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Effects of water aerobics on body composition in obesity and overweight people: a systematic review and metaanalysis

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Keywords:	Meta-Analysis, Obesity, Overweight





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water aerobics on body composition in obesity and ht people: a systematic review and meta-analysis

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48	18	overweight people: a systematic review and meta-analysis
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53	20	Abstract
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55 56	04	Background . The problem of obesity and overweight earievely offects people's health
57	21	Dackground . The problem of obesity and overweight seriously affects people's health.
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59	22	The benefits of water aerobics have been shown in obesity and overweight people, but
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1	the effects of water aerobics on body composition improvement are still unclear.
2	Methods: A systematic literature search was conducted on October 26, 2023 using the
3	PubMed MEDLINE, Ovid MEDLINE, Embase, Scopus, Web of Science, and the
4	Cochrane Library. The studies were independently screened by 2 researchers. All
5	randomized clinical trials on water aerobics that evaluated the anthropometric and body
6	composition parameters of overweight and obesity subjects were included, and a
7	reporting of eligible studies was conducted in accordance with PRISMA statement.
8	Finally, 10 articles out of the 4329 articles searched. Depending on the level of study
9	heterogeneity, the use of a fixed-effects model or a random-effects model was
10	determined. The risk of bias of the selected studies was assessed using the Risk of Bias
11	2.0 tool, and sensitivity analyses and subgroup analyses were performed on the outcome
12	indicators. The study protocol was registered in PROSPERO (CRD42023466969).
13	Results: A total of 10 studies with 286 patients were included. Sensitivity analyses are
14	performed for PBF with high heterogeneity, and the results are robust. WAs are able to
15	reduce BW (WMD = -2.69, 95%CI: -4.10 to -1.27, $p < 0.05$, $I^2 = 0.0\%$) and WC (WMD
16	= -2.75, 95%CI: -4.41 to -1.09, p < 0.05, I^2 = 27.0%), but the effect on other body
17	indicators is not significant.

Conclusions: For the obesity and overweight people, WAs interventions over 10 weeks (i.e., 12 weeks) reduced BW and WC, with more significant effects in women and better improvements in body composition in middle-aged and older adults (average age ≥ 45 years).

Key words: water aerobics; meta-analysis; body composition; obesity; overweight

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8 Background

The global prevalence of obesity has risen significantly over the past 40 years [1-3]. By 2022, more than 43% of adults worldwide will be overweight, with 504 million female and 374 million male obese [4]. Obesity is a chronic disease that increases the risk of various complications and leads to an estimated 2.8 million deaths each year [5-7]. Although weight management through exercise is highly effective [8-10]. However, due to their weight, obesity and overweight people are prone to serious damage to their bones and joints during exercise [11]. Traditional land-based aerobic exercise methods increase musculoskeletal damage in obese patients [12]. Water aerobics (WAs) interventions are more beneficial and effective as a new approach to treating obesity [13, 14]. WAs can use the buoyant effect of water to reduce joint injuries associated with exercise in obesity and overweight people [15, 16]. Therefore, WAs, as a beneficial exercise method, can be an important way to lose weight for obesity and overweight people [17, 18]. However, fewer studies have been reported on the effects of WAs on physical indicators in obesity and overweight people.

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> The previous literature review [13, 19, 20]. only provided a wide-ranging overview of the relevant evidence. For example, Haifeng Zhu [21] summarizes the physical effects of aquatic exercise on adults. However, this study only included randomized controlled trials (RCTs) on healthy adults and did not consider studies of obesity and overweight people [21].

- 6 Thus, the systematic review and meta-analysis of the present study can, to some 7 extent, fill the research gap on the effects of WAs interventions on obesity and 8 overweight people. The main discussion is whether WAs has a significant improvement 9 in physical indicators in obesity and overweight people.
- 10
- 11 Methods

12 Registration

This meta-analysis study is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement [22, 23]. The study protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) (registration number: CRD42023466969). Minor changes were made to the initial PROSPERO protocol submitted in October 2023 (**Table S1** in Supplementary information 2).

19 Search strategy

Six databases were searched: PubMed MEDLINE, Ovid MEDLINE, Embase, Scopus,
Web of Science, and the Cochrane Library. The time span of the search was from the
construction of the database to 26 October 2023. Retrieval strategy based on PICOS

tool [24]: (P) Population: adults with overweight and obesity; (I) Intervention: WAs; (C) Comparator: other exercise modalities or no exercise control; (O) Outcome: body composition; (S) Study type: RCTs. The core terms for the searches were identified in the MeSH Database in the PubMed database, respectively, to ensure the scientific validity and accuracy of the search vocabulary, and the comprehensiveness of the search scope (details of the search strategy are in **Table S2** in Supplementary information 2). In addition to the database, reference lists of included articles were screened for articles that satisfied the inclusion criteria.

9 Eligibility criteria

Inclusion criteria: (1) RCTs; (2) Participants were obesity (BMI≥30 kg/m²) and overweight (BMI ≥25kg/m²) [25] adults (≥18 years, including older adults); (3) The intervention group participated in WAs for at least 4 weeks, and the control group did not participate in exercise or chose other ways of exercising; (4) Results on changes in body composition were obtained in the original article; (5) Full text available in English (i.e., not a review, letter, case series or conference proceedings).

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Exclusion criteria: (1) Trials that did not satisfy all inclusion criteria; (2) Participants diagnosed with other diseases were included; (3) Exercise interventions combined with dietary control, medication or other lifestyle changes; (4) There was no exercise of any form, just a trial of being immersed in water or receiving a massage.

20 Study selection

21 The study used EndNote (version 21) to manage the articles. First, duplicate articles

22 were removed. Second, the titles and abstracts of the articles were read and qualified

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articles were selected. Finally, full-text review was performed. The process was independently screened by 2 researchers (D.Z.Y., Z.H.X.). Disagreements were adjudicated by a third researcher (G.Z.X.). **Data extraction** Data from included studies were recorded using an adapted Cochrane Collaboration [26] standardized data extraction form. The study characteristics are extracted as follows: year of publication, authors, region, study period, study design, sample size, participants, and mean age. Outcome measures: body weight (BW), body mass index (BMI), percent body fat (PBF), lean mass (LM), fat mass (FM), waist-hip ratio (WHR), waist circumference (WC), hip circumference (HC). Two researchers (D.Z.Y., Z.H.X.) independently extracted this information from each study and resolved any disagreements through discussion. **Risk of bias** Two researchers (D.Z.Y. and Z.H.X.) subjected the included RCTs to an independent risk of bias assessment. The Cochrane risk-of-bias tool (RoB 2) was used for the review according to the evaluation criteria of the Cochrane Handbook for Systematic Reviews of Interventions (Version 6.4) [27]. Disagreements arising from the review were discussed and resolved with the participation of the third researcher (G.Z.X.) on the review team.

20 Data analysis

 21 Meta-analysis was conducted using Stata 18.0 software. Heterogeneity of studies was 22 assessed using Cochrane's Q and I² tests [28]. when P > 0.1, $I^2 \le 50\%$, there was

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Fig. 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)
 Flow Diagram

Study characteristics

The RCTs included in the study had 286 participants [34-43]. Publication dates range from 2009 to 2021. A small number of subjects from 5 trials [34, 36, 38, 41, 42] dropped out of the experiment for various reasons, and trial data from those who dropped out was not used. A study [34] had more than 2 groups of trial participants, so the included studies were numbered separately (Yusof-1 and Yusof-2). The basic characteristics of

10 each study are shown in **Table 1**.

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 Table 1 Experimental details.

		Duration		Mean age/			
Study	Country	(weeks)	Sample	range (SD)	Exercise Category	Study design (Frequency, time)	Outcome
Yusof-1 et al., 2018	Malaysia	12	40 (F)	45.13(5.17)	Aqua Zumba	3 days/week, 60 minutes per session	BW, PBF, WC
Yusof-2 et al., 2018	Malaysia	12	40 (F)	45.28(5.09)	Aqua jog	3 days/week, 60 minutes per session	BW, PBF, WC
Penaforte et al., 2015	Brazil	8	16 (F)	42.8(7.4)	Water aerobics	3 days/week, 60minutes per session	BW, BMI, LM, FM, WC, HC
Palekar et al., 2018	India	9	14 (M)	20.71	Underwater treadmill training	3 days/week, 25minutes per session	BMI, PBF, WC
Rezaeipour, 2020	Iran	12	24 (F)	69.5(4.3)	Aquatic exercises (dancing and walking)	3 days/week, 60minutes per session	BW, BMI, LM, FM,
Greene et al., 2009	American	12	57 (Mix)	42(18.67)	Underwater treadmill	Three times per week	BW, BMI, LM, FM, WC, HC, WHR
Rica et al., 2012	Brazil	12	38 (F)	68.5(5)	Water-based exercise with aerobic	Three times per week, 60-min sessions	BW, BMI, PBF, LM, FM, WC, HC, WHR
Wouters et al., 2009	Netherlands	9	14 (Mix)	44	Aquajogging	2 per week, one hour	BW, BMI, PBF, WC
Rezaeipour, 2021	Iran	12	27 (M)	68.7(3.2)	Water-based exercise with aerobic	3 days/week, 60minutes per session	BW, BMI
Soori et al., 2017	Iran	10	16 (F)	45-60	Swimming or walking in the water	3 per week, 45 min per day	BW, BMI, PBF, WC
Colato et al., 2016	Brazil	12	20 (F)	49.36(11.69)	Water running training	3 per week, 70 minutes/session	BW, BMI, FM, WC, HC
Note: body weight (BW) mixed sex (Mix); male (h	t; body mass ind M); female(F).	lex BMI); pu	ercent body fai	t (PBF); lean mas	s (LM); fat mass (FM); Wai	st-hip ratio (WHR); Waist circumference (WC); Hip circumference (HC);

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D1a D1b

2 After a bias risk assessment, the 10 included studies were rated as follows: 6 had low

3 risk, 3 had some concerns, and 1 had high risk (Fig. 2).

<u>D2</u>

<u>D3</u>

<u>D4</u>

<u>D5</u>

Overall

	Yusof et al., 2018 (+) (+) (+) (+) (+) (+)	+ Low risk
	Penaforte et al., 2015 🔸 🔸 🗧 🔸 🔸 🕂	Some concerns
	Palekar et al., 2018 😛 + + + + +	- High risk
	Rezaeipour, 2020 😛 + ! + + !	
	Greene et al., 2009 🧜 + ! + 🕂	D1a Randomisation process
	Rica et al., 2012 ! + 😦 + + 🕒	D1b Timing of identification or recruitment of participants
	Wouters et al., 2009 (+) (+) (+) (+) (+) (+)	D2 Deviations from the intended interventions
	Rezaeipour, 2021 (+) (+) (+) (+) (+) (+)	D3 Missing outcome data
	Soori et al., 2017 (+) (+) (+) (+) (+) (+)	D4 Measurement of the outcome
	Colato et al., 2016 (+) (+) (+) (+) (+) (+)	D5 Selection of the reported result
	Selection of the reported result Measurement of the outcome Mising outcome data Deviations from intended interventions Timing of identification or recruitment of participants Randomization process 0 10	20 30 40 50 60 70 80 90 100
4	Low risk Some	concerns High risk
4		
5	Fig. 2 Risk of bias	
6		
7	Physical outcome	
8	WAs are effective interventions for BW (WMD = -2.69, 95%CI: -4.10 to -1.27, p <
9	0.05, $I^2 = 0.0\%$) and WC (WMD = -2.75, 9	5%CI: -4.41 to -1.09, p < 0.05, $I^2 = 27.0\%$)
10	in obesity and overweight people (Fig. S1	and Fig. S2 in Supplementary information
11	1). Other physical indicators, such as BMI	(WMD = -0.55, 95%CI: -1.29 to 0.19, p >
12	$0.05, I^2 = 0.0\%$) (Fig. S3 in Supplementary	information 1), PBF (WMD = -4.83, 95%CI:
13	-10.32 to 0.66, $p > 0.05$, $I^2 = 93.6\%$) (Fig	. S4 in Supplementary information 1), LM

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1	(WMD = -0.19, 95%CI: -2.75 to 2.37, $p > 0.05$, $I^2 = 0.0\%$) (Fig. S5 in Supplementary
2	information 1), FM (WMD = -0.92, 95%CI: -3.20 to 1.36, p > 0.05, I ² = 0.0%) (Fig. S6
3	in Supplementary information 1), WHR (WMD = -0.02 , 95%CI: -0.05 to 0.01 , p > 0.05,
4	$I^2 = 0.0\%$) (Fig. S7 in Supplementary information 1) and HC (WMD = -1.05, 95%CI:
5	-3.64 to 1.55, $p > 0.05$, $I^2 = 0.0\%$) (Fig. S8 in Supplementary information 1), did not
6	show significant improvement (Table 2).
7	

8 Subgroup analysis of outcomes

9 Subgroup analyses of WAs were performed on the included studies to identify
10 appropriate WAs regularity and to explore sources of heterogeneity. Due to the number
11 of subgroups, the results of the subgroup analyses of WAs are summarized in the table

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Table 2 Subgroup analysis of water aerobics on anthropometric measures

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	Ν	WMD (95% CI)	P within group	P heterogeneity	I^2
Subgroup analyses of WA on BW		-			
Overall effect	10	-2.69(-4.10, -1.27)	0.000*	0.670	0.0%
Trial duration (week)					
>10	7	-3.31(-5.23, -1.40)	0.001*	0.455	0.0%
≤10	3	-1.93(-4.03, 0.16)	0.071	0.971	0.0%
Sex					
Male	1	-0.60(-8.58, 7.38)	0.883	-	-
Female	7	-2.90(-4.37, -1.43)	0.000*	0.486	0.0%
Mix (male & female)	2	0.24(-6.54, 7.02)	0.944	0.678	0.0%
Average age					
≥45	7	-2.85(-4.31, -1.40)	0.000^{*}	0.465	0.0%
<45	3	0.05(-5.89, 5.98)	0.988	0.911	0.0%
Subgroup analyses of WA on BMI					
Overall effect	9	-0.55(-1.29, 0.13)	0.146	0.984	0.0%
Trial duration (week)					
>10	5	-0.14(-1.25, 0.97)	0.806	0.943	0.0%
≤10	4	-0.88(-1.88, 0.12)	0.083	0.979	0.0%

^{12 (}**Table 2**).

Sex					
Male	2	-0.47(-2.52, 1.57)	0.649	0.932	0.0
Female	5	-0.55(-1.41, 0.31)	0.208	0.757	0.0
Mix (male & female)	2	-0.63(-2.79, 1.52)	0.565	0.932	0.0
Average age					
≥45	5	-0.55(-1.38, 0.29)	0.199	0.757	0.0
<45	4	-0.57(-2.21, 1.07)	0.498	0.999	0.0
Subgroup analyses of WA on PBF					
Overall effect	6	-4.83(-10.32, 0.66)	0.085	0.000	93.
Trial duration (week)					
>10	3	-9.01(-18.05, 0.02)	0.051	0.000	94.
≤10	3	-0.26(-1.87, 1.36)	0.755	0.938	0.0
Sex					
Male	1	-0.83(-6.28, 4.61)	0.765	-	-
Female	4	-6.71(-14.24, 0.82)	0.081	0.000	96.
Mix (male & female)	1	-0.80(-5.25, 3.65)	0.724	-	-
Average age					
≥45	4	-6.71(-14.24, 0.82)	0.081	0.000	96.
<45	2	-0.81(-4.26, 2.63)	0.644	0.993	0.0
Subgroup analyses of WA on WC					
Overall effect	8	-2.75(-4.41, -1.09)	0.001*	0.213	27.
Trial duration (week)					
>10	5	-2.88(-4.63, -1.12)	0.001*	0.057	56.
≤10	3	-1.67(-6.76, 3.42)	0.520	0.889	0.0
Sex					
Male	1	-0.89(-17.54, 15.76)	0.917	-	-
Female	5	-2.89(-4.65, -1.13)	0.001*	0.058	56.
Mix (male & female)	2	-1.69(-6.90, 3.52)	0.525	0.626	0.0
Average age					
≥45	4	-3.03(-4.85, -1.22)	0.001*	0.034	65.
<45	4	-1.27(-5.40, 2.86)	0.546	0.959	0.0
Subgroup analyses of WA on LM					
Overall effect	4	-0.19(-2.75, 2.37)	0.883	0.889	0.0
Subgroup analyses of WA on FM					
Overall effect	5	-0.92(-3.20, 1.36)	0.429	0.991	0.0
Subgroup analyses of WA on WHR					
Overall effect	3	-0.02(-0.05, 0.01)	0.256	0.830	0.0
Subgroup analyses of WA on HC	-				
Overall effect	1	-1 05(-3 64 1 55)	0.429	0.610	0.0

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As seen by subgroup analyses of BW, WAs with a trial duration > 10 weeks (i.e.

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1	12 weeks) significantly reduced BW (WMD = -3.31, 95%CI: -5.23 to -1.40, $p < 0.05$,
2	$I^2 = 0.0\%$). In addition, WAs significantly reduced BW in the female population (WMD
3	= -2.90, 95%CI: -4.37 to -1.43, p < 0.05, $I^2 = 0.0\%$) and in the population with a mean
4	age of \geq 45 years (WMD = -2.85, 95%CI: -4.31 to -1.40, p < 0.05, I ² = 0.0%).
5	From the subgroup analysis of WC, it is shown that WAs with a trial duration >10
6	weeks significantly reduced WC (WMD = -2.88, 95%CI: -4.63 to -1.12, $p < 0.05$, $I^2 =$
7	56.3%). Among them, WAs were mainly able to significantly reduce WC in the female
8	population (WMD = -2.89, 95%CI: -4.65 to -1.13, $p < 0.05$, $I^2 = 56.1\%$) and in the
9	population (WMD = -3.03, 95%CI: -4.85 to -1.22, $p < 0.05$, $I^2 = 65.5\%$) with a mean
10	age \geq 45 years.
11	Other subgroup analyses found that BMI (P = 0.146, $I^2 = 0.0\%$), LM (P = 0.883,
12	$I^2 = 0.0\%$), FM (P = 0.429, $I^2 = 0.0\%$), WHR (P = 0.256, $I^2 = 0.0\%$) and HC (P = 0.429,
13	$I^2 = 0.0\%$) were neither heterogeneous nor significant. In contrast, PBF ($I^2 = 93.6\%$)
14	and WC ($I^2 = 27.0\%$) were heterogeneous. However, separate subgroup analyses
15	revealed multiple sources of heterogeneity, which could not be adequately explained
16	by only one pair of subgroup analyses.
17	Sensitivity analysis of PBF
18	PBF has high heterogeneity. Thus, the robustness of the results was assessed through

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sensitivity analyses to identify sources of heterogeneity. The results show that the
95%CI excludes 0 (Fig. 3). This means that the results are robust, the sensitivity is small,

21 and the original meta-analysis results are statistically significant.

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2 Fig. 3 Sensitivity analysis of percentage body fat

Publication bias

 Evaluation of publication bias for the inclusion of more than 10 studies [44]. The study
will assess the risk of bias in the BW outcome measures through funnel plots and
Egger's regression test [26]. Based on Egger's regression test (P = 0.841 > 0.05)
indicates that there is no publication bias, and the visual weight funnel plot (Fig. 4)
supports this argument.





Discussion

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This study systematically reviewed the effects of WAs on body composition in obesity
and overweight people. The results showed that WAs had an ameliorative effect on
body composition [45], with significant effects on reducing BW and WC [46, 47] ,
mainly: (1) WAs had a reducing effect on BW and WC in female; (2) WAs with a trial
duration of 10 weeks or more (i.e., 12 weeks) showed significant reduction in BW and
WC; (3) Continuous WAs performed in the middle-aged and older people [48, 49]
(average age \geq 45 years) reduced BW and WC better.
The results of the subgroup analyses show in more detail the factors that influence
the impact of WAs on the obesity and overweight people. According to the subgroup
analysis of BW, WAs with trial duration >10 weeks (i.e., 12 weeks) showed a more
significant reduction in BW, and those with 10 weeks and less showed no significant
effect. It is possible that due to the short trial duration, short-term (e.g., six weeks) WAs
had little effect on BW and body composition [35, 50], and that WAs of 12 weeks and
longer had a better effect [19, 51]. It has been suggested that WAs have an ameliorative
effect on BW in overweight older male [52]. However, the present study found that
WAs reduced BW significantly in female and not in male, probably due to the small
number of males included in the study, resulting in non-significant differences. WAs
were more effective in reducing BW in middle-aged and older adults (average age \geq 45
years). Aerobic exercise in water is beneficial for middle-aged and elderly people,
improving body composition while easing the joint loads associated with land-based

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22 exercise [53].

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1	In addition, subgroup analyses based on WC showed that the WAs intervention
2	significantly reduced WC in obesity and overweight people. WC is an important
3	measure of abdominal obesity [54, 55]. 12-week WAs have a significant effect on
4	reducing WC in obesity and overweight female [47]. Detailed subgroup analyses
5	showed that WAs with trial duration >10 weeks (i.e., 12 weeks) had a greater effect on
6	WC, and that trial periods of 10 weeks and less did not have a significant effect on WC.
7	Due to the small number of male participants in the included studies, the reducing effect
8	of WAs on male WC needs to be further confirmed. WAs reduced WC better in middle-
9	aged and older people (average age \geq 45 years) and not significantly in other (average
10	age < 45 years) people.

11 Obesity and overweight people can receive many health benefits through exercise. 12 However, subgroup analyses showed that the effect of WAs on improving BMI and PBF in obesity and overweight people was not significant. It has been suggested that 8 13 weeks of continuous training is not long enough to show beneficial effects, and that the 14 benefits of anthropometric parameters are only gradually revealed when the training 15 period is between 12 and 32 weeks [56]. If subgroups were divided according to trial 16 period, sex, and age for several other body components (LM, FM, WHR, HC), the 17 number of studies in each subgroup would be small, producing results with less 18 confidence. Therefore, several other body components were not analysed in this study. 19

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21 Limitations

22 Studies of registered or ongoing RCTs were not included in the search for articles, and

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1	study inclusion was limited to English. Judgements made by persons are more
2	subjective when using ROB tools for literature quality assessment. There were certain
3	limitations to the articles included in the study: (1) Some of the studies had short (6-
4	week) duration of trials, small sample sizes, and less research data; (2) A small number
5	of participants in the study dropped out of the trial halfway through; (3) Differences in
6	the age, sex ratio, and location of the trial participants in three aspects.
7	
8	Conclusions
9	For obesity and overweight people, WAs over 10 weeks reduced BW and WC, with
10	more significant effect in female. Middle-aged and elderly people are also better able
11	to improve their body composition after WAs intervention. In conclusion, WAs is an
12	important form of exercise for overweight and obesity people to improve their body
13	composition and overall health.
14	
15	
10	Abbreviations
18	PROSPERO: International Prospective Register of Systematic Reviews
19	WAs: Water aerobics
20	RCTs: randomized controlled trials
21	PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analysis
22	PICOS: Population, Intervention, Comparison, Outcome, Study type
23	MeSH: Medical Subject Headings
24	BW: body weight
25	BMI: body mass index
26	PBF: percent body fat
27	LM: lean mass
28	FM: fat mass
29	WHR: waist-hip ratio
30	WC: waist circumference
31	HC: hip circumference

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SEM: standard error of the mean

WMD: weighted mean differences

Additional file 1. Supplementary information 1. Additional file 2. Supplementary information 2.

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agreed to the published version of the manuscript.

Supplementary information

SD: standard deviation Risk of Bias 2.0: RoB 2

CI: confidence interval

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Declarations

Not applicable.

