From Dryland to Aquatic Exercise: Improving Selected Physical Fitness and Swimming Performance Parameters of Elite Adolescent Athletes With Disabilities

PAAH
PHYSICAL ACTIVITY AND HEALTH

RESEARCH

ubiquity press

BAZURI FADILLAH AMIN
ABDUL SUKUR
SUDRADJAT WIRADIHARDJA
SAMSUDIN
HERNAWAN
RUSLAN ABDUL GANI
AHMET KURTOĞLU
AMAYRA TANNOUBI
CRISTINA IOANA ALEXE
EDI SETIAWAN

*Author affiliations can be found in the back matter of this article

ABSTRACT

Our current study was to examine the effects of a 7-week dryland (DL)+aquatic exercise (AE) program to improve selected physical fitness and swimming performance parameters of elite adolescent athletes with disabilities. This study involved 48 elite adolescent athletes with disabilities. They were divided into two groups, DL+AE (n = 24, 16.4 ± 0.77 years, 159 ± 2.57 cm, 57.2 ± 2.45 kg) and control (n = 24, 16.3 ± 0.81 year, 159 ± 2.23 cm, 58.1 ± 2.33 kg). Measurements of physical fitness parameters (handgrip strength [HGS], counter movement jump [CMJ], yo-yo intermittent recovery test level 1 [YYIRTL1], and swimming performance were carried out before started the DL+AE and control programs, then repeated after a 7-week intervention. After the training program was completed, there was an increase in physical fitness (HGS [$p < .001$, $d = -2.19$], CMJ [$p < .001$, $d = -2.05$), YYIRTL1 [$p < .001$, $d = -1.49$]), and swimming performance (freestyle [$p < .001$, $d = 1.98$], backstroke [$p < .001$, $d = 2.02$]) was significant in DL+AE. In the control group there was the same increase in physical fitness HGS [$p < .001$, $d = -1.43$], CMJ [$p < .001$, $d = -1.24$], YYIRTL1 [$p = 0.015$, $d = -0.53$]), and swimming performance (freestyle [$p < .001$, $d = 1.50$], backstroke [$p < .001$, $d = 0.91$], breaststroke [$p = 0.003$, $d = 0.67$]). The findings of 2-Way Anova repeated measures showed that there was a significant effect of "time", "group" and "interaction" on physical fitness and swimming performance parameters. In addition, there was a correlation between physical fitness parameters and swimming performance with demographic characteristics of the group DL+AE and controls observed. The DL+AE program significantly improve the physical fitness parameters and swimming performance of elite adolescent athletes over a 7-week period.

CORRESPONDING AUTHOR:
Bazuri Fadillah Amin
Faculty of Sport Science, Universitas Negeri Jakarta, Indonesia
bazuri@gmail.com

KEYWORDS:
Dryland+Aquatic Exercise; Disabilities; Performance; Swimming

TO CITE THIS ARTICLE:
Fadillah Amin, B., Sukur, A., Wiradihardja, S., Samsudin, Hernawan, Gani, R. A., Kurtoğlu, A., Tannoubi, A., Alexe, C. I., & Setiawan, E. (2024). From Dryland to Aquatic Exercise: Improving Selected Physical Fitness and Swimming Performance Parameters of Elite Adolescent Athletes With Disabilities. *Physical Activity and Health*, 8(1), pp. 210–222. https://doi.org/10.5334/paah.384

DOI: 10.5334/paah.384

INTRODUCTION

Swimming is a type of sport that can be done by anyone, including disabled and non-disabled athletes, and data shows that swimming can have positive impacts such as helping develop endurance, strength (Carter & Koch, 2023), and fundamental movement skills (Sinclair & Rosco, 2023). Swimming is one of the competitive water sports that requires every athletes non-disabilities (Espada et al., 2022; Fone & van den Tillaar, 2022; Price et al., 2024), as well as disabilities to have high performance. Performance is an accurate predictor of success for elite athletes with disabilities (Dimyati et al., 2022; Zhao et al., 2020). A lot of evidence in the previous literature recorded that elite swimming athletes must pay attention and develop performance related to physical fitness (Amara et al., 2022; Gani et al., 2023; Karpiński et al., 2020; Lopes et al., 2021), and technical (Amara et al., 2023; Chortane et al., 2022). Developing physical fitness in disabled or non-disabled athletes is important, because it has been proven to optimize several parameters such as strength, power and endurance (Ji et al., 2021; Makaruk et al., 2024), therefore the performance of swimming (e.g., freestyle, breaststroke, backstroke) shows quality enhancement (Hermosilla et al., 2021). As explained by Guo et al. (2022), that physical fitness especially muscle strength in the arms and feet affect the speed of swimming performance. Considering the increase in physical fitness and swimming performance is crucial factor for the success of swimming athletes (Cavaggioni et al., 2024), a proper training method is needed, namely dryland (DL).

Based on literature, DL can be interpreted as a type of training conducted by athletes in dryland (Selvamoorthy et al., 2024). DL training program involve several types of movements such as push-ups, lunge steps, high knee, which can be conducted with tools, such as dumbbell (Tsoltos et al., 2023), or rubber band. Previous studies have proven that DL provides many benefits, including to increased swimming performance (e.g., stroke depth, stroke rate, stroke depth) (Norberto et al., 2023). Recent DL research shows that 24 national level swimmers experienced performance improvement after participating the DL program for 6 weeks (Arsoniadis et al., 2024). Meanwhile, Zaras et al. (2022), revealed that 13 adolescent swimmers experienced improvement in freestyle swimming performance, due to the effect of DL treatment. DL training has advantages in focusing exercises to develop strength, muscle endurance, so that it has an impact on significantly improving swimming performance (Ozeker et al., 2020). Although the DL training provides many benefits for swimming elite athletes (Chalkiadakis et al., 2023), but there is still a lack of coaches who combine DL with aquatic exercise (AE). The term AE can be interpreted as a training condition carried out in water (Schinzel et al., 2023; Tang et al., 2022), and forms of exercise that can be carried out include jumping or kicking (Gani et al., 2023). Meanwhile, DL+AE is a conditioning training that begins with sessions in dryland then continuing in water. Combination of DL+AE is an appropriate strategy to develop athletes. However, current research pays little attention to the combination of DL+AE. Even though DL+AE can provide benefits, as revealed by a previous study, 20 national level tertiary swimmers showed improvements on swimming performance due to the impact of combination DL with AE (Lopes et al., 2021).

According to our best knowledge, there is still a lack of research in swimming that investigated the effect of a combination DL+AE on increasing physical fitness parameters and swimming performance in elite adolescent athletes with disabilities. In addition, previous research was only focused on researching on athletes non-disabilities (Liu & Wang, 2023). Thus, this study aims to investigate the effect of DL+AE increasing the selected physical fitness parameters and swimming performance.

METHODS

PARTICIPANTS

First, G*Power analysis (version 3.1.9.4) was seletected to determine the needs of participants (samples) in this study. Based on the analysis of a G*Power that the effect of size f = 0.30, power (1– β err prob) = 0.80 and α err prob = 0.05, it shows that the minimum required participants were 24 athletes.

Based on the calculation of a priori power, 48 elite adolescent athletes with disabilities (deaf type) in swimming sports from the Indonesian deaf sports union were involved in this study. Participants who involved in this study should meet inclusion criteria, namely: (i) not injured,

(ii) male, (iii) has a minimum 6 years experience in competitive swimming, (iv) adolescent athletes with elite levels (Ericsson et al., 1993; Ericsson & Ward, 2007), and (v) athletes with hearing impairment disability. Participants and their parents should sign the agreement letter after understood the rules of this study. In addition, the entire series of activities from this experiment research has followed the Helsinki Declaration (2013). Participants were divided into groups DL+AE (n = 24) and control (n = 24) (Table 1). This study was carried out at the Jakarta State University which had been approved with Code Number: 1527/UN39.6.Ps/Lt/Lt/2024.

