The Effects of Aquatic Exercise on Variables related to Body Composition in Children and Adolescents: a systematic review

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Summary

Objective: The aim of this study was to analyse the current scientific evidence on the effects of aquatic exercise on variables related to body composition in children and adolescents.
Material and method: Articles published up to March 2022 were identified in six databases using the following search strategy: ["aquatic exercise"] OR ["water based exercise"] AND ["children"] OR ["weight loss"] OR ["body composition"]. Methodological quality was evaluated using the Physiotherapy Evidence Database, Methodological Index for Non-Randomized Studies, and "Quality Assessment Tool for Before-After Studies with No Control Group" scales. Additionally, the Consensus on Exercise Reporting Template was applied to analyse the quality of the interventions.
Results: Finally, 8 studies (349 participants) were selected. Six of them were considered "high" quality and two were "low" quality. After applying the Consensus on Exercise Reporting Template to assess the quality of intervention descriptions, four were rated as "good," while the other four were rated as "poor" or "unreliable." Aquatic exercise programs were found to be effective in improving variables related to body composition such as body weight, body mass index, and body fat percentage. Additionally, variables related to the physical capacity of participants were also found to benefit.
Conclusion: The implementation of aquatic exercise programs appears to be useful in improving variables related to body composition in children and adolescents. Additionally, they could be a valuable intervention to improve their physical capabilities. However, given that the methodological quality of the interventions was not high, further exploration of these relationships is necessary.

Key words:
Adiposity. Aquatic therapy. Body composition. Child. Weight loss.

Efectos del ejercicio acuático en variables relacionadas con la composición corporal en niños y adolescentes: revisión sistemática

Resumen

Objetivo: El objetivo de este estudio fue analizar la evidencia científica actual sobre los efectos del ejercicio acuático en variables relacionadas con la composición corporal de niños y adolescentes.
Material y método: Se identificaron artículos publicados hasta marzo de 2022 en seis bases de datos utilizando la siguiente estrategia de búsqueda y palabras clave: [*"aquatic exercise"*] OR [*"water based exercise"*] AND [*"children"*] OR [*"weight loss"*] OR [*"body composition"*]. Se evaluó la calidad metodológica utilizando las escalas de *Physiotherapy Evidence Database, Methodological Index for Non-Randomized Studies* y *"Quality Assessment Tool for Before-After Studies with No Control Group"*. Además, se aplicó la escala *Consensus on Exercise Reporting Template* para analizar la calidad de las intervenciones.
Resultados: Se seleccionaron finalmente 8 artículos (349 participantes). Seis de ellos fueron considerados como artículos de "alta" calidad y dos de "baja" calidad. Tras aplicar la escala *Consensus on Exercise Reporting Template* para conocer la calidad de la descripción de las intervenciones, cuatro de ellas fueron calificadas como "buenas", mientras que las otras cuatro fueron calificadas como "malas" o "poco fiables". Los programas de ejercicio acuático demostraron ser eficaces para mejorar variables relacionadas con la composición corporal como el peso, el IMC o el porcentaje graso. Además, las variables relacionadas con la capacidad física de los participantes también se encontraron beneficiadas.
Conclusión: La realización de programas de ejercicio acuático parece ser útil para mejorar variables relacionadas con la composición corporal de niños y adolescentes. Además, también podrían ser una intervención valiosa para mejorar las capacidades físicas de estos. Sin embargo, dado que la calidad metodológica de las intervenciones no era alta, es necesario seguir explorando estas relaciones.

Palabras clave:
Adiposidades. Composición corporal. Ejercicio acuático. Niños. Pérdida de peso corporal.

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Introduction

Obesity and overweight in children and adolescents have important health consequences, both in the short and long term. Children and adolescents with overweight and obesity are at greater risk of developing obesity, premature death and disability in adulthood. However, besides the increased future risks, obese children experience breathing difficulty, greater risk of fractures, high blood pressure, early cardiovascular disease markers, resistance to insulin and psychological effects[1].

Child and adolescent obesity and overweight are a global problem that is on the rise. According to the World Health Organisation, the amount of young people with overweight or obesity has multiplied ten-fold in the last four decades, and the number is expected to keep growing[1]. In Spain, it is estimated that more than 30% of children and adolescents have overweight or obesity[2].

For this reason, finding effective strategies to prevent and treat obesity and overweight in children and adolescents is essential. Regular physical exercise is one of the main tools for dealing with this situation, and it is recommended that children and adolescents engage in at least 60 minutes of moderate or vigorous physical activity per day[3]. With that in mind, aquatic exercise can be a beneficial and interesting option for promoting physical activity in this group due to a series of advantages. Physical exercise in the water has a reduced impact on joints and lowers the risk of injury, which would also encourage motivation and adherence[4]. Furthermore, water offers a natural resistance that increases the intensity of effort and energy expenditure, potentially favouring a body fat reduction and improved muscle strength and cardiovascular capacity[5,6].

Despite the potential advantages of aquatic exercise in the prevention and treatment of obesity and overweight in children and adolescents, a systematic review of existing studies on this topic is necessary. This would enable analysis of the effectiveness of aquatic exercise in the prevention and treatment of obesity and overweight, as well as identification of possible factors capable of impacting its effectiveness.

This systematic review of literature sought to analyse the scientific evidence in this regard on the effects of aquatic exercise on variables tied to body composition in children and adolescents.

Material and method

This systematic review was carried out according to the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)[7]. This review was registered on the Open Science Framework (OSF), https://doi.org/10.17605/OSF.IO/HY385

Search strategy

Articles published up to March 2022 were identified using the following databases: Scopus® (Elsevier B.V.), PubMed (United States National Library of Medicine), and SPORTDiscus (EBSCO Industries Inc.). Other secondary databases were also used, such as Google Scholar, Dialnet and ERIC (Education Resources Information Centre). The following search strategy and keywords were used: ["aquatic exercise"] OR ["water based exercise"] AND ["children"] OR ["weight loss"] OR ["body composition"].

Eligibility criteria

The research articles were included or excluded using the criteria defined with the PICO (*P*opulation, *I*ntervention, *C*omparison, *O*utcome) method (Table 1), and the bibliographic literature searches were limited to those articles that provided information on the effects of aquatic exercise on variables related to body composition in children and adolescents. Theses, dissertations and conference proceedings and summaries were also excluded. No restrictions were imposed on language, but the studies needed to be written in English, Portuguese or Spanish.

