity on improving physical fitness and aquatic skills in children with autism.

METHOD

Search strategy

In order to access the relevant studies, the following electronic databases were searched: EBSCOhost, ScienceDirect and Web of Knowledge. The following keywords were used: autism, along with aquatic, or swimming, or hydrotherapy. Within electronic databases, advanced research was used, and the option of searching for keywords only in the title or in the title, abstract and abstract keywords.

Inclusion strategy

The final analysis included all studies (group and single study design) published in the last 10 years, namely between 2004 and 2014, which applied any form of aquatic activity (swimming, aquatic exercise, hydrotherapy), where all participants in the study were children younger than 18 years of age, and where tests for physical fitness and aquatic skills assessment were used as outcomes.

Data analysis

Table 1 provides an overview of close analysis of the 13 studies which satisfied the criteria set. Following conventions for systematic reviews, the table presents the following parameters: study type, participant sample information (number of subjects, ASD type, and gender), a description of the experimental program which was applied, its total duration, weekly frequency and duration of each session, outcomes and results.

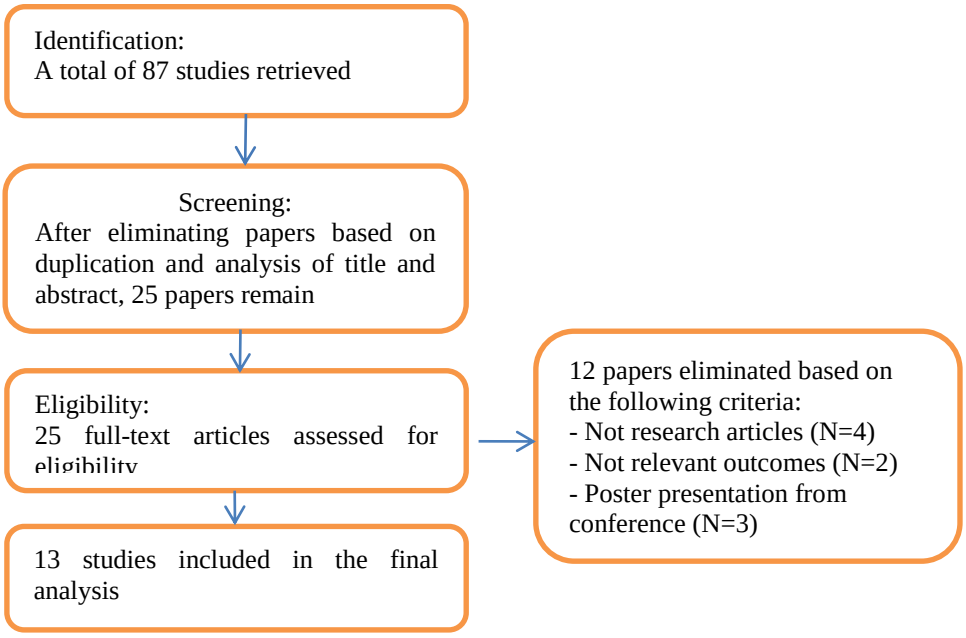

Fig. 1

Table 1 Summary of characteristics of all studies meeting the inclusion criteria

Reference	Study type	Participants (number, ASD type, age and gender)	Activity type	Program duration, weekly frequency, individual session duration	Outcomes or tests	Results
Huettig et al. (2004)	Single subject design	N: 4, T: Autism, Y: 3-9, G: male	Armbruster method for learning swimming skills	DP: 4 years, no other information provided	Texas Woman's University - Aquatic Skills Assessment	All children showed improvement in aquatic skills. No statistical procedure used.
Yilmaz et al. (2004)	Single subject design	N: 1, T: Autism, Y: 9, G: male	Halliwick Method	DP: 10 weeks, FD: 3 times per week, 60 minute sessions	Six minute walking test, Hand dynamometer, Shoulder flexion and knee extension, Sit and reach test, Body lateral flexion and Body hyper-extension tests, Balance test, Thrust test, Standing broad jump, 22.86 m running test for assessing Peak VO2, Grip strength, strength, flexibility, for assessing balance, agility, power, speed. Aquatic orientation checklist for assessment of orientation in water	Improvement in all outcomes. No statistical procedure used.
Yilmaz et al. (2005)	Single subject design	N:4, T: Autism,; Y:7-9, G: male	Learning aquatic play skills from the Halliwick method using Constant time delay procedure	DP: 10 weeks, FD: 60 minute session, 3 times per week	Task analyses of aquatic play skills	Sig.↑ aquatic play skills. The improvement persisted into the period of maintenance and generalization sessions