Table 1 Characteristics of the participants.

Note: DL+AE = Dryland+aquatic exercise.

PARAMETER CHARACTERISTICS	DL+AE (n = 24)	CONTROL GROUP (n = 24)
Age (years)	16.40 ± 0.77	16.30 ± 0.81
Body height (cm)	159 ± 2.57	159 ± 2.23
Body weight (kg)	57.20 ± 2.45	58.10 ± 2.33
Body mass index (kg·m^{-2})	21.70 ± 1.05	22.0 ± 1.32
Competitive swimming experience (years)	6.71 ± 0.69	6.63 ± 0.65
DL+AE experience (years)	3.08 ± 0.58	3.17 ±0.48

MEASUREMENTS

Physical Fitness

Muscular strength: Handgrip strength (HGS)

HGS (Takei Kiki Kogyo, Tokyo, Japan) was used to measure hand muscle strength (kg) in disability athletes (Kurtoğlu et al., 2022). Participants stood straight by holding the HGS tool in the right or left hand. After an instruction, the participants squeezed HGS as hard as possible (Oskarsson et al., 2023). Each participant had 3 times opportunity. The highest score of 3 experiments was used as the final data for analysis.

Power: Counter movement jump (CMJ)

CMJ was used to measure the leg muscle power of athletes with disabilities (Sammoud et al., 2021). This test can be done inside or outside with a non-slippery floor surface (Prieto-González & Sedlacek, 2022). First, the participants stood upright, when there were instructions, the participants quickly bent the knee 90°, then as hard as possible to jump vertically. Participants had 3 times opportunity and the best results of vertical leap (cm) was recorded to be used as data analysis.

Endurance: Yo-Yo Intermittent Recovery Test Level 1 (YYIRTL1)

Based on previous studies, YYIRTL1 was an appropriate instrument to measure the durability of athletes non-disabilities (Villaseca-Vicuña et al., 2021), but in this research YYIRTL1 had been modified for athletes with disabilities. For this, a green light was used when the audio bleep sounds to give a sign or instruction for running. First, participants stood on the star line (cone B). When the green light was on, the participants ran to cone C (the distance between cone B to C was 20 m) and ran back to cone B. Then the participant runs to cone A to recover for 5 seconds (cone A is located behind cone B), runs back to cone B. This activity was carried out continuously until the participant felt tired and was unable to keep on running. Running distance (m) was recorded for statistical analysis.

Swimming Performance

Swimming performance which includes freestyle, breaststroke, backstroke was assessed through a 50-meter swimming speed test recorded in seconds (s) using a stopwatch (Seiko S120–4030, Tokyo, Japan) (Amara et al., 2021). First, participants stood in the star block. When the signal was on, the participants swam as fast as possible towards the finish line. The time duration was recorded and analyzed statistically.

DESIGN AND PROCEDURES

This study adopted the experimental method with a random controlled trial design for 7 weeks. At the first meeting (02/04/2024), all participation carried out pre-tests including physical fitness (HGS, CMJ, YYIRTL1), and swimming performance (freestyle, backstroke, breaststroke) from 08.00 to 10.00 am. The second meeting (09/04/2024), participants were divided into two groups DL+AE (n = 24) and control (n = 24) based on the Random Group Generator (RGG) application. The DL+AE and control program was carried out until (23/05/2024). In the last meeting (28/05/2024), all participants held a post-test including physical fitness (HGS, CMJ, YYIRTL1), and swimming performance (freestyle, backstroke, breaststroke) from 09.00–11.00 am. Design and program DL+AE is presented in Figure 1 and Table 2.

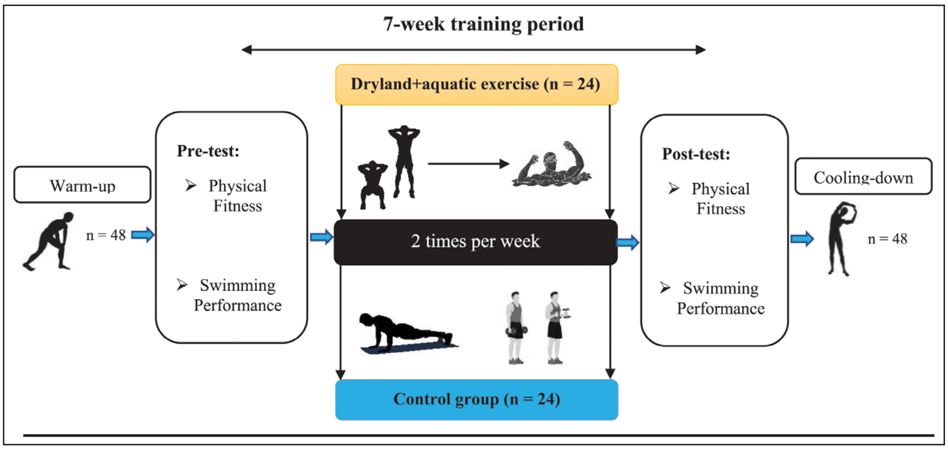

Figure 1 Experiment study design.

DL+WT AND CONTROL PROGRAM

The DL+AE program session was conducted in a 25 m a swimming pool with a water temperature of 26.1 °C, an air temperature 27.9 °C, and a relative humidity of 65%. The program took 7 weeks with details of two meetings in a week (Tuesday, Thursday). Before DL+AE begins, all participants were required to carry out warm-ups (3 min). DL+AE program was carried out in 2–3 sets and 5–20 repetitions (Table 2). While the control group carried out standard training programs (e.g., push-up [5 × 2 sets, rest: 20 sec], dumble [5 × 2 sets, rest: 20 sec], burpee [5 × 3 sets, rest: 20 sec], high knee [10 × 3 sets, rest: 30 sec], plank to push-up [15 × 3 sets, rest: 30 sec]). After all the exercises had been carried out, all participants were required cooling-down (3 min).

WEEK	1 DAY (TUESDAY)	2 DAY (THURSDAY)
1 week	Work: Rotations with a rubber band in dryland (5 × 2 sets) Rest: 20 sec	Work: Plank to push in dryland (5 × 3 sets) Rest: 20 sec
	Work: Romanian deadlift with a rubber band in dryland (5 × 2 sets) Rest: 20 sec	Work: Ball Crunch in dryland (5 × 3 sets) Rest: 20 sec
	Work: Both hands rotations in water (5 × 2 sets) Rest: 20 sec	Work: Front kick in water (5 × 3 sets) Rest: 20 sec
	Work: Rotatios with a rubber band in water (5 × 2 sets) Rest: 20 sec	Work: Swimming technique training (5 × 3 sets) Rest: 20 sec
2 weeks	Work: Lunge step with a rubber band in dryland (10 × 2 sets) Rest: 20 sec	Work: Hanging knee raise in dryland (10 × 2 sets) Rest: 20 sec
	Work: Push-up to burpee-streamline in dryland (10 × 2 sets) Rest: 20 sec	Work: Side to side twist in dryland (10 × 2 sets) Rest: 20 sec
	Work: Lunge step with a rubber band in water (10 × 2 sets) Rest: 20 sec	Work: High knee in water (10 × 2 sets) Rest: 20 sec
	Work: Pulling the tire in water (10 × 2 sets) Rest: 20 sec	Work: Swimming technique training (10 × 2 sets) Rest: 20 sec

(Contd.)