Study selection

Two authors reviewed the titles and summaries of the identified articles to check their eligibility. After independently reviewing the studies selected for inclusion, the two authors compared them to reach an agreement. Upon reaching an agreement, a copy of the full text of each potentially relevant study was obtained. If it was unclear whether a study met the criteria for inclusion, a third author was consulted to reach a consensus. Furthermore, the full texts of the studies that met the criteria for inclusion and various systematic reviews were reviewed manually in search of other relevant references.

Table 1. Search strategy and criteria for inclusion/exclusion based on PICO.

Database	Search terms	PICO	Criteria for inclusion	Criteria for exclusion
Scopus PubMed SPORTDiscus Google Scholar Dialnet ERIC	["aquatic exercise"] OR ["water based exercise"] AND ["children"] OR ["weight loss"] OR ["body composition"]	Population	Children and adolescents	Middle-aged adults or senior citizens.
		Intervention	Aquatic exercise strategies	The aquatic intervention proposal was combined with other therapies. The interventions did not take place in neutral environments.
		Comparison	Aquatic exercise strategies/conditions	There is no comparison between the structured strategies or the control condition with previous and subsequent results.
		Outcome	Variables related to body composition	The results did not consider those related to body composition. Data is lacking on the effects of the aquatic exercise strategies.

Data extraction

General details on the study title, the authors and the design were extracted. Any available data on the participants, the characteristics of the intervention, the variables analysed, the tests used, the results obtained and the adherence/dropout rate were also obtained. All this information was extracted from the original articles by two of the authors and a descriptive table was created (Table 2). A third researcher supervised this process.

Methodological quality assessment

The methodological quality of the studies was assessed using three different scales. The methodological quality of each randomised controlled trial (RCT) was obtained from Physiotherapy Evidence Database (PEDro). If a trial was not included in PEDro, two authors assessed its quality and any disagreements were resolved by consensus. The suggested cut-off points for categorising the studies based on quality were: excellent (9-10), good (6-8), standard (4-5) and poor (≤3)[8]. The Methodological Index for Non-Randomised Studies (MINORS)[9] was used to determine the methodological quality of comparison studies. They were considered to be of high quality if the total MINORS score was ≥17, while a total score of <17 was considered low quality[10]. The Quality Assessment Tool for Before–After Studies with No Control Group of the National Heart, Lung and Blood Institute (NHLBI) was used for uncontrolled interventions[11]. The levels of evidence were considered to be high, moderate or low[12]. The methodological quality of comparison and uncontrolled studies was assessed by one author and then checked by a second author. In the event of a disagreement, a third author was consulted.

Furthermore, the quality of the information reported in the interventions was assessed using the Consensus on Exercise Reporting Template (CERT). A decision was made to use this tool due to the differences found in the design of the articles. A final score of ≤8 was considered low quality and a final score of ≥9 was considered high quality[13].

Results

2,011 records were obtained from the database search. After excluding duplicates and examining the titles and summaries, 62 articles were recovered for assessment of the full text. Finally, eight studies met the criteria for inclusion and were included in the systematic review (Figure 1).

Table 2. Descriptive summary of the randomised and controlled articles.

Author (Year), Design, Participants and Adherence/Dropout Rate	Intervention	Variables (Test)	Results
Irandoust *et al.* (2020) **Design:** RCT **Participants (n; condition; gender):** 71 (59); children; M (G1 = 20; G2 = 19; CON = 20) *Age, years (average; SD):* G1 = 8.91 ± 1.21; G2 = 9.30 ± 1.30; CON = 8.95 ± 1.15 *Height, cm (average; SD):* G1 = 135.40 ± 7.38; G2 = 133.82 ± 5.17; CON = 133.87 ± 5.66 *Weight, kg (average; SD):* G1 = 39.92 ± 6.62; G2 = 39.52 ± 6.16; CON = 39.20 ± 4.49 *Fat percentage, % (range):* >25 BMI, kg/m^2 (average; SD): G1 = 29.39 ± 3.84; G2 = 29.44 ± 3.67; CON = 29.28 ± 2.95 **Dropout rate (n; reasons):** 12; (9 = do not meet inclusion criteria and 3 for missing the sessions)	**Frequency:** 3 sessions/week **Duration:** 4 weeks **G1:** Video games group **Description:** *Combination of games (Wii Sports, Kinect Ultimate Sports, Wii Fit and Just Dance)* **Volume:** 60 min **Intensity:** 50–70 % FCR (11–13 RPE) **G2:** Aquatic exercise group **Description:** – 5 min. Warm-up: Stretching movements, static walking, jogging on the spot, side-to-side steps. – 50–60 min. Main part: Jumping jacks, high knees, jabs, quick kicks, backward kicks, running laps and jumps with rotation. – 10 min. Return to rest: Stretching, ball game, relaxation and deep breathing. **Volume:** 65-75 min **Intensity:** Warm-up: 40–50% HRR (7–9 RPE): Main part: 50–70% HRR (11–13 RPE), Return to rest: 40–50% HRR (7–9 RPE) **CON** **Description:** No organised PE was performed	**Anthropometric measurements** Body weight (kg) Fat percentage (%) WHR BMI (kg/m^2) **Physical capacity measurements** *Muscle function:* – FVC (ml) – FEV_1 (ml) **Perceptive measurements** RPE- Borg Scale (6-20)	**Intra-group** (*P* <0.05) Body weight ↓ in G1 (pre-intervention *vs.* monitoring and post intervention *vs.* monitoring) Body weight ↓ in G2 (pre-intervention *vs.* monitoring and pre-intervention *vs.* post-intervention) BMI ↓ in G1 (pre-intervention *vs.* monitoring, pre-intervention *vs.* post-intervention and post-intervention *vs.* monitoring) BMI ↓ in G2 (pre-intervention *vs.* monitoring, pre-intervention *vs.* post-intervention) FVC ↑ in G1 (pre-intervention *vs.* monitoring and pre-intervention *vs.* post-intervention) FVC ↑ in G2 (pre-intervention *vs.* monitoring and pre-intervention *vs.* post-intervention) **Inter-group (P <0.05)** > Body weight in CON that in G1 and G2 in the monitoring and post-intervention > WHR in CON that in G1 and G2 > BMI in CON that in G1 and G2 in the monitoring and post-intervention > FVC in G1 and G2 that in CON in the monitoring and post-intervention > FEV_1 in CON that in G1 and G2 in the monitoring and post-intervention

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Table 2. Descriptive summary of the randomised and controlled articles *(continuation)*.