Pan (2010)	Group design, two experimental groups (A and B)	N:16, ASD (8 with high functioning autism and 8 with Asperger's syndrome), all participants distributed equally into two groups, Y: 6-9, G: male	WESP - consists of four categories: (A) social and floor warm-up activities, (B) one-to-two small group instruction, (C) whole group games/ activities, and (D) cool-down activities.	DP: 21 weeks, FD: 2 times per week, 90 minutes per session. During first 10 weeks group A applied WESP, during following 10 weeks groups B applied WESP, 1 week was transition	HAAR checklist for assessing aquatic skills	Sig. ↑ increased in HAAR test results for both experimental groups. 10 weeks after program application, HAAR test results were still increased.

Rogers et al. (2010)	Single subject design	N:3, T: 2 with Autism and 1 PDD-NOS, Y: 4 - 5, G: male	Learning 3 swimming skills using the Constant time delay procedure	DP: 32 sessions in total, FD: 2-3 times per week, 45-60 minutes per session	Task analyses of swimming skills	Sig.↑ of swimming skills
Yilmaz et al. (2010a)	Single subject design	N:3, T: Autism,; Y: 8-9, G: male	Learning aquatic rotation skills from the Halliwick method using the Constant time delay procedure	DP: 10 weeks, FD: 3 times a week, 60 minutes per session	Task analyses of aquatic rotation skills	Sig.↑ aquatic rotation skills. The skill improvement persisted into the period of maintenance and generalization sessions
Yilmaz et al. (2010b)	Single subject design	N:3, T: Autism, Y: 9, G: male	Learning simple Halliwick method progression swimming skills using Most to least prompting procedure	DP: 10 weeks, FD: 3 sessions/week, 60 minutes each	Task analyses of swimming skills	Sig.↑ in simple progression swimming skills. The improvement persisted into the period of maintenance and generalization sessions
Ennis (2011)	Single subject design	N: six completed program (4 with Autism, 1 with Asperger syndrome, 1 with PDD-NOS) Y: 3-9, no data on gender	Walking in the pool, swimming, respiratory activities, pulling through water, sequence breathing, floating, jumping, diving	DP: 10 weeks, FD: 1 per week, 60 minutes	WOTA Test 1 and 2 for assessing aquatic skills	MDC registered after program application in all children in terms of results of WOTA test
Fragala-Pinkham et al. (2011)	Group design, one experimental and one control group)	N: 12; 7 children in Experimental group, five of them have Asperger Syndrome and two PDD-NOS, 5 children in Control group, 3 of them have PDD-NOS, one Asperger syndrome and one High functioning autism Y: 6–12, G:	Each session consisted of 20–30 minutes of aerobic activities (different types of running and front stroke, elementary backstroke, front crawl, back crawl, breast stroke and kicking), 5–10 minutes of muscular strength and endurance	DP: 14 weeks, FD: 40 minutes, 2 times per week	Swimming Classification Scale and YMCA Water Skills Checklist for assessing swimming skills, half mile walk/run, modified curl-up and isometric push-up tests for assessing Cardio-respiratory and muscle endurance, M-PEDI test for assessing mobility skills	No Sig.↑ differences between groups post-application for any of the outcomes. Sig.↑ improvement in tests assessing swimming skills in experimental group.