Mix: mixed sex

M: male F: female

N: numbers

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JP and ZD concept and design. ZD, ZG, and HZ acquisition, analysis, or interpretation of data. ZD, HZ, and ZG drafting of the manuscript. JP critical revision of the manuscript for important intellectual content. ZD, ZG, and HZ statistical analysis. JP, ZG, and HZ administrative, technical, or material support. All authors have read and

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20	15	References
20 21	16	
ו כ כי		
33	17	1. Health Effects of Overweight and Obesity in 195 Countries over 25 Years. New
34		
35	18	England Journal of Medicine 2017, 377 (1):13-27.
30 27		
37 38	19	2. Jaacks LM, Vandevijvere S, Pan A, McGowan CJ, Wallace C, Imamura F, Mozaffarian
39		
40	20	D. Swinburn B. Ezzati M: The abovity transition; stages of the global opidamia. The
41	20	D, Swindun B, Ezzan W. The obesity transition. stages of the global epidemic. The
42		
43	21	Lancet Diabetes & Endocrinology 2019, 7(3):231-240.
44		
45	00	A Second Se
46	22	3. Inoue Y, Qin B, Poti J, Sokol R, Gordon-Larsen P: Epidemiology of Obesity in Adults:
47		
48	23	Latest Trends, Current Obesity Reports 2018, 7(4):276-288.
49		
50		
51	24	4. Phelps NH, Singleton RK, Zhou B, Heap RA, Mishra A, Bennett JE, Paciorek CJ,
52		
53	05	Lineste MDE, Cerrille Leves DM, Charles of Allerdebuilde fremde in underweight
54	25	Lnoste VPF, Carrillo-Larco RM, Stevens GA et al. Worldwide trends in underweight
55		
56	26	and obesity from 1990 to 2022; a pooled analysis of 3663 population-representative
57	20	
58		
59	27	studies with 222 million children, adolescents, and adults. The Lancet 2024,
60		

403(10431):1027-1050. 5. Askari A, Jambulingam P, Gurprashad R, Al-Taan O, Adil T, Munasinghe A, Jain V, Rashid F, Whitelaw D: The surgical management of obesity. Clinical Medicine 2023, 23(4):330-336. 6. Organization WH: Global health observatory data repository. In.; 2013. 7. Chu D-T, Minh Nguyet NT, Dinh TC, Thai Lien NV, Nguyen K-H, Nhu Ngoc VT, Tao Y, Son LH, Le D-H, Nga VB et al. An update on physical health and economic consequences of overweight and obesity. Diabetes & Metabolic Syndrome: Clinical Research & Reviews 2018, 12(6):1095-1100. 8. Garber CE: The Health Benefits of Exercise in Overweight and Obese Patients. Current Sports Medicine Reports 2019, 18(8):287-291. 9. Petridou A, Siopi A, Mougios V: Exercise in the management of obesity. Metabolism 2019, **92**:163-169. 10. Swift DL, McGee JE, Earnest CP, Carlisle E, Nygard M, Johannsen NM: The Effects of Exercise and Physical Activity on Weight Loss and Maintenance. Progress in Cardiovascular Diseases 2018, 61(2):206-213. 11. Wearing SC, Hennig EM, Byrne NM, Steele JR, Hills AP: Musculoskeletal disorders associated with obesity: a biomechanical perspective. Obesity Reviews 2006, 7(3):239-250. 12. Gobbi M, Aquiri A, Monoli C, Cau N, Capodaglio P: Aquatic Exercise. In: Rehabilitation interventions in the patient with obesity. edn.; 2020: 35-50. 13. Oral O: Effects of Aquatic Exercise in the Treatment of Obesity. Biomedical Journal of

1			
2			
3			
4	1		Scientific & Technical Research 2021, 33(1).
5			
6	•		
7	2	14.	Bergamin M, Ermolao, Tolomio S, Berton, Sergi, Zaccaria: Water- versus land-based
8			
9	З		exercise in elderly subjects: effects on physical performance and body composition
10	0		exclose in eldeny subjects, checks on physical performance and body composition.
11			
12	4		Clinical Interventions in Aging 2013.
13			
14	_		
15	5	15.	Lim JY, Tchai E, Jang SN: Effectiveness of Aquatic Exercise for Obese Patients with
16			
17	6		Knee Osteparthritis: A Randomized Controlled Trial Pm&R 2010 2(8):723-731
18	0		
19			
20	7	16.	Pianna B, Moreno BC, de Souza CA, Bôscoa TF, Alcalde GE, Barrile SR, Gimenes C,
20			
21	•		
22	8		Martinelli B, Zamuner AR, Pessoa-Santos BV et al. Impact of deep water running in
23			
24	q		interval training (DWR-IT) on body composition, functional capacity, and quality of life
25	0		interval training (DVVIC-IT) of body composition, functional capacity, and quality of inc
20			
27	10		in overweight adults: study protocol for a randomized controlled trial. <i>Trials</i> 2019, 20 (1).
28			
29			
30	11	17.	Ferrigan K, Hice J, Leemkuil K, Singer S, Charles D, Michaels NN, Jones T: Aquatic
31			
32	12		Exercise for Weight Reduction in Middle-Aged Adults: A Pilot Study The Journal of
33	12		Excluse for weight frequencies in which every a Addite. A filler of dudy. The boundar of
34			
35	13		Aquatic Physical Therapy 2017, 25 (2):16-21.
36			
37			
38	14	18.	Nosrani SE, Tartibian B, Eslami R, Farinha C, Serrano J, Ferreira JP, Texeira AM: The
39			
40	15		Effects of Combined Aquatic Exercise on Physical Performance and Metabolic Indices
41	.0		
42			
43	16		in Overweight Healthy Older Adults. International Journal of Exercise Science 2023,
44			
45	47		10(4) 4400
46	17		16(4):1499.
47			
48	18	19.	Earnest CP. Pereira Neiva H. Brandão Faíl L. Izquierdo M. Marques MC. Marinho DA:
49			
50			
51	19		The effect of 12 weeks of water-aerobics on health status and physical fitness: An
52			
53	20		$\mathbf{a} = \mathbf{a} = $
54	20		$\frac{1}{2} \frac{1}{2} \frac{1}$
55			
56	21	20.	Theodorou M, Kabir R: Exploring the Effects of Cold-Water Swimming on Obese
57		-	
58			
59	22		Population: A Systematic Review. Journal of Applied Sports Sciences 2019,
60			
			22

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

2			
3			
4	1		2 (December):3-21.
5			
6	~	0 4	
7	2	21.	Zhu H, Jin J, Zhao G: The effects of water-based exercise on body composition: A
8			
9	2		eveteretic review and mote analysis. Complementary Therenics in Oliviari Breatics
10	3		systematic review and meta-analysis. Complementary Theraples in Clinical Practice
10			
11	1		2023 52
12	4		2020, J2 .
13			
14	5	22	Moher D ⁻ Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The
15	•		
16			
17	6		PRISMA Statement. Annals of Internal Medicine 2009, 151(4).
18			
19			
20	7	23.	Booth A: PROSPERO's progress and activities 2012/13. Systematic Reviews 2013,
21			
27	•		
22	8		2(1).
25			
24	0	04	Alcare I. Aquian Ibéñaz D. Daha Alchari A. Quatamatia regional CDDia quidence for
25	9	24.	Akers J, Aguiar-Ibariez R, Baba-Akbarr A. Systematic reviews: CRD's guidance for
26			
27	10		undertaking reviews in health care University of York 2009
28	10		undertaking reviews in nealth care. On versky of Fork 2000.
29			
30	11	25.	Consultation W: Obesity: preventing and managing the global epidemic. World Health
31	••		
32			
33	12		Organization technical report series 2000, 894:1-253.
34			
25			
20	13	26.	Higgins JPT, Green S: Cochrane Handbook for Systematic Reviews of Interventions;
20			
3/	11		2000
38	14		2000.
39			
40	15	27	Higgins JPT Altman DG, Gotzsche PC, Juni P, Moher D, Oxman AD, Savovic J, Schulz
41	10	21.	
42			
43	16		KF. Weeks L. Sterne JAC: The Cochrane Collaboration's tool for assessing risk of bias
44	-		
45			
46	17		in randomised trials. Bmj 2011, 343(oct18 2):d5928-d5928.
40 47			
47			
48	18	28.	DerSimonian R, Kacker R: Random-effects model for meta-analysis of clinical trials:
49			
50	40		A
51	19		An update. Contemporary Clinical Trials 2007, 28(2):105-114.
52			
53	20	20	Ashtany Larky D. Bagheri P. Abhasnozhad A. Tinslov C.M. Alinour M. Mana A. Effects
54	20	29.	Ashtary-Larky D, Daynen R, Abbashezhau A, Tinsiey GW, Alipour W, Wong A: Effects
55			
56	21		of gradual weight loss v rapid weight loss on body composition and RMR: a systematic
57	- '		or gradeal molent loop in rapid molent loop on body composition and rama, a systematic
58			
50	22		review and meta-analysis. British Journal of Nutrition 2020, 124(11):1121-1132.
17			-
60			

1			
2			
3		~~	
4	1	30.	Lee YH: An overview of meta-analysis for clinicians. The Korean Journal of Internal
5			
7	2		<i>Medicine</i> 2018, 33 (2):277-283.
8			
9	2	21	Jakabaan JC, Wattaralay, J. Winkel D. Janga T. Cluud C: Threabelds for statistical and
10	5	51.	Jakobsell JC, Wellerslev J, Willker F, Lange T, Gludu C. Thresholds for statistical and
11			
12	4		clinical significance in systematic reviews with meta-analytic methods. BMC Medical
13			
14	5		Research Methodology 2014, 14(1).
15	·		
16	•	~~	
1/ 10	6	32.	Ashtary-Larky D, Bagheri R, Asbaghi O, Tinsley GM, Kooti W, Abbasnezhad A,
10			
20	7		Afrisham R, Wong A: Effects of resistance training combined with a ketogenic diet on
20			
22	0		hady composition a systematic review and mate analysis. Critical Bayiews in Food
23	0		body composition: a systematic review and meta-analysis. Critical Reviews in Food
24			
25	9		<i>Science and Nutrition</i> 2021, 62(21):5717-5732.
26			
27	10	33	Cumpston M. Li T. Page M.I. Chandler, J. Welch VA. Higgins, JPT. Thomas, J. Undated
28	10	00.	
29			
30	11		guidance for trusted systematic reviews: a new edition of the Cochrane Handbook for
31			
32 22	12		Systematic Reviews of Interventions. Cochrane Database of Systematic Reviews 2019.
33			
35	40	0.4	Verst CM Chari M Kadis 7 Adam A Kali TI Aiman C Idvis NM Jahan M AQUA
36	13	34.	Yusot SM, Shari M, Kadir Z, Adam A, Kek TL, Aiman S, Idris NM, Johar M: AQUA
37			
38	14		ZUMBA VERSUS AQUA JOGGING: COMPARATIVE EFFECTS ON HEALTH
39			
40	15		PARAMETERS AMONG OBESE MIDDLE AGED WOMEN Malaysian Journal of
41	10		
42			
43	16		Movement, Health & Exercise 2018, 7(2):11-22.
44			
45	17	35.	Penaforte FRO, Calhau R, Mota GR, Chiarello PG: Impact of short-term water exercise
40			
48	40		no man an anisht hada anna sitian matakalia mafila and malita af life of share
49	18		programs on weight, body composition, metabolic profile and quality of life of obese
50			
51	19		women. Journal of Human Sport and Exercise 2015, 10(4):915-926.
52			
53	20	36	Rica RL Carneiro RMM Serra A L Rodriguez D. Pontes Junior EL Rocalini DS: Effecte
54	20	00.	Rourte, Garreno Rivini, Gerrazio, Rounguez D, Fontes Juliior FE, Docanni DS. Ellecis
55			
56	21		of water-based exercise in obese older women: Impact of short-term follow-up study
5/			
58 50	22		on anthropometric, functional fitness and quality of life parameters. Geriatrics &
29 29			
50			24

3			
4	1		Gerontology International 2012, 13(1):209-214.
5			
6	2	27	Colote A. France L. Demoles C. Vienne D. Chies JAD. Deves A. Import of combining
7	Z	37.	Colato A, Fraga L, Dorneles G, Vianna P, Chies JAB, Peres A: Impact of aerobic water
8			
9	3		running training on peripheral immune-endocrine markers of overweight-obese women.
10	-		· · · · · · · · · · · · · · · · · · ·
11			
12	4		<i>Science & Sports</i> 2017, 32 (1):46-53.
13			
14	5	38	Principal D: Effect of Lindenwater Treadmill Training on Young Obese Adults 2018
15	5	50.	The part of Check of Checkwater Treadmin Training of Toding Obese Addits. 2010.
16			
17	6	39.	Rezaeipour M: Investigation of pool workouts on weight, body composition, resting
18			
19	-		
20	1		energy expenditure, and quality of life among sedentary obese older women.
21			
22	8		Montenearin Journal of Sports Science and Medicine 2020, 9(1):67.
23	•		
24			
25	9	40.	Rezaeipour M: Effects of two water-based exercise programs on body weight and blood
26			
27	10		linid parameters in elderly obese males with a sedentary lifestyle. Diabetes & Metabolic
28	10		ipid parameters in eldeny obese males with a sedemary mestyle. Diabetes a metabolic
29			
30	11		Syndrome: Clinical Research & Reviews 2021, 15(4).
31			
32	10	44	Coord D. Devenier M. Khanneri N. Abreadined C. Telesheri I.M. Javekeeh M. Sternard
33	IZ	41.	Soon R, Rezaelan N, Khosravi N, Anmadizad S, Taleghani Him, Jourkesh M, Stanhard
34			
35	13		SR: Effects of water-based endurance training, resistance training, and combined
36			
37			
38	14		water and resistance training programs on vistatin and ICAM-1 levels in sedentary
39			
40	15		obese women. <i>Science & Sports</i> 2017, 32 (3):144-151
41			
42			
43	16	42.	Greene NP, Lambert BS, Greene ES, Carbuhn AF, Green JS, Crouse SF: Comparative
44			
45	17		Efficacy of Water and Land Treadmill Training for Overweight or Obese Adults
46	17		Lincacy of Water and Land Treadmin Training for Overweight of Obese Addits.
47			
48	18		Medicine & Science in Sports & Exercise 2009, 41(9):1808-1815.
49			
50	10	40	Wautara E M. Van Nunan AMA, Caanan D. Kalatkin DL. Vingarhaata A LMI Effects of
51	19	43.	Woulers EJM, Van Nuhen AMA, Geenen R, Kololkin RL, Vingemoels AJJM. Ellecis of
52			
53	20		Aquajogging in Obese Adults: A Pilot Study. Journal of Obesity 2010, 2010:1-7.
54			
55	C (
50	21	44.	Page MJ, Higgins JPT, Sterne JAC: Assessing risk of bias due to missing results in a
5/			
50 50	22		synthesis. In: Cochrane Handbook for Systematic Reviews of Interventions. edn · 2019
59 60			
00			25

1			
2			
3			
4	1		349-374.
5			
6	2	45	Tkachova A. Dutchak M. Kashuba V. Goncharova N. Lytyvnenko V. Vako I. Kolos M
7	2	45.	
8			
9	3		Lopatskyi S: Practical implementation of differentiated approach to developing water
10			
11			
12	4		aerobics classes for early adulthood women with different types of body build. Journal
13			
14	5		of Physical Education and Sport 2020 20 :456-460
15	U		
16			
17	6	46.	Vijayaraj V, Shaju MF: Effectiveness of aqua-aerobic exercises on cardio vascular
18			
19	7		Stress and which have smann above college students. Internetic set for set of Dturing t
20	1		ntness and weight loss among obese college students. International Journal of Physical
21			
22	8		Education. Sports and Health 2019, 6(3):111-116.
23			
24	•		
25	9	47.	Jones LM, Legge M, Meredith-Jones K: Circuit Based Deep Water Running Improves
26			
27	10		Cardiovascular Fitness, Strength and Abdominal Obesity in Older, Overweight Women
28	10		
29			
30	11		Aquatic Exercise Intervention in Older Adults. <i>Medicina Sportiva</i> 2009, 13 (1):5-12.
31			
32	10	40	Pakkan DC, Caray ID, Di Fahia DD, Friandson TJ, Haka II, Intihar TW/: Effect of
33	12	40.	Darken RC, Carey JR, DI Fabio RP, Enandson IJ, Hare JL, Indinai TW. Ellect of
34			
35	13		Aerobic Exercise on Tracking Performance in Elderly People: A Pilot Study. <i>Physical</i>
36			
37			
38	14		<i>Therapy</i> 2001, 81 (12):1870-1879.
39			
40	15	49	Kalapatapu RK Campbell A Abaropovich E Hu M-C Levin ER Nunes EV
41	10	10.	
42			
43	16		Demographic and Clinical Characteristics of Middle-aged Versus Younger Adults
44			
45	17		Enrolled in a Clinical Trial of a Web-delivered Revelopsocial Treatment for Substance
46	17		Lindieu in a Cillical Inal di a Web-delivereu Psychosocial Treatment foi Substance
47			
48	18		Use Disorders. Journal of Addiction Medicine 2013, 7(1):66-72.
49			
50	10	50	Absorbelenders C. Effect of Water Association on Dady Mass Index, Livid Profile, and
51	19	50.	Anoognalandary 5: Effect of water Aerobics on Body Mass Index, Lipid Profile, and
52			
53	20		Atherogenic Factors of Middle-aged Obese Women. Jundishapur Journal of Medical
54			
55	o <i>i</i>		
50	21		<i>Sciences</i> 2022, 21 (5):638-649.
5/			
50 50	22	51.	Green JS: Effects of a Water Aerobics Program on the Blood Pressure. Percentage of
27 27	_		
00			26

3			
4	1		Body Fat, Weight, and Resting Pulse Rate of Senior Citizens, Journal of Applied
5			
6			
7	2		<i>Gerontology</i> 2016, 8 (1):132-138.
8			
9	3	52.	Yaqhoubi M. Ramezani S. Shamsi B. Barfi V: The Effect of a Water Exercise Course
10	-		
11			
12	4		on Body Composition and Quality of Life of Overweight Elderly Men. Journal of Marine
13			
14	5		<i>Medicine</i> 2022. 3 (4):180-187.
15	-		
16			
17	6	53.	Martins V, Lima GdSO, Silva LPd, Silva AGd, Bastos AD, Coëlho PGD, Noleto DCdS,
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19	7		Borges DBdS, Nascimento MAd, Lourenco BdS; The practice of water aerobics with
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25	9		Advancing the Boundaries of Knowledge. edn.; 2023.
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28	10	54.	Vasiljevic I, Gardasevic J, Kezunovic M, Bojanic D: Waist circumference as an indicator
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30	11		abdominal obesity in middle age. Sport Mont 2017. 15(1):21-22.
31			
32	40		
33	12	55.	Baioumi AYAA: Comparing Measures of Obesity: Waist Circumference, Waist-Hip, and
34			
35	13		Waist-Height Ratios. In: Nutrition in the Prevention and Treatment of Abdominal
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37	4.4		Objective adm. 2010: 00.10
38	14		<i>Obesity.</i> edn.; 2019: 29-40.
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40	15	56.	Clark J: The impact of duration on effectiveness of exercise, the implication for
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Fig. S2 Meta-analysis of waist circumference

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Fig. S3 Meta-analysis of body mass index



Fig. S4 Meta-analysis of percent body fat

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%

Weight

29.93

33.61

16.78

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Fig. S7 Meta-analysis of waist-hip ratio



Fig. S8 Meta-analysis of hip circumference

Supplementary information 2

Table S1 Minor changes

Numbers	Changes
1	Delete "body fat mass" and add "waist-to-hip ratio, waist circumference, and hip
	circumference".
2	Delete "mean baseline, follow-up" from the data extraction content.
3	Statistical software Change the "Review Manager" to "Stata".
4	Add water aerobics subgroup analysis.

Table S2 Database search terms

Database	Search terms	Results
PubMed	(((((((((((((((((((((((((((((((((((())))	357
Medline	(Physical Activity)) OR (Activities, Physical)) OR (Activity, Physical))	
	OR (Physical Activities)) OR (Exercise, Physical)) OR (Exercises,	
	Physical)) OR (Physical Exercise)) OR (Physical Exercises)) OR (Acute	
	Exercise)) OR (Acute Exercises)) OR (Exercise, Acute)) OR (Exercises,	
	Acute)) OR (Exercise, Isometric)) OR (Exercises, Isometric)) OR	
	(Isometric Exercises)) OR (Isometric Exercise)) OR (Exercise, Aerobic))	
	OR (Aerobic Exercise)) OR (Aerobic Exercises)) OR (Exercises,	
	Aerobic)) OR (Exercise Training)) OR (Exercise Trainings)) OR	
	(Training, Exercise)) OR (Trainings, Exercise)) AND ("Water"[Mesh]))	
	OR (((((((((water aerobics)) OR (waterobics))) OR (aquarobics))) OR	
	(aquatic fitness)) OR (aquafitness)) OR (aquafit)) OR (aqua zumba)) OR	
	(water yoga)) OR (aqua aerobics)) OR (aqua jog))) AND	
	((("Obesity"[Mesh]) OR ((fat) OR (obese))) OR ("Overweight"[Mesh])))	
	AND (("Randomized Controlled Trials as Topic"[Mesh]) OR	
	((((((Randomised controlled trial) OR (controlled trial)) OR (randomized	
	controlled study)) OR (Clinical Trials, Randomized)) OR (Trials,	
	Randomized Clinical)) OR (Controlled Clinical Trials, Randomized)))	
Embase	('randomised controlled trial'/exp OR 'randomised controlled trial' OR	2099
	'randomized controlled trials as topic'/exp OR 'randomized controlled	
	trials as topic' OR 'controlled trial'/exp OR 'controlled trial' OR	
	'randomized controlled study'/exp OR 'randomized controlled study' OR	
	'clinical trials, randomized' OR 'trials, randomized clinical' OR 'controlled	
	clinical trials, randomized') AND ('obesity'/exp OR 'obesity' OR 'fat'/exp	

	OR 'fat' OR 'obese' OR 'overweight/exp OR 'overweight') AND ('water aerobics'/exp OR 'water aerobics' OR 'aquarobics' OR 'aquatic fitness' OR 'aquafitness' OR 'aquafit' OR 'aqua zumba' OR 'water yoga' OR 'aqua aerobics' OR 'aqua jog' OR (('water'/exp OR 'water') AND ('exercise'/exp OR 'exercise' OR 'aerobics'/exp OR 'aerobics' OR 'exercises' OR 'cycling'/exp OR 'cycling' OR 'physical activity'/exp OR 'physical activity' OR 'activities, physical' OR 'activity, physical'/exp OR 'activity, physical' OR 'physical activities' OR 'exercise, physical' OR 'exercises, physical' OR 'physical exercise'/exp OR 'physical exercise' OR 'physical exercises' OR 'acute exercise'/exp OR 'physical exercise' OR 'physical exercises' OR 'acute exercise'/exp OR 'acute exercise' OR 'physical exercises' OR 'acute exercise'/exp OR 'acute exercise, isometric'/exp OR 'exercise, acute' OR 'exercises, acute' OR 'exercise, isometric'/exp OR 'exercise, isometric' OR 'exercises, isometric' OR 'isometric exercise' OR 'aerobic exercise'/exp OR 'aerobic exercise'/exp OR 'aerobic exercise' OR 'aerobic exercise' OR 'aerobic exercise'/exp OR 'aerobic exercise' OR 'aerobic exercises' OR 'aerobic exercise'/exp OR 'aerobic exercise' OR 'aerobic exercises' OR 'exercise, aerobic' OR 'exercise, aerobic'/exp OR 'exercise, aerobic' OR 'exercises, aerobic' OR 'exercise training'/exp OR 'exercise training' OR 'exercise trainings' OR 'training, exercise' OR 'trainings, exercise')))		
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MEDLINE	2 exp Randomized Controlled Trials as Topic/		
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	4 "randomized controlled study".mp.		
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	6 "Trials, Randomized Clinical".mp.		
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	9 exp Obeshy/		
	11 "obese" mp		
	12 exp Overweight/		
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	14 "water aerobics ".mp.		
	15 "aquarobics ".mp.		
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	17 "aquafitness ".mp.		
	18 "aquafit".mp.		
	19 "water yoga".mp.		
	20 "aqua aerobics".mp.		
	21 14 or 15 or 16 or 17 or 18 or 19 or 20		
	22 exp Water/		
	23 exp Exercise/		
	24 "aerobics ".mp.		
	25 "Exercises".mp.		
	26 "cycling".mp.		
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3		27 "Physical Activity".mp.	
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12		33 "Physical Exercise".mp.	
13		34 "Physical Exercises".mp.	
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16		37 "Exercise, Acute".mp.	
18		38 "Exercises, Acute".mp.	
19		39 "Exercise, Isometric".mp.	
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52		(obesity) OR TITLE-ABS-KEY (fat) OR TITLE-ABS-KEY (obese)	
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54		(water)) AND ((TITLE-ABS-KEY (exercise) OR TITLE-ABS-KEY	
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28 #41 "Isometric Exercises"	
#42 "Isometric Exercise"	
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TS=("aquarobics ")) OR TS=("aquatic fitness ")) OR TS=("aquafitness "))
OR TS=("aquafit")) OR TS=(" aqua zumba")) OR TS=(" water yoga"))
OR TS=("aqua aerobics")) OR TS=(" aqua jog") AND
((((((TS=("Randomised controlled trial ")) OR TS=("Randomized
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randomized controlled study ")) OR TS=("Clinical Trials, Randomized"))
OR TS=("Trials, Randomized Clinical")) OR TS=("Controlled Clinical
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TS=(obese)) OR TS=(Overweight)

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Fig. 4 Funnel plot for body weight

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Effects of water aerobics on body composition in obesity and overweight people: a systematic review and metaanalysis

Journal:	BMJ Open
Manuscript ID	bmjopen-2024-091743.R1
Article Type:	Original research
Date Submitted by the Author:	13-Dec-2024
Complete List of Authors:	DING, ZIYAN; Pukyong National University - Daeyeon Campus, Gao, Zixuan; Chaoyang Normal University Zhou, Haixu; Jilin Sport University Park, Jongchul; Pukyong National University, Department of Smart Healthcare
Primary Subject Heading :	Sports and exercise medicine
Secondary Subject Heading:	Public health, Rehabilitation medicine, Research methods, Sports and exercise medicine
Keywords:	Meta-Analysis, Obesity, Overweight, SPORTS MEDICINE





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Effects of water aerobics on body composition in obesity and overweight people: a systematic review and meta-analysis

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Effects of water aerobics on body composition in obesity and overweight people: a systematic review and meta-analysis Abstract

5 Objectives The problem of obesity and overweight seriously affects people's health.
6 The benefits of WAs have been shown in obesity and overweight people, but the effects
7 of WAs on body composition improvement are still unclear.
8 Design Systematic review and meta-analysis.