Author (Year), Design, Participants and Adherence/Dropout Rate	Intervention	Variables (Test)	Results
Honório *et al.* (2018) **Design:** RCT **Participants (n; condition; gender):** 28; children who practised swimming; NR (G1 = 9; G2 = 19) *Age, years (range):* 6-12 *Height, cm (average; SD):* G1 = NR; G2 = 130.32 ± 7.80 *Weight, kg (average; SD):* G1 = 23.7 ± 3.64; G2 = 29.6 ± 6.15 *Fat percentage, % (average; SD):* G1 = 18.4 ± 2.66; G2 = 17.6 ± 3.57 *BMI, kg/m² (average; SD):* G1 = 15.4 ± 1.72; G2 = 17.3 ± 2.37 **Dropout rate (n; reasons):** NR	**Frequency:** 2 sessions/week **Duration:** 12 weeks **G1:** Swimming group **Description:** Swimming classes **Volume:** 45 min **Intensity:** NR **G2:** Swimming + aquatic walking group **Description:** 39 min., swimming classes + 6 min. aquatic walking at the end of each session (water at chest height) **Volume:** 45 min. **Intensity:** NR	**Anthropometric measurements** Body weight (kg) Fat percentage (%) Muscle mass (kg) Water percentage (%) Waist circumference (cm) BMI (kg/m²) BMI percentiles (kg/m²) **Physical capacity measurements** *Muscle function:* – FVC (ml) – FEV_1 (ml) – PEF (ml) **Perceptive measurements** RPE (Borg Scale, 6-20)	**Intra-group (*P* <0.05)** Body weight ↑ in G1 at week 12 compared with at the start (23.7 ± 3.64 *vs.* 25.5 ± 4.38 kg) Body weight ↑ in G2 at week 6 (30.1 ± 6.01 kg) and 12 (30.4 ± 6.05 kg) compared with at the start (29.6 ± 6.14 kg) Fat percentage ↑ in G2 at week 12 compared with at the start (17.6 ± 3.57 *vs.* 17.9 ± 3.70%) Water percentage ↑ in G2 at week 12 compared with at the start (56.7 ± 4.21 *vs*. 56.0 ± 4.24%) Waist circumference ↑ in G1 at week 6 compared with at the start (54.4 ± 5.17 *vs*. 56.3 ± 5.73 cm) BMI ↑ in G1 at week 12 compared with at the start (15.4 ± 1.72 *vs.* 16.7 ± 2.70 kg/m²) BMI ↑ in G2 at week 6 (17.6 ± 2.22 kg/m²) and 12 (17.8 ± 2.30 kg/m²) compared with at the start (17.3 ± 2.37 kg/m²) BMI percentiles ↑ in G2 at week 12 compared with at the start (59.4 ± 32.4 *vs*. 68.0 ± 29.8 kg/m²) FVC ↑ in G2 at week 6 (1.83 ± 0.42 ml) and 12 (1.81 ± 0.41 ml) compared with at the start (1.63 ± 0.49 ml) FEV_1 ↑ in G2 at week 6 (1.68 ± 0.42 ml) and 12 (1.71 ± 0.39 ml) compared with at the start (1.55 ± 0.47 ml) **Inter-grup (*P* <0.05)** > Body weight - in G2 that in G1 at week 6 (30.1 ± 6.01 *vs.* 24.9 ± 4.54 kg) and at week 12 (30.4 ± 6.05 *vs*. 25.5 ± 4.38 kg) > FVC in G2 that in G1 at week 6 (1.83 ± 0.42 *vs*. 1.47 ± 0.31 ml) > FEV1 in G2 that in G1 at week 6 (1.68 ± 0.42 *vs*. 1.33 ± 0.23 ml) and at week 12 (1.71 ± 0.39 *vs.* 1.41 ± 0.26 ml) > PEF in G2 that in G1 at week 6 (3.77 ± 1.00 *vs*. 2.88 ± 0.43 ml) ant at week 12 (3.87 ± 1.02 *vs*. 3.19 ± 0.44 ml)

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Table 2. Descriptive summary of the randomised and controlled articles *(continuation)*.