		only one female	training and 5 minutes of cool-down and stretching activities.			
Pan (2011)	Group design, two groups (experimental A, and control B)	N: 30 (15 with ASD and 15 siblings without ASD). Participants distributed equally into two groups. Y: 7 - 12, G: male and female	Similar to a previous aquatic program (Pan, 2010), with more emphasis on utilizing the principles of motor learning and physical fitness learning	DP: 32 weeks, FD: 2 sessions/week, 60 minutes each. During first 14 weeks group A completed the program, after which group B did. Remaining 4 weeks used for assessment and transition. Same group of brothers with and without ASD in each group.	HAAR checklist for assessing Aquatic skills, Curl-ups for 30s, Curl-ups for 60s, Sit-and-reach test, 16-m PACER for assessing Muscular endurance, flexibility of the hamstring muscles and lower back, cardiovascular fitness (estimation of VO2max)	Sig. ↑ improvement in relation to comparison between A and B for Curl-ups for 30s and Curl-ups for 60s, and areas 2, 4, and 5 of HAAR test. Muscular endurance results unchanged after 14 weeks without exercise in group A
Chu et al. (2012)	Group design, 3 groups, two experimental (PG, SD) and one control group (CG)	N: 42, 21 with ASD (14 mild or high-functioning autism, and 7 Asperger's syndrome), and 21 with no disabilities (brothers of ASD and peers) All participants distributed equally into 3 groups, Y: 7-12, G: male and female	The program consisted of: 1. 10 min warm-up activities, 2. 35 min one-to-two teacher-to-students instruction, 3. 15 min of group games (voluntary peer/sibling support condition) and cool-down activities at the end of class.	DP: 16 weeks, FD: 2 sessions/week, 60 minutes each	HAAR checklist for assessing Aquatic skills	Sig.↑ Significant improvement in all three groups in areas 2, 3, 4, and 5 of HAAR checklist. No statistically significant differences between groups in HAAR checklist results
Yanardag et al. (2013)	Single subject design	N:3 with Autism, Y: 6-8, G: 2 boys and one girl	Teaching 3 aquatic play skills (kangaroo, cycling and snake) from Halliwick method, using Video prompting model and aquatic exercise training	DP: 12 weeks, FD: 60 minutes, 3 times per week	Task analyses of swimming skills, Movement ABC-2 test for assessing motor skills of manual dexterity, aiming and catching and balance.	Improvement in all results of Movement ABC-2 test, without using statistical analysis. Participants also increased their correct target aquatic skills with video prompting, and maintained them

Lawson et al. (2014)	Group design, one group	N: 42, of whom 40 completed the program, ASD (Autism: 30, Asperger's: 2, Other: 3, more than one: 1, missing: 4, Y: 4-15, G: 39 male and 3 female	Sensory supported swimming program	DP: 8 sessions, FD: 30 minutes 1 or 2 times per week	American Red Cross Learn to swim level for assessing swimming skills	Improvement in result within the same level or 1-2 levels up for all children. No statistical procedure applied for assessing differences

RESULTS

Study selection

Database searches returned a total of 87 studies. After eliminating any duplicated papers and analyzing the title and abstract, 25 studies entered the next stage of analysis. Next, a further 12 papers were eliminated as ineligible, as they were not research articles, did not include relevant outcomes, were poster presentations from conferences, and for similar reasons. The final number of studies in the final analysis was 13. The results of study search are provided in Figure 1.