9 Data sources A systematic literature search was conducted on November 16, 2024,
10 using the PubMed MEDLINE, Ovid MEDLINE, Embase, Scopus, Web of Science, and
11 the Cochrane Library.

12 Eligibility criteria for selecting studies These studies were RCTs and were screened 13 independently by 2 researchers. All RCTs on WAs that evaluated the anthropometric 14 and body composition parameters of overweight and obesity subjects were included, 15 and a reporting of eligible studies was conducted in accordance with PRISMA 16 statement.

Data extraction and synthesis All process were independently screened by 2 researchers (D.Z.Y., Z.H.X.). Depending on the level of study heterogeneity, the use of a fixed-effects model or a random-effects model was determined. The risk of bias of the selected studies was assessed using the Risk of Bias 2.0 tool, and sensitivity analyses and subgroup analyses were performed on the outcome indicators. The quality of evidence for each outcome was evaluated using the GRADE system.

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1	Results A total of 10 studies with 286 patients were included. Sensitivity analyses were
2	performed for PBF with high heterogeneity, and the results were robust. WAs were able
3	to reduce BW (WMD = -2.69, 95%CI: -4.10 to -1.27, $p < 0.05$, $I^2 = 0.0\%$) and WC
4	(WMD = -2.75, 95%CI: -4.41 to -1.09, p < 0.05, $I^2 = 27.0\%$), but the effect on other
5	body indicators was not significant. The GRADE assessment revealed that the certainty
6	of evidence was low for BMI, LM, FM, WHR, and HC, and very low for PBF. However,
7	the moderate certainty of evidence for BW and WC.
8	Conclusion For the obesity and overweight people, WAs interventions over 10 weeks
9	(i.e., 12 weeks) reduced BW and WC, with more significant effects in women and better
10	improvements in body composition in middle-aged and older adults (average age ≥ 45
11	years). The certainty of evidence, as assessed using the GRADE framework, was
12	moderate for both BW and WC, indicating that these findings were robust.
13	PROSPERO registration number CRD42023466969.
14	Strengths and limitations of this study
15	• This study systematically reviewed and meta-analyzed RCTs, the gold standard in
16	clinical research, ensuring a high level of methodological rigor.
17	• Studies of registered or ongoing RCTs were not included in the search for articles,
18	and study inclusion was limited to English.
19	• Judgements made by persons were more subjective when using ROB tools and the
20	GRADE system for literature and outcome quality assessment.
21	• There were certain limitations to the articles included in the study: (1) Some of the

studies had a short (6-week) duration of trials, small sample sizes, and less research

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8 Introduction

The global prevalence of obesity has risen significantly over the past 40 years [1-3]. By 2022, more than 43% of adults worldwide will be overweight, with 504 million female and 374 million male obese [4]. Obesity is a chronic disease that increases the risk of various complications and leads to an estimated 2.8 million deaths each year [5-7]. Although weight management through exercise is highly effective [8-10]. However, due to their weight, obesity and overweight people are prone to serious damage to their bones and joints during exercise [11]. Traditional land-based aerobic exercise methods increase musculoskeletal damage in obese patients [12]. American College Sports Medicine recommends water aerobics (WAs) for obesity people to reduce injury risk and increase adherence to exercise [13]. WAs interventions are more beneficial and effective as a new approach to treating obesity [14, 15]. WAs can use the buoyant effect of water to reduce joint injuries associated with exercise in obesity and overweight people [16, 17]. Studies have shown that WAs have a better effect on improving body composition in obesity and overweight people. Young obese adults (mean age 18-25

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1	years) lost weight and improved their body mass index (BMI) after 12 weeks of WAs
2	[18]. Middle-aged adults (mean age 47-70 years) also showed greater improvements in
3	body weight (BW) and percent body fat (PBF) after participating in the 6-week WAs
4	[19]. WAs had significant improvements in body composition (e.g., PBF, BW, BMI,
5	and waist-hip ratio (WHR)) in a population of overweight older men (mean age 62-70
6	years) [20]. Overweight older adults (mean age 72 years) who participated in a 28-week
7	WAs had reduced body fat mass (FM), leg and waist circumference (WC) [21].
8	Therefore, WAs, as a beneficial exercise method, can be an important way to lose
9	weight for obesity and overweight people [19, 21].
10	However, fewer studies have been reported on the effects of WAs on physical indicators
11	in obesity and overweight people. The previous literature review [14, 22, 23], only
12	provided a wide-ranging overview of the relevant evidence. For example, Haifeng Zhu
13	[24] summarizes the physical effects of aquatic exercise on adults. However, this study
14	only included randomized controlled trials (RCTs) on healthy adults and did not
15	consider studies of obesity and overweight people [24].
16	Thus, the systematic review and meta-analysis of the present study can, to some
17	extent, fill the research gap on the effects of WAs interventions on obesity and
18	overweight people. The main discussion is whether WAs has a significant improvement

- 19 in physical indicators in obesity and overweight people.
- 21 Methods

22 Registration

This meta-analysis study is reported according to the Preferred Reporting Items for
Systematic Reviews and Meta-Analysis (PRISMA) statement [25, 26]. The study
protocol was registered in the International Prospective Register of Systematic Reviews
(PROSPERO) (registration number: CRD42023466969). Minor changes were made to
the initial PROSPERO protocol submitted in October 2023 (Table S1 in
Supplementary information 2).

7 Search strategy

Six databases were searched: PubMed MEDLINE, Ovid MEDLINE, Embase, Scopus, Web of Science, and the Cochrane Library. The time span of the search was from the construction of the database to 26 October 2023. We have updated the search records (as of November 16, 2024) to make the search more comprehensive. Retrieval strategy based on PICOS tool [27]: (P) Population: adults with overweight and obesity; (I) Intervention: WAs; (C) Comparator: other exercise modalities or no exercise control; (O) Outcome: body composition; (S) Study type: RCTs. Search using core terms: water aerobics (e.g., aquatic fitness, aqua aerobics), obesity or overweight (e.g., fat, obese), and RCTs (e.g., randomized controlled study, controlled clinical trials). The core terms for the searches were identified in the MeSH Database in the PubMed database, respectively, to ensure the scientific validity and accuracy of the search vocabulary, and the comprehensiveness of the search scope (details of the search strategy are in Table **S2** in Supplementary information 2). In addition to the database, reference lists of included articles were screened for articles that satisfied the inclusion criteria.

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22 Eligibility criteria

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1	Inclusion criteria: (1) RCTs; (2) Participants were obesity (BMI \ge 30 kg/m ²) and
2	overweight (BMI ≥ 25 kg/m ²) [28] adults (≥ 18 years, including older adults); (3) The
3	intervention group participated in WAs for at least 4 weeks, and the control group did
4	not participate in exercise or chose other ways of exercising; (4) Results on changes in
5	body composition were obtained in the original article; (5) Full text available in English
6	(i.e., not a review, letter, case series or conference proceedings). Grey literature (i.e.,
7	dissertations, conference abstracts) was not included, as it has been shown that these
8	represent only a small percentage of the studies included in the systematic review and
9	rarely affect the statistical or clinical significance of the results [29].
10	Exclusion criteria: (1) Trials that did not satisfy all inclusion criteria; (2) Participants
11	diagnosed with other diseases were included; (3) Exercise interventions combined with
12	dietary control, medication or other lifestyle changes; (4) There was no exercise of any

13 form, just a trial of being immersed in water or receiving a massage.

14 Study selection

The study used EndNote (Version 21) to manage the articles. First, duplicate articles were removed. Second, the titles and abstracts of the articles were read and qualified articles were selected. Finally, full-text review was performed. The process was independently screened by 2 researchers (D.Z.Y., Z.H.X.). Disagreements were adjudicated by a third researcher (G.Z.X.).

20 Data extraction

Data from included studies were recorded using an adapted Cochrane Collaboration [30]
standardized data extraction form. The study characteristics are extracted as follows:

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year of publication, authors, region, study period, study design, sample size, participants, and mean age.

BW, measured in kilograms (kg), serves as a direct indicator of overall weight loss and is a key measure of intervention effectiveness in obesity management [31]. BMI, a widely used but indirect measure of body fatness, is calculated as weight in kilograms divided by height in meters squared (kg/m²) [32]. PBF is an important metric for distinguishing between lean mass (LM) and FM [33]. FM and LM were assessed using bioelectrical impedance analysis or dual-energy X-ray absorptiometry, with PBF calculated using the formula: PBF = (FM (kg)/BW (kg)) \times 100 [34]. WC reflects abdominal fat distribution and is a validated marker of central obesity and metabolic risk [35]. Risk thresholds for WC are ≥ 102 cm for male and ≥ 88 cm for female [36]. Both WC and hip circumference (HC) were measured in centimeters (cm) using an inelastic tape. WC was defined as the minimum circumference between the rib margins and iliac crests, while HC was defined as the maximum circumference between the waist and thighs. The WHR was calculated as WC/HC [34]. WHR is a measure of upper and lower body fat distribution, with higher values indicating a greater risk of obesity-related health problems. Risk thresholds for WHR are male ≥ 1.0 and female ≥ 0.85 [36]. Therefore, the primary outcomes were BW, BMI, PBF, WHR, WC, and HC, while the secondary outcomes were FM and LM.

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Two researchers (D.Z.Y., Z.H.X.) independently extracted this information from each
study and resolved any disagreements through discussion.

22 Risk of bias

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Two researchers (D.Z.Y. and Z.H.X.) subjected the included RCTs to an independent risk of bias assessment. The Cochrane risk-of-bias tool (RoB 2) was used for the review according to the evaluation criteria of the Cochrane Handbook for Systematic Reviews of Interventions (Version 6.4) [37]. Disagreements arising from the review were discussed and resolved with the participation of the third researcher (G.Z.X.) on the review team.

Data analysis

Meta-analysis was conducted using Stata 18.0 software. Heterogeneity of studies was assessed using Cochrane's Q and I² tests [38]. When P > 0.1, I² \leq 50%, there was homogeneity, and a fixed-effects model was used for the meta-analysis; when $P \le 0.1$, $I^2 > 50\%$, there was heterogeneity, and a random-effects model was used [39, 40]. Therefore, this study uses a fixed-effects model for the meta-analysis, which will be changed when $I^2 > 50\%$.

To further test the stability of the results, we conducted a sensitivity analysis using the leave-one-out method [41]. The leave-one-out method involves excluding 1 study, combining the remaining studies in a meta-analysis, and evaluating whether the results of the original meta-analysis were significantly altered by the influence of certain studies by observing the changes in the combined results [42]. Publication bias of studies was assessed using funnel plots in which the asymmetric distribution of studies suggested bias [43]. Quantitative analysis of funnel plot asymmetry using the Egger regression test [44].

Differences were considered significant at P < 0.05 [45].

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The standard error of the mean (SEM) of the extracted data were converted to standard
 deviation (SD) [46]. Using the formula in the Cochrane Handbook [47] (N represents
 the number of trial participants):

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$SD = SEM \times \sqrt{N}$

5 Quality of GRADE evidence

6 The quality of evidence for each outcome was assessed using the Grading of 7 Recommendations Assessment, Development, and Evaluation (GRADE) methodology 8 [48]. Two researchers (D.Z.Y. and Z.H.X.) independently conducted the assessments. 9 Any disagreements were resolved through discussion and, when necessary, consultation with a third researcher (G.Z.X.) to reach a consensus. As all included 10 studies were RCTs, the initial evidence quality was rated as high. However, the 11 confidence in the evidence could be downgraded based on specific limitations in the 12 original studies, including risk of bias, inconsistency, indirectness, imprecision, and 13 publication bias [49]. Following GRADE guidelines, the final quality of evidence was 14 categorized into one of four levels: high, moderate, low, and very low [50]. 15

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17 **Results**

18 Study search results

A total of 4517 studies were searched. 1185 studies were deleted due to duplication and
3332 studies were further screened. After reading the titles and abstracts 3267 studies
were deleted. 65 articles were eligible for full-text screening, of which 55 were deleted.
Finally, 10 studies were included in the meta-analysis (Fig. 1).

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Study	characteristics
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The RCTs included in the study had 286 participants [51-60]. Publication dates range from 2009 to 2021. Inclusion of research trials in Malaysia, Brazil, India, American, and the Netherlands. From 20 to 70 years old was the average age of the participants. A small number of subjects from 5 trials [51, 53, 55, 58, 59] dropped out of the experiment for various reasons, and trial data from those who dropped out was not used. One study [51] included two distinct intervention groups: Aqua Zumba (Yusof-1) and Aqua Jogging (Yusof-2). Due to the differing exercise programs, these groups were treated as separate studies (Yusof-1 and Yusof-2) in the analysis. The types of WAs included in this review were diverse and encompassed activities such as water aerobics, agua Zumba, water yoga, and agua jogging. Across all included trials, the intervention period ranged from 6 to 12 weeks. One of the trials [55] had an exercise frequency of 2 times a week; others were 3 times a week. The exercise time varied according to the needs of the trials, with most being 60 minutes each.

The units for BW, LM, and FM are kilograms (kg); for BMI, kilograms per square
meter (kg/m²); and for WC and HC, centimeters (cm). The basic characteristics of each
study are shown in Table 1.

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 Table 1 Experimental details.

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Study	Country	Duration (weeks)	Sample	Mean age/ range (SD)	Exercise Category	Study design (Frequency, time)	Outcome
Yusof-1 et al., 2018	Malaysia	12	40 (F)	45.13(5.17)	Aqua zumba	3 days/week, 60 minutes per session	BW, PBF, WC
Yusof-2 et al., 2018	Malaysia	12	40 (F)	45.28(5.09)	Aqua jog	3 days/week, 60 minutes per session	BW, PBF, WC
Penaforte et al., 2015	Brazil	×	16 (F)	42.8(7.4)	Water aerobics	3 days/week, 60minutes per session	BW, BMI, LM, FM, WC, HC
Palekar et al., 2018	India	9	14 (M)	20.71	Underwater treadmill training	3 days/week, 25minutes per session	BMI, PBF, WC
Rezaeipour, 2020	Iran	12	24 (F)	69.5(4.3)	Aquatic exercises (dancing and walking)	3 days/week, 60minutes per session	BW, BMI, LM, FM,
Greene et al., 2009	American	12	57 (Mix)	42(18.67)	Underwater treadmill	Three times per week	BW, BMI, LM, FM, WC, HC, WHR
Rica et al., 2012	Brazil	12	38 (F)	68.5(5)	Water-based exercise with aerobic	Three times per week, 60-min sessions	BW, BMI, PBF, LM, FM, WC, HC, WHR
Wouters et al., 2009	Netherlands	9	14 (Mix)	44	Aquajogging	2 per week, one hour	BW, BMI, PBF, WC
Rezaeipour, 2021	Iran	12	27 (M)	68.7(3.2)	Water-based exercise with aerobic	3 days/week, 60minutes per session	BW, BMI
Soori et al., 2017	Iran	10	16 (F)	45-60	Swimming or walking in the water	3 per week, 45 min per day	BW, BMI, PBF, WC
Colato et al., 2016	Brazil	12	20 (F)	49.36(11.69)	Water running training	3 per week, 70 minutes/session	BW, BMI, FM, WC, HC
Note: body weight (BW) mixed sex (Mix): male (); body mass ind M): female(F).	lex BMI); p	ercent body fai	t (PBF); lean mas	s (LM); fat mass (FM); Wai	st-hip ratio (WHR); Waist circumference (WC); Hip circumference (HC);

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After a bias risk assessment, the 10 included studies were rated as follows: 6 had low risk, 3 had some concerns, and 1 had high risk (Fig. 2). **Physical outcome** WAs are effective interventions for BW (WMD = -2.69, 95%CI: -4.10 to -1.27, p < $0.05, I^2 = 0.0\%$) and WC (WMD = -2.75, 95%CI: -4.41 to -1.09, p < 0.05, I^2 = 27.0\%) in obesity and overweight people (Fig. S1 and Fig. S2 in Supplementary information 1). Other physical indicators, such as BMI (WMD = -0.55, 95%CI: -1.29 to 0.19, p > 0.05, $I^2 = 0.0\%$) (Fig. S3 in Supplementary information 1), PBF (WMD = -4.83, 95%CI: -10.32 to 0.66, p > 0.05, I² = 93.6%) (Fig. S4 in Supplementary information 1), LM $(WMD = -0.19, 95\%CI: -2.75 \text{ to } 2.37, p > 0.05, I^2 = 0.0\%)$ (Fig. S5 in Supplementary information 1), FM (WMD = -0.92, 95%CI: -3.20 to 1.36, p > 0.05, I² = 0.0%) (Fig. S6 in Supplementary information 1), WHR (WMD = -0.02, 95%CI: -0.05 to 0.01, p > 0.05, $I^2 = 0.0\%$) (Fig. S7 in Supplementary information 1) and HC (WMD = -1.05, 95%CI: -3.64 to 1.55, p > 0.05, $I^2 = 0.0\%$) (Fig. S8 in Supplementary information 1), did not show significant improvement (Table 2). Subgroup analysis of outcomes

Results of ROB assessment

Subgroup analyses of WAs were performed on the included studies to identify
appropriate WAs regularity and to explore sources of heterogeneity. Due to the number
of subgroups, the results of the subgroup analyses of WAs are summarized in the table
(Table 2).

	Ν	WMD (95% CI)	P within group	P heterogeneity	I^2
Subgroup analyses of WA on BW					
Overall effect	10	-2.69(-4.10, -1.27)	0.000*	0.670	0.0%
Trial duration (week)					
>10	7	-3.31(-5.23, -1.40)	0.001*	0.455	0.0%
≤10	3	-1.93(-4.03, 0.16)	0.071	0.971	0.0%
Sex					
Male	1	-0.60(-8.58, 7.38)	0.883	-	-
Female	7	-2.90(-4.37, -1.43)	0.000*	0.486	0.0%
Mix (male & female)	2	0.24(-6.54, 7.02)	0.944	0.678	0.0%
Average age					
≥45	7	-2.85(-4.31, -1.40)	0.000*	0.465	0.0%
<45	3	0.05(-5.89, 5.98)	0.988	0.911	0.0%
Subgroup analyses of WA on BMI					
Overall effect	9	-0.55(-1.29, 0.13)	0.146	0.984	0.0%
Trial duration (week)					
>10	5	-0.14(-1.25, 0.97)	0.806	0.943	0.0%
≤10	4	-0.88(-1.88, 0.12)	0.083	0.979	0.0%
Sex					
Male	2	-0.47(-2.52, 1.57)	0.649	0.932	0.0%
Female	5	-0.55(-1.41, 0.31)	0.208	0.757	0.0%
Mix (male & female)	2	-0.63(-2.79, 1.52)	0.565	0.932	0.0%
Average age					
≥45	5	-0.55(-1.38, 0.29)	0.199	0.757	0.0%
<45	4	-0.57(-2.21, 1.07)	0.498	0.999	0.0%
Subgroup analyses of WA on PBF					
Overall effect	6	-4.83(-10.32, 0.66)	0.085	0.000	93.69
Trial duration (week)					
>10	3	-9.01(-18.05, 0.02)	0.051	0.000	94.8
<10	3	-0.26(-1.87, 1.36)	0.755	0.938	0.0%
Sex	-				
Male	1	-0.83(-6.28, 4.61)	0.765	-	-
Female	4	-6.71(-14.24, 0.82)	0.081	0.000	96.0
Mix (male & female)	1	-0.80(-5.25, 3.65)	0 724	-	-
Average age					
>45	4	-6 71(-14 24 0 82)	0.081	0.000	96.0
<45	2	-0.81(-4.26, 2.63)	0.644	0.993	0.0
Subgroup analyses of WA on WC	2	0.01(1.20, 2.05)	0.011	0.775	0.07
Overall effect	8	-2 75(-4 41 -1 09)	0.001*	0.213	27.0
Trial duration (week)	0	-2.75(-4.41, -1.07)	0.001	0.215	27.0
>10	5	-2 88(-4 63 -1 12)	0.001*	0.057	56 2
	5	-2.00(-4.03, -1.12)	0.001	0.037	0.0

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Sex					
Male	1	-0.89(-17.54, 15.76)	0.917	-	-
Female	5	-2.89(-4.65, -1.13)	0.001*	0.058	56.1
Mix (male & female)	2	-1.69(-6.90, 3.52)	0.525	0.626	0.09
Average age					
≥45	4	-3.03(-4.85, -1.22)	0.001*	0.034	65.5
<45	4	-1.27(-5.40, 2.86)	0.546	0.959	0.0
Subgroup analyses of WA on LM					
Overall effect	4	-0.19(-2.75, 2.37)	0.883	0.889	0.0
Subgroup analyses of WA on FM					
Overall effect	5	-0.92(-3.20, 1.36)	0.429	0.991	0.09
Subgroup analyses of WA on WHR					
Overall effect	3	-0.02(-0.05, 0.01)	0.256	0.830	0.0
Subgroup analyses of WA on HC					
Overall effect	4	-1.05(-3.64, 1.55)	0.429	0.610	0.0

3	As seen by subgroup analyses of BW, WAs with a trial duration > 10 weeks (i.e.,
4	12 weeks) significantly reduced BW (WMD = -3.31, 95%CI: -5.23 to -1.40, $p < 0.05$,
5	$I^2 = 0.0\%$). In addition, WAs significantly reduced BW in the female population (WMD
6	= -2.90, 95%CI: -4.37 to -1.43, p < 0.05, I^2 = 0.0%) and in the population with a mean
7	age of \geq 45 years (WMD = -2.85, 95%CI: -4.31 to -1.40, p < 0.05, I ² = 0.0%).
8	From the subgroup analysis of WC, it is shown that WAs with a trial duration >10
9	weeks significantly reduced WC (WMD = -2.88, 95%CI: -4.63 to -1.12, $p < 0.05$, $I^2 =$
10	56.3%). Among them, WAs were mainly able to significantly reduce WC in the female
11	population (WMD = -2.89, 95%CI: -4.65 to -1.13, $p < 0.05$, $I^2 = 56.1\%$) and in the
12	population (WMD = -3.03, 95%CI: -4.85 to -1.22, $p < 0.05$, $I^2 = 65.5\%$) with a mean
13	age \geq 45 years.
14	Other subgroup analyses found that BMI (P = 0.146, $I^2 = 0.0\%$), LM (P = 0.883,
15	$I^2 = 0.0\%$), FM (P = 0.429, $I^2 = 0.0\%$), WHR (P = 0.256, $I^2 = 0.0\%$), and HC (P = 0.429,

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I² = 0.0%) were neither heterogeneous nor significant. In contrast, PBF (I² = 93.6%)
and WC (I² = 27.0%) were heterogeneous. However, separate subgroup analyses
revealed multiple sources of heterogeneity, which could not be adequately explained
by only one pair of subgroup analyses.