Author (Year), Design, Participants and Adherence/Dropout Rate	Intervention	Variables (Test)	Results
Lopera *et al.* (2016) **Design:** *Comparative* **Participants (n; condition; gender):** 210 (150); adolescents; G1 = 28 (11 M + 27 F); G2 = 57 (29 M + 28 F); CON = 66 (36 M + 30 F) *Age, years (average, SD):* G1 = 13.0 ± 1.4; G2 = 13.1 ± 1.9; CON = 13.3 ± 1.9 *Height, cm:* NR *Weight, kg (average, SD):* G1 = 78.3 ± 17.5; G2 = 81.0 ± 17.8; CON = 77.8 ± 16.0 *Fat percentage, % (average, SD):* G1 = 40.1 ± 7.6; G2 = 44.4 ± 6.6; CON = 43.5 ± 6.4 *BMI, kg/m² (average; SD):* G1 = 29.2 ± 5.0; G2 = 31.2 ± 4.7; CON = 29.4 ± 4.3 **Dropout rate (n; reasons):** 80; 59 did not complete the protocol due to transport problems (G1 = 7; G2 = 33; CON = 19), 25 preferred other activities (G1 = 2: G2 = 23); 10 lost motivation (G1 = 2; G2 = 8) and 19 did not attend the last session (CON = 19)	**Frequency:** 3 sessions/week **Duration:** 16 weeks **G1:** Aquatic exercise group **Description:** Psychological intervention + nutritional intervention + educational programme on physical activity + training session. – interval walking/running training in water. – endurance exercise with aquatic equipment to simulate endurance exercises. – swimming exercises (mainly crawl and backstroke) and diving to pick up dumbbells and other objects. – continuous recreational exercises. **Volume:** 60 min **Intensity:** NR **G2:** On-land exercise group **Descripction:** Psychological intervention + nutritional intervention + educational programme on physical activity + training session – endurance training (sit-ups, push-ups, squats and exercises with medicine balls). – aerobic exercises (walking and running). – group games. **Volume:** 60 min **Intensity:** NR **CON** **Description:** Performed no organised PE	**Anthropometric measurements** Body weight (kg) Fat percentage (%) Fat-free weight (kg) Waist circumference (cm) Waist circumference (cm) BMI (kg/m²) **Physical capacity measurements** Abdominal strength/ endurance (rep) - Maximum curl-ups in 1 min. Flexibility (cm)- Sit-and-reach test. VO_{2max} (ml/min/kg) - 20 m Shuttle Run Test or Cooper Test adapted to the pool (m) **Perceptive measurements** Quality of life - Paediatric Quality of Life Inventory™ – Physical – Emotional – Social – School – Psychosocial – Total	**Intra-group (*P* <0.05)** Body weight ↑ in CON (77.8 ± 16 *vs.* 78.6 ± 16.2 kg) Fat percentage ↓ in G1 (40.1 ± 7.6 *vs.* 36.3 ± 8.5%) Fat percentage ↓ in G2 (44.4 ± 6.6 *vs.* 42.0 ± 7.6%) Fat-free weight ↑ in CON (41.6 ± 8.7 *vs.* 42.6 ± 8.8 kg) Waist circumference ↓ in G1 (87.7 ± 10.5 *vs*. 86.5 ± 10.9 cm) Waist circumference ↓ en G2 (91.4 ± 10.9 *vs.* 89.3 ± 10.7 cm) Hip circumference ↓ in G1 (106.9 ± 9.5 *vs.* 105.5 ± 8.8 cm) Hip circumference ↓ in G2 (109.6 ± 10.9 *vs.* 108.5 ± 10.8 cm) BMI ↓ in G1 (29.2 ± 5 *vs.* 28.1 ± 5.1 kg/m²) BMI ↓ in G2 (31.2 ± 4.7 *vs.* 30.6 ± 4.8 kg/m²) Abdominal strength/endurance ↑ in G1 (18.8 ± 10.4 *vs*. 24.1 ± 10.9 rep) Abdominal strength/endurance ↑ in G2 (20.4 ± 10.8 *vs*. 29.1 ± 11.7 rep) Flexibility ↑ in CON (22.1 ± 9.1 *vs.* 24.4 ± 9.8 cm) Flexibility ↑ in G1 (21.0 ± 10.1 *vs*. 24.3 ± 9.4 cm) Flexibility ↑ in G2 (22.9 ± 11.7 *vs*. 25.7 ± 8.6 cm) VO_{2max} ↑ in G1 (24.2 ± 4.8 *vs*. 26.5 ± 5.7 ml/min/kg) VO_{2max} ↑ in G2 (25.2 ± 5.4 *vs.* 27.9 ± 6.4 ml/min/kg) Physical (perceived) ↑ in G1 (75.8 ± 11.5 *vs*. 81.6 ± 10.5) Physical (perceived) ↑ in G2 (77.7 ± 14.0 *vs*. 83.2 ± 12.6) Social (perceived) ↑ in G2 (77.1 ± 21.7 *vs*. 82.1 ± 17.8) Psychosocial (perceived) ↑ in G2 (73.1 ± 14.5 *vs*. 75.9 ± 14.1) Total quality of life (perceived) ↑ in G2 (74.3 ± 13.2 *vs*. 78.0 ± 12.6) **Inter-group (*P* <0.05)** > Body weight reduction in G2 that in CON (–1.7% ± 5.3 *vs.* 1.2% ± 3.3) > Fat percentage reduction in G2 and G1 that in CON (–1.1 ± 4.3%), and > G2 *vs.* G1 (–9.8 ± 7.2 *vs*. –6.1 ± 6.2%) > Fat-free weight increase in G1 (4.6 ± 4 kg) and G2 (4.4 ± 4.1 kg) that in CON (2.5 ± 3.9 kg) > VO_{2max} increase in G1 (7.3%) and G2 (10.7%) that in CON (2%) > Abdominal strength/endurance increase in G2 *vs*. G1 (34.7 *vs*. 26.1%)

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Table 2. Descriptive summary of the randomised and controlled articles *(continuation)*.