Study characteristic

Out of 13 analyzed articles 5 were group study design (Pan, 2010; Fragala – Pinkham, Haley, & O'Neil, 2011; Pan, 2011; Chu & Pan, 2012; Lawson, Foster, Harrington, & Oxley, 2014), and another 8 were single subject design (Huettig & Darden-Melton, 2004; Yilmaz, Yanardag, Birkan, & Bumin, 2004; Yilmaz, Birkan, Konukman, & Erkan, 2005; Yılmaz, Konukman, Birkan, Özen, Yanardag, & Çamursoy, 2010a; Yılmaz, Konukman, Birkan, & Yanardag, 2010b, Rogers, Hemmeter, & Wolery, 2010; Ennis, 2011; Yanardag, Akmanoglu, & Yilmaz, 2013). The total number of participants in all studies was 167, where Yilmaz et al. (2004) had the lowest number of participants, at 1, while Chu et al. (2012) and Lawson et al. (2014) had the highest number of participants, at 42. The highest number of separate participant groups was three (Chu et al., 2012). The included ASD disorder types were Autism, high-functioning Autism, Asperger Syndrome, and PDD-NOS. Gender-wise, boys were the more represented group, with six studies including only male participants (Huettig et al. (2004), Yilmaz et al. (2004, 2005, 2010a, 2010b) and Pan (2010)). The studies by Pan (2011) and Chu et al. (2012) included, in addition to participants with ASD, typically developing children (siblings of ASD children and peers).

The experimental program's duration ranged from 8 weeks (Lawson et al., 2014) to 32 weeks (of which 28 weeks of aquatic activity only) in the study by Pan (2011). Huettig et al. (2004) tested the swimming abilities of children following 4 years of application of the program, but with no explanation of the weekly training frequency or session duration. The ten-week program was the most frequently applied form of exercise, in Yilmaz et al. (2004, 2005, 2010a and 2010b) and Ennis (2011). Weekly frequency was 2

and 3 times per week in 8 studies. It was only in the study by Ennis (2011) that the frequency was once weekly, and in Lawson et al. (2014) it was once or twice per week, depending on the participants. Individual training session duration ranged from a minimum of 30 minutes in Lawson et al. (2014) to a maximum of 90 minutes in Pan (2010). Session duration was 40 minutes in Fragala-Pinkham et al. (2011), and 60 minutes in the other studies.

The aquatic program's content varied depending on the objective set by the researchers. In those studies where the principal objective was improving physical fitness and aquatic skill levels, a program comprising aerobic and strength exercises was mostly applied (Yilmaz et al., 2004; Pan, 2010; Ennis, 2011; Fragala-Pinkham et al., 2011; Pan, 2011). In others, the objective was to establish how a particular way of giving instructions affects the acquisition of aquatic skills in children with autism. These included the Constant time delay procedure (Yilmaz et al., 2010a, 2010b), Most to least prompting procedure (Yilmaz et al., 2010), Video prompting (Yanardag et al., 2013), and including peers and siblings (Pan, 2011; Chu et al., 2012). The tests applied in the analyzed studies were carefully selected, in the sense that they could be administered to children with ASD and had adequate reliability and validity. The HAAR test (Pan, 2010, 2011; Chu et al., 2012) and Task analysis (Yilmaz et al., 2005, 2010a, 2010b; Yanardag et al., 2013) were the most used for assessing aquatic skills. The other tests applied included: TWU Aquatic Skills Assessment (Huettig et al., 2004), Aquatic orientation checklist (Yilmaz et al., 2004), WOTA2 test (Ennis, 2011), Swimming Classification Scale and YMCA and Water Skills Checklist (Fragala - Pinkham et al., 2011), and the American Red Cross Learn-to-Swim (Lawson et al., 2014). The most tested physical fitness components were aerobic endurance, muscle strength and endurance, flexibility and balance.

Regarding the effect of the applied programs on improving physical fitness and aquatic skills, the results of the studies vary. In terms of improvement of aquatic skill, all experimental programs applied can be said to have been effective, regardless of the test that was used for assessment. In terms of improvement in physical fitness, positive results were found by Yilmaz et al. (2004). In this study there was improvement across all measured physical fitness parameters (aerobic endurance, flexibility, muscle strength, etc.). Pan (2011) established improvement only in tests for assessing muscle strength/endurance, whereas the changes identified via tests of aerobic endurance and flexibility were not statistically significant. Unlike these two studies, the study by Fragala-Pinkham et al. (2011) found no statistically significant changes in any of the tests assessing physical fitness components.