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Sensitivity analysis of PBF

PBF has high heterogeneity. Thus, the robustness of the results was assessed through sensitivity analyses to identify sources of heterogeneity. A leave-one-out sensitivity analysis was performed, revealing that the direction of the combined estimates did not change significantly with the removal of any individual study. This finding suggests that the meta-analysis was robust and not unduly influenced by any single study [61]. The results show that the 95%CI excludes 0 (Fig. 3). This means that the results are robust, the sensitivity is small, and the original meta-analysis results are statistically significant.

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Publication bias

Evaluation of publication bias for the inclusion of more than 10 studies [62]. The study will assess the risk of bias in the BW outcome measures through funnel plots and Egger's regression test [30]. Based on Egger's regression test (P = 0.841 > 0.05) indicates that there is no publication bias, and the visual weight funnel plot (**Fig. 4**) supports this argument.

GRADE Assessment

The quality of evidence for each outcome was evaluated using the GRADE system. The
results indicated that the quality of evidence was moderate for BW and WC, low for

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BMI, LM, FM, WHR, and HC, and very low for PBF (Table 3). Primary reasons for downgrading included small sample sizes in the included studies, 95%CI crossing equivalence thresholds, and high heterogeneity.

Table 3 GRADE quality of evidence

Outcomes	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Quality of evidence
BW	not serious	not serious	not serious	serious ^a	none	$\oplus \oplus \oplus \bigcirc \bigcirc$
DW	not serious	not serious	not serious	serious	none	Moderate
BMI	not serious	not serious	not serious	very serious ab	none	$\oplus \oplus \bigcirc \bigcirc$
DIVII	not serious	liot serious	not serious	very serious	none	Low
DDF	not serious	very serious c	not serious	very serious ab	none	$\oplus 000$
I DI	not serious	very serious	not serious	very serious	none	Very low
ΙM	not serious	not serious	not serious	very serious ab	none	$\oplus \oplus \bigcirc \bigcirc$
LIVI	not serious	not serious	not serious	very serious	none	Low
FM	not serious	not serious	not serious	very serious ab	none	$\oplus \oplus \bigcirc \bigcirc$
1 101	not serious	not serious	not serious	very serious	none	Low
WHR	not serious	not serious	not serious	very serious ab	none	$\oplus \oplus \bigcirc \bigcirc$
WIII	not serious	not serious	not serious	very serious	none	Low
WC	not serious	not serious	not serious	serious ^a	none	$\oplus \oplus \oplus \bigcirc$
we	not serious	not senous	not serious	serious	none	Moderate
нс	not serious	not serious	not serious	very serious ab	none	$\oplus \oplus \bigcirc \bigcirc$
110	not serious	not serious	not serious	very serious	none	Low

5 Note: a. small sample sizes in the included studies; b. 95% CI crossing equivalence thresholds; c. high heterogeneity.

7 Discussion

This study systematically reviewed the effects of WAs on body composition in obesity and overweight people. The results showed that WAs had an ameliorative effect on body composition [63], with significant effects on reducing BW and WC [18, 64], mainly: (1) WAs had a reducing effect on BW and WC in female; (2) WAs with a trial duration of 10 weeks or more (i.e., 12 weeks) showed significant reduction in BW and WC; (3) Continuous WAs performed in the middle-aged and older people [65, 66]

1 (average age \geq 45 years) reduced BW and WC better.

The results of the subgroup analyses show in more detail the factors that influence the impact of WAs on the obesity and overweight people. According to the subgroup analysis of BW, WAs with trial duration >10 weeks (i.e., 12 weeks) showed a more significant reduction in BW, and those with 10 weeks and less showed no significant effect. It is possible that due to the short trial duration, short-term (e.g., six weeks) WAs had little effect on BW and body composition [52, 67], and that WAs of 12 weeks and longer had a better effect [22, 68]. It has been suggested that WAs have an ameliorative effect on BW in overweight older male [20]. However, the present study found that WAs reduced BW significantly in female and not in male, probably due to the small number of males included in the study, resulting in non-significant differences. WAs were more effective in reducing BW in middle-aged and older adults (average age ≥ 45 years). Aerobic exercise in water is beneficial for middle-aged and elderly people, improving body composition while easing the joint loads associated with land-based exercise [69].

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In addition, subgroup analyses based on WC showed that the WAs intervention significantly reduced WC in obesity and overweight people. WC is an important measure of abdominal obesity [70, 71]. 12-week WAs have a significant effect on reducing WC in obesity and overweight female [64]. Detailed subgroup analyses showed that WAs with trial duration >10 weeks (i.e., 12 weeks) had a greater effect on WC, and that trial periods of 10 weeks and less did not have a significant effect on WC. Due to the small number of male participants in the included studies, the reducing effect

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of WAs on male WC needs to be further confirmed. WAs reduced WC better in middleaged and older people (average age ≥ 45 years) and not significantly in other (average
age < 45 years) people.

Obesity and overweight people can receive many health benefits through exercise. However, subgroup analyses showed that the effect of WAs on improving BMI and PBF in obesity and overweight people was not significant. It has been suggested that 8 weeks of continuous training is not long enough to show beneficial effects, and that the benefits of anthropometric parameters are only gradually revealed when the training period is between 12 and 32 weeks [72]. If subgroups were divided according to trial period, sex, and age for several other body components (LM, FM, WHR, HC), the number of studies in each subgroup would be small, producing results with less confidence. Therefore, several other body components were not analyzed in this study. The GRADE assessment revealed that the certainty of evidence was low for BMI, LM, FM, WHR, and HC, and very low for PBF. The downgrading was primarily due to small sample sizes, which reduce statistical power and the precision of effect estimates. In addition, high heterogeneity among studies, particularly in PBF outcomes, indicated variability in study populations, methodologies, and intervention effects. Imprecision, as evidenced by wide confidence intervals crossing equivalence thresholds, further contributed to the reduced quality of evidence.

These findings have significant implications for clinical practice. The low
certainty of evidence for BMI, WHR, HC, and other secondary outcomes and very low
for PBF suggests that current evidence was insufficient to reliably inform clinical

guidelines for using WAs to improve these parameters. Health professionals should approach these results with caution and prioritize interventions with stronger evidence when aiming to target these specific outcomes. However, the moderate certainty of evidence for BW and WC supports the use of WAs as effective interventions for reducing overall body weight and central obesity, which were critical factors in managing obesity-related health risks [73, 74].

Conclusions

The results of this systematic review and meta-analysis suggest that WAs is an effective intervention for reducing BW and WC in overweight and obesity adults. For obesity and overweight people, WAs over 10 weeks reduced BW and WC, with more significant effect in female. Middle-aged and elderly people are also better able to improve their body composition after WAs intervention. The certainty of evidence, as assessed using the GRADE framework, was moderate for both BW and WC, indicating that these findings are robust but would benefit from further research to enhance confidence. In contrast, the certainty of evidence for other outcomes was rated as low or very low, primarily due to small sample sizes, high heterogeneity, and imprecision in the included studies. Future research should aim to address these limitations by conducting larger, well-designed RCTs with standardized methodologies and diverse populations. Additionally, exploring the long-term effects of WAs and comparing its efficacy with other exercise modalities will provide valuable insights. In conclusion, WAs is an important form of exercise for overweight and obesity people to improve

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their body composition and overall health.

Abbreviations

- **PROSPERO:** International Prospective Register of Systematic Reviews
- WAs: Water aerobics
 - RCTs: randomized controlled trials
- PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analysis
- PICOS: Population, Intervention, Comparison, Outcome, Study type
- MeSH: Medical Subject Headings
- GRADE: Grading of Recommendations Assessment, Development, and Evaluation
- BW: body weight
- BMI: body mass index
- PBF: percent body fat
- LM: lean mass
- FM: fat mass
- WHR: waist-hip ratio
- WC: waist circumference
- HC: hip circumference
- SEM: standard error of the mean
- SD: standard deviation
- Risk of Bias 2.0: RoB 2
- Mix: mixed sex
- M: male
 - F: female
- CI: confidence interval
- N: numbers
- WMD: weighted mean differences
 - **Supplementary information**
 - Additional file 1. Supplementary information 1.
- Additional file 2. Supplementary information 2.
 - - Acknowledgements
 - Thanks to all those who helped with this paper.
 - **Author contributions**
 - Study conception and design: ZD, JP. Acquisition, analysis or interpretation of data: ZD, ZG, HZ. Drafting the manuscript: ZD, HZ, ZG. Critical revision of the manuscript

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47 48	25	
49 50	26	References
51 52	27	
53 54	28	1. Collaborators TGO: Health Effects of Overweight and Obesity in 195 Countries over 25
55 56 57	29	Years. New England Journal of Medicine 2017, 377(1):13-27.
58 59	30	2. Jaacks LM, Vandevijvere S, Pan A, McGowan CJ, Wallace C, Imamura F, Mozaffarian
60		22

Enseignement Superieur (ABES) Protected by copyright, including for uses related to text and data mining, Al training, and similar technologies.

Page 24 of 47

Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, Al training, and similar technologies.

BMJ Open

4 5	1		D, Swinburn B, Ezzati M: The obesity transition: stages of the global epidemic. The
6 7	2		Lancet Diabetes & Endocrinology 2019, 7(3):231-240.
8 9 10	3	3.	Inoue Y, Qin B, Poti J, Sokol R, Gordon-Larsen P: Epidemiology of Obesity in Adults:
11 12 13	4		Latest Trends. Current Obesity Reports 2018, 7(4):276-288.
14 15	5	4.	Phelps NH, Singleton RK, Zhou B, Heap RA, Mishra A, Bennett JE, Paciorek CJ,
16 17 18	6		Lhoste VPF, Carrillo-Larco RM, Stevens GA et al: Worldwide trends in underweight
19 20 21	7		and obesity from 1990 to 2022: a pooled analysis of 3663 population-representative
21 22 23	8		studies with 222 million children, adolescents, and adults. The Lancet 2024,
24 25 26	9		403 (10431):1027-1050.
27 28	10	5.	Askari A, Jambulingam P, Gurprashad R, Al-Taan O, Adil T, Munasinghe A, Jain V,
29 30 31	11		Rashid F, Whitelaw D: The surgical management of obesity. Clinical Medicine 2023,
32 33 24	12		23 (4):330-336.
35 36	13	6.	Organization WH: Global health observatory data repository. In.; 2013.
37 38 39	14	7.	Chu D-T, Minh Nguyet NT, Dinh TC, Thai Lien NV, Nguyen K-H, Nhu Ngoc VT, Tao Y,
40 41	15		Son LH, Le D-H, Nga VB et al. An update on physical health and economic
42 43 44	16		consequences of overweight and obesity. Diabetes & Metabolic Syndrome: Clinical
45 46 47	17		<i>Research & Reviews</i> 2018, 12 (6):1095-1100.
47 48 49	18	8.	Garber CE: The Health Benefits of Exercise in Overweight and Obese Patients. Current
50 51 52	19		<i>Sports Medicine Reports</i> 2019, 18 (8):287-291.
53 54	20	9.	Petridou A, Siopi A, Mougios V: Exercise in the management of obesity. Metabolism
55 56 57	21		2019, 92 :163-169.
58 59	22	10.	Swift DL, McGee JE, Earnest CP, Carlisle E, Nygard M, Johannsen NM: The Effects

Page 25 of 47

1

BMJ Open

2			
3			
4	1		of Exercise and Physical Activity on Weight Loss and Maintenance. Progress in
5			
6	2		Cardiavasaular Diasasas 2019 61/2):206 212
7	2		Cardiovascular Diseases 2018, 01(2):200-213.
8			
9	3	11	Wearing SC Hennig EM Byrne NM Steele JR Hills AP [.] Musculoskeletal disorders
10	Ū	• • •	
11			
12	4		associated with obesity: a biomechanical perspective. Obesity Reviews 2006,
13			
14	_		
15	5		7(3):239-250.
16			
17	6	10	Cobbi M. Aquiri A. Monoli C. Cou N. Conodoglio P: Aquatia Exercise. In: <i>Pohabilitation</i>
18	0	12.	Gobbi M, Aquin A, Monoli C, Cau N, Capodagilo F. Aqualic Exercise. In. Nerrabilitation
10			
20	7		interventions in the patient with obesity, edn.: 2020: 35-50.
20			
21			
22	8	13.	Medicine ACoS: ACSM's health-related physical fitness assessment manual:
23			
24	0		Linging of the Milling R Milling 2012
25	9		Lippincott Williams & Wilkins; 2013.
26			
27	10	14	Oral O [•] Effects of Aquatic Exercise in the Treatment of Obesity <i>Biomedical Journal of</i>
28	10		
29			
30	11		Scientific & Technical Research 2021, 33(1).
31			
32		. –	
33	12	15.	Bergamin M, Ermolao, Tolomio S, Berton, Sergi, Zaccaria: Water- versus land-based
34			
35	13		exercise in elderly subjects: effects on physical performance and body composition
36	10		exercise in elderly subjects, checks on physical performance and bedy composition.
37			
38	14		Clinical Interventions in Aging 2013.
39			
40	4.5		
41	15	16.	Lim JY, Tchai E, Jang SN: Effectiveness of Aquatic Exercise for Obese Patients with
42			
43	16		Knee Osteparthritis: A Randomized Controlled Trial Pm&R 2010 2(8):723-731
44	10		
45			
-15 46	17	17.	Pianna B, Moreno BC, de Souza CA, Bôscoa TF, Alcalde GE, Barrile SR, Gimenes C.
- 10 //7			
47			
40	18		Martinelli B, Zamunér AR, Pessoa-Santos BV et al. Impact of deep water running in
49			
50	10		interval training (DW/P-IT) on body composition, functional canacity, and quality of life
51	15		
52			
53	20		in overweight adults: study protocol for a randomized controlled trial. Trials 2019. 20(1).
54			
55	_		
56	21	18.	Vijayaraj V, Shaju MF: Effectiveness of aqua-aerobic exercises on cardio vascular
57			
58	22		fitness and weight loss among obese college students. International Journal of Physical
59	~~		nanooo ana weigina iooo among obese oollege saadenas. maanaalonal oountal oli rittysidal
60			24
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 19.

20.

21.

22.

23.

24.

25.

Education, Sports and Health 2019, 6(3):111-116.
Ferrigan K, Hice J, Leemkuil K, Singer S, Charles D, Michaels NN, Jones T: Aquatic
Exercise for Weight Reduction in Middle-Aged Adults: A Pilot Study. The Journal of
Aquatic Physical Therapy 2017, 25 (2):16-21.
Yaghoubi M, Ramezani S, Shamsi B, Barfi V: The Effect of a Water Exercise Course
on Body Composition and Quality of Life of Overweight Elderly Men. Journal of Marine
<i>Medicine</i> 2022, 3 (4):180-187.
Nosrani SE, Tartibian B, Eslami R, Farinha C, Serrano J, Ferreira JP, Texeira AM: The
Effects of Combined Aquatic Exercise on Physical Performance and Metabolic Indices
in Overweight Healthy Older Adults. International Journal of Exercise Science 2023,
16 (4):1499.
Earnest CP, Pereira Neiva H, Brandão Faíl L, Izquierdo M, Marques MC, Marinho DA:
The effect of 12 weeks of water-aerobics on health status and physical fitness: An
ecological approach. Plos One 2018, 13(5).
Theodorou M, Kabir R: Exploring the Effects of Cold-Water Swimming on Obese
Population: A Systematic Review. Journal of Applied Sports Sciences 2019,
2 (December):3-21.
Zhu H, Jin J, Zhao G: The effects of water-based exercise on body composition: A
systematic review and meta-analysis. Complementary Therapies in Clinical Practice
2023, 52 .
Moher D: Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The
PRISMA Statement. Annals of Internal Medicine 2009, 151(4).
25

BMJ Open

1			
2			
3			
4	1	26.	Booth A: PROSPERO's progress and activities 2012/13. Systematic Reviews 2013,
5			
6	0		0(4)
7	2		2(1).
8			
9	З	27	Akers I. Aquiar-Ibáñez R. Baba-Akbari A: Systematic reviews: CRD's quidance for
10	5	21.	Akers 5, Aguidi-Ibariez IX, Daba-Akbari A. Oystematic reviews. OKD 3 guidance for
11			
12	4		undertaking reviews in health care. University of York 2009.
13			
14	_		
15	5	28.	Consultation W: Obesity: preventing and managing the global epidemic. World Health
16			
17	6		Organization technical report corios 2000 901:1 253
12	0		Organization technical report series 2000, 894 .1-255.
10			
20	7	29.	Hartling L. Featherstone R. Nuspl M. Shave K. Drvden DM. Vandermeer B: Grev
20		-	
21			
22	8		literature in systematic reviews: a cross-sectional study of the contribution of non-
23			
24	0		English reports uppublished studies and discontations to the results of mate analyses
25	9		English reports, unpublished studies and dissertations to the results of meta-analyses
26			
27	10		in child-relevant reviews. BMC medical research methodology 2017. 17:1-11.
28			
29			
30	11	30.	Higgins JPT, Green S: Cochrane Handbook for Systematic Reviews of Interventions;
31			
32	10		2000
32 33	12		2008.
32 33 34	12		2008.
32 33 34 35	12 13	31.	2008. Nimptsch K. Konigorski S. Pischon T: Diagnosis of obesity and use of obesity
32 33 34 35 36	12 13	31.	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity
32 33 34 35 36 37	12 13	31.	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity
32 33 34 35 36 37 38	12 13 14	31.	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine . <i>Metabolism</i> 2019, 92 :61-70.
32 33 34 35 36 37 38 39	12 13 14	31.	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine. <i>Metabolism</i> 2019, 92 :61-70.
32 33 34 35 36 37 38 39 40	12 13 14	31.	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine . <i>Metabolism</i> 2019, 92 :61-70.
32 33 34 35 36 37 38 39 40 41	12 13 14 15	31. 32.	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine . <i>Metabolism</i> 2019, 92 :61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology,
32 33 34 35 36 37 38 39 40 41 42	12 13 14 15	31. 32.	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine . <i>Metabolism</i> 2019, 92 :61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology,
32 33 34 35 36 37 38 39 40 41 42 43	12 13 14 15 16	31. 32.	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine . <i>Metabolism</i> 2019, 92 :61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology, and treatment . <i>Physical therapy</i> 2003. 83 (3):276-288.
32 33 34 35 36 37 38 39 40 41 42 43 44	12 13 14 15 16	31. 32.	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine . <i>Metabolism</i> 2019, 92 :61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology, and treatment . <i>Physical therapy</i> 2003, 83 (3):276-288.
32 33 34 35 36 37 38 39 40 41 42 43 44	12 13 14 15 16	31. 32.	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine. <i>Metabolism</i> 2019, 92 :61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology, and treatment. <i>Physical therapy</i> 2003, 83 (3):276-288.
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46	12 13 14 15 16 17	31. 32. 33.	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine. <i>Metabolism</i> 2019, 92 :61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology, and treatment. <i>Physical therapy</i> 2003, 83 (3):276-288. Goonasegaran AR: Comparison of the effectiveness of body mass index and body fat
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47	12 13 14 15 16 17	31. 32. 33.	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine. <i>Metabolism</i> 2019, 92 :61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology, and treatment. <i>Physical therapy</i> 2003, 83 (3):276-288. Goonasegaran AR: Comparison of the effectiveness of body mass index and body fat
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48	12 13 14 15 16 17	31. 32. 33.	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine. <i>Metabolism</i> 2019, 92:61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology, and treatment. <i>Physical therapy</i> 2003, 83(3):276-288. Goonasegaran AR: Comparison of the effectiveness of body mass index and body fat
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49	12 13 14 15 16 17 18	31. 32. 33.	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine. <i>Metabolism</i> 2019, 92:61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology, and treatment. <i>Physical therapy</i> 2003, 83(3):276-288. Goonasegaran AR: Comparison of the effectiveness of body mass index and body fat percentage in defining body composition. <i>Singapore medical journal</i> 2012, 53(6).
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50	12 13 14 15 16 17 18	31. 32. 33.	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine. <i>Metabolism</i> 2019, 92 :61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology, and treatment. <i>Physical therapy</i> 2003, 83 (3):276-288. Goonasegaran AR: Comparison of the effectiveness of body mass index and body fat percentage in defining body composition. <i>Singapore medical journal</i> 2012, 53 (6).
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51	12 13 14 15 16 17 18 19	31. 32. 33.	 2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine. <i>Metabolism</i> 2019, 92:61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology, and treatment. <i>Physical therapy</i> 2003, 83(3):276-288. Goonasegaran AR: Comparison of the effectiveness of body mass index and body fat percentage in defining body composition. <i>Singapore medical journal</i> 2012, 53(6). Peltz G, Aguirre MT, Sanderson M, Fadden MK: The role of fat mass index in
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52	12 13 14 15 16 17 18 19	31.32.33.34.	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine. <i>Metabolism</i> 2019, 92:61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology, and treatment. <i>Physical therapy</i> 2003, 83(3):276-288. Goonasegaran AR: Comparison of the effectiveness of body mass index and body fat percentage in defining body composition. <i>Singapore medical journal</i> 2012, 53(6). Peltz G, Aguirre MT, Sanderson M, Fadden MK: The role of fat mass index in
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53	12 13 14 15 16 17 18 19	31. 32. 33.	 2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine. <i>Metabolism</i> 2019, 92:61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology, and treatment. <i>Physical therapy</i> 2003, 83(3):276-288. Goonasegaran AR: Comparison of the effectiveness of body mass index and body fat percentage in defining body composition. <i>Singapore medical journal</i> 2012, 53(6). Peltz G, Aguirre MT, Sanderson M, Fadden MK: The role of fat mass index in
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54	12 13 14 15 16 17 18 19 20	31.32.33.34.	 2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine. <i>Metabolism</i> 2019, 92:61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology, and treatment. <i>Physical therapy</i> 2003, 83(3):276-288. Goonasegaran AR: Comparison of the effectiveness of body mass index and body fat percentage in defining body composition. <i>Singapore medical journal</i> 2012, 53(6). Peltz G, Aguirre MT, Sanderson M, Fadden MK: The role of fat mass index in determining obesity. <i>American Journal of Human Biology</i> 2010, 22(5):639-647.
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55	12 13 14 15 16 17 18 19 20	31. 32. 33. 34.	 2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine. <i>Metabolism</i> 2019, 92:61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology, and treatment. <i>Physical therapy</i> 2003, 83(3):276-288. Goonasegaran AR: Comparison of the effectiveness of body mass index and body fat percentage in defining body composition. <i>Singapore medical journal</i> 2012, 53(6). Peltz G, Aguirre MT, Sanderson M, Fadden MK: The role of fat mass index in determining obesity. <i>American Journal of Human Biology</i> 2010, 22(5):639-647.
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 55	 12 13 14 15 16 17 18 19 20 21 	 31. 32. 33. 34. 	 2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine. <i>Metabolism</i> 2019, 92:61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology, and treatment. <i>Physical therapy</i> 2003, 83(3):276-288. Goonasegaran AR: Comparison of the effectiveness of body mass index and body fat percentage in defining body composition. <i>Singapore medical journal</i> 2012, 53(6). Peltz G, Aguirre MT, Sanderson M, Fadden MK: The role of fat mass index in determining obesity. <i>American Journal of Human Biology</i> 2010, 22(5):639-647.
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57	12 13 14 15 16 17 18 19 20 21	 31. 32. 33. 34. 35. 	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine. <i>Metabolism</i> 2019, 92:61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology, and treatment. <i>Physical therapy</i> 2003, 83(3):276-288. Goonasegaran AR: Comparison of the effectiveness of body mass index and body fat percentage in defining body composition. <i>Singapore medical journal</i> 2012, 53(6). Peltz G, Aguirre MT, Sanderson M, Fadden MK: The role of fat mass index in determining obesity. <i>American Journal of Human Biology</i> 2010, 22(5):639-647. Janssen I, Katzmarzyk PT, Ross R: Waist circumference and not body mass index
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58	12 13 14 15 16 17 18 19 20 21	 31. 32. 33. 34. 35. 	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine. <i>Metabolism</i> 2019, 92 :61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology, and treatment. <i>Physical therapy</i> 2003, 83 (3):276-288. Goonasegaran AR: Comparison of the effectiveness of body mass index and body fat percentage in defining body composition. <i>Singapore medical journal</i> 2012, 53 (6). Peltz G, Aguirre MT, Sanderson M, Fadden MK: The role of fat mass index in determining obesity. <i>American Journal of Human Biology</i> 2010, 22 (5):639-647. Janssen I, Katzmarzyk PT, Ross R: Waist circumference and not body mass index
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59	 12 13 14 15 16 17 18 19 20 21 22 	 31. 32. 33. 34. 35. 	 2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine. <i>Metabolism</i> 2019, 92:61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology, and treatment. <i>Physical therapy</i> 2003, 83(3):276-288. Goonasegaran AR: Comparison of the effectiveness of body mass index and body fat percentage in defining body composition. <i>Singapore medical journal</i> 2012, 53(6). Peltz G, Aguirre MT, Sanderson M, Fadden MK: The role of fat mass index in determining obesity. <i>American Journal of Human Biology</i> 2010, 22(5):639-647. Janssen I, Katzmarzyk PT, Ross R: Waist circumference and not body mass index
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60	12 13 14 15 16 17 18 19 20 21 21 22	 31. 32. 33. 34. 35. 	2008. Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity biomarkers in science and clinical medicine. <i>Metabolism</i> 2019, 92:61-70. Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology, and treatment. <i>Physical therapy</i> 2003, 83(3):276-288. Goonasegaran AR: Comparison of the effectiveness of body mass index and body fat percentage in defining body composition. <i>Singapore medical journal</i> 2012, 53(6). Peltz G, Aguirre MT, Sanderson M, Fadden MK: The role of fat mass index in determining obesity. <i>American Journal of Human Biology</i> 2010, 22(5):639-647. Janssen I, Katzmarzyk PT, Ross R: Waist circumference and not body mass index