WEEK	1 DAY (TUESDAY)	2 DAY (THURSDAY)
3 weeks	Work: Streamline-squat jump in dryland (10 × 3 sets) Rest: 30 sec	Work: Burpee in dryland (10 × 3 sets) Rest: 30 sec
	Work: Push-up in dryland (10 × 3 sets) Rest: 30 sec	Work: Burpee+walk out in dryland (10 × 3 sets) Rest: 30 sec
	Work: High knee in water (10 × 3 sets) Rest: 30 sec	Work: Jumping with dumble in water (10 × 3 sets) Rest: 30 sec
	Work: Jumping jack in water (10 × 3 sets) Rest: 30 sec	Work: Jogging with dumble in water (10 × 3 sets) Rest: 30 sec
4 weeks	Work: Plank in dryland (15 × 3 sets) Rest: 30 sec	Work: Rapid lunge in dryland (15 × 3 sets) Rest: 30 sec
	Work: Dumbbell side bend in dryland (15 × 3 sets) Rest: 30 sec	Work: Mt. Climber in dryland (15 × 3 sets) Rest: 30 sec
	Work: Kick to the left and right side in water (15 × 3 sets) Rest: 30 sec	Work: Lunge step with a rubber band in water (15 × 3 sets) Rest: 30 sec
	Work: Swimming technique training (15 × 3 sets) Rest: 30 sec	Work: 3D knee swing in water (15 × 3 sets) Rest: 30 sec
5 weeks	Work: Squat+toe touch in dryland (15 × 2 sets) Rest: 20 sec	Work: Streamline lunge in dryland (15 × 2 sets) Rest: 20 sec
	Work: Walk out in dryland (15 × 2 sets) Rest: 20 sec	Work: Lunge Steps in dryland (15 × 2 sets) Rest: 20 sec
	Work: 3D knee swing in water (15 × 2 sets) Rest: 20 sec	Work: Medicine ball chest pass in water (15 × 2 sets) Rest: 20 sec
	Work: 3D calf stretch in water (15 × 2 sets) Rest: 20 sec	Work: Swimming technique training (15 × 2 sets) Rest: 20 sec
6 weeks	Work: Spider man in dryland (20 × 3 sets) Rest: 30 sec	Work: Left side lateral raise in dryland (20 × 3 sets) Rest: 30 sec
	Work: Reverse crunch dryland (20 × 3 sets) Rest: 30 sec	Work: Glute ham raise in dryland (20 × 3 sets) Rest: 30 sec
	Work: Horizontal arm sweeps in water (20 × 3 sets) Rest: 30 sec	Work: Side kick in water (20 × 3 sets) Rest: 30 sec
	Work: Straight leg kicks in water (20 × 3 sets) Rest: 30 sec	Work: Pulling the tire in water (20 × 3 sets) Rest: 30 sec
7 weeks	Work: Side to side twist in dryland (20 × 3 sets) Rest: 30 sec	Work: Sit-up in dryland (20 × 3 sets) Rest: 30 sec
	Work: Prone plank in dryland (20 × 3 sets) Rest: 30 sec	Work: Jackknife in dryland (20 × 3 sets) Rest: 30 sec
	Work: Jooging in water (20 × 3 sets) Rest: 30 sec	Work: Swimming technique training (20 × 3 sets) Rest: 30 sec
	Work: Swimming technique training (20 × 3 sets) Rest: 30 sec	Work: Barrier jump 5 m in water (20 × 3 sets) Rest: 30 sec

Table 2 Dryland+aquatic exercise (DL+AE) program.

STATISTICAL ANALYSIS

Data from the measurement of dependent variable was presented in mean and standard deviation. Normality tests (Shapiro-Wilk's) and homogeneity (Levene's) were carried out. Paired sample t-test was used to verify whether there were differences between groups in the pre-test and post-test using. The size of the effect (ES) was calculated by Cohen's d: large (0.80 >) medium (0.50–0.79), small (0.20–0.49) and trivial (0-0.19) (Cohen, 1988). Meanwhile, to verify the effect of the "group" (DL+AE vs. control), "time" (pre-test vs post-test), and "interaction" on physical fitness variables and swimming performance was carried out in 2-Way Anova Repeated Measures. The time, group and interaction effect was tested with formula ηp^2: large (0.138 >), moderate (0.059 >) to small (0.01 >). The percentage of delta (%Δ) was calculated as follows: (posttest-pretest/pretest) × 100. This study involved the Spearman (r) correlation to find out the relationships between data obtained in this study. In addition, the reliability value of all dependent variables was tested to find the intra-class correlation coefficient (ICC). Finally, we determined the level of significance was $p < 0.05$, and statistical analysis was carried out with Jamovi v. 2.3.28.

DOI: 10.5334/paah.384

RESULTS

Table 3 presents the results the ICC, normality, and homogeneity of the physical fitness and swimming performance variables.

Table 3 Results of intra-class correlation coefficient (ICC), Shapiro-Wilk's (SW) and Levene's- test (LT).

PARAMETER	ICC	95% CI	SW	LT
HGS (kg)	0.983	0.97–0.99	0.242	0.326
CMJ (cm)	0.988	0.98–0.99	0.061	0.470
YYIRTL1 (m)	0.925	0.84–0.95	0.129	0.339
Freestyle (s)	0.920	0.80–0.93	0.102	0.394
Backstroke (s)	0.897	0.79–0.95	0.397	0.242
Breaststroke (s)	0.896	0.76–0.94	0.121	0.188

Note: HGS = Handgrip strength, CMJ = Counter movement jump, YYIRTL1 = Yo-Yo Intermittent Recovery Test Level 1, ICC = intra-class correlation coefficient, CI = Confidence interval, SW = Shapiro-Wilk's, LT = Levene's-test.

EFFECT OF DL+AE AND CONTROL ON PHYSICAL FITNESS

Based on the results of the Paired sample t-test (Table 4), we observed an increase in the pre-test at DL+AE related to physical fitness in the HGS parameter ($p < .001$, $d = -2.19$ [large], %Δ = +13.6), CMJ ($p < .001$, $d = -2.05$ [large], %Δ = +17.1), YYIRTL1 ($p < .001$, $d = -1.49$ [large], %Δ = +10.2). At the same time, there was an increase in physical fitness in the HGS parameter ($p < .001$, $d = -1.43$ [large], %Δ = +5.4), CMJ ($p < .001$, $d = -1.24$ [large], %Δ = +8.6), dan YYIRTL1 ($p = 0.015$, $d = -0.53$ [medium], %Δ = +4.1) in the observed control group.

According to the results of the 2-Way ANOVA repeated measures test between DL+AE and control, we observed a significant "time" effect on physical fitness in the HGS parameter ($F_{(1.46)} = 163.2$, $p < .001$, $\eta p^2 = 0.780$), CMJ ($F_{(1.46)} = 136.8$, $p < .001$, $\eta p^2 = 0.748$), dan YYIRTL1 ($F_{(1.46)} = 49.5$, $p < .001$, $\eta p^2 = 0.518$), there is effect "group" on physical fitness on HGS parameters $F_{(1.46)} = 23.8$, $p < .001$, $\eta p^2 = 0.341$), CMJ ($F_{(1.46)} = 18.7$, $p < .001$, $\eta p^2 = 0.469$), and YYIRTL1 ($F_{(1.46)} = 16.7$, $p < .001$, $\eta p^2 = 0.266$). At the same time showing the effect of "interaction" on physical fitness in the HGS parameter ($F_{(1.46)} = 34.8$, $p < .001$, $\eta p^2 = 0.431$), CMJ ($F_{(1.46)} = 40.6$, $p < .001$, $\eta p^2 = 0.289$), and YYIRTL1 ($F_{(1.46)} = 11.4$, $p = 0.002$, $\eta p^2 = 0.199$) (Table 4).