Author (Year), Design, Participants and Adherence/Dropout Rate	Intervention	Variables (Test)	Results
Pan (2011) **Design:** Comparative **Participants (n; condition; gender):** 30 (G1 = 7; ASD; M, G2 = 7; No-ASD; 1M + 6F, G3 = 8; ASD; 8M, G4 = 8; No-ASD; 4M + 4F) *Age, years (average, SD):* G1 = 9.31 ± 1.67; G2 = 8.89 ± 1.98; G3 = 8.75 ± 1.76; G4 = 7.39 ± 2.94 *Height, cm (average, SD):* G1 = 134.89 ± 7.82; G2 = 133.14 ± 16.39; G3 = 135.05 ± 11.27; G4 = 125.11 ± 2.94 *Weight, kg (average, SD):* G1 = 29.16 ± 3.53; G2 = 28.76 ± 12.59; G3 = 36.05 ± 12.35; G4 = 30.25 ± 15.07 *Fat percentage, %: NR* *BMI, kg/m² (average; SD):* G1 = 16.03 ± 1.36; G2 = 15.56 ± 2.18; G3 = 19.41 ± 5.06; G4 = 18.18 ± 3.69 **Dropout rate (n; reasons):** NR	**Duration:** 32 weeks; 14 (Stage 1) + 14 (Stage 2) + 4 transition Aquatic programme **Description:** – 10 min. Social and floor warm-up. – 35 min. Main part: they practised the training objectives individually or in pairs. – 15 min. Main part: group games/ activities. – 10 min. Return to rest: cool-down activities. **Volume:** 70 min **Intensity:** NR **Frecuency:** 2 sessions/week **G1:** Aquatic programme (Stage 1) + CON (Stage 2) **G2:** Aquatic programme (Stage 1) + CON (Stage 2) **G3:** CON (Stage 1) + Aquatic programme (Stage 2) **G4:** CON (Stage 1) + Aquatic programme (Stage 2)	**Anthropometric measurements** Body weight (kg) Fat percentage (%) Fat weight (kg) Fat-free weight (kg) BMI (kg/m²) **Physical capacity measurements** Abdominal strength/ endurance (rep) - Curl-up test Flexibility (cm) - Sit-and-reach test. $VO_{2máx}$ (ml/min/kg) - PACER (m) *Aquatic skills* - HAAR checklist – Mental adaptation – Introduction to the aquatic medium – Turns – Balance and control – Free movement in the water	**Inter-group (*P* <0.05)** > Curl ups (30 s) in G1 that in G3 and G4 (12.29 ± 2.93 *vs.* 8.25 ± 3.88 and 8.00 ± 2.62) at the end of Stage 1 > Curl ups (30 s) in G2 that in G4 (12.71 ± 3.99 *vs.* 8.00 ± 2.62) at the end of Stage 1 > Curl ups (60 s) in G1 and G2 that in G4 (22.57 ± 7.04 and 23.43 ± 7.41 *vs.* 13.63 ± 5.71) at the end of Stage 1 > Curl ups (60 s) in G2 that in G3 (22.57 ± 7.04 *vs.*14.88 ± 6.56) at the end of Stage 1 > Score in introduction to the aquatic medium in G1 and G2 that in G4 (100 ± 0 and 100 ± 0 *vs.* 91.25 ± 8.35) at the end of Stage 1 > Score in balance and control in G1 and G2 that in G3 and G4 (96.43 ± 9.45 and 100 ± 0 *vs.* 73.44 ± 24.49 and 57.81 ± 28.30) at the end of Stage 1 > Score in free movement in the water in G1 that in G3 and G4 (83.33 ± 21.52 *vs.* 43.75 ± 36.66 and 33.33 ± 39.84) at the end of Stage 1 > Score in free movement in the water in G2 that in G4 (78.57 ± 23.00 *vs.* 33.33 ± 39.84) at the end of Stage 1
Lee & Oh (2014) **Design:** Comparative **Participants (n; condition; gender):** 24 (20); children (G1 = 10; CON = 10) *Age, years (average, SD):* G1 = 11.45 ± 2.87; CON = 11.11 ± 1.69 *Height, cm (average, SD):* G1 = 127.46 ± 5.37; CON = 126.74 ± 3.25 *Weight, kg (average, SD):* G1 = 44.53 ± 8.83; CON = 46.73 ± 8.86 *Fat percentage, % (average; SD):* G1 = 34.45 ± 3.24; CON = 33.92 ± 2.70 *BMI, kg/m²:* NR **Dropout rate (n; reasons):** 4; personal reasons or physical limitations	**Frequency:** 3 sessions/week **Duration:** 12 weeks **G1:** Aquatic exercise group **Description:** – 10 min. Warm-up: Stretching. – 40 min. Main part: 1) side kick, 2) free kick, 3) free pull, 4) pull and kick, 5) freestyle swim, 6) back kick, 7) back pull, 8) pull and kick, 9) freestyle and back simulation, 10) interval swimming. – 10 min. Return to rest: Stretching, ball game, relaxation and deep breathing. **Volume:** 60 min **Intensity:** Warm-up: 7–9 RPE; Main part: 1-6 weeks 50–60% HR_{max} (11–13 RPE) and 7-12 weeks 60–70% HR_{max} (13–15 RPE), Return to rest: 7–9 RPE **CON** **Description:** Performed no organised PE	**Anthropometric measurements** Body weight (kg) Fat percentage (%) Fat-free weight (kg) **Physiological measurements** Vascular distention in hands and feet **Physical capacity measurements** Abdominal strength/endurance (rep) - *Sit-ups* Grip strength Flexibility (cm) - *Sit-and-reach test* Cardiovascular endurance 20 m *Shuttle Run Test*	**Intra-group (*P* <0.05)** Body weight ↓ in G1 (44.53 ± 4.56 *vs.* 40.80 ± 2.11 kg) Fat percentage ↓ in G1 (34.45 ± 2.28 *vs.* 29.90 ± 1.75%) Fat-free weight ↑ in G1 (30.64 ± 1.41 *vs.* 35.34 ± 1.91 kg) Vascular change in right leg ↑ in G1 (361.34 ± 25.66 *vs.* 381.93 ± 16.87) *Sit-ups* ↑ in G1 (49.49 ± 15.73 *vs.* 60.1 ± 11.54 rep) Flexibility ↑ in G1 (6.11 ± 6.34 *vs.* 18.71 ± 9.58 cm) Cardiovascular endurance ↑ in G1 (13.72 ± 2.45 *vs.* 17.45 ± 2.22 cm) **Inter-group (*P* <0.05)** > Body weight in CON that in G1 (44.38 ± 4.75 *vs.* 40.80 ± 2.11 kg) at 12 weeks > Fat percentage in CON that in G1 (35.1 ± 1.65 *vs.* 29.90 ± 1.75%) at 12 weeks < Fat-free weight in CON that in G1 (30.94 ± 1.66 *vs.* 35.34 ± 1.91%) at 12 weeks < Vascular change in right leg in CON that in G1 (349.16 ± 28.24 *vs.* 381.93 ± 16.87) at 12 weeks < *Sit-ups* in CON that in G1 (47.6 ± 10.29 *vs.* 60.1 ± 11.54) at 12 weeks < Flexibility in CON that in G1 (11.1 ± 5.89 *vs.* 18.71 ± 9.58 cm) at 12 weeks < Cardiovascular endurance in CON that in G1 (13.67 ± 2.17 *vs.* 17.45 ± 2.22) at 12 weeks

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Table 2. Descriptive summary of the randomised and controlled articles *(continuation)*.

Author (Year), Design, Participants and Adherence/Dropout Rate	Intervention	Variables (Test)	Results
Lopes *et al.* (2021) **Design:** Uncontrolled **Participants (n; condition; gender):** 22 (18); adolescents; 13M, 5F *Age, years (average, SD):* 13.26 ± 1.27 *Height, cm (average, SD):* 164.61 ± 8.85 *Weight, kg (average, SD):* 85.09 ± 20.81 *Fat percentage, % (average; SD):* 36.99 ± 5.19 *BMI, kg/m² (average; SD):* 31.25 ± 6.35 **Dropout rate (n; reasons):** 2; due to illness; 2 did not complete all the activities	**Frequency:** 3 sessions/week **Duration:** 12 weeks HIITAQ programme **Description:** – 10 min. Warm-up. – 12-24 min. Main part: HIIT series (static running, front kicks and ski) with active rests. – Return to rest: recreational exercises. **Volume:** NR **Intensity:** 80-95% HR_{max} and 50% HR_{max} during the rest periods; RPE 7-9	**Anthropometric measurements** Height (cm) Body weight (kg) Fat percentage (%) Fat-free weight (kg) WHR Waist circumference (cm) BMI (kg/m²) Z-BMI **Physiological measurements** Glucose (mg/dl) Insulin (mg/dl) TC (mg/dl) HDL-C (mg/dl) LDL-C (mg/dl) **Physical capacity measurements** VO_{2max} (ml/kg/min^{-1}) RHGS (kg) LHGS (kg) BMR (kcal/day)	**Intra-grupo (p <0,05)** Height ↑ at the end of the 12 weeks (164.61 ± 8.85 *vs.* 167.81 ± 8.80 cm) Body weight ↑ at the end of the 12 weeks (85.08 ± 20.80 *vs.* 87.41 ± 21.37 kg) Fat-free weight ↑ at the end of the 12 weeks (52.99 ± 10.54 *vs*. 55.17 ± 12.45 kg) Waist circumference ↑ at the end of the 12 weeks (107.27 ± 14.10 *vs*. 109.48 ± 14.95 cm) Z-BM I ↓ at the end of the 12 weeks (2.75 ± 0.95 *vs*. 2.62 ± 0.95) TC ↓ at the end of the 12 weeks (175.08 ± 25.95 *vs*. 163.97 ± 22.71 mg/dl) LDL-C ↓ at the end of the 12 weeks (107.46 ± 21.79 *vs*. 97.29 ± 23.80 mg/dl) VO_{2max} ↑ at the end of the 12 weeks (32.2 ± 5.24 *vs*. 33.90 ± 4.93 ml/kg/min^{-1}) BMR ↑ at the end of the 12 weeks (1644.22 ± 341.16 *vs.* 1765.94 ± 356.87 kcal/day)
Pal & Sarkar (2019) **Design:** Uncontrolled **Participants (n; condition; gender):** 20; adolescents; M *Age, years (range):* 8-14 *Height, cm:* NR *Weight, kg:* NR *Fat percentage, % (average; SD):* 38.27 ± 4.52 *BMI, kg/m²:* NR **Dropout rate (n; reasons):** NR	**Frequency:** 5 sessions/week **Duration:** 6 weeks Aquatic exercises and swimming **Description:** – Dynamic warm-up. – 30-45 min. Main part: Aquatic exercises and swimming. Small field games. **Volume:** NR **Intensity:** NR	**Anthropometric measurements** Fat percentage (%) **Physical capacity measurements** 6 min *Run and Walk Test* - adapted to the pool (m)	**Intra-group (*P* <0.05)** Fat percentage ↓ at the end of the 6 weeks (38.27 ± 4.52 *vs*. 37.07 ± 4.50%) Distance travelled during the 6 min. *Run and Walk Test* ↑ at the end of the 6 weeks (3.0550E2 ± 31.49 *vs.* 3.7725E2 ± 29.40)
Stan (2012) **Design:** Uncontrolled **Participants (n; condition; gender):** 7, children; NR *Age, years (range):* 5-8 *Height, cm (range):* 112-126 *Weight, kg (range):* 37-46 *Fat percentage, %:* NR *BMI, kg/m²:* NR **Dropout rate (n; reasons):** NR	**Frequency:** 2 sessions/week **Duration:** 12 weeks Aquatic aerobic exercises **Description:** running in shallow water (static and in motion), running in deep water, crawl swimming, modified arm, backstroke legs with float on the chest. **Volume:** 60 min. **Intensity:** NR	**Anthropometric measurements** BMI (kg/m²)	**Intra-group (*P* <0.05)** Average BMI ↓ at the end of the 12 weeks (29.14 *vs.* 28.23 kg/m²)