1		79 (3):379-384.
2	36.	Kuriyan R: Body composition techniques. Indian Journal of Medical Research 2018,
3		148 (5):648-658.
4	37.	Higgins JPT, Altman DG, Gotzsche PC, Juni P, Moher D, Oxman AD, Savovic J, Schulz
5		KF, Weeks L, Sterne JAC: The Cochrane Collaboration's tool for assessing risk of bias
6		in randomised trials. <i>Bmj</i> 2011, 343 (oct18 2):d5928-d5928.
7	38.	DerSimonian R, Kacker R: Random-effects model for meta-analysis of clinical trials:
8		An update. Contemporary Clinical Trials 2007, 28(2):105-114.
9	39.	Ashtary-Larky D, Bagheri R, Abbasnezhad A, Tinsley GM, Alipour M, Wong A: Effects
10		of gradual weight loss v. rapid weight loss on body composition and RMR: a systematic
11		review and meta-analysis. British Journal of Nutrition 2020, 124(11):1121-1132.
12	40.	Lee YH: An overview of meta-analysis for clinicians. The Korean Journal of Internal
13		<i>Medicine</i> 2018, 33 (2):277-283.
14	41.	Luo L, Shen X, Fang S, Wan T, Liu P, Li P, Tan H, Fu Y, Guo W, Tang X: Sarcopenia
15		as a risk factor of progression-free survival in patients with metastases: a systematic
16		review and meta-analysis. BMC cancer 2023, 23(1):127.
17	42.	Duko B, Belayhun Y, Bedaso A: Prevalence of common mental disorder and its
18		association with perceived stigma and social support among people living with
19		HIV/AIDS in Ethiopia: A systematic review and meta-analysis. International Journal of
20		Mental Health Systems 2024, 18 (1):25.
21	43.	Sterne JAC, Sutton AJ, Ioannidis JPA, Terrin N, Jones DR, Lau J, Carpenter J, Rucker
22		G, Harbord RM, Schmid CH et al. Recommendations for examining and interpreting
		27

1			
2			
3			
4	1		funnel plot asymmetry in meta-analyses of randomised controlled trials. Bmj 2011,
5			
7	2		343 (jul22 1):d4002-d4002.
, 8			
9	2	11	Eason M. Smith CD. Schneider M. Minder C: Bigs in meta analysis detected by a
10	3	44.	Egger M, Smith GD, Schneider M, Minder C. Dias in mela-analysis delected by a
11			
12	4		simple, graphical test. <i>Bmj</i> 1997, 315 (7109):629-634.
13			
14	5	45	Jakobsen JC. Wettersley J. Winkel P. Lange T. Gluud C: Thresholds for statistical and
15	0	40.	
16	-		
1/	6		clinical significance in systematic reviews with meta-analytic methods. BMC Medical
18 10			
20	7		Research Methodology 2014, 14 (1).
20			
27	0	40	Ashtan Ladu D. Banhari D. Asharki O. Tinslay CM. Kasti W. Akhaanashad A
23	0	40.	Ashtary-Larky D, Bagneri R, Asbagni O, Tinsley GM, Kooti W, Abbashezhad A,
24			
25	9		Afrisham R, Wong A: Effects of resistance training combined with a ketogenic diet on
26			
27	10		hody composition: a systematic review and meta-analysis Critical Reviews in Food
28	10		body composition, a systematio review and meta analysis. Childar Neviews in rood
29			
30	11		<i>Science and Nutrition</i> 2021, 62 (21):5717-5732.
31 22			
32 33	12	47.	Cumpston M, Li T, Page MJ, Chandler J, Welch VA, Higgins JPT, Thomas J: Updated
34			
35	10		guidenes for trusted systematic reviews a new adition of the Cashrone Handheek for
36	15		guidance for indisted systematic reviews, a new edition of the Cochrane Handbook for
37			
38	14		Systematic Reviews of Interventions. Cochrane Database of Systematic Reviews 2019.
39			
40	15	48.	Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, Schünemann
41			
42			
43	16		HJ: GRADE: an emerging consensus on rating quality of evidence and strength of
44 45			
45	17		recommendations. <i>Bmj</i> 2008, 336 (7650):924-926.
47			
48	10	40	Puhan MA, Schüngmann HJ, Murad MH, Li T, Brignardelle Poterson P, Singh JA
49	10	49.	
50			
51	19		Kessels AG, Guyatt GH: A GRADE Working Group approach for rating the quality of
52			
53	20		treatment effect estimates from network meta-analysis. Bmi 2014. 349.
54			······································
55 56	04	50	
57	21	50.	Han A, JIA H, ZNU S, LU B, LI Y, MA J, MA X: KOMOSOZUMAD VERSUS TERIPARATIDE FOR
58			
59	22		the Treatment of Postmenopausal Osteoporosis: A Systematic Review and Meta-
60			
			28
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BMJ Open

1		analysis through a Grade Analysis of Evidence. Orthopaedic Surgery 2021,
2		13 (7):1941-1950.
3	51.	Yusof SM, Shari M, Kadir Z, Adam A, Kek TL, Aiman S, Idris NM, Johar M: AQUA
4		ZUMBA VERSUS AQUA JOGGING: COMPARATIVE EFFECTS ON HEALTH
5		PARAMETERS AMONG OBESE MIDDLE AGED WOMEN. Malaysian Journal of
6		Movement, Health & Exercise 2018, 7(2):11-22.
7	52.	Penaforte FRO, Calhau R, Mota GR, Chiarello PG: Impact of short-term water exercise
8		programs on weight, body composition, metabolic profile and quality of life of obese
9		women. Journal of Human Sport and Exercise 2015, 10(4):915-926.
10	53.	Rica RL, Carneiro RMM, Serra AJ, Rodriguez D, Pontes Junior FL, Bocalini DS: Effects
11		of water-based exercise in obese older women: Impact of short-term follow-up study
12		on anthropometric, functional fitness and quality of life parameters. Geriatrics &
13		Gerontology International 2012, 13(1):209-214.
14	54.	Colato A, Fraga L, Dorneles G, Vianna P, Chies JAB, Peres A: Impact of aerobic water
15		running training on peripheral immune-endocrine markers of overweight-obese women.
16		<i>Science & Sports</i> 2017, 32 (1):46-53.
17	55.	Principal D: Effect of Underwater Treadmill Training on Young Obese Adults. 2018.
18	56.	Rezaeipour M: Investigation of pool workouts on weight, body composition, resting
19		energy expenditure, and quality of life among sedentary obese older women.
20		Montenegrin Journal of Sports Science and Medicine 2020, 9 (1):67.
21	57.	Rezaeipour M: Effects of two water-based exercise programs on body weight and blood
22		lipid parameters in elderly obese males with a sedentary lifestyle. Diabetes & Metabolic

BMJ Open

2			
3			
4	1		Syndrome: Clinical Research & Reviews 2021, 15(4).
5			
6	2	58	Soori P. Pezaeian N. Khosravi N. Ahmadizad S. Taleghani HM. Jourkesh M. Stannard
7	Z	50.	Soon R, Rezdelan N, Rhoslavi N, Annaulzau S, Taleghani Tim, Sourkesh M, Stannaru
8			
9	3		SR: Effects of water-based endurance training, resistance training, and combined
10	-		
11			
12	4		water and resistance training programs on visfatin and ICAM-1 levels in sedentary
13			
14	F		chase wemen Science & Sporte 2017 22(2):114 151
15	Э		obese women. Science & Spons 2017, $32(3)$:144-151.
16			
17	6	59.	Greene NP. Lambert BS. Greene ES. Carbuhn AF. Green JS. Crouse SF: Comparative
18	•	•••	
19			
20	7		Efficacy of Water and Land Treadmill Training for Overweight or Obese Adults.
21			
22	0		Madiaina & Caianaa in Charte & Everaina 2000 11(0):1808 181E
23	8		inedicine & Science in Sports & Exercise 2009, 41(9):1808-1815.
24			
25	9	60.	Wouters FJM, Van Nunen AMA, Geenen R, Kolotkin RL, Vingerhoets AJJM; Effects of
25	·	•••	
20			
27	10		Aquajogging in Obese Adults: A Pilot Study. Journal of Obesity 2010, 2010:1-7.
20			
29	44	04	
50 21	11	61.	WU M-S, Chen K-H, Chen I-F, Huang SK, Tzeng P-C, Yen M-L, Lee F-P, Lin J-G, Chen
20			
5Z	12		C: The efficacy of acupuncture in post-operative pain management: a systematic
33 24			
34 25			
30	13		review and meta-analysis. PloS one 2016, 11(3):e0150367.
30			
3/	11	60	Dage MIL Higging IDT. Storne IAC: Appending risk of higg due to missing regults in a
38	14	02.	rage wid, higglins of t, diethe dAC. Assessing lisk of bias due to missing results in a
39			
40	15		synthesis. In: Cochrane Handbook for Systematic Reviews of Interventions. edn.; 2019:
41			
42			
43	16		349-374.
44			
45	17	63	Tkachova A. Dutchak M. Kashuha V. Goncharova N. Lytwynenko V. Vako I. Kolos M.
46	17	00.	
47			
48	18		Lopatskyi S: Practical implementation of differentiated approach to developing water
49			
50	40		
51	19		aerobics classes for early adulthood women with different types of body build. <i>Journal</i>
52			
53	20		of Physical Education and Sport 2020 20 :456-460
54	20		
55			
56	21	64.	Jones LM, Legge M, Meredith-Jones K: Circuit Based Deep Water Running Improves
57			
58	00		Oordieveneules Eitnesse Otenseth and Abdeminal Obesits in Olden Oresentations
	11		Carolovascular Filness, Strength and Addominal Obesity in Older, Overweight Women
59			
59 60			

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3 4 5	1		Aquatic Exercise Intervention in Older Adults. Medicina Sportiva 2009, 13(1):5-12.
6 7	2	65.	Bakken RC, Carey JR, Di Fabio RP, Erlandson TJ, Hake JL, Intihar TW: Effect of
8 9 10	3		Aerobic Exercise on Tracking Performance in Elderly People: A Pilot Study. Physical
11 12 13	4		<i>Therapy</i> 2001, 81 (12):1870-1879.
14 15 16	5	66.	Kalapatapu RK, Campbell A, Aharonovich E, Hu M-C, Levin FR, Nunes EV:
17 18	6		Demographic and Clinical Characteristics of Middle-aged Versus Younger Adults
19 20 21	7		Enrolled in a Clinical Trial of a Web-delivered Psychosocial Treatment for Substance
22 23 24	8		Use Disorders. Journal of Addiction Medicine 2013, 7(1):66-72.
25 26	9	67.	Ahooghalandary S: Effect of Water Aerobics on Body Mass Index, Lipid Profile, and
27 28 29	10		Atherogenic Factors of Middle-aged Obese Women. Jundishapur Journal of Medical
30 31 32	11		<i>Sciences</i> 2022, 21 (5):638-649.
33 34	12	68.	Green JS: Effects of a Water Aerobics Program on the Blood Pressure, Percentage of
35 36 37	13		Body Fat, Weight, and Resting Pulse Rate of Senior Citizens. Journal of Applied
38 39 40	14		<i>Gerontology</i> 2016, 8 (1):132-138.
41 42	15	69.	Martins V, Lima GdSO, Silva LPd, Silva AGd, Bastos AD, Coêlho PGD, Noleto DCdS,
43 44 45	16		Borges DBdS, Nascimento MAd, Lourenço BdS: The practice of water aerobics with
46 47 48	17		the elderly: Physical and psychological aspects. In: Innovation in Health Research
49 50	18	70	Vaciliavia L. Cardasovia L. Kazunovia M. Pajania D: Weist sizeumforenzo es en indiseter
51 52 53	20	70.	abdominal obseity in middle age. Sport Mont 2017 15 (1):21.22
54 55 56	20	71	Bajoumi AVAA: Comparing Measures of Obesity: Waist Circumference Waist-Hin and
57 58	27		Waist-Height Ratios In: Nutrition in the Prevention and Treatment of Abdominal
59 60			04

1			
2			
3			
4	1		<i>Obesity</i> , edn.: 2019: 29-40.
5	-		
6			
7	2	72.	Clark J: The impact of duration on effectiveness of exercise, the implication for
, 8			
0	-		
9 10	3		periodization of training and goal setting for individuals who are overfat, a meta-
10			
11	1		analysia Rialagy of Enart 2016 22(1):200 222
12	4		analysis. <i>Diology of Sport</i> 2016, 33 (4).309-333.
13			
14	5	73.	Harbuwono DS. Tahapary DL. Tarigan TJE. Yunir E: New proposed cut-off of waist
15	-	-	
16			
17	6		circumference for central obesity as risk factor for diabetes mellitus: Evidence from the
18			
19	7		Indension Proje National Lighth Current, Die Course 20000, 45/44) - 0040447
20	/		Indonesian Basic National Health Survey. Plos one 2020, 15(11):e0242417.
21			
22	8	74	Darsini D. Hamidah H. Notobroto HB. Cabyono FA: Health risks associated with high
23	Ũ		Barolini B, Hanidan H, Rocostoto HB, Ganyono Era Hoalan note accostated man ngh
24			
25	9		waist circumference: A systematic review. Journal of public health research 2020,
26			
27	10		0(2) vinhr 2020 1811
28	10		9 (2).jpnr. 2020. 1011.
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2 Fig. 1 Preferred reporting items for systematic reviews and meta-analyses (PRISMA)

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- 3 flow diagram.
- **Fig. 2** Risk of bias.
- 5 Fig. 3 Sensitivity analysis of percentage body fat.
- **Fig. 4** Funnel plot for body weight.



Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow diagram

160x122mm (300 x 300 DPI)

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	<u>D1a</u>	<u>D1b</u>	<u>D2</u>	<u>D3</u>	<u>D4</u>	<u>D5</u>	<u>Overall</u>						
Yusof et al., 2018	+	•	•	•	•	•	+	•	Low risk				
Penaforte et al., 2015	•	•	•	•	•	•	!	•	Some concerns	5			
Palekar et al., 2018	•	•	•	•	•	•	+	•	High risk				
Rezaeipour, 2020	•	•	1	•	•	•							
Greene et al., 2009	1	•	1	•	•	•		Dla	Randomisation	n process			
Rica et al., 2012	1	•	•	•	•	•	•	D1b	Timing of iden	tification or	recruitm	ent of part	ticipa
Wouters et al., 2009	•	•	•	•	•	•	+	D2	Deviations from	n the inten	ded interv	ventions	
Rezaeipour, 2021	•	•	•	•	•	•	+	D3	Missing outcom	ne data			
Soori et al., 2017	•	•	•	•	•	•	+	D4	Measurement	of the outco	ome		
Colato et al., 2016	•	•	•	•	•	•	+	D5	Selection of th	e reported r	esult		
		Over	all Bias										
Sele	ction of th	e reporte	d result										
M	easureme	nt of the o	utcome										
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Funnel plot for body weight 137x79mm (300 x 300 DPI)









Fig. S2 Meta-analysis of waist circumference

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Fig. S3 Meta-analysis of body mass index



Fig. S4 Meta-analysis of percent body fat

38

39 40

41 42

43 44

45 46

51 52

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%

Weight

29.93

33.61

16.78

19.68

100.00

WMD (95% CI)

0.00 (-4.68, 4.68)

-0.10 (-4.52, 4.32)

1.40 (-4.85, 7.65)

-2.00 (-7.77, 3.77)

-0.19 (-2.75, 2.37)

7.77







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Fig. S7 Meta-analysis of waist-hip ratio



Fig. S8 Meta-analysis of hip circumference

Supplementary information 2

Table S1 Minor changes

Numbers	Changes
1	Delete "body fat mass" and add "waist-to-hip ratio, waist circumference, and hip
	circumference".
2	Delete "mean baseline, follow-up" from the data extraction content.
3	Statistical software Change the "Review Manager" to "Stata".
4	Add water aerobics subgroup analysis.