EFFECT OF DL+AE AND CONTROL ON SWIMMING PERFORMANCE

Based on the results of the Paired sample t-test in Table 5, we observed an increase in the pre-test at DL+AE related to swimming performance in the freestyle parameter ($p < .001$, $d = 1.98$ [large], %Δ = –25.4), backstroke ($p < .001$, $d = 2.05$ [large], %Δ = –17.0), breaststroke ($p < .001$, $d = 2.02$ [large], %Δ = –20.0) At the same time, there was an increase in the control group in swimming performance in the freestyle parameter ($p < .001$, $d = 1.50$ [large], %Δ = –4.8), backstroke ($p < .001$, $d = 0.91$ [large], %Δ = –3.9), breaststroke ($p = 0.003$, $d = 0.67$ [medium], %Δ = –4.7).

According to the results of the 2-Way ANOVA repeated measures test between DL+AE and control, we observe a significant "time" effect on physical fitness in the freestyle parameter ($F_{(1.46)} = 124.7$, $p < .001$, $\eta p^2 = 0.731$), backstroke ($F_{(1.46)} = 120.1$, $p < .001$, $\eta p^2 = 0.723$), dan breaststroke ($F_{(1.46)} = 100.5$, $p < .001$, $\eta p^2 = 0.686$), there was an effect of "group" on physical fitness in freestyle parameters ($F_{(1.46)} = 12.0$, $p = 0.001$, $\eta p^2 = 0.207$), backstroke ($F_{(1.46)} = 13.0$,

PARAMETER	DL+AE (n = 24)					CONTROL (n = 24)				
	PRE	POST	%Δ	PS T-TEST (p)	COHEN'S d	PRE	POST	%Δ	PS T-TEST (p)	COHEN'S d
HGS (kg)	32.3 ± 1.59	36.7 ± 1.95	+13.6	<.001	−2.19 [large]	31.5 ± 1.61	33.2 ± 1.63	+5.4	<.001	−1.43 [large]
CMJ (cm)	20.5 ± 1.41	24.0 ± 1.05	+17.1	<.001	−2.05 [large]	19.7 ± 1.30	21.4 ± 1.24	+8.6	<.001	−1.24 [large]
YYIRTL1 (m)	1219 ± 149	1343 ± 117	+10.2	<.001	−1.49 [large]	1061 ± 205	1104 ± 207	+4.1	0.015	−0.53 [medium]

	2-WAY ANOVA REPEATED MEASURES		
	TIME (F, p, ηp^2)	GROUP (F, p, ηp^2)	INTERACTION (F, p, ηp^2)
HGS (kg)	$F_{(1.46)} = 163.2$ $p < .001$ $\eta p^2 = 0.780$	$F_{(1.46)} = 23.8$ $p < .001$ $\eta p^2 = 0.341$	$F_{(1.46)} = 34.8$ $p < .001$ $\eta p^2 = 0.431$
CMJ (cm)	$F_{(1.46)} = 136.8$ $p < .001$ $\eta p^2 = 0.748$	$F_{(1.46)} = 40.6$ $p < .001$ $\eta p^2 = 0.469$	$F_{(1.46)} = 18.7$ $p < .001$ $\eta p^2 = 0.289$
YYIRTL1 (m)	$F_{(1.46)} = 49.5$ $p < .001$ $\eta p^2 = 0.518$	$F_{(1.46)} = 16.7$ $p < .001$ $\eta p^2 = 0.266$	$F_{(1.46)} = 11.4$ $p = 0.002$ $\eta p^2 = 0.199$

Table 4 Changes in physical fitness between pre- and post-test after the 7 week intervention period.

Note: HGS = Handgrip strength, CMJ = Counter movement jump, YYIRTL1 = Yo-Yo Intermittent Recovery Test Level 1, DL+AE = Dryland+aquatic exercise, %Δ = Delta percentage, PS t-test = Paired sample t-test, ηp^2 = Partial eta-squared, *significant differences (p < 0.05).

$p < .001$, $\eta p^2 = 0.220$), and breaststroke ($F_{(1.46)} = 4.11$, $p = 0.048$, $\eta p^2 = 0.082$). At the same time shows the effect of "interaction" on physical fitness in the freestyle parameter ($F_{(1.46)} = 59.4$, $p < .001$, $\eta p^2 = 0.564$), backstroke ($F_{(1.46)} = 47.1$, $p < .001$, $\eta p^2 = 0.506$), and breaststroke ($F_{(1.46)} = 39.8$, $p < .001$, $\eta p^2 = 0.464$) (Table 5).

Figure 2 presents the relationship between performance parameters and demographic characteristics of the DL+AE group. Accordingly, there was a positive correlation between the height of the participants and HGS-post (r = 0.47, p = 0.020) and a negative correlation between breaststroke-post (r = –0.43, p = 0.035). There was a negative correlation between the participants' weight and breaststroke-pre (r = –0.042, p = 0.041) and breaststroke-post (r = –0.048, p = 0.038) (Figure 4).

In Figure 3, the relationship between the performance parameters and demographic characteristics of the control group was analyzed. Accordingly, there was a positive correlation between the participants' BMI values and breaststroke-post values (r = 0.048, p = 0.032) (Figure 5).

DISCUSSION

Current research aims to investigate the effect of DL+AE program for 7 weeks towards physical fitness parameters and swimming performance in elite adolescent athletes with disabilities.

Our main finding shows that the combination exercise between DL+AE generated a better effect on increasing physical fitness parameters (HGS, CMJ, YYIRTL1) and swimming performance (freestyle, backstroke, breaststroke) compared to the control group. This is because the adaptation obtained during the DL+AE training with a duration of 2 times a week for 7 weeks. Related to these results, a previous study that was reviewed extensively and supported by experimental findings reported that training conducted on dryland before aquatic exercises promoted positive benefits for the development of physical performance in elite athletes (Arsoniadis et al., 2024). Basically, the main advantages of the DL+AE program was provided exercises that focus on increasing strength, power, and muscle endurance (e.g., push-up, squat) (Amara et al., 2023) which carried out dryland before aquatic exercise (Kim et al., 2018; Gani et al., 2023). Another study had proven and reported similar results, for example Lopes et al. (2021), involved 14 men and 6 women athletes at the national level (elite), and the results showed that DL combined with swimming exercises (AE) had a positive increase in the physical fitness component related to strength and development of swimming performance quality. Therefore, in our research, improvement in arm strength, limb power and endurance were observed clearly and performance improvement in 50 m was identified. Nevertheless, the results of our study showed different results from other studies that reported the dryland combined with swimming exercises was not improved performance

PARAMETER	DL+AE (n = 24)					CONTROL (n = 24)				
	PRE	POST	%Δ	PS T-TEST (p)	COHEN'S d	PRE	POST	%Δ	PS T-TEST (p)	COHEN'S d
Freestyle (s)	51.2 ± 5.65	38.2 ± 2.92	−25.4	<.001	1.98 [large]	50.4 ± 5.41	48.0 ± 5.93	−4.8	<.001	1.50 [large]
Backstroke (s)	50.3 ± 4.73	41.5 ± 3.93	−17.0	<.001	2.05 [large]	51.5 ± 4.79	49.5 ± 5.50	−3.9	<.001	0.91 [large]
Breaststroke (s)	49.6 ± 6.59	39.7 ± 4.48	−20.0	<.001	2.02 [large]	48.8 ± 4.96	46.5 ± 5.74	−4.7	0.003	0.67 [medium]