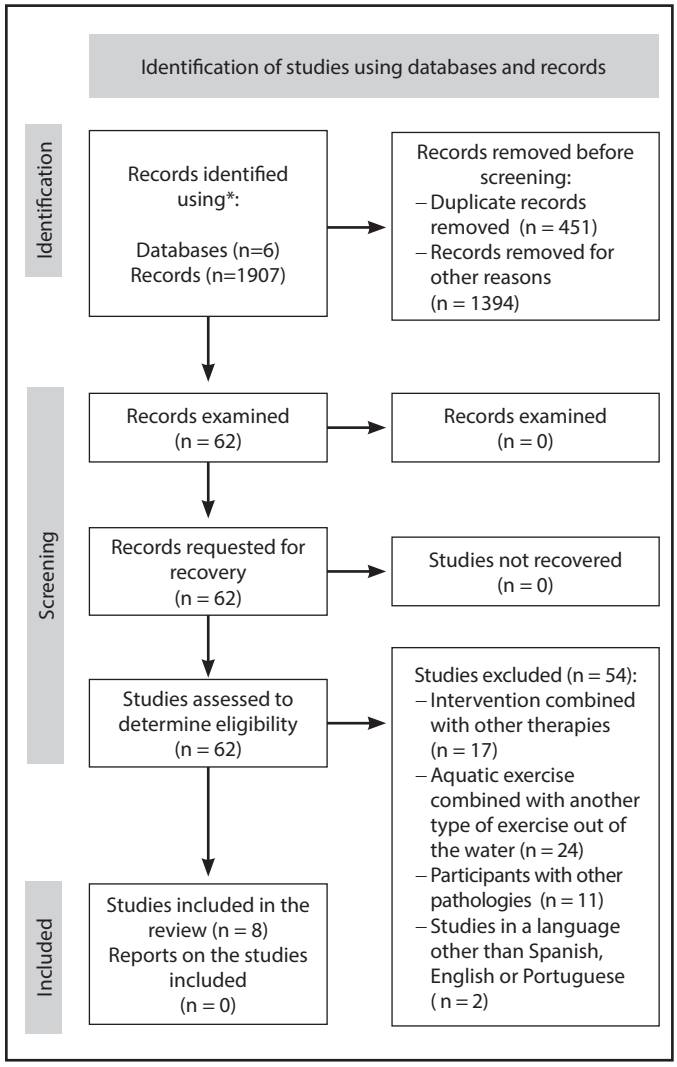
>: Greater than; <: Less than ↑: Increase; ↓: Decrease; PE: Physical exercise; BMR: Basal metabolic rate; CON: Control group; RCT: Randomised controlled trial; F: Female; HR: Heart rate; HR_{max}: Maximum heart rate; HRR: Heart rate reserve; FEV_1: Forced expiratory volume in the first second; FVC: Forced vital capacity; G: Experiment group; HDL: High-density lipoproteins; HIITAQ: Programme of High-Intensity Interval Training in Aquatic Medium; BMI: Body mass index; LDL: Low-density lipoproteins; LHGS: Left hand grip strength; M: Male; NR: Not reported; PACER: *Progressive Aerobic Cardiovascular Endurance Run*; PEF: Maximal expiratory flow; RHGS: Right hand grip strength; RPE: Rate of perceived exertion; TC: Total cholesterol; ASD: Autism spectrum disorders; VO_2: Oxygen volume; VO_{2max}: Maximum oxygen volume: WHR: Waist-to-hip ratio; Z-BMI: Body mass index Z-score.

Design and samples

Of the eight studies included, two were described as RCTs[14,15], three as comparison studies[16-18] and three as uncontrolled studies[19–21]. Table 2 shows a summary of the characteristics of all eight studies reviewed.

In total, 349 participants were included in the studies. The samples used in the studies varied from 7 to 210 participants, with ages ranging from 5 to 18 years. Of the articles analysed, seven showed the sample distribution in terms of gender. Of those seven, four reported mixed

Figure 1. PRISMA diagram (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*) for the study.



samples while the other three only conducted the exercise programmes with children (ranges of 228-256 boys and 93-121 girls).