Table S2 Database search terms

Database	Search terms	Results
PubMed	(((((((((((((((((((((((((((((((((((())))	375
Medline	(Physical Activity)) OR (Activities, Physical)) OR (Activity, Physical))	
	OR (Physical Activities)) OR (Exercise, Physical)) OR (Exercises,	
	Physical)) OR (Physical Exercise)) OR (Physical Exercises)) OR (Acute	
	Exercise)) OR (Acute Exercises)) OR (Exercise, Acute)) OR (Exercises,	
	Acute)) OR (Exercise, Isometric)) OR (Exercises, Isometric)) OR	
	(Isometric Exercises)) OR (Isometric Exercise)) OR (Exercise, Aerobic))	
	OR (Aerobic Exercise)) OR (Aerobic Exercises)) OR (Exercises,	
	Aerobic)) OR (Exercise Training)) OR (Exercise Trainings)) OR	
	(Training, Exercise)) OR (Trainings, Exercise)) AND ("Water"[Mesh]))	
	OR (((((((((water aerobics)) OR (waterobics))) OR (aquarobics))) OR	
	(aquatic fitness)) OR (aquafitness)) OR (aquafit)) OR (aqua zumba)) OR	
	(water yoga)) OR (aqua aerobics)) OR (aqua jog))) AND	
	((("Obesity"[Mesh]) OR ((fat) OR (obese))) OR ("Overweight"[Mesh])))	
	AND (("Randomized Controlled Trials as Topic"[Mesh]) OR	
	((((((Randomised controlled trial) OR (controlled trial)) OR (randomized	
	controlled study)) OR (Clinical Trials, Randomized)) OR (Trials,	
	Randomized Clinical)) OR (Controlled Clinical Trials, Randomized)))	
Embase	('randomised controlled trial'/exp OR 'randomised controlled trial' OR	2169
	'randomized controlled trials as topic'/exp OR 'randomized controlled	
	trials as topic' OR 'controlled trial'/exp OR 'controlled trial' OR	
	'randomized controlled study'/exp OR 'randomized controlled study' OR	
	'clinical trials, randomized' OR 'trials, randomized clinical' OR 'controlled	
	clinical trials, randomized') AND ('obesity'/exp OR 'obesity' OR 'fat'/exp	

	OR 'fat' OR 'obese' OR 'overweight'/exp OR 'overweight') AND ('water aerobics'/exp OR 'water aerobics' OR 'waterobics' OR 'aquarobics' OR 'aquatic fitness' OR 'aquafitness' OR 'aquafit' OR 'aqua zumba' OR 'water yoga' OR 'aqua aerobics' OR 'aqua jog' OR (('water'/exp OR 'water') AND ('exercise'/exp OR 'exercise' OR 'aerobics'/exp OR 'aerobics' OR 'exercises' OR 'cycling'/exp OR 'cycling' OR 'physical activity'/exp OR 'physical activity' OR 'activities, physical' OR 'activity, physical'/exp OR 'activity, physical' OR 'physical activities' OR 'exercise, physical' OR 'exercises, physical' OR 'physical exercise'/exp OR 'physical exercise' OR 'physical exercises' OR 'acute exercise'/exp OR 'physical exercise' OR 'physical exercises' OR 'acute exercise'/exp OR 'acute exercise' OR 'physical exercises, acute' OR 'exercises, acute' OR 'exercise, isometric'/exp OR 'exercise, isometric' OR 'exercises, isometric' OR 'isometric exercises' OR 'aconte exercise'/exp OR 'isometric exercise'/exp OR 'aerobic exercise' OR 'aerobic exercise'/exp OR 'aerobic exercise'/exp OR 'aerobic exercise' OR 'aerobic exercise'/exp OR 'asometric' OR 'isometric exercises' OR 'aerobic exercise, aerobic' OR 'exercise, aerobic'/exp OR 'exercise, aerobic' OR 'aerobic exercise'/exp OR 'aerobic exercise' OR 'aerobic exercises' OR 'aerobic exercise'/exp OR 'aerobic exercise' OR 'aerobic exercises' OR 'exercise, aerobic' OR 'exercise training'/exp OR 'exercise training' OR 'exercise trainings' OR 'training, exercise' OR 'trainings, exercise'))))	
Ovid	1 "Randomised controlled trial " mp	19
MEDLINE	2 exp Randomized Controlled Trials as Topic/	17
	3 " controlled trial" mp	
	4 "randomized controlled study " mp	
	5 "Clinical Trials Randomized" mp	
	6 "Trials, Randomized Clinical".mp.	
	7 "Controlled Clinical Trials, Randomized".mp.	
	8 1 or 2 or 3 or 4 or 5 or 6 or 7	
	9 exp Obesity/	
	10 exp Fats/	
	11 "obese".mp.	
	12 exp Overweight/	
	13 9 or 10 or 11 or 12	
	14 "water aerobics ".mp.	
	15 "aquarobics ".mp.	
	16 "aquatic fitness ".mp.	
	17 "aquafitness ".mp.	
	18 "aquafit".mp.	
	19 "water yoga".mp.	
	20 "aqua aerobics".mp.	
	21 14 or 15 or 16 or 17 or 18 or 19 or 20 22 own Water/	
	22 exp water/	
	25 exp Exercise/ 24 "aerobics " mp	
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3		27 "Physical Activity".mp.	
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28		46 "Exercises, Aerobic".mp.	
29		47 "Exercise Training".mp.	
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33		50 "Trainings Exercise" mp	
34		51 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34	
35		or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or	
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44	Scopus	((TITLE-ABS-KEY ("randomised controlled trial ") OR TITLE-ABS-	468
45		KEY ("randomized controlled trials as topic ") OR TITLE-ABS-KEY ("	
46		controlled trial") OR TITLE-ABS-KEY (" randomized controlled study	
4/ 48		") OR TITLE-ABS-KEY ("clinical trials, randomized") OR TITLE-	
49		ABS-KEY ("trials, randomized clinical") OR TITLE-ABS-KEY	
50		("controlled clinical trials, randomized"))) AND ((TITL E-ABS-KEY)	
51		(obesity $)$ OR TITLE-ABS-KEV $($ fat $)$ OR TITLE-ABS-KEV $($ obese $)$	
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53 54		(water)) AND ((TITLE ADS KEY (average)) OD TITLE ADS KEY	
55		(water)) AND ((IIILE-ABS-KEY (exercise) OK IIILE-ABS-KEY	
56		(exercises) OR TITLE-ABS-KEY (cycling) OR TITLE-ABS-KEY	
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Effects of water aerobics on body composition in obesity and overweight people: a systematic review and metaanalysis

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Manuscript ID	bmjopen-2024-091743.R2
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Keywords:	Meta-Analysis, Obesity, Overweight, SPORTS MEDICINE





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Effects of water aerobics on body composition in obesity and overweight people: a systematic review and meta-analysis

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Effects of water aerobics on body composition in obesity and overweight people: a systematic review and meta-analysis

4 Abstract

Objectives Obesity and overweight significantly impact public health. The benefits of
water aerobics (WAs) have been shown in obesity and overweight people, but the
effects of WAs on body composition improvement are still unclear.

8 **Design** Systematic review and meta-analysis.

9 Data sources A systematic literature search was conducted on November 16, 2024,
10 across the PubMed MEDLINE, Ovid MEDLINE, Embase, Scopus, Web of Science,
11 and the Cochrane Library.

Eligibility criteria for selecting studies Only randomized controlled trials (RCTs) were included, which were independently screened by two researchers. All RCTs on WAs that evaluated the anthropometric and body composition parameters of overweight and obesity subjects were included. Eligible studies were reported following the PRISMA statement. Enseignement Superieur (ABES) Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Data extraction and synthesis All process were independently screened by 2 researchers (D.Z.Y., Z.H.X.). A fixed-effects or random-effects model was chosen based on the heterogeneity of the studies. The risk of bias in the included studies was assessed using the Risk of Bias 2.0 tool, and sensitivity and subgroup analyses were conducted for outcome indicators. The quality of evidence for each outcome was assessed using the GRADE system.

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1	Results A total of 10 studies involving 286 participants were included. Sensitivity
2	analyses were performed for PBF with high heterogeneity, and the results were robust.
3	WAs were able to reduce BW (WMD = -2.69, 95% CI: -4.10 to -1.27, p < 0.05, I^2 =
4	0.0%) and WC (WMD = -2.75, 95%CI: -4.41 to -1.09, p < 0.05, $I^2 = 27.0$ %), but the
5	effect on other body indicators was not significant. The GRADE assessment revealed
6	that the certainty of evidence was low for BMI, LM, FM, WHR, and HC, and very low
7	for PBF. In contrast, the certainty of evidence for BW and WC was moderate.
8	Conclusion For the obesity and overweight people, WAs interventions over 10 weeks
9	(i.e., 12 weeks) reduced BW and WC, with more significant effects in women and
10	greater improvements in body composition in middle-aged and older adults (average
11	age \geq 45 years). The moderate certainty of evidence for BW and WC, as assessed using
12	the GRADE framework, indicates that these findings are robust.
13	PROSPERO registration number CRD42023466969.
14	Strengths and limitations of this study
15	• This study systematically reviewed and meta-analyzed RCTs, the gold standard in
16	clinical research, ensuring a high level of methodological rigor.
17	• Studies of registered or ongoing RCTs were not included in the search for articles,
18	and only studies published in English were considered.
19	• Judgements made by persons were more subjective when using ROB tools and the
20	GRADE system for literature and outcome quality assessment.
21	• There were certain limitations to the articles included in the study: (1) Some studies

had short durations (e.g., 6 weeks), small sample sizes, and limited data; (2) A

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small number of participants in the study dropped out of the trial halfway through;(3) Differences in the age, sex ratio, and location of the trial participants in three aspects.

8 Introduction

The global prevalence of obesity has increased significantly over the past 40 years [1-3]. By 2022, more than 43% of adults worldwide will be overweight, with 504 million female and 374 million male obese [4]. Obesity is a chronic disease that raises the risk of various complications and contributes to an estimated 2.8 million deaths annually [5-7]. Exercise is a highly effective method for weight management [8-10], but individuals with obesity and overweight are prone to severe bone and joint injuries during physical activity due to their weight [11]. Traditional land-based aerobic exercise methods increase musculoskeletal damage in obese patients [12]. The American College of Sports Medicine recommends water aerobics (WAs) for people with obesity to reduce the risk of injury and enhance exercise adherence [13]. WAs interventions are increasingly recognized as a beneficial and effective approach to treating obesity [14, 15]. The buoyant effect of water helps reduce joint injuries commonly associated with exercise in overweight and obese individuals [16, 17]. Studies have shown that WAs have a better effect on improving body composition in

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1	obesity and overweight people. For example, young obese adults (mean age 18-25 years)
2	lost weight and improved their body mass index (BMI) after 12 weeks of WAs [18].
3	Middle-aged adults (mean age 47 - 70 years) also demonstrated significant reductions
4	in body weight (BW) and percent body fat (PBF) after participating in 6 weeks of WAs
5	[19]. Additionally, WAs led to significant improvements in body composition (e.g.,
6	PBF, BW, BMI, and waist-to-hip ratio [WHR]) in overweight older men (mean age
7	62 - 70 years) [20]. Overweight older adults (mean age 72 years) who participated in a
8	28-week WAs program showed reductions in body fat mass (FM) and both leg and
9	waist circumference (WC) [21]. Therefore, WAs is a valuable exercise method and can
10	be an important strategy for weight loss in individuals with obesity and overweight [19,
11	21].

However, fewer studies have been reported on the effects of WAs on physical indicators in obesity and overweight people. Previous literature review have provided broad overviews of the relevant evidence, but none have specifically focused on obesity and overweight people [14, 22, 23]. For example, Haifeng Zhu [24] summarizes the physical effects of aquatic exercise on adults. However, this study only included randomized controlled trials (RCTs) on healthy adults and did not consider those with obesity or overweight [24].

Thus, the systematic review and meta-analysis presented in this study aims to fill this research gap by specifically examining the effects of WAs on physical indicators in obesity and overweight people. The primary focus of this study is to determine whether WAs significantly improve physical indicators in obesity and overweight people.

1	
2	Methods
3	Registration
4	This meta-analysis was conducted and reported in accordance with the Preferred
5	Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement [25,
6	26]. The study protocol was registered in the International Prospective Register of
7	Systematic Reviews (PROSPERO) (registration number: CRD42023466969). Minor
8	changes were made to the initial PROSPERO protocol submitted in October 2023
9	(Table S1 in Supplementary information 2).
10	Search strategy
11	Six databases were searched: PubMed MEDLINE, Ovid MEDLINE, Embase, Scopus,
12	Web of Science, and the Cochrane Library. The search covered the period from the
13	inception of the database up to November 16, 2024. Retrieval strategy based on PICOS
14	tool [27]: (P) Population: adults with overweight and obesity; (I) Intervention: WAs;
15	(C) Comparator: other exercise modalities or no exercise control; (O) Outcome: body
16	composition; (S) Study type: RCTs. Search using core terms: water aerobics (e.g.,
17	aquatic fitness, aqua aerobics), obesity or overweight (e.g., fat, obese), and RCTs (e.g.,
18	randomized controlled study, controlled clinical trials). The core terms for the searches
19	were identified in the MeSH Database in the PubMed database, respectively, to ensure
20	the scientific validity and accuracy of the search vocabulary, and the
21	comprehensiveness of the search scope (details of the search strategy are in Table S2
22	in Supplementary information 2). In addition to the database search, the reference lists

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1 of included articles were screened for studies that met the inclusion criteria.

2 Eligibility criteria

Inclusion criteria: (1) RCTs; (2) Participants were adults (\geq 18 years) with obesity (BMI \geq 30 kg/m²) or overweight (BMI > 25 kg/m²), including older adults [28]; (3) The intervention group participated in WAs for at least 4 weeks, and the control group did not participate in exercise or chose other ways of exercising; (4) The study reported results on changes in body composition; (5) The full text of the study was available in English (i.e., not a review, letter, case series, or conference proceedings). Grey literature (i.e., dissertations, conference abstracts) was excluded, as it has been shown that these represent only a small percentage of the studies included in the systematic review and rarely affect the statistical or clinical significance of the results [29].

Exclusion criteria: (1) Trials that did not satisfy all inclusion criteria; (2) Studies that included participants diagnosed with other diseases; (3) Exercise interventions combined with dietary control, medication or other lifestyle changes; (4) There was no exercise of any form, just a trial of being immersed in water or receiving a massage.

16 Study selection

The study used EndNote (Version 21) to manage the articles. First, duplicate articles were removed. Second, the titles and abstracts of the articles were read and qualified articles were selected. Finally, full-text review was performed. The process was independently screened by 2 researchers (D.Z.Y., Z.H.X.). Disagreements were adjudicated by a third researcher (G.Z.X.).

22 Data extraction

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ata from the included studies were recorded using an adapted Cochrane Collaboration standardized data extraction form [30]. The following study characteristics were extracted: year of publication, authors, region, study period, study design, sample size, participants, and mean age. BW, measured in kilograms (kg), serves as a direct indicator of overall weight loss and is a key measure of intervention effectiveness in obesity management [31]. BMI, a widely used but indirect measure of body fatness, is calculated as weight in kilograms divided by height in meters squared (kg/m^2) [32]. PBF is an important metric for distinguishing between lean mass (LM) and FM [33]. FM and LM were assessed using bioelectrical impedance analysis or dual-energy X-ray absorptiometry, with PBF calculated using the formula: PBF = (FM (kg)/BW (kg)) \times 100 [34]. WC reflects abdominal fat distribution and is a validated marker of central obesity and metabolic risk [35]. Risk thresholds for WC are ≥ 102 cm for male and ≥ 88 cm for female [36].

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Both WC and hip circumference (HC) were measured in centimeters (cm) using an inelastic tape. WC was defined as the minimum circumference between the rib margins and iliac crests, while HC was defined as the maximum circumference between the waist and thighs. The WHR was calculated as WC/HC [34]. WHR is a measure of upper and lower body fat distribution, with higher values indicating a greater risk of obesity-related health problems. Risk thresholds for WHR are male ≥ 1.0 and female ≥ 0.85 [36]. Therefore, the primary outcomes were BW, BMI, PBF, WHR, WC, and HC, while the secondary outcomes were FM and LM.

22 Two researchers (D.Z.Y., Z.H.X.) independently extracted this information from each

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1 study, and any disagreements were resolved through discussion.

2 Risk of bias

Two researchers (D.Z.Y. and Z.H.X.) independently assessed the risk of bias in the
included RCTs using the Cochrane risk-of-bias tool (RoB 2), following the evaluation
criteria outlined in the Cochrane Handbook for Systematic Reviews of Interventions
(Version 6.4) [37]. Any disagreements during the review process were discussed and
resolved through consultation with a third researcher (G.Z.X.) from the review team.

8 Data analysis

9 Meta-analysis was conducted using Stata 18.0 software. Heterogeneity among studies
10 was assessed using Cochran's Q and I² tests [38]. When P > 0.1, I² ≤ 50%, there was
11 homogeneity, and a fixed-effects model was used for the meta-analysis; when P ≤ 0.1,
12 I² > 50%, there was heterogeneity, and a random-effects model was used [39, 40].
13 Therefore, this study uses a fixed-effects model for the meta-analysis, which was
14 changed to a random-effects model when I² > 50%.

To further test the stability of the results, a sensitivity analysis was performed using the leave-one-out method [41]. This method involves excluding one study at a time, combining the remaining studies in a meta-analysis, and assessing whether the results of the original meta-analysis were significantly altered by the influence of certain studies by observing the changes in the combined results [42]. Publication bias was assessed using funnel plots, with asymmetric distribution indicating potential bias [43]. Quantitative analysis of funnel plot asymmetry was conducted using the Egger regression test [44].

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Differences were considered significant at P < 0.05 [45]. The standard error of the mean (SEM) of the extracted data was converted to standard deviation (SD) [46], using the formula in the Cochrane Handbook [47] (N represents the number of trial participants): $SD = SEM \times \sqrt{N}$ **Quality of GRADE evidence** The quality of evidence for each outcome was assessed using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) methodology [48]. Two researchers (D.Z.Y. and Z.H.X.) independently conducted the assessments. Any disagreements were resolved through discussion and, when necessary, consultation with a third researcher (G.Z.X.) to reach a consensus. As all included studies were RCTs, the initial evidence quality was rated as high. However, the confidence in the evidence could be downgraded based on specific limitations in the original studies, including risk of bias, inconsistency, indirectness, imprecision, and publication bias [49]. Following GRADE guidelines, the final quality of evidence was categorized into one of four levels: high, moderate, low, and very low [50]. Results **Study search results**

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A total of 4517 studies were searched. Of these, 1,185 were removed due to duplication,
leaving 3,332 studies for further screening. After reviewing the titles and abstracts,
3,267 studies were excluded. 65 articles were eligible for full-text screening, of which

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55 were deleted. Ultimately, 10 studies were included in the meta-analysis (Fig. 1).

2 Study characteristics

The 10 RCTs included in this study involved a total of 286 participants [51-60]. Publication dates range from 2009 to 2021 (note: this refers to the publication date of articles analyzed that met the inclusion criteria; the search strategy was from database construction to November 16, 2024). The studies included trials conducted in Malaysia, Brazil, India, the United States, and the Netherlands. The participants' ages ranged from 20 to 70 years.

9 A small number of subjects from 5 trials [51, 53, 55, 58, 59] dropped out of the
10 experiment for various reasons, and trial data from those who dropped out was not used.
11 One study [51] included two distinct intervention groups: Aqua Zumba (Yusof-1) and
12 Aqua Jogging (Yusof-2). Due to the differing exercise programs, these groups were
13 treated as separate studies (Yusof-1 and Yusof-2) in the analysis.

The types of WAs included in this review were diverse and encompassed activities such as water aerobics, aqua Zumba, water yoga, and aqua jogging. The intervention periods ranged from 6 to 12 weeks across all included trials. One of the trials [55] had an exercise frequency of 2 times a week; others were 3 times a week. The exercise time varied according to the needs of the trials, with most being 60 minutes each.

The units for BW, LM, and FM are kilograms (kg); for BMI, kilograms per square meter (kg/m²); and for WC and HC, it is centimeters (cm). The basic characteristics of each study are shown in **Table 1**.

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 Table 1 Experimental details.

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Study	Country	Duration (weeks)	Sample	Mean age/ range (SD)	Exercise Category	Study design (Frequency, time)	Outcome
Yusof-1 et al., 2018	Malaysia	12	40 (F)	45.13(5.17)	Aqua zumba	3 days/week, 60 minutes per session	BW, PBF, WC
Yusof-2 et al., 2018	Malaysia	12	40 (F)	45.28(5.09)	Aqua jog	3 days/week, 60 minutes per session	BW, PBF, WC
Penaforte et al., 2015	Brazil	×	16 (F)	42.8(7.4)	Water aerobics	3 days/week, 60minutes per session	BW, BMI, LM, FM, WC, HC
Palekar et al., 2018	India	9	14 (M)	20.71	Underwater treadmill training	3 days/week, 25minutes per session	BMI, PBF, WC
Rezaeipour, 2020	Iran	12	24 (F)	69.5(4.3)	Aquatic exercises (dancing and walking)	3 days/week, 60minutes per session	BW, BMI, LM, FM,
Greene et al., 2009	American	12	57 (Mix)	42(18.67)	Underwater treadmill	Three times per week	BW, BMI, LM, FM, WC, HC, WHR
Rica et al., 2012	Brazil	12	38 (F)	68.5(5)	Water-based exercise with aerobic	Three times per week, 60-min sessions	BW, BMI, PBF, LM, FM, WC, HC, WHR
Wouters et al., 2009	Netherlands	9	14 (Mix)	44	Aquajogging	2 per week, one hour	BW, BMI, PBF, WC
Rezaeipour, 2021	Iran	12	27 (M)	68.7(3.2)	Water-based exercise with aerobic	3 days/week, 60minutes per session	BW, BMI
Soori et al., 2017	Iran	10	16 (F)	45-60	Swimming or walking in the water	3 per week, 45 min per day	BW, BMI, PBF, WC
Colato et al., 2016	Brazil	12	20 (F)	49.36(11.69)	Water running training	3 per week, 70 minutes/session	BW, BMI, FM, WC, HC
Note: body weight (BW) mixed sex (Mix): male (); body mass ind M): female(F).	lex BMI); p	ercent body fai	t (PBF); lean mas	s (LM); fat mass (FM); Wai	st-hip ratio (WHR); Waist circumference (WC); Hip circumference (HC);

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1 Results of ROB assessment

Following the risk of bias assessment, the 10 included studies were rated as follows: 6
studies had a low risk of bias, 3 had some concerns, and 1 study had a high risk (Fig.
2).

5 Physical outcome

WAs proved to be an effective intervention for reducing BW (WMD = -2.69, 95%CI: -4.10 to -1.27, p < 0.05, $I^2 = 0.0\%$) and WC (WMD = -2.75, 95%CI: -4.41 to -1.09, p < 0.050.05, $I^2 = 27.0\%$ in obesity and overweight people (Fig. S1 and Fig. S2 in Supplementary information 1). However, other physical indicators, such as BMI $(WMD = -0.55, 95\%CI: -1.29 \text{ to } 0.19, p > 0.05, I^2 = 0.0\%)$ (Fig. S3 in Supplementary information 1), PBF (WMD = -4.83, 95%CI: -10.32 to 0.66, p > 0.05, I² = 93.6%) (Fig. S4 in Supplementary information 1), LM (WMD = -0.19, 95%CI: -2.75 to 2.37, p > $0.05, I^2 = 0.0\%$ (Fig. S5 in Supplementary information 1), FM (WMD = -0.92, 95%CI: -3.20 to 1.36, p > 0.05, $I^2 = 0.0\%$) (Fig. S6 in Supplementary information 1), WHR $(WMD = -0.02, 95\%CI: -0.05 \text{ to } 0.01, p > 0.05, I^2 = 0.0\%)$ (Fig. S7 in Supplementary information 1) and HC (WMD = -1.05, 95%CI: -3.64 to 1.55, p > 0.05, I² = 0.0%) (Fig. S8 in Supplementary information 1), did not show significant improvements (Table 2). Subgroup analysis of outcomes

Subgroup analyses of WAs were performed on the included studies to identify
appropriate WAs regularity and to explore sources of heterogeneity. Due to the number
of subgroups, the results of the subgroup analyses of WAs are summarized in table 2
(Table 2).

	Ν	WMD (95% CI)	P within group	P heterogeneity	I^2
Subgroup analyses of WA on BW					
Overall effect	10	-2.69(-4.10, -1.27)	0.000*	0.670	0.0%
Trial duration (week)					
>10	7	-3.31(-5.23, -1.40)	0.001*	0.455	0.0
≤10	3	-1.93(-4.03, 0.16)	0.071	0.971	0.0
Sex					
Male	1	-0.60(-8.58, 7.38)	0.883	-	-
Female	7	-2.90(-4.37, -1.43)	0.000*	0.486	0.0
Mix (male & female)	2	0.24(-6.54, 7.02)	0.944	0.678	0.0
Average age					
≥45	7	-2.85(-4.31, -1.40)	0.000*	0.465	0.0
<45	3	0.05(-5.89, 5.98)	0.988	0.911	0.0
Subgroup analyses of WA on BMI					
Overall effect	9	-0.55(-1.29, 0.13)	0.146	0.984	0.0
Trial duration (week)					
>10	5	-0.14(-1.25, 0.97)	0.806	0.943	0.0
≤10	4	-0.88(-1.88, 0.12)	0.083	0.979	0.0
Sex					
Male	2	-0.47(-2.52, 1.57)	0.649	0.932	0.0
Female	5	-0.55(-1.41, 0.31)	0.208	0.757	0.0
Mix (male & female)	2	-0.63(-2.79, 1.52)	0.565	0.932	0.0
Average age					
≥45	5	-0.55(-1.38, 0.29)	0.199	0.757	0.0
<45	4	-0.57(-2.21, 1.07)	0.498	0.999	0.0
Subgroup analyses of WA on PBF					
Overall effect	6	-4.83(-10.32, 0.66)	0.085	0.000	93.0
Trial duration (week)					
>10	3	-9.01(-18.05, 0.02)	0.051	0.000	94.8
≤10	3	-0.26(-1.87, 1.36)	0.755	0.938	0.0
Sex					
Male	1	-0.83(-6.28, 4.61)	0.765	-	-
Female	4	-6.71(-14.24, 0.82)	0.081	0.000	96.0
Mix (male & female)	1	-0.80(-5.25, 3.65)	0.724	-	-
Average age					
≥45	4	-6.71(-14.24, 0.82)	0.081	0.000	96.
<45	2	-0.81(-4.26, 2.63)	0.644	0.993	0.0
Subgroup analyses of WA on WC					
Overall effect	8	-2.75(-4.41, -1.09)	0.001*	0.213	27.0
Trial duration (week)					

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>10	5	-2.88(-4.63, -1.12)	0.001*	0.057	56.3%
≤10	3	-1.67(-6.76, 3.42)	0.520	0.889	0.0%
Sex					
Male	1	-0.89(-17.54, 15.76)	0.917	-	-
Female	5	-2.89(-4.65, -1.13)	0.001*	0.058	56.1%
Mix (male & female)	2	-1.69(-6.90, 3.52)	0.525	0.626	0.0%
Average age					
<u>≥</u> 45	4	-3.03(-4.85, -1.22)	0.001*	0.034	65.5%
<45	4	-1.27(-5.40, 2.86)	0.546	0.959	0.0%
Subgroup analyses of WA on LM					
Overall effect	4	-0.19(-2.75, 2.37)	0.883	0.889	0.0%
Subgroup analyses of WA on FM					
Overall effect	5	-0.92(-3.20, 1.36)	0.429	0.991	0.0%
Subgroup analyses of WA on WHR					
Overall effect	3	-0.02(-0.05, 0.01)	0.256	0.830	0.0%
Subgroup analyses of WA on HC					
Overall effect	4	-1.05(-3.64, 1.55)	0.429	0.610	0.0%

Note: confidence interval (CI); numbers (N); weighted mean differences (WMD); *P < 0.05.