	2-WAY ANOVA REPEATED MEASURES		
	TIME (F, p, ηp^2)	GROUP (F, p, ηp^2)	INTERACTION (F, p, ηp^2)
Freestyle (s)	$F_{(1.46)} = 124.7$ $p < .001$ $\eta p^2 = 0.731$	$F_{(1.46)} = 12.0$ $p = 0.001$ $\eta p^2 = 0.207$	$F_{(1.46)} = 59.4$ $p < .001$ $\eta p^2 = 0.564$
Backstroke (s)	$F_{(1.46)} = 120.1$ $p < .001$ $\eta p^2 = 0.723$	$F_{(1.46)} = 13.0$ $p < .001$ $\eta p^2 = 0.220$	$F_{(1.46)} = 47.1$ $p < .001$ $\eta p^2 = 0.506$
Breaststroke (s)	$F_{(1.46)} = 100.5$ $p < .001$ $\eta p^2 = 0.686$	$F_{(1.46)} = 4.11$ $p = 0.048$ $\eta p^2 = 0.082$	$F_{(1.46)} = 39.8$ $p < .001$ $\eta p^2 = 0.464$

Table 5 Changes in swimming performance between pre- and post-test after the 7 week intervention period.

Note: DL+AE = Dryland+aquatic exercise, %Δ = Delta percentage, PS t-test = Paired sample t-test, ηp^2 = Partial eta-squared, *significant differences ($p < 0.05$).

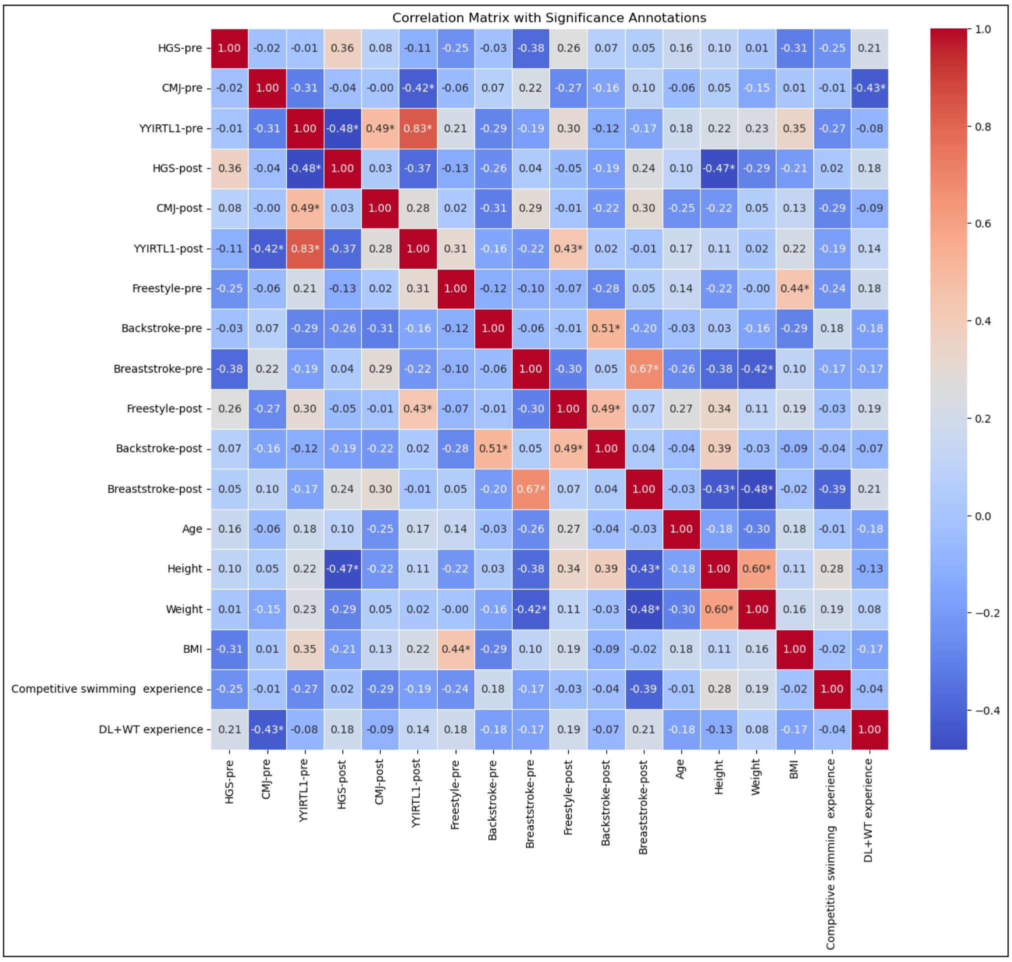

Figure 2 Pearson's heatmap of DL+AE.

of competitive swimmer athletes (Sadowski et al., 2020). In addition, Raineteau et al. (2023), reported the perception of several swimming trainers who commented that the exercise from DL to AE could cause problems to the achievement and they emphasized that (i) strength can only develop after certain activities, (ii) water could not provide sufficient resistance to develop high strength level for adaptation. However, these statements were denied by the previous study which reported that by conducting training in water continuously for 14 weeks had an effect to improve several aspects such as the strength of the upper body, muscle mass, flexibility, and