DISCUSSION

Based on the studies analyzed, it is evident that over the past 10 years, between 2004 and 2014, only 13 papers were published on the effects of aquatic activity on improving physical fitness and aquatic skills in children with ASD were published, with most research activity during 2010 and 2011. In addition to a scarcity of published papers, it is of interest that only a few researchers addressed this topic, with only 6 different groups of researchers producing the 13 selected studies. The low numbers of both papers and scholars producing them is a clear indication of a need for other researchers based in autism research centers to become involved so adequate conclusions can be drawn on the topic. Beside this, none of the analyzed studies is an experimental study of the highest level, such as a randomized control trial. In terms of

participant samples, the total number of participants in the studies is not high enough to warrant drawing conclusions relating to the entire ASD children population. As can be seen in the results, the oldest children in these studies were under 15. This implies that no studies were conducted on the effects of aquatic activity in children after puberty or during adolescence, which should certainly be addressed in a future study. The significantly higher representation of boys in the studies analyzed is normal, given the significantly higher number of registered boys with ASD compared to girls registered as affected (Werling & Geschwind, 2013). According to the comprehensive study of the Center for Disease Control and Prevention (2008), the male to female ratio is 4.6.

The aquatic exercise programs applied were versatile in terms of including various aquatic activities. One of the most used programs was the Halliwick method (Martin, 1981). In addition, in many of the studies the researchers applied their own aquatic programs, designed specially for their studies. The total program duration, as shown in the results, was commonly 10 weeks, with a weekly frequency of mostly two to three times per week, except in Ennis (2011) and Lawson et al. (2014). As there was improvement in terms of aquatic skills across all studies, it can be concluded that a period of at least 10 weeks of application of aquatic activity with a frequency of 2-3 times per week is sufficient for improving the aquatic skills in children with ASD. This is further supported by the fact that enhancement of aquatic skills was confirmed across such different tests as: HAAR, WOTA, YMCA-Water Skills Checklist, etc.

Regarding physical fitness, only three studies explored the influence of aquatic programs of exercise on physical fitness components (Fragala-Pinkham et al., 2011; Pan, 2011; Yilmaz et al., 2004). The results of the three studies differ in terms of physical fitness improvements. Only Yilmaz et al. (2004) found improvement across all tests assessing physical fitness components, from aerobic endurance, through muscle endurance and strength, to flexibility and balance. The results from this study should be taken with great caution when it comes to drawing any conclusions or generalizations, as the authors did not use any statistical procedure that would establish the statistical significance of the effects obtained in the tests applied. Furthermore, the study had only one participant and only two measurements, pre- and post-test (AB design). Unlike the study by Yilmaz et al. (2004), the non-randomized control study by Fragala-Pinkham et al. (2011) found no statistically significant effects in any physical fitness component. According to the authors themselves, one of the reasons for this is the small participant sample which may have led to a Type II error. Another reason for lack of statistically significant differences may be the very statistical analysis method used. In order to establish differences, the authors used the t- test, which however cannot equate the differences between the groups at the start of measuring, unlike the ANCOVA or two-way ANOVA analysis which considers the time and group factors. Pan (2011) found significant improvement of muscle endurance following the applied experimental program, whereas there were no statistically significant differences between the groups in the other physical fitness parameters. Additionally, this study reported statistically significant improvement within the groups in all physical fitness tests. One possible reason why there was improvement in muscle endurance in this study but not in Fragala-Pinkham et al. (2011) is the session duration, which was 20 minutes longer in Pan (2011), while the other components of the training session were equal. Also, Pan (2011) had siblings participate alongside coaches during the sessions with children with ASD, whereas only coaches were administering the program in Fragala-Pinkham et al. (2011). According to Zhang & Wheeler (2011) the role of siblings is very important for

better functioning of children with ASD, which could in itself be the reason for better progress of the children in the study by Pan (2011). Taking into account the recommendations from American College of Sports Medicine (ACSM) (2014), stating that aerobic-type exercise should be done every day for at least 60 minutes, and exercises for muscle strength at least three times per week, the weekly exercise frequency in the studies analyzed, and especially in Fragala-Pinkham et al. (2011), seems insufficient for realizing any substantial changes in physical fitness components.