Quality assessment

The RCT articles[14,15] were considered of "high" quality after being analysed using the PEDro scale. The three comparison studies assessed using the MINORS scale were also considered of "high" quality[16–18]. Finally, the NIHL scale was used to assess the methodological quality of the uncontrolled articles, of which two were considered "low" quality[20,21] and one "high" quality[19]. A full description of the quality analysis is provided (Table 3).

The eight interventions were assessed using the CERT scale and four of them were classified as "high" quality[14,18,19,21]. The other four were classified as "low quality" or unreliable. No harmful effects were reported by the participants in any of the interventions (Table 4).

Intervention

Generally, the interventions were conducted over a period of 3 to 16 weeks, with a frequency of 2 to 5 sessions per week and a duration of 30 to 70 minutes. The content of the interventions mainly included aerobic exercise (n = 6), aerobic exercise combined with strength training (n = 1) or aerobic exercise combined with the development of aquatic skills (n = 1).

Two studies compared the effects of the aquatic exercise using a control group[16,17]. The effects of two types of aquatic exercise were compared in one study, with the two groups engaging in swimming sessions but only one of them combined that with aquatic walking[15]. Finally, two articles were reviewed in which the sample was divided into three groups: the control group engaged in regular daily activity; another group engaged in aquatic exercises; and another group engaged in an alternative intervention[14,18]. In this regard, both the interventions based on aquatic exercises and the proposed alternatives were shown to be more effective than the control conditions at reducing body weight.

Main results

We classified the variables into four large groups: anthropometric measurements (n = 8), physiological measurements (n = 2), physical capacity measurements (n = 7) and perceptive measurements (n = 3).

Anthropometric measurements

All the studies assessed variables related to anthropometric measurements. Aquatic exercise presented favourable results in terms of body weight[14,15,17–19,21], BMI[14,15,18,21], body fat percentage[15–18,20], fat-free mass[17–19], waist circumference[15,18] and hip circumference[18,19] after the interventions when compared with before them.

The body weight variable was studied in six articles[14,15,17–19,21]. Three of the six articles[14,17,18] revealed that the control group was less effective than the interventions at reducing body weight. In this regard, Honório *et al.*[15] also discovered differences between the swimming group and the swimming combined with aquatic walking group, the latter being more effective at reducing body weight. The BMI was also studied in six articles, with inter-group differences being found in three of them[14,15,18]. In the studies by Lopera *et al.*[18] and Irandoust *et al.*[14], it was observed that the BMI was higher in the control group than in the intervention groups.

Furthermore, Lopera *et al.*[18] reported improvements in fat percentage and fat-free weight in the aquatic exercise group and on-land exercise group when compared with the control group. Similar results were obtained in the work by Lee & Oh[17], showing lower fat percentages and higher fat-free weight in the aquatic exercise group when compared with the control group.

Waist circumference was studied in two articles[15,18]. Honório *et al.*[15] only found significant differences in the initial assessment of this variable between the swimming group and the swimming combined with aquatic walking group. However, Lopera *et al.*[18] found significant

Table 3. Methodological quality assessment of the studies included.

Authors	Assessment Components												
PEDro scale (randomised and controlled articles)	**0. Eligibility criteria**	**1. Random allocation**	**2. Concealed allocation**	**3. Comparability baseline**	**4. Participant blinding**	**5. Therapist blinding**	**6. Assessor blinding**	**7. Results from 85% assigned**	**8. Intention to treat analysis**	**9. Comparison between groups analysis**	**10. Point measures and variability**	**Total (0-11)**	
Irandoust *et al.* (2020)	1	1	0	1	0	0	1	1	0	1	1	7/11	
Honório *et al.* (2018)	0	1	0	1	0	0	0	1	1	1	1	6/11	
MINORS scale (comparative articles)	**1. Clearly stated aim**	**2. Inclusion of consecutive patients**	**3. Prospective data collection**	**4. Endpoints appropriate to study aim**	**5. Unbiased assessment of study endpoint**	**6. Follow-up period appropriate to study aim**	**7. <5% lost to follow-up**	**8. Prospective calculation of study size**	**9. Adequate control group**	**10. Contemporary groups**	**11. Baseline equivalence of groups**	**12. Adequate statistical analysis**	**Total (0-24)**
Lopera *et al.* (2016)	2	2	2	2	2	2	0	2	2	2	2	2	22/24
Pan (2011)	2	2	2	2	2	2	2	1	2	2	1	2	22/24
Lee & Oh (2014)	2	2	1	2	2	2	0	1	2	2	2	2	20/24
NHLBI scale (uncontrolled articles)	**1. Study aim**	**2. Criterios de elección**	**2. Eligibility criteria**	**4. Elected participants**	**5. Adequate sample**	**6. Intervention and application described**	**7. Result measures**	**8. Assessor blinding**	**9. Loss to follow-up (<20%)**	**110. Statistical values**	**11. Uninterrupted series of data**	**12. Individual data / group result**	**Total (0-12)**
Lopes *et al.* (2021)	1	1	1	1	1	1	1	0	1	1	0	0	9/12
Pal & Sarkar (2019)	1	1	0	1	0	0	0	0	1	1	0	0	5/12
Stan (2012)	1	0	0	0	0	1	0	0	1	1	0	0	4/12

changes in the intervention groups when compared with the control group and also reported a smaller hip circumference in the physical exercise groups when compared with the control group.

Physiological measurements

Two studies included physiological measurements as a result[17,19]. Lopes *et al.*[19] observed that total cholesterol and low-density lipoproteins levels fell after a 12-week programme of high-intensity interval training in an aquatic environment. Furthermore, a change in the vascular distention of the right leg was found in the group engaging in aquatic exercises when compared with the levels recorded prior to the intervention and when compared with the control group[17].

Physical capacity measurements

Seven of the eight studies assessed variables related to the physical capacity of the participants. Aquatic exercise presented favourable results in forced expiratory volume in one second[15], maximal expiratory flow[15], forced vital capacity[14,15] and maximal oxygen uptake[17–20]. In this regard, Honório *et al.*[15] showed that the swimming combined with aquatic walking group was more effective than the only swimming group at improving forced expiratory volume in one second, forced vital capacity and maximal expiratory flow.

Abdominal strength/endurance[16–18], flexibility[17] and the basal metabolic rate[17] were also positively affected by the training programmes, while hand grip strength showed no significant change[17,19]. Furthermore, a programme of aquatic exercise led to significant improvements in aquatic skill scores[16].

Perceptive measurements

Both a 16-week programme of aquatic exercises and one of exercises on land led to a significant increase in perceived fitness among participants when compared with levels prior to the intervention. On the other hand, no significant changes were recorded in fitness among the control group. Nonetheless, only the programme of exercises on land generated an increase in the perceived levels of social status, psycho-social status and quality of life among adolescents[18].