DOI: 10.5334/paah.384

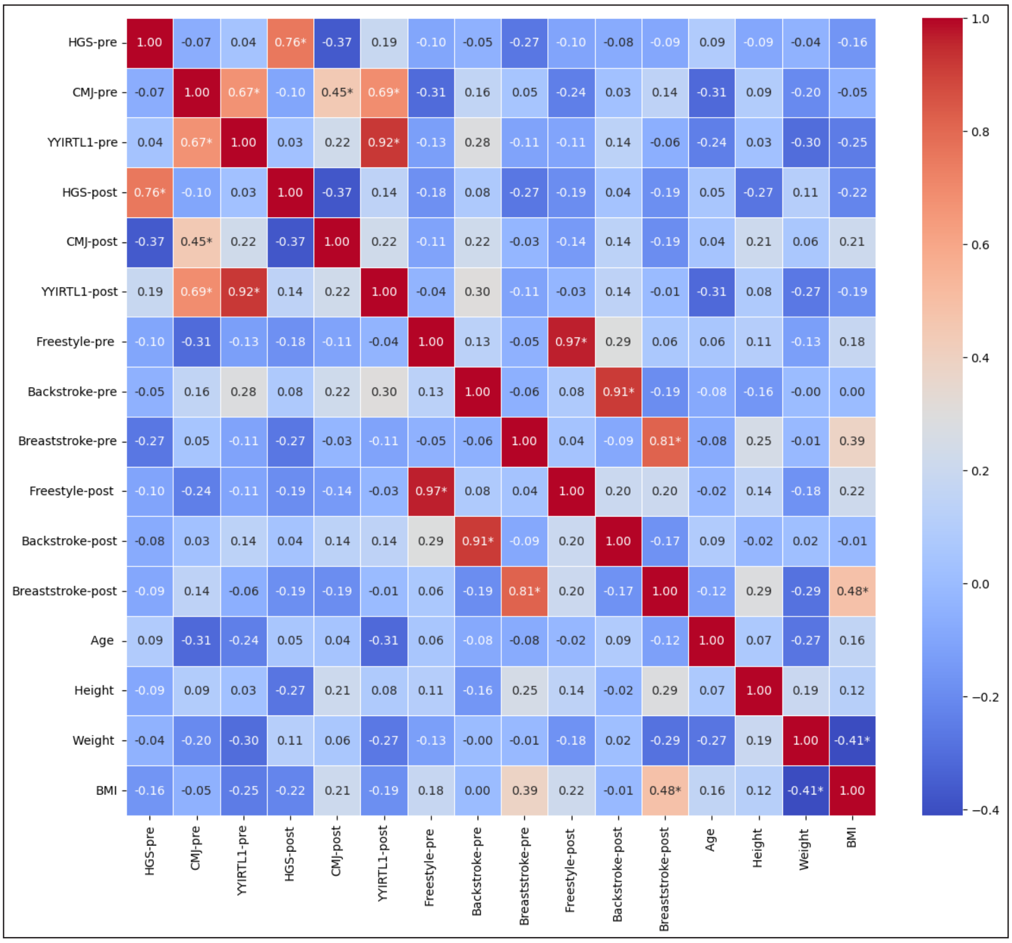

Figure 3 Pearson's heatmap of control group.

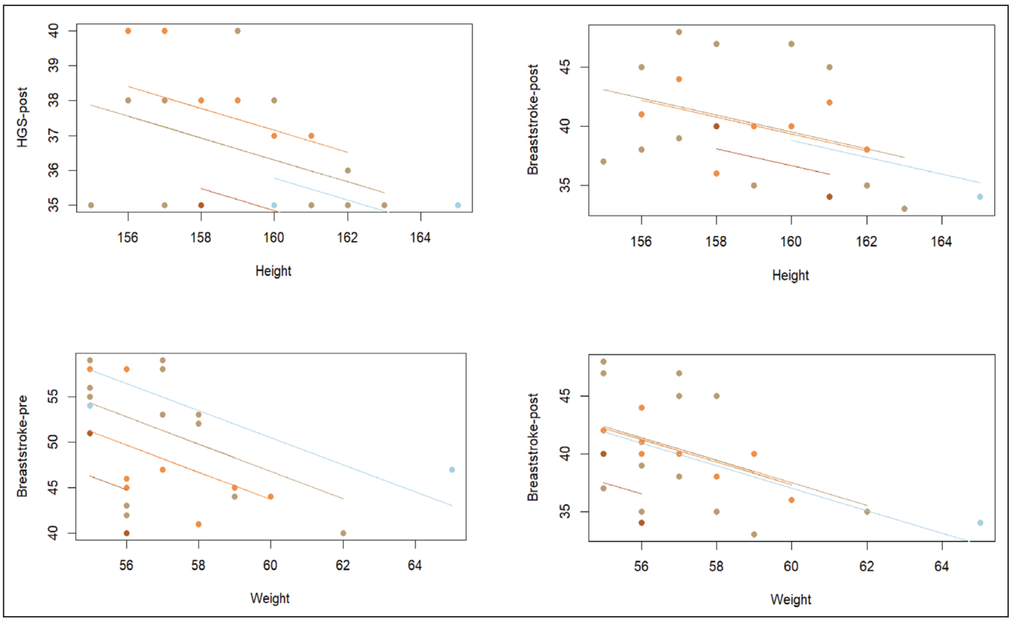

Figure 4 Repeated measures correlation analysis results between demographic characteristics and performance parameters of DL-AE group.

aerobic capacity (Martínez-Rodríguez et al., 2022). In addition, several previous studies showed that combination between DL and aquatic exercises could help to obtain positive results (Lopes et al., 2021). In this study, we also found that the improvement in arm strength, power and endurance was clearly visible and swimming performance of 50 m was perceived after the DL to AE program. All the presented results support the evidence that the DL+AE program is a starting point in increasing physical fitness and contributing to swimming performance improvement. One of the other important findings in our research is the detection of the relationship between performance parameters and demographic characteristics of DL+AE. In addition, we found a relationship between performance parameters and demographic characteristics of the control group.

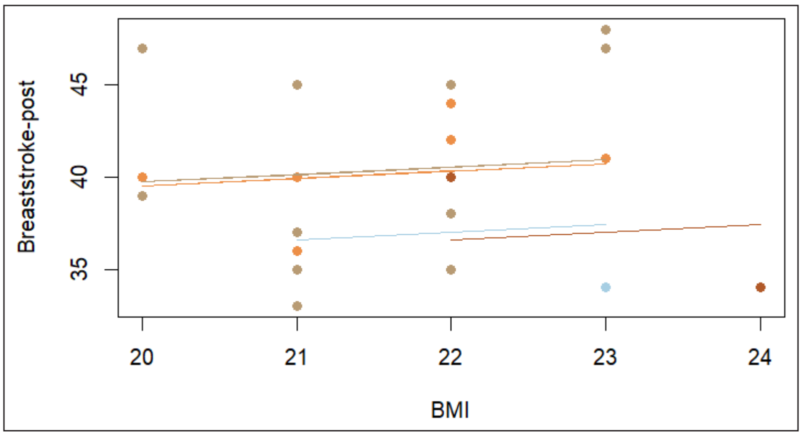

Figure 5 Repeated measures correlation analysis between BMI and breaststroke-post value.

The advantages of this study include (i) a combination of DL and AE session training for elite adolescent athletes with disabilities, (ii) creating DL and AE programs that were easy to carry out daily for elite adolescent athletes with disabilities. Nevertheless, this study has several limitations. First, the number of participants (athletes) are relatively small. Second, this study only involved male. Third, participants only came from one club in the Jakarta city (Indonesia). Fourth, this study only involved elite adolescent athletes with hiearing impairment disabilities. Thus, future research is needed to involve more participants, both from male and female athletes from several swimming clubs in Indonesia. In addition, it is expected that the DL+AE program can be applied in the future to elite adolescent athletes with other types of disabilities.

CONCLUSION

We emphasize and highlight the importance of the combination DL and AE which has proven effective in increasing physical fitness parameters (HGS, CMJ, YYIRTL1) and swimming performance (freestyle, backstroke, breastroke) among elite adolescent athletes with hearing impairment disability for 7 weeks. This study contributes to the development of swimming training methods specifically for elite athletes with disabilities to improve achievement in competitive swimming sports. In addition, it is expected that the DL+AE program that we designed in this study can be used by practitioners, trainers and elite adolescent athlete with disability in Indonesia or other countries.

DATA ACCESSIBILITY STATEMENT

All data supporting the findings of this study are available from the corresponding author on reasonable request.

ACKNOWLEDGEMENTS

The author thanks the participants who have been involved and committed to participating in this research activity. The author would like to especially thank the State University of Jakarta for providing facilities to carry out this research.

COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

All authors had access to the data used in this study and are responsible for the integrity of the data. This study was designed by BFA, ES, and AS. BFA was responsible for data analysis. All authors are responsible for data interpretation and manuscript preparation. Final approval of the manuscript was granted by all authors.