As shown by the subgroup analyses of BW, WAs with a trial duration greater than 10 weeks (i.e., 12 weeks) significantly reduced BW (WMD = -3.31, 95%CI: -5.23 to -1.40, p < 0.05, $I^2 = 0.0\%$). Additionally, WAs significantly reduced BW in the female population (WMD = -2.90, 95%CI: -4.37 to -1.43, p < 0.05, $I^2 = 0.0\%$) and in the population with a mean age of \geq 45 years (WMD = -2.85, 95%CI: -4.31 to -1.40, p < $0.05, I^2 = 0.0\%$). From the subgroup analysis of WC, it is shown that WAs with a trial duration >10 weeks significantly reduced WC (WMD = -2.88, 95%CI: -4.63 to $-1.12, p < 0.05, I^2 =$

56.3%). Among them, WAs were mainly able to significantly reduce WC in the female population (WMD = -2.89, 95%CI: -4.65 to -1.13, p < 0.05, $I^2 = 56.1\%$) and in the population (WMD = -3.03, 95%CI: -4.85 to -1.22, p < 0.05, I² = 65.5%) with a mean age \geq 45 years.
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1	Other subgroup analyses found that BMI ($P = 0.146$, $I^2 = 0.0\%$), LM ($P = 0.883$,
2	$I^2 = 0.0\%$), FM (P = 0.429, $I^2 = 0.0\%$), WHR (P = 0.256, $I^2 = 0.0\%$), and HC (P = 0.429,
3	$I^2 = 0.0\%$) were neither heterogeneous nor significant. In contrast, PBF ($I^2 = 93.6\%$)
4	and WC ($I^2 = 27.0\%$) were heterogeneous. However, separate subgroup analyses
5	revealed multiple sources of heterogeneity, which could not be adequately explained
6	by only one pair of subgroup analyses.

7 Sensitivity analysis of PBF

PBF exhibited high heterogeneity. Therefore, the robustness of the results was assessed through sensitivity analyses to identify potential sources of heterogeneity. A leave-oneout sensitivity analysis was performed, revealing that the direction of the combined estimates did not change significantly with the removal of any individual study. This finding suggests that the meta-analysis was robust and not unduly influenced by any single study [61]. The results show that the 95%CI excludes 0 (Fig. 3). This means that the results are robust, the sensitivity is small, and the original meta-analysis results are statistically significant.

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Publication bias

Publication bias was evaluated for the inclusion of more than 10 studies [62]. The risk of bias for the BW outcome measures was assessed using funnel plots and Egger's regression test [30]. Based on Egger's regression test (P = 0.841 > 0.05), no significant publication bias was detected. The visual inspection of the funnel plot (**Fig. 4**) further supports this conclusion.

22 GRADE Assessment

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The quality of evidence for each outcome was evaluated using the GRADE system. The results indicated that the quality of evidence was moderate for BW and WC, low for BMI, LM, FM, WHR, and HC, and very low for PBF (Table 3). Primary reasons for downgrading included small sample sizes in the included studies, 95%CI crossing equivalence thresholds, and high heterogeneity.

Table 3 GRADE quality of evidence

Outcomes	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Quality of evidence
DW	not corious	not corious	not corious	aorious à	2020	$\oplus \oplus \oplus \bigcirc$
DW	not serious	not serious	not serious	serious "	none	Moderate
DMI	not corious	not corious	not serious	very serious ^{a,b}	none	$\oplus \oplus \bigcirc \bigcirc$
DIVII	not serious	not serious				Low
DDE	, .	voru corious 6	not sorious	very serious ^{a,b}	none	$\oplus 000$
ГDГ	not serious	very serious ·	not serious			Very low
IM	not serious	not serious	not serious	very serious ab	none	$\oplus \oplus \bigcirc \bigcirc$
LIVI	not serious	not serious	not serious	very serious	none	Low
ЕM	not sorious	not corious	not serious	very serious ^{a,b}	none	$\oplus \oplus \bigcirc \bigcirc$
L IAI	not serious	not serious				Low
WID	not sorious	not corious	not corious	voru corious ab	nono	$\oplus \oplus \bigcirc \bigcirc$
W IIK	not serious	not serious	not serious	very serious 4,0	none	Low
WC	not serious	not serious	not serious	serious a	none	$\oplus \oplus \oplus \bigcirc$
wc	not serious	not serious	not serious	serious -	none	Moderate
НС	not serious not serious	not serious	very serious ab	none	$\oplus \oplus \bigcirc \bigcirc$	
iit	not serious	not serious	not serious	very serious **	none	Low

7 Note: a. small sample sizes in the included studies; b. 95% CI crossing equivalence thresholds; c. high heterogeneity.

9 Discussion

This study systematically reviewed the effects of WAs on body composition in obesity
and overweight people. The results showed that WAs had a positive impact on body
composition [63], with significant effects on reducing BW and WC [18, 64].
Specifically, the findings were: (1) WAs significantly reduced BW and WC in females;

1	(2) WAs with a trial duration of 10 weeks or more (i.e., 12 weeks) showed significant
2	reduction in BW and WC; (3) Continuous WAs in middle-aged and older individuals
3	(average age \geq 45 years) led to better reductions in BW and WC [65, 66].
4	The results of the subgroup analyses provide more detailed insights into the factors
5	influencing the effects of WAs on obesity and overweight people. According to the
6	subgroup analysis of BW, WAs with a trial duration greater than 10 weeks (i.e., 12
7	weeks) resulted in a more significant reduction in BW, while those with a duration of
8	10 weeks or less showed no significant effect. This suggests that short-term WAs (e.g.,
9	six weeks) had a limited impact on BW and body composition [52, 67], whereas longer
10	interventions (12 weeks or more) were more effective [22, 68]. It has been suggested
11	that WAs are effective for reducing BW in overweight older males [20]. However, the
12	present study found that WAs reduced BW significantly in female and not in male,
13	probably due to the small number of males included in the study, resulting in non-
14	significant differences. WAs were more effective in reducing BW in middle-aged and
15	older adults (average age \geq 45 years). Aerobic exercise in water is beneficial for middle-
16	aged and elderly people, improving body composition while easing the joint loads
17	associated with land-based exercise [69].
18	In addition, subgroup analyses based on WC revealed that the WAs intervention
19	significantly reduced WC in obesity and overweight people. WC is a key indicator of

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abdominal obesity [70, 71], and 12 weeks of WAs were particularly effective in reducing WC in obese and overweight females [64]. Further subgroup analysis showed that WAs with a trial duration greater than 10 weeks (i.e., 12 weeks) had a more

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> significant impact on WC, while trials lasting 10 weeks or less had no significant effect on WC. Due to the small number of male participants in the included studies, the effect of WAs on male WC requires further confirmation. WAs also had a greater effect on reducing WC in middle-aged and older individuals (average age \ge 45 years), while no significant effect was observed in other (average age < 45 years) people.

Obesity and overweight people can receive many health benefits through exercise. However, the subgroup analyses showed that the effect of WAs on BMI and PBF was not significant in obesity and overweight people. Previous studies have suggested that 8 weeks of continuous training may be insufficient to observe significant benefits, and that beneficial effects on anthropometric parameters typically become evident after training periods of 12 to 32 weeks [72]. If subgroups were divided according to trial period, sex, and age for several other body components (LM, FM, WHR, HC), the number of studies in each subgroup would be small, producing results with less confidence. Therefore, several other body components were not analyzed in this study. The GRADE assessment revealed that the certainty of evidence was low for BMI, LM, FM, WHR, and HC, and very low for PBF. The downgrading of evidence was primarily due to small sample sizes, which reduced statistical power and the precision of effect estimates. In addition, high heterogeneity among studies, particularly in PBF outcomes, indicated variability in study populations, methodologies, and intervention effects. Imprecision, as evidenced by wide confidence intervals crossing equivalence thresholds, further contributed to the reduced quality of evidence.

These findings have significant implications for clinical practice. However, there

are several limitations to this study. Studies of registered or ongoing RCTs were not included in the search for articles, and only studies published in English were considered. Judgments made using the RoB tools for literature quality assessment are inherently subjective. Some of the studies had short (6-week) duration of trials, small sample sizes, and less research data. A small number of participants in the study dropped out of the trial halfway through. There were differences in the age, sex ratio, and geographic location of participants across the studies. The low certainty of evidence for BMI, WHR, HC, and other secondary outcomes, and very low certainty for PBF suggests that current evidence was insufficient to reliably inform clinical guidelines for using WAs to improve these parameters. Health professionals should approach these results with caution and prioritize interventions with stronger evidence when aiming to target these specific outcomes. However, the moderate certainty of evidence for BW and WC supports the use of WAs as an effective interventions for reducing overall body weight and central obesity, which were critical factors in managing obesity-related health risks [73, 74].

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17 Conclusions

The results of this systematic review and meta-analysis suggest that WAs is an effective intervention for reducing BW and WC in overweight and obesity adults. Specifically, WAs interventions lasting over 10 weeks significantly reduced BW and WC, with a more pronounced effect observed in females. Middle-aged and elderly individuals also showed better improvements in body composition following WAs interventions. The

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1	certainty of evidence, as assessed using the GRADE framework, was moderate for both
2	BW and WC, indicating that these findings are robust but would benefit from further
3	research to enhance confidence. In contrast, the certainty of evidence for other
4	outcomes was rated as low or very low, primarily due to small sample sizes, high
5	heterogeneity, and imprecision in the included studies. Future research should aim to
6	address these limitations by conducting larger, well-designed RCTs with standardized
7	methodologies and diverse populations. Additionally, investigating the long-term
8	effects of WAs and comparing its efficacy with other exercise modalities will provide
9	valuable insights. In conclusion, WAs is an important form of exercise for overweight
10	and obesity people, offering significant benefits in improving body composition and
11	overall health.
12	
13	Abbreviations
14	PROSPERO: International Prospective Register of Systematic Reviews
15	WAs: Water aerobics
16	RCTs: randomized controlled trials
17	PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analysis
18	PICOS: Population, Intervention, Comparison, Outcome, Study type
19	MeSH: Medical Subject Headings
20	GRADE: Grading of Recommendations Assessment, Development, and Evaluation
21	BW: body weight
22	BMI: body mass index
23	PBF: percent body fat
24	LM: lean mass
25	FM: fat mass
26	WHR: waist-hip ratio
27	WC: waist circumference
28	HC: hip circumference
29	SEM: standard error of the mean
30	SD: standard deviation
31	Risk of Bias 2.0: RoB 2

Mix: mixed sex 32 60

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2 3	1	M: male
4	י ס	F: famala
5	2	Cl. confidence interval
0 7	3	
8	4	N: numbers
9	5	WMD: weighted mean differences
10	6	
11	7	Supplementary information
12	8	
14	9	Additional file 1. Supplementary information 1.
15	10	Additional file 2. Supplementary information 2.
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45	27	Patients and/or the public were not involved in the design, or conduct, or reporting, or
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52	31	Not applicable.
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54 55	32	
56	33	Ethics approval
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58	34	Not applicable.
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2	Prove	enance and peer review
3	Not co	ommissioned; externally peer reviewed.
4		
5	Data	availability statement
6 7	All da inforn	ta relevant to the study are included in thearticle or uploaded as supplementary nation.
8		
9 10	Refer	ences
11	1.	Collaborators TGO: Health Effects of Overweight and Obesity in 195 Countries over 25
12		Years. New England Journal of Medicine 2017, 377(1):13-27.
13	2.	Jaacks LM, Vandevijvere S, Pan A, McGowan CJ, Wallace C, Imamura F, Mozaffarian
14		D, Swinburn B, Ezzati M: The obesity transition: stages of the global epidemic. The
15		Lancet Diabetes & Endocrinology 2019, 7(3):231-240.
16	3.	Inoue Y, Qin B, Poti J, Sokol R, Gordon-Larsen P: Epidemiology of Obesity in Adults:
17		Latest Trends. Current Obesity Reports 2018, 7(4):276-288.
18	4.	Phelps NH, Singleton RK, Zhou B, Heap RA, Mishra A, Bennett JE, Paciorek CJ,
19		Lhoste VPF, Carrillo-Larco RM, Stevens GA et al. Worldwide trends in underweight
20		and obesity from 1990 to 2022: a pooled analysis of 3663 population-representative
21		studies with 222 million children, adolescents, and adults. The Lancet 2024,
22		403 (10431):1027-1050.
23	5.	Askari A, Jambulingam P, Gurprashad R, Al-Taan O, Adil T, Munasinghe A, Jain V,
24		Rashid F, Whitelaw D: The surgical management of obesity. Clinical Medicine 2023,
25		23 (4):330-336.

2			
3			
4	1	6.	Organization WH: Global health observatory data repository. In.; 2013.
5			
6	2	7	Chu D-T, Minh Nouvet NT, Dinh TC, Thai Lien NV, Nouven K-H, Nhu Nooc VT, Tao Y
/	-	••	
8			
9	3		Son LH, Le D-H, Nga VB et al. An update on physical health and economic
10			
11	1		consequences of evenuelist and electry Diabetes & Metabolic Syndrome: Clinical
12	4		consequences of overweight and obesity. Diabetes & metabolic Syndrome. Clinical
13			
14	5		<i>Research & Reviews</i> 2018, 12 (6):1095-1100.
15			
10	<u> </u>	0	Or the CE. The Use Mt. Description of Excession in Ocean which the difference Detion to Comment
17	0	8.	Garber CE: The Health Benefits of Exercise in Overweight and Obese Patients. Current
10			
19	7		Sports Medicine Reports 2019. 18(8):287-291.
20			
21	-	_	
22	8	9.	Petridou A, Siopi A, Mougios V: Exercise in the management of obesity. Metabolism
23			
24	9		2019 92 163-169
25	Ū		
20			
27	10	10.	Swift DL, McGee JE, Earnest CP, Carlisle E, Nygard M, Johannsen NM: The Effects
20			
30	11		of Exercise and Dhysical Activity on Weight Loss and Maintenance. Bragress in
31	11		of Exercise and Physical Activity of Weight Loss and Maintenance. Progress in
32			
33	12		<i>Cardiovascular Diseases</i> 2018, 61 (2):206-213.
34			
35	40		Wassing CO. Hannin FM, Dung NM, Charles ID, Hills AD: Museulaskalatel disenders
36	13	11.	wearing SC, Hennig EM, Byrne NM, Steele JR, Hills AP: Musculoskeletal disorders
37			
38	14		associated with obesity: a biomechanical perspective. Obesity Reviews 2006,
39			
40	45		
41	15		7(3):239-250.
42			
43	16	12.	Gobbi M. Aguiri A. Monoli C. Cau N. Capodaglio P: Aguatic Exercise. In: Rehabilitation
44			
45			
46	17		interventions in the patient with obesity. edn.; 2020: 35-50.
47			
48	18	13	Medicine ACoS: ACSM's health-related physical fitness assessment manual:
49	10	10.	medicine Acco. Accord noutrillated physical nances accounting manual.
50			
51	19		Lippincott Williams & Wilkins; 2013.
52			
53	20	14	Oral O: Effects of Aquatic Exercise in the Treatment of Obesity Riemodical Journal of
54	20	14.	Oral O. Ellects of Aqualic Exercise in the Treatment of Obesity. Diomedical Journal of
55			
56	21		Scientific & Technical Research 2021, 33(1).
57			
58	22	15	Borgamin M. Ermolao, Tolomio S. Porton, Sorgi, Zaparria, Water, Versus land based
59	22	15.	Dergamin wi, Emiorao, Tolomio S, Derlon, Sergi, Zaccana: Water- versus land-Dased
60			24
			Ζ4

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1		exercise in elderly subjects: effects on physical performance and body composition.
2		Clinical Interventions in Aging 2013.
3	16.	Lim JY, Tchai E, Jang SN: Effectiveness of Aquatic Exercise for Obese Patients with
4		Knee Osteoarthritis: A Randomized Controlled Trial. Pm&R 2010, 2(8):723-731.
5	17.	Pianna B, Moreno BC, de Souza CA, Bôscoa TF, Alcalde GE, Barrile SR, Gimenes C,
6		Martinelli B, Zamunér AR, Pessoa-Santos BV et al. Impact of deep water running in
7		interval training (DWR-IT) on body composition, functional capacity, and quality of life
8		in overweight adults: study protocol for a randomized controlled trial. <i>Trials</i> 2019, 20 (1).
9	18.	Vijayaraj V, Shaju MF: Effectiveness of aqua-aerobic exercises on cardio vascular
10		fitness and weight loss among obese college students. International Journal of Physical
11		Education, Sports and Health 2019, 6(3):111-116.
12	19.	Ferrigan K, Hice J, Leemkuil K, Singer S, Charles D, Michaels NN, Jones T: Aquatic
13		Exercise for Weight Reduction in Middle-Aged Adults: A Pilot Study. The Journal of
14		Aquatic Physical Therapy 2017, 25(2):16-21.
15	20.	Yaghoubi M, Ramezani S, Shamsi B, Barfi V: The Effect of a Water Exercise Course
16		on Body Composition and Quality of Life of Overweight Elderly Men. Journal of Marine
17		<i>Medicine</i> 2022, 3 (4):180-187.
18	21.	Nosrani SE, Tartibian B, Eslami R, Farinha C, Serrano J, Ferreira JP, Texeira AM: The
19		Effects of Combined Aquatic Exercise on Physical Performance and Metabolic Indices
20		in Overweight Healthy Older Adults. International Journal of Exercise Science 2023,
21		16 (4):1499.
22	22.	Earnest CP, Pereira Neiva H, Brandão Faíl L, Izquierdo M, Marques MC, Marinho DA:

1 2			
3 4 5	1		The effect of 12 weeks of water-aerobics on health status and physical fitness: An
6 7	2		ecological approach. <i>Plos One</i> 2018, 13 (5).
8 9 10	3	23.	Theodorou M, Kabir R: Exploring the Effects of Cold-Water Swimming on Obese
11 12 13	4		Population: A Systematic Review. Journal of Applied Sports Sciences 2019,
14 15 16	5		2 (December):3-21.
17 18	6	24.	Zhu H, Jin J, Zhao G: The effects of water-based exercise on body composition: A
19 20 21	7		systematic review and meta-analysis. Complementary Therapies in Clinical Practice
22 23 24	8		2023, 52 .
25 26	9	25.	Moher D: Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The
27 28 29	10		PRISMA Statement. Annals of Internal Medicine 2009, 151(4).
30 31 32	11	26.	Booth A: PROSPERO's progress and activities 2012/13. Systematic Reviews 2013,
33 34	12		2 (1).
35 36 37	13	27.	Akers J, Aguiar-Ibáñez R, Baba-Akbari A: Systematic reviews: CRD's guidance for
38 39 40	14		undertaking reviews in health care. University of York 2009.
41 42	15	28.	Consultation W: Obesity: preventing and managing the global epidemic. World Health
43 44 45	10	20	Hartling L. Eastherstone P. Nuspl M. Shave K. Dryden DM. Vandermeer B: Grov
46 47 48	17	29.	literature in systematic reviews: a cross-sectional study of the contribution of non-
49 50 51	19		English reports unpublished studies and dissertations to the results of meta-analyses
52 53	20		in child-relevant reviews. BMC medical research methodology 2017, 17:1-11.
54 55 56	21	30.	Higgins JPT. Green S: Cochrane Handbook for Systematic Reviews of Interventions:
57 58	22		2008.
60			

Page 28 of 47

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BMJ Open

4 5	1	31.	Nimptsch K, Konigorski S, Pischon T: Diagnosis of obesity and use of obesity
6 7 8	2		biomarkers in science and clinical medicine. <i>Metabolism</i> 2019, 92:61-70.
9 10 11	3	32.	Racette SB, Deusinger SS, Deusinger RH: Obesity: overview of prevalence, etiology,
12 13	4		and treatment. Physical therapy 2003, 83(3):276-288.
14 15 16	5	33.	Goonasegaran AR: Comparison of the effectiveness of body mass index and body fat
17 18	6		percentage in defining body composition. Singapore medical journal 2012, 53(6).
20 21	7	34.	Peltz G, Aguirre MT, Sanderson M, Fadden MK: The role of fat mass index in
22 23 24	8		determining obesity. American Journal of Human Biology 2010, 22(5):639-647.
25 26 27	9	35.	Janssen I, Katzmarzyk PT, Ross R: Waist circumference and not body mass index
27 28 29	10		explains obesity-related health risk. The American journal of clinical nutrition 2004,
30 31 32	11		79 (3):379-384.
33 34	12	36.	Kuriyan R: Body composition techniques. Indian Journal of Medical Research 2018,
35 36 37	13		148 (5):648-658.
38 39 40	14	37.	Higgins JPT, Altman DG, Gotzsche PC, Juni P, Moher D, Oxman AD, Savovic J, Schulz
41 42	15		KF, Weeks L, Sterne JAC: The Cochrane Collaboration's tool for assessing risk of bias
43 44 45	16		in randomised trials. <i>Bmj</i> 2011, 343 (oct18 2):d5928-d5928.
46 47 48	17	38.	DerSimonian R, Kacker R: Random-effects model for meta-analysis of clinical trials:
48 49 50	18		An update. Contemporary Clinical Trials 2007, 28(2):105-114.
51 52 53	19	39.	Ashtary-Larky D, Bagheri R, Abbasnezhad A, Tinsley GM, Alipour M, Wong A: Effects
54 55	20		of gradual weight loss v. rapid weight loss on body composition and RMR: a systematic
50 57 58	21	40	review and meta-analysis. British Journal of Nutrition 2020, 124(11):1121-1132.
59 60	22	40.	Lee YH: An overview of meta-analysis for clinicians. The Korean Journal of Internal

BMJ Open

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2			
<u>л</u>	1		Madiaina 2018 33 (2):077 282
	1		<i>Medicine</i> 2016, 33 (2).211-265.
6			
7	2	41.	Luo L, Shen X, Fang S, Wan T, Liu P, Li P, Tan H, Fu Y, Guo W, Tang X: Sarcopenia
8			
0 0	•		
10	3		as a risk factor of progression-free survival in patients with metastases: a systematic
10			
12	4		review and meta-analysis. BMC cancer 2023. 23(1):127.
13	-		······································
14	_		
15	5	42.	Duko B, Belayhun Y, Bedaso A: Prevalence of common mental disorder and its
16			
17	6		association with perceived stigma and social support among people living with
18	Ŭ		according the percented eligina and ecolar support among people wing war
19			
20	7		HIV/AIDS in Ethiopia: A systematic review and meta-analysis. International Journal of
21			
22	Q		Montal Haalth Systems 2024 18(1):25
23	0		wental Health Systems 2024, 10(1).25.
24			
25	9	43.	Sterne JAC, Sutton AJ, Ioannidis JPA, Terrin N, Jones DR, Lau J, Carpenter J, Rucker
26			
27	40		C. Usehand DM. Cabusid Cliff of Decommendations for superinting and intermediate
28	10		G, Harbord RM, Schmid CH et al. Recommendations for examining and interpreting
29			
30	11		funnel plot asymmetry in meta-analyses of randomised controlled trials. Bmi 2011.
31			
32			
33	12		343 (jul22 1):d4002-d4002.
34			
35	13	44	Egger M. Smith GD. Schneider M. Minder C: Bias in meta-analysis detected by a
36			Ligger in, ennar es, connerter in, innitier et site in meta analysie acteded by a
37			
38	14		simple, graphical test. <i>Bmj</i> 1997, 315 (7109):629-634.
39			
40	15	45	Jakobsen JC. Wettersley J. Winkel P. Lange T. Gluud C: Thresholds for statistical and
41	10	40.	bakobserroo, wetterstevo, winkerr, Eanger, Oldud O. Thesholds for statistical and
42			
43	16		clinical significance in systematic reviews with meta-analytic methods. BMC Medical
44			
45	17		Pasaarch Mathadalagu 2014 14(1)
46	17		$Research memouology = CO(4, T_{A}(1)).$
47			
48	18	46.	Ashtary-Larky D, Bagheri R, Asbaghi O, Tinsley GM, Kooti W, Abbasnezhad A,
49			
50	10		Africham D. Wang A: Effects of registeres training combined with a ketegonic dist on
51	19		Ansham R, wong A. Enecis of resistance training combined with a ketogenic diet on
52			
23 F 4	20		body composition: a systematic review and meta-analysis. Critical Reviews in Food
54 55			
55 56	24		Oning and Nutritian 2024 (0) (24) (747 (722)
50 57	21		Science and inutrition 2021 , $02(21):5/17-5/32$.
ر 50			
50	22	47.	Cumpston M, Li T, Page MJ, Chandler J, Welch VA, Higgins JPT, Thomas J: Updated
60			
00			

Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, Al training, and similar technologies.