Discussion

This review sought to research the effects of aquatic exercise on variables related to body composition in children and adolescents. The results obtained would indicate its potential interest when reducing body weight, BMI and fat percentage, as well as positively impacting the physical capacity of participants. Nonetheless, the scientific evidence found is not sound.

Table 4. Results of CERT methodological assessment.

Criteria	Irandoust *et al.* (2020)	Honório *et al.* (2018)	Lopera *et al.* (2016)	Pan (2011)	Lee & Oh (2014)	Lopes (2021)	Pal & Sarkar (2019)	Stan (2012)
1. Description of the type of equipment used in the exercise.	1	0	0	0	0	0	0	1
2. Description of the qualifications, experience and/or training.	1	1	1	1	1	1	1	1
3. Describes whether the exercises are individual or group-based.	0	1	0	1	1	0	0	0
4. Describes whether the exercises are supervised or not, how they are taught.	1	1	1	1	0	0	0	1
5. Detailed description of how adherence is measured and reported.	1	0	1	1	1	1	0	1
6. Detailed description of the motivation strategies.	1	0	1	1	0	1	0	0
7a. Detailed description of the rule(s) for deciding on determining exercise progression.	0	0	0	0	0	0	0	0
7b. Detailed description of how the exercise programme is progressing.	0	0	1	0	0	1	0	1
8. Detailed description of each exercise to enable replication.	1	0	1	0	1	1	0	1
9. Detailed description of any component of the programme at home.	0	0	0	0	0	0	0	0
10. Describes any component that is not an exercise.	1	0	1	1	0	0	0	0
11. Describes the type and number of adverse events during the exercise.	0	0	0	0	0	0	0	0
12. Describes the environment in which the exercises take place.	0	1	0	1	0	1	0	1
13. Detailed description of the exercise intervention.	1	0	1	0	1	1	1	1
14a. Describes whether the exercises are generic (the same for all) or personalised.	1	0	1	0	1	1	0	1
14b. Description of how the exercises are adapted to each person.	0	0	0	0	0	0	0	0
15. Describes the rule for determining initial level.	1	1	1	0	0	1	1	1
16a. Describes how adherence or faithfulness are measured.	1	0	1	0	1	0	0	0
16b. Describes the extent to which the intervention went according to plan.	1	1	1	1	1	1	1	1
Final score	**12/19**	**6/19**	**12/19**	**8/19**	**8/19**	**10/19**	**4/19**	**11/19**

Based on the studies included in this review, aquatic exercise seems to be a successful intervention for reducing weight, BMI, fat percentage, fat-free mass, waist circumference and the waist-to-hip ratio in children and adolescents. These results are in line with previous studies on aquatic exercise programmes in adults, which have reported reductions in body weight[22,23], BMI[24], fat percentage[25,] fat-free mass[26] or waist circumference and waist-to-hip ratio[27].

One important aspect to take into consideration is that, generally speaking, the groups in the studies included for this review that engaged in some form of physical exercise outside of water also showed benefits in the majority of these variables, while the control groups generally remained unchanged. All the studies included that examined body weight as a variable showed improvements in the exercise groups both in and out of the water. According to the results from the studies by Stan[21], Honório *et al.*[15], Irandoust *et al.*[14] and Lopera *et al.*[18], those participants who engaged in some form of intervention obtained reductions to their BMI regardless of whether the exercise was aquatic, on land or with videogames. In the work by Honório *et al.*[15], there was a small difference in the BMI at the start of the intervention between the swimming group and the swimming plus aquatic walking group. However, this

inter-group difference after the intervention was insignificant and both groups saw a reduction to BMI levels. Similarly, fat percentage reductions were found in the groups engaging in exercise out of the water in all the studies that examined this variable. These results seem to indicate that, in general, physical exercise favours the loss of adipose tissue, as already indicated by current scientific evidence[28,29]. Nonetheless, more studies of a better quality are needed to identify whether aquatic exercise is more effective than exercise out of the water at preventing or reducing overweight and obesity in children and adolescents.

Excess body weight in children and adolescents is tied to health risks that include respiratory complications[30], metabolic disorders[31] and an inability to exercise[32]. The data from this review indicated that aquatic exercise was more effective than the control group at improving the variables related to physical capacity, which include breathing capacity, cardiovascular endurance, flexibility and abdominal strength/endurance. Hence, this type of interventions could improve some of the problems associated with overweight and obesity. The results from this review can be added to the existing evidence that indicates the need for children and adolescents to engage in physical activity[33].

Furthermore, in order to analyse the methodological quality of the studies included in this review, several different scales (as stated above) were used to assess the randomised and controlled, and comparison and uncontrolled studies. The methodological quality was good, generally speaking, which is positive because it increases the quality of this work and the results obtained are more reliable. As a result, the scientific evidence extracted from the studies could be described as "valid" [14–16,18,19]. However, there are another two studies in which the evidence extracted might be doubtful due to the "poor" quality of the research[20,21]. In terms of the quality with which the physical exercise interventions were reported (assessed using the CERT scale), half of the articles (n = 4) showed a poor quality. The quality of the interventions was affected on numerous occasions because several studies did not report the pace of progress made by the interventions; something that is essential in any kind of intervention. Neither did any of the studies report whether any problem or adverse event arose during the intervention. Finally, the method used to measure adherence to the exercise programme was not reported at all. For these reasons, the interventions were explained in some of the studies in such a way that left many issues unspecified. As a result, their application to other environments with other participants could be more complicated.

This review has a number of limitations that should be considered when interpreting the results obtained. The most significant of them is tied to the differences between the studies included, especially with regard to their methodological quality. Only four of the eight articles included in this review used a control group[14,16–18]. Of those four, two also had a group that engaged in an activity other than the aquatic exercise[14,18], and the study by Honório *et al.*[15] had a group that combined aquatic exercise with aquatic walking. As a result, only five of the eight initial articles allowed the results obtained following the interventions in the water to be compared with other groups. Finally, there are limitations related to linguistic restrictions owing to the fact that grey literature with publication bias was not reviewed, which could have conditioned the results from this review.

Conclusion

Scientific evidence on the effects of aquatic exercise on variables related to body composition in children and adolescents is scarce. The studies included in this review seem to indicate that aquatic exercise could be useful for preventing or reducing certain variables related to adiposity in children and adolescents, as well as for improving their physical capacity. However, future randomised and controlled studies are necessary to assess the effectiveness of aquatic exercise programmes and these studies should provide a more detailed description of the interventions to enable replication.

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Conflict of interest

The authors declare no conflict of interest.

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