AUTHOR AFFILIATIONS

Bazuri Fadillah Amin orcid.org/0009-0005-1016-4222
Faculty of Sport Science, Universitas Negeri Jakarta, Indonesia

Abdul Sukur orcid.org/0000-0003-4008-9719
Faculty of Sport Science, Universitas Negeri Jakarta, Indonesia

Sudradjat Wiradihardja orcid.org/0000-0003-1798-4117
Faculty of Sport Science, Universitas Negeri Jakarta, Indonesia

Samsudin orcid.org/0009-0007-5790-1917
Faculty of Sport Science, Universitas Negeri Jakarta, Indonesia

Hernawan orcid.org/0000-0002-4257-5713
Faculty of Sport Science, Universitas Negeri Jakarta, Indonesia

Ruslan Abdul Gani orcid.org/0000-0002-7608-1658
Faculty of Teacher Training and Education, Universitas Singaperbangsa Karawang, Indonesia

Ahmet Kurtoğlu orcid.org/0000-0002-9292-5419
Faculty of Sport Science, Bandirma Onyedi Eylul University, Balıkesir, Turkey

Amayra Tannoubi orcid.org/0000-0002-6277-2220
High Institute of Sport and Physical Education of Kef, University of Jendouba, Tunisia

Cristina Ioana Alexe orcid.org/0000-0001-7424-7741
Department of Physical Education and Sports Performance, "Vasile Alecsandri" University of Bacau, Romania

Edi Setiawan orcid.org/0000-0001-7711-002X
Faculty of Teacher Training and Education, Universitas Suryakancana, Indonesia

REFERENCES

Amara, S., Barbosa, T. M., Chortane, O. G., Hammami, R., Attia. ahmed, Chortane, S. G., & **van den Tillaar, R.** (2022). Effect of High-Volume Training on Psychological State and Performance in Competitive Swimmers. *International Journal of Environmental Research and Public Health*, *19*(13). https://doi.org/10.3390/ijerph19137619

Amara, S., Barbosa, T. M., Negra, Y., Hammami, R., Khalifa, R., & **Chortane, S. G.** (2021). The effect of concurrent resistance training on upper body strength, sprint swimming performance and kinematics in competitive adolescent swimmers. A randomized controlled trial. *International Journal of Environmental Research and Public Health*, *18*(19). https://doi.org/10.3390/ijerph181910261

Amara, S., Hammami, R., Zacca, R., Mota, J., Negra, Y., & **Chortane, S. G.** (2023). The effect of combining HIIT and dry-land training on strength, technique, and 100-m butterfly swimming performance in age-group swimmers: a randomized controlled trial. *Biology of Sport*, *40*(1), 85–92. https://doi.org/10.5114/biolsport.2023.110747

Arsoniadis, G. G., Chalkiadakis, I., & **Toubekis, A. G.** (2024). Concurrent Sprint Swimming Interval and Dryland Training: Performance and Biomechanical Variable Changes within a Mesocycle. *Applied Sciences (Switzerland)*, *14*(6). https://doi.org/10.3390/app14062403

Carter, B. C., & **Koch, L.** (2023). Swimming Lessons for Children With Autism: Parent and Teacher Experiences. *OTJR: occupation, participation and health*, 43(2), 245–254. https://doi.org/10.1177/15394492221143048

Cavaggioni, L., Scurati, R., Tosin, M., Vernole, R., Bonfanti, L., Trecroci, A., & **Formenti, D.** (2024). Are Dryland Strength and Power Measurements Associated with Swimming Performance? Preliminary Results on Elite Paralympic Swimmers. *Sports*, *12*(4). https://doi.org/10.3390/sports12040094

Chalkiadakis, I., Arsoniadis, G. G., & **Toubekis, A. G.** (2023). Dry-Land Force–Velocity, Power–Velocity, and Swimming-Specific Force Relation to Single and Repeated Sprint Swimming Performance. *Journal of Functional Morphology and Kinesiology*, *8*(3). https://doi.org/10.3390/jfmk8030120

Chortane, O. G., Amara, S., Barbosa, T. M., Hammami, R., Khalifa, R., Chortane, S. G., & **van den Tillaar, R.** (2022). Effect of High-Volume Training on Psychological State and Performance in Competitive Swimmers. *International Journal of Environmental Research and Public Health*, *19*(13). https://doi.org/10.3390/ijerph19137619

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*, 2nd ed., Volume 2. Hillsdale, MI, USA: Lawrence Erlbaum Associates.

Dimyati, A., Setiawan, E., Dewi, R. K., Meirizal, Y., Gani, R. A., & **Saputro, Y. D.** (2022). The Effect Of Movement Games On The Level Of Physical Fitness And Mental Health Of Students With Disabilities: Mixed Method. *Physical Education Theory and Methodology*, *22*(4), 466–472. https://doi.org/10.17309/tmfv.2022.4.02

Ericsson, K. A., Krampe, R. T., & **Tesch-Römer, C.** (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological review*, *100*(3), 363. https://doi.org/10.1037/0033-295X.100.3.363

Ericsson, K. A., & **Ward, P.** (2007). Capturing the naturally occurring superior performance of experts in the laboratory: Toward a science of expert and exceptional performance. *Current Directions in Psychological Science*, *16*(6), 346–350. https://doi.org/10.1111/j.1467-8721.2007.00533.x

Espada, M. C., Santos, F. J., Conceição, A., Louro, H., Ferreira, C. C., Reis, J. F., Pessôa-Filho, D. M., & **Pereira, A.** (2022). The Effects of 12 Weeks In-Water Training in Stroke Kinematics, Dry-Land Power, and Swimming Sprints Performance in Master Swimmers. *Journal of Men's Health*, *18*(9). https://doi.org/10.31083/j.jomh1809186

Fone, L., & **van den Tillaar, R.** (2022). Effect of Different Types of Strength Training on Swimming Performance in Competitive Swimmers: A Systematic Review. *Sports Medicine – Open*, *8*(1). https://doi.org/10.1186/s40798-022-00410-5

Gani, R. A., Setiawan, E., Achmad, I. Z., & **Aminudin, R.** (2023). Virtual reality-based tabata training: a professional method for changing levels physical fitness and psychological well-being on student-athletes. *Pedagogy of Physical Culture and Sports*, *27*(2), 91–101. https://doi.org/10.15561/26649837.2023.0201

Guo, W., Soh, K. G., Zakaria, N. S., Hidayat Baharuldin, M. T., & **Gao, Y.** (2022). Effect of Resistance Training Methods and Intensity on the Adolescent Swimmer's Performance: A Systematic Review. *Frontiers in Public Health*, *10*(April), 1–10. https://doi.org/10.3389/fpubh.2022.840490

Hermosilla, F., Sanders, R., González-mohíno, F., Yustres, I., & **González-rave, J. M.** (2021). Effects of dry-land training programs on swimming turn performance: a systematic review. *International Journal of Environmental Research and Public Health*, *18*(17). https://doi.org/10.3390/ijerph18179340

Ji, M. Y., Yoon, J. H., Song, K. J., & **Oh, J. K.** (2021). Effect of dry-land core training on physical fitness and swimming performance in adolescent elite swimmers. *Iranian Journal of Public Health*, *50*(3), 540–549. https://doi.org/10.18502/ijph.v50i3.5595

Karpiński, J., Rejdych, W., Brzozowska, D., Gołaś, A., Sadowski, W., Swinarew, A. S., Stachura, A., Gupta, S., & **Stanula, A.** (2020). The effects of a 6-week core exercises on swimming performance of national level swimmers. *PLoS ONE*, *15*(8 August), 1–12. https://doi.org/10.1371/journal.pone.0227394

Kim, K. H., Lee, B. A., & **Oh, D. J.** (2018). Effects of aquatic exercise on health-related physical fitness, blood fat, and immune functions of children with disabilities. *Journal of Exercise Rehabilitation*, *14*(2), 289–293. https://doi.org/10.12965/jer.1836068.034