Only two of the studies assessed the effect of the applied exercise programs on motor skills. Fragal-Pinkham et al. (2011) found no statistically significant result improvement of the M-PEDI test. In contrast, Yanardag et al. (2013) reported improvement in the results of the Movement ABC-2 test. Nevertheless, the results of these two studies ought to be inspected critically, taking into account the quality of the single subject design study, its low level due to including only two measurements (AB) and failure to use some form of statistical analysis which could confirm the statistical significance of the effects observed.

The studies showed that different forms of learning applied in children with ASD, such as Constant time delay procedure, Most to least prompting and Video prompting, also have positive effects on the acquisition of aquatic skills. Of particular interest, in terms of human resources rationalization was the inclusion of peers in learning aquatic skills for children with ASD. The positive effects of using peers were confirmed in the study by Chu et al. (2012), in line with the earlier study by Klavina and Block (2008), on the possibility of successfully using peers to help children with ASD engage with motor tasks and activities.

CONCLUSION

In terms of influence on aquatic skills, aquatic programs at least 10 weeks in duration can effect improvement in aquatic skills in children with autism, through employing learning methods well-used with autistic children, such as the Constant time delay procedure, Most to least prompting procedure, and assistance from siblings and peers. Regarding physical fitness improvements following aquatic activity, it is difficult to draw conclusions based on the results obtained in only three studies. One reason is that different effects were obtained in the studies, but also that none of the studies was of the highest level of evidence like is randomized controlled trial. Recommendations for future research include the application of aquatic programs with a higher weekly frequency, as well as the use of heart rate monitors during aerobic exercise in order to control heart rate training zones.

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EFEKTI AKTIVNOSTI U VODI NA FIZIČKI FITNES I PLIVAČKE SPOSOBNOSTI KOD DECE SA PEREMEĆAJIMA IZ AUTISTIČNOG SPEKTRA: SISTEMATSKO PREGLEDNO ISTRAŽIVANJE

Poremećaji autističnog spektra predstavljaju kompleksni poremećaj razvoja mozga karakterističan po restriktivnim i ponavljajućim ponašanjima i značajnom smanjenju sposobnosti za interakciju za ostalim ljudima i ostvarivanje verbalne i neverbalne komunikacije. Jedan od oblika fizičke aktivnosti koja se može koristiti sa uspehom kod osoba sa autizmom su akivnosti u vodi. Cilj ovog sistematskog preglednog istraživanja je bio analiza istraživanja o efektima aktivnosti u vodi na poboljšanje fizičkog fitnesa i plivačkih sposobnosti kod dece sa autizmom. Analizom pretraživačkih baza i ulaznih kriterijuma, 13 istraživanja je uključeno u konačnu analizu. Na osnovu njihove analize donešeni su sledeći zaključci: aktivnosti u vodi kje traju najmanje 10 dana mogu imati pozitivne efekte u smislu poboljašanja plivačkih sposobnosti, ukoliko se koriste poznate metode učenja kod dece sa autizmom, kao što su konstantno vreme odlaganja, procedura od većeg ka manjem sufliranju i učenje uz pomoć vršanjaka ili braće. Kada je u pitanju fizički fitness ne mogu se doneti odgovarajući zaključci na osnovu samo tri istraživanja. Preporuke za buduća istraživanja su da se koristi veća nedeljna frekvencija vežbanja, i da se tokom aerobnih vežbi koriste monitori srčane frekvencije radi kontrole trenažnih zona.

Ključne reči: *plivanje, metod učenja, autzam, efekti*