Kurtoğlu, A., Çar, B., & **Konar, N.** (2022). The effect of 8 weeks plyometric exercise on physical and motoric features of mental disabled. *Pedagogy of Physical Culture and Sports*, *26*(4), 228–232. https://doi.org/10.15561/26649837.2022.0402

Liu, H., & **Wang, J.** (2023). The Effects of Incorporating Dry-land Short Intervals to Long Aerobic-dominant In-Water Swimming Training on Physiological Parameters, Hormonal Factors, and Performance: A Randomized-Controlled Intervention Study. *Journal of Sports Science and Medicine*, *22*(2), 329–337. https://doi.org/10.52082/jssm.2023.329

Lopes, T. J., Neiva, H. P., Gonçalves, C. A., Nunes, C., & **Marinho, D. A.** (2021). The effects of dry-land strength training on competitive sprinter swimmers. *Journal of Exercise Science and Fitness*, *19*(1), 32–39. https://doi.org/10.1016/j.jesf.2020.06.005

Makaruk, H., Starzak, M., Tarkowski, P., Sadowski, J., & **Winchester, J.** (2024). The Effects of Resistance Training on Sport-Specific Performance of Elite Athletes: A Systematic Review with Meta-Analysis. *Journal of Human Kinetics, 91*, 135–155. https://doi.org/10.5114/jhk/185877

Martínez-Rodríguez, A., Cuestas-Calero, B. J., García de Frutos, J. M., Yáñez-Sepúlveda, R., & **Marcos-Pardo, P. J.** (2022). Effect of aquatic resistance interval training and dietary education program on physical and psychological health in older women: Randomized controlled trial. *Frontiers in Nutrition*, *9*(November), 1–13. https://doi.org/10.3389/fnut.2022.980788

Norberto, M. S., Kalva-Filho, C. A., Schneider, G. N., Campos, E. Z., & **Papoti, M.** (2023). Two Different Approaches to Dry-land Training Do Not Improve the Water Performance of Swimmers. *International Journal of Exercise Science*, *16*(6), 770–790.

Oskarsson, J., Fjellström, S., Hansen, E., & **Ohlsson, M. L.** (2023). Differences in Special Olympics athletes and non-athletes with intellectual disability: Physical activity, strength and aerobic fitness. *European Journal of Adapted Physical Activity*, *16*, 1–16. https://doi.org/10.5507/euj.2022.015

Ozeker, K. Y., Bilge, M., & **Yildirim Kose, D. S.** (2020). The effect of dry-land training on functional strength and swimming performance of 10–12 years old swimmers. *Progress in Nutrition*, *22*(September). https://doi.org/10.23751/pn.v22i2-S.10615

Price, T., Cimadoro, G., & **Legg, H. S.** (2024). Physical performance determinants in competitive youth swimmers: a systematic review. *BMC Sports Science, Medicine and Rehabilitation*, *16*(1), 1–19. https://doi.org/10.1186/s13102-023-00767-4

Prieto-González, P., & **Sedlacek, J.** (2022). Effects of Running-Specific Strength Training, Endurance Training, and Concurrent Training on Recreational Endurance Athletes' Performance and Selected Anthropometric Parameters. *International Journal of Environmental Research and Public Health*, *19*(17), 1–17. https://doi.org/10.3390/ijerph191710773

Raineteau, Y., Pla, R., Bideau, B., Bideau, N., & **Nicolas, G.** (2023). From dry-land to the water: training and testing practices of strength and conditioning coaches in high level French sprint swimmers. *Frontiers in Sports and Active Living*, *5*(January), 1–13. https://doi.org/10.3389/fspor.2023.1338856

Sadowski, J., Mastalerz, A., & **Gromisz, W.** (2020). Transfer of Dry-Land Resistance Training Modalities to Swimming Performance. *Journal of Human Kinetics*, *74*(1), 195–203. https://doi.org/10.2478/hukin-2020-0025

Sammoud, S., Negra, Y., Bouguezzi, R., Hachana, Y., Granacher, U., & **Chaabene, H.** (2021). The effects of plyometric jump training on jump and sport-specific performances in prepubertal female swimmers. *Journal of Exercise Science and Fitness*, *19*(1), 25–31. https://doi.org/10.1016/j.jesf.2020.07.003

Schinzel, E., Kast, S., Kohl, M., von Stengel, S., Jakob, F., Kerschan-Schindl, K., Kladny, B., Lange, U., Peters, S., Thomasius, F., Clausen, J., Uder, M., & **Kemmler, W.** (2023). The effect of aquatic exercise on bone mineral density in older adults. A systematic review and meta-analysis. *Frontiers in physiology*, *14*, 1135663. https://doi.org/10.3389/fphys.2023.1135663

Selvamoorthy, R., Macgregor, L. J., Donald, N., & **Hunter, A. M.** (2024). Dryland Performance Tests Are Not Good Predictors of World Aquatics Points in Elite Male and Female Swimmers. *Sports*, *12*(4), 1–13. https://doi.org/10.3390/sports12040104

Sinclair, L., & **Roscoe, C. M. P.** (2023). The Impact of Swimming on Fundamental Movement Skill Development in Children (3–11 Years): A Systematic Literature Review. *Children (Basel, Switzerland)*, *10*(8), 1411. https://doi.org/10.3390/children10081411

Tang, Z., Wang, Y., Liu, J., & **Liu, Y.** (2022). Effects of aquatic exercise on mood and anxiety symptoms: A systematic review and meta-analysis. *Frontiers in psychiatry*, *13*, 1051551. https://doi.org/10.3389/fpsyt.2022.1051551

Tsoltos, A., Arsoniadis, G., Tsolakis, C., Koulouvaris, P., Simeonidis, T., Chatzigiannakis, A., & **Toubekis, A.** (2023). Delayed Effect of Dry-Land Strength Training Sessions on Swimming Performance. *Journal of Functional Morphology and Kinesiology*, *8*(3), 4–13. https://doi.org/10.3390/jfmk8030087

Villaseca-Vicuña, R., Molina-Sotomayor, E., Zabaloy, S., & **Gonzalez-Jurado, J. A.** (2021). Anthropometric profile and physical fitness performance comparison by game position in the Chile women's senior national football team. *Applied Sciences (Switzerland)*, *11*(5), 1–16. https://doi.org/10.3390/app11052004

Zaras, N., Apostolidis, A., Kavvoura, A., & **Hadjicharalambous, M.** (2022). Comparison between Dry-Land and Swimming Priming on 50 m Crawl Performance in Well-Trained Adolescent Swimmers. *Sports (Basel, Switzerland)*, *10(4)*(52). https://doi.org/10.3390/sports10040052

Zhao, K., Hohmann, A., Faber, I., Chang, Y., & **Gao, B.** (2020). A 2-year longitudinal follow-up of performance characteristics in Chinese male elite youth athletes from swimming and racket sports. *PLoS ONE*, *15*(10 October 2020), 1–18. https://doi.org/10.1371/journal.pone.0239155

TO CITE THIS ARTICLE:
Fadillah Amin, B., Sukur, A., Wiradihardja, S., Samsudin, Hernawan, Gani, R. A., Kurtoğlu, A., Tannoubi, A., Alexe, C. I., & Setiawan, E. (2024). From Dryland to Aquatic Exercise: Improving Selected Physical Fitness and Swimming Performance Parameters of Elite Adolescent Athletes With Disabilities. *Physical Activity and Health*, 8(1), pp. 210–222. https://doi.org/10.5334/paah.384

Submitted: 19 June 2024
Accepted: 28 August 2024
Published: 04 October 2024