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3			
4 5	1		guidance for trusted systematic reviews: a new edition of the Cochrane Handbook for
6	2		Systematic Reviews of Interventions Cochrane Database of Systematic Reviews 2019
7 8	2		Cystematic Reviews of Interventions. Cochrane Database of Cystematic Reviews 2013.
9	3	48	Guvatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, Schünemann
10	Ū	10.	
11 12	4		HJ: GRADE: an emerging consensus on rating quality of evidence and strength of
13			
14	5		recommendations. <i>Bmj</i> 2008, 336 (7650):924-926.
15 16			
17	6	49.	Puhan MA, Schünemann HJ, Murad MH, Li T, Brignardello-Petersen R, Singh JA,
18			
19 20	7		Kessels AG, Guyatt GH: A GRADE Working Group approach for rating the quality of
21			
22	8		treatment effect estimates from network meta-analysis. Bmj 2014, 349.
23 24			
25	9	50.	Tian A, Jia H, Zhu S, Lu B, Li Y, Ma J, Ma X: Romosozumab versus Teriparatide for
26			
27 29	10		the Treatment of Postmenopausal Osteoporosis: A Systematic Review and Meta-
20			
30	11		analysis through a Grade Analysis of Evidence. Orthopaedic Surgery 2021,
31 22			
33	12		13 (7):1941-1950.
34			
35 36	13	51.	Yusof SM, Shari M, Kadir Z, Adam A, Kek TL, Aiman S, Idris NM, Johar M: AQUA
37			
38	14		ZUMBA VERSUS AQUA JOGGING: COMPARATIVE EFFECTS ON HEALTH
39 40			
41	15		PARAMETERS AMONG OBESE MIDDLE AGED WOMEN. Malaysian Journal of
42			
43 44	16		Movement, Health & Exercise 2018, 7(2):11-22.
45	. –		
46	17	52.	Penaforte FRO, Calhau R, Mota GR, Chiarello PG: Impact of short-term water exercise
47 48	40		
49	18		programs on weight, body composition, metabolic profile and quality of life of obese
50	10		warran Jaurnal of Livran Chart and Eversion 2015 10 (4):045 020
51 52	19		women. Journal of Human Sport and Exercise 2015, 10(4):915-926.
52	20	F 2	Dias DL. Correctes DMM. Serre A. L. Dedriguez D. Dentes Junier El. Deselini DS: Effecte
54	20	53.	Rica RL, Cameiro Rivini, Serra AJ, Rodriguez D, Pontes Junior FL, Bocalini DS. Ellects
55 56	21		of water-based eversise in obese older women: Impact of short term follow up study
57	21		or water-based exercise in obese order women. Impact or short-term follow-up study
58	22		on anthronometric functional fitness and quality of life parameters. Cariatrics &
59 60			on ananopometrio, functional nulces and quality of the parameters. Centarity α
			20

1			
2			
3			
4	1		<i>Gerontology International</i> 2012, 13 (1):209-214.
5			
6 7	2	54.	Colato A, Fraga L, Dorneles G, Vianna P, Chies JAB, Peres A: Impact of aerobic water
/	_	• · ·	
8			
9	3		running training on peripheral immune-endocrine markers of overweight-obese women.
10			
11	4		Science & Sports 2017 32(1):46-53
12	-		Science & Spons 2011, SZ(1).+0-33.
15			
14	5	55.	Principal D: Effect of Underwater Treadmill Training on Young Obese Adults. 2018.
15			
17	6	56	Developer Milliprestigation of pool worksyte on weight, body composition, resting
12	0	50.	Rezacipour M. Investigation of poor workouts on weight, body composition, resulting
10			
20	7		energy expenditure, and quality of life among sedentary obese older women.
20			
21			
22	8		Montenegrin Journal of Sports Science and Medicine 2020, 9(1):67.
23			
27	9	57	Rezaeinour M. Effects of two water-based exercise programs on body weight and blood
25	U	07.	The zaciped in the Ended of the water babed exercise programs on bedy weight and blood
20			
2/	10		lipid parameters in elderly obese males with a sedentary lifestyle. Diabetes & Metabolic
20			
29			
3U 21	11		Syndrome: Clinical Research & Reviews 2021, 15(4).
31			
3Z	12	58.	Soori R. Rezaeian N. Khosravi N. Ahmadizad S. Taleghani HM. Jourkesh M. Stannard
33 24			
24 25			
35 26	13		SR: Effects of water-based endurance training, resistance training, and combined
30 27			
2/ 20	14		water and resistance training programs on visfatin and ICAM-1 levels in sedentary
20	14		
39 40			
40	15		obese women. Science & Sports 2017, 32(3):144-151.
41			
42	16	E0	Creans ND Lembert BS, Creans ES, Carbuhn AE, Crean IS, Creuse SE, Comparative
4J AA	10	59.	Greene NF, Lambert BS, Greene ES, Carbunn AF, Green JS, Crouse SF. Comparative
44			
45	17		Efficacy of Water and Land Treadmill Training for Overweight or Obese Adults.
40			
47			
40 70	18		Medicine & Science in Sports & Exercise 2009, 41 (9):1808-1815.
50			
51	19	60	Wouters FJM, Van Nunen AMA, Geenen R, Kolotkin RL, Vingerhoets A.I.IM. Effects of
52			
53			
54	20		Aquajogging in Obese Adults: A Pilot Study. Journal of Obesity 2010, 2010:1-7.
55			
56	04	61	Wu M S. Chan K H. Chan J E. Huang SK. Trang D C. Vak M L. Las F. D. Lin J C. Okar
57	21	01.	wu wi-o, onen K-n, onen i-r, nuany ok, i zeny P-o, i en M-L, Lee F-P, Lin J-G, Onen
58			
50	22		C: The efficacy of acupuncture in post-operative pain management: a systematic
60			
			30

Page 32 of 47

2			
3			
4	1		review and meta-analysis. PloS one 2016, 11(3):e0150367.
5			
0	2	62.	Page MJ, Higgins JPT, Sterne JAC: Assessing risk of bias due to missing results in a
/	_	•=-	
8			
9	3		synthesis. In: Cochrane Handbook for Systematic Reviews of Interventions. edn.; 2019:
10			
11	4		040.074
12	4		349-374.
13			
14	5	63	Tkachova A. Dutchak M. Kashuba V. Goncharova N. Lytyynenko Y. Vako I. Kolos M.
15	Ũ	00.	
16			
17	6		Lopatskyi S: Practical implementation of differentiated approach to developing water
18			
19	7		
20	1		aerobics classes for early adulthood women with different types of body build. <i>Journal</i>
21			
22	8		of Physical Education and Sport 2020 20:456-460
23	0		bit hysical Education and Spon 2020, 20.430-400.
24			
25	9	64.	Jones LM, Legge M, Meredith-Jones K: Circuit Based Deep Water Running Improves
26			
27			
28	10		Cardiovascular Fitness, Strength and Abdominal Obesity in Older, Overweight Women
29			
30	11		Aquatic Evercise Intervention in Older Adults Medicina Sportiva 2000 13(1):5.12
31			
32			
32	12	65.	Bakken RC, Carey JR, Di Fabio RP, Erlandson TJ, Hake JL, Intihar TW: Effect of
34			
35			
36	13		Aerobic Exercise on Tracking Performance in Elderly People: A Pilot Study. <i>Physical</i>
27			
27 20	14		Therany 2001 81(12):1870-1879
20	14		
39			
40	15	66.	Kalapatapu RK, Campbell A, Aharonovich E, Hu M-C, Levin FR, Nunes EV:
41			
42	4.0		
43	16		Demographic and Clinical Characteristics of Middle-aged Versus Younger Adults
44			
45	17		Enrolled in a Clinical Trial of a Web-delivered Psychosocial Treatment for Substance
46	.,		
47			
48	18		Use Disorders. Journal of Addiction Medicine 2013, 7(1):66-72.
49			
50	40	07	
51	19	07.	Anoognalandary 5: Effect of water Aerodics on Body Mass Index, Lipid Profile, and
52			
53	20		Atherogenic Factors of Middle-aged Obese Women Jundishapur Journal of Medical
54	20		, and egene i decre er maare agea ebete fremen. Banabapar boarnar er meulear
55			
56	21		<i>Sciences</i> 2022, 21 (5):638-649.
57			
58	00	~~	One on 10. Effects of a Mistan Associate December of the Distance of the Dista
59	22	b 8.	Green JS: Effects of a water Aeropics Program on the Blood Pressure, Percentage of
60			
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1			
2			
3			
4	1		Body Fat, Weight, and Resting Pulse Rate of Senior Citizens. Journal of Applied
5			
7	2		<i>Gerontology</i> 2016, 8 (1):132-138.
, 8			
9	2	60	Martine V/ Line CdCO, Cilve LDd, Cilve ACd, Dester AD, Caâlle DCD, Nalata DCdC
10	3	69.	Martins V, Lima Guso, Silva LPu, Silva AGu, Dastos AD, Coeino PGD, Noieto DCus,
11			
12	4		Borges DBdS, Nascimento MAd, Lourenço BdS: The practice of water aerobics with
13			
14	5		the elderly: Physical and psychological aspects. In: Innovation in Health Research
15	0		
16			
17	6		Advancing the Boundaries of Knowledge. edn.; 2023.
18			
19	7	70	Vasilievic L Gardasevic J Kezunovic M Bojanic D [.] Waist circumference as an indicator
20	•		
21	-		
22	8		abdominal obesity in middle age. Sport Mont 2017, 15 (1):21-22.
23			
25	9	71.	Baioumi AYAA: Comparing Measures of Obesity: Waist Circumference, Waist-Hip, and
26			
27	10		Weist Height Dation In Mutation in the Drevention and Treatment of Abdeminal
28	10		waist-Height Ratios. In: Nutrition in the Prevention and Treatment of Abdominal
29			
30	11		<i>Obesity.</i> edn.; 2019: 29-40.
31			
32	10	70	Clark I: The impact of duration on official pages of exercise the implication for
33	12	12.	Clark 5. The impact of duration on enectiveness of exercise, the implication for
34 25			
35 26	13		periodization of training and goal setting for individuals who are overfat, a meta-
30			
38	14		analysis, <i>Biology of Sport</i> 2016, 33 (4):309-333,
39			
40	45	70	
41	15	73.	Harbuwono DS, Tahapary DL, Tarigan TJE, Yunir E: New proposed cut-off of waist
42			
43	16		circumference for central obesity as risk factor for diabetes mellitus: Evidence from the
44			
45	17		Indonesian Basic National Health Survey Plas are 2020 15/11):e0242417
46	17		$\mathbf{Huohesiah Dasic Nauoha Healuh Suivey. Fios one 2020, 13(11).e0242417.}$
47			
48	18	74.	Darsini D, Hamidah H, Notobroto HB, Cahyono EA: Health risks associated with high
49 50			
50	19		waist circumference: A systematic review Journal of public health research 2020
52			
53			
54	20		9 (2):jphr. 2020.1811.
55			
56	21		
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2 Fig. 1 Preferred reporting items for systematic reviews and meta-analyses (PRISMA)

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- 3 flow diagram.
- **Fig. 2** Risk of bias.
- 5 Fig. 3 Sensitivity analysis of percentage body fat.
- **Fig. 4** Funnel plot for body weight.



Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow diagram

160x122mm (300 x 300 DPI)

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Funnel plot for body weight 137x79mm (400 x 400 DPI)

WMD

-5

-10

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Fig. S2 Meta-analysis of waist circumference





Fig. S3 Meta-analysis of body mass index



Fig. S4 Meta-analysis of percent body fat

38

39 40

41 42

43 44

45 46

51 52

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%

Weight

29.93

33.61

16.78

19.68

100.00

%

-0.60 (-8.26, 7.06)

-0.70 (-7.83, 6.43)

0.00 (-4.48, 4.48)

-1.40 (-9.29, 6.49)

-1.45 (-4.78, 1.88)

-0.92 (-3.20, 1.36)

9.29

Weight

8.84

10.19

25.85

8.33

46.79

100.00





Fig. S6 Meta-analysis of fat mass

-9.29

Penaforte et al., 2015

Rezaeipour, 2020

Rica et al., 2012

Wouters et al., 2009

Colato et al., 2016

Overall (I-squared = 0.0%, p = 0.991)

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Fig. S7 Meta-analysis of waist-hip ratio



Fig. S8 Meta-analysis of hip circumference

Supplementary information 2

Table S1 Minor changes

Numbers	Changes
1	Delete "body fat mass" and add "waist-to-hip ratio, waist circumference, and hip
1	circumference".
2	Delete "mean baseline, follow-up" from the data extraction content.
3	Statistical software Change the "Review Manager" to "Stata".
4	Add water aerobics subgroup analysis.

Table S2 Database search terms

Database	Search terms	Results
PubMed	((((((((((((((((((((((((((((((((((((((375
Medline	(Physical Activity)) OR (Activities, Physical)) OR (Activity, Physical))	
	OR (Physical Activities)) OR (Exercise, Physical)) OR (Exercises,	
	Physical)) OR (Physical Exercise)) OR (Physical Exercises)) OR (Acute	
	Exercise)) OR (Acute Exercises)) OR (Exercise, Acute)) OR (Exercises,	
	Acute)) OR (Exercise, Isometric)) OR (Exercises, Isometric)) OR	
	(Isometric Exercises)) OR (Isometric Exercise)) OR (Exercise, Aerobic))	
	OR (Aerobic Exercise)) OR (Aerobic Exercises)) OR (Exercises,	
	Aerobic)) OR (Exercise Training)) OR (Exercise Trainings)) OR	
	(Training, Exercise)) OR (Trainings, Exercise)) AND ("Water"[Mesh]))	
	OR ((((((((((water aerobics)) OR (waterobics))) OR (aquarobics))) OR	
	(aquatic fitness)) OR (aquafitness)) OR (aquafit)) OR (aqua zumba)) OR	
	(water yoga)) OR (aqua aerobics)) OR (aqua jog))) AND	
	((("Obesity"[Mesh]) OR ((fat) OR (obese))) OR ("Overweight"[Mesh])))	
	AND (("Randomized Controlled Trials as Topic"[Mesh]) OR	
	((((((Randomised controlled trial) OR (controlled trial)) OR (randomized	
	controlled study)) OR (Clinical Trials, Randomized)) OR (Trials,	
	Randomized Clinical)) OR (Controlled Clinical Trials, Randomized)))	
Embase	('randomised controlled trial'/exp OR 'randomised controlled trial' OR	2169
	'randomized controlled trials as topic'/exp OR 'randomized controlled	
	trials as topic' OR 'controlled trial'/exp OR 'controlled trial' OR	
	'randomized controlled study'/exp OR 'randomized controlled study' OR	
	'clinical trials, randomized' OR 'trials, randomized clinical' OR 'controlled	
	clinical trials, randomized') AND ('obesity'/exp OR 'obesity' OR 'fat'/exp	

	OR 'fat' OR 'obese' OR 'overweight'/exp OR 'overweight') AND ('water aerobics'/exp OR 'water aerobics' OR 'waterobics' OR 'aquarobics' OR 'aquatic fitness' OR 'aquafitness' OR 'aquafit' OR 'aqua zumba' OR 'water yoga' OR 'aqua aerobics' OR 'aqua jog' OR (('water'/exp OR 'water') AND ('exercise'/exp OR 'exercise' OR 'aerobics'/exp OR 'aerobics' OR 'exercises' OR 'cycling'/exp OR 'cycling' OR 'physical activity'/exp OR 'physical activity' OR 'activities, physical' OR 'activity, physical'/exp OR 'activity, physical' OR 'physical activities' OR 'exercise, physical' OR 'exercises, physical' OR 'physical exercise'/exp OR 'physical exercise' OR 'physical exercises' OR 'acute exercise'/exp OR 'physical exercise' OR 'physical exercises' OR 'acute exercise'/exp OR 'acute exercise' OR 'physical exercises, acute' OR 'exercises, acute' OR 'exercise, isometric'/exp OR 'exercise, isometric' OR 'exercises, isometric' OR 'isometric exercises' OR 'acoute exercise'/exp OR 'isometric exercise'/exp OR 'aerobic exercise' OR 'aerobic exercise'/exp OR 'aerobic exercise'/exp OR 'aerobic exercise' OR 'aerobic exercise'/exp OR 'asometric' OR 'isometric exercises' OR 'aerobic exercise, aerobic' OR 'exercise, aerobic'/exp OR 'exercise, aerobic' OR 'aerobic exercise'/exp OR 'aerobic exercise' OR 'aerobic exercises' OR 'aerobic exercise'/exp OR 'aerobic exercise' OR 'aerobic exercises' OR 'exercise, aerobic' OR 'exercise training'/exp OR 'exercise training' OR 'exercise trainings' OR 'training, exercise' OR 'trainings, exercise'))))	
Ovid	1 "Randomised controlled trial " mp	19
MEDLINE	2 exp Randomized Controlled Trials as Topic/	17
	3 " controlled trial" mp	
	4 "randomized controlled study " mp	
	5 "Clinical Trials Randomized" mp	
	6 "Trials, Randomized Clinical".mp.	
	7 "Controlled Clinical Trials, Randomized".mp.	
	8 1 or 2 or 3 or 4 or 5 or 6 or 7	
	9 exp Obesity/	
	10 exp Fats/	
	11 "obese".mp.	
	12 exp Overweight/	
	13 9 or 10 or 11 or 12	
	14 "water aerobics ".mp.	
	15 "aquarobics ".mp.	
	16 "aquatic fitness ".mp.	
	17 "aquafitness ".mp.	
	18 "aquafit".mp.	
	19 "water yoga".mp.	
	20 "aqua aerobics".mp.	
	21 14 or 15 or 16 or 17 or 18 or 19 or 20 22 own Water/	
	22 exp water/	
	25 exp Exercise/ 24 "aerobics " mp	
	24 actobics .inp. 25 "Exercises" mp	
	25 Exercises .mp.	
	20 cycling .mp.	

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3		27 "Physical Activity".mp.	
4		28 "Activities Physical" mp	
5		20 "Activity Physical" mp	
7		20 "Deviced Activities" mp	
8		30 Physical Activities .htp.	
9		31 "Exercise, Physical".mp.	
10		32 "Exercises, Physical".mp.	
11		33 "Physical Exercise".mp.	
12		34 "Physical Exercises".mp.	
14		35 "Acute Exercise".mp.	
15		36 "Acute Exercises".mp.	
16		37 "Exercise, Acute".mp.	
1/		38 "Exercises. Acute".mp.	
18		39 "Exercise Isometric" mp	
20		40 "Exercises Isometric" mp	
21		40 Exercises, isometricip.	
22		41 Isometric Exercises .mp.	
23		42 "Isometric Exercise".mp.	
24 25		43 "Exercise, Aerobic".mp.	
26		44 "Aerobic Exercise".mp.	
27		45 "Aerobic Exercises".mp.	
28		46 "Exercises, Aerobic".mp.	
29		47 "Exercise Training".mp.	
31		48 "Exercise Trainings".mp.	
32		49 "Training, Exercise".mp.	
33		50 "Trainings Exercise" mp	
34		51 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34	
35		or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or	
30		47 or 48 or 40 or 50	
38			
39		52 22 and 51	
40		53 21 or 52	
41		54 8 and 13 and 53	
42			
44	Scopus	((TITLE-ABS-KEY ("randomised controlled trial ") OR TITLE-ABS-	468
45		KEY ("randomized controlled trials as topic ") OR TITLE-ABS-KEY ("	
46		controlled trial") OR TITLE-ABS-KEY (" randomized controlled study	
4/ 48		") OR TITLE-ABS-KEY ("clinical trials, randomized") OR TITLE-	
49		ABS-KEY ("trials, randomized clinical") OR TITLE-ABS-KEY	
50		("controlled clinical trials, randomized"))) AND ((TITL E-ABS-KEY)	
51		(obesity $)$ OR TITLE-ABS-KEV $($ fat $)$ OR TITLE-ABS-KEV $($ obese $)$	
52		(OD TITLE ADS KEV (overweight)) AND ((TITLE ADS KEV	
53 54		(water)) AND ((TITLE ADS KEY (average)) OD TITLE ADS KEY	
55		(water)) AND ((IIILE-ABS-KEY (exercise) OK IIILE-ABS-KEY	
56		(exercises) OR TITLE-ABS-KEY (cycling) OR TITLE-ABS-KEY	
57		("physical activity") OR TITLE-ABS-KEY ("activities, physical") OR	
58		TITLE-ABS-KEY ("activity, physical") OR TITLE-ABS-KEY	
59 60		("physical activities") OR TITLE-ABS-KEY ("exercise, physical") OR	
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3		TITLE-ABS-KEY ("exercises, physical") OR TITLE-ABS-KEY	
4		("nhysical exercises") OR TITLE-ABS-KEY ("nhysical exercises") OR	
6		TITLE ARS KEV ("agute averaise") OP TITLE ARS KEV ("agute	
7		IIILE-ADS-KET (acute exercise) OK IIILE-ADS-KET (acute	
8		exercises") OR IIILE-ABS-KEY ("exercise, acute") OR IIILE-ABS-	
9		KEY ("exercises, acute") OR TITLE-ABS-KEY ("exercise, isometric")	
10		OR TITLE-ABS-KEY ("exercises, isometric") OR TITLE-ABS-KEY	
11		("isometric exercises") OR TITLE-ABS-KEY ("isometric exercise")	
12		OR TITLE-ABS-KEY ("exercise, aerobic") OR TITLE-ABS-KEY	
14		("aerobic exercise") OR TITLE-ABS-KEY ("aerobic exercises") OR	
15		TITLE-ABS-KEY ("exercises. aerobic") OR TITLE-ABS-KEY	
16		("evercise training") OR TITLE-ARS-KEV ("evercise trainings") OR	
17		TITLE ADS VEV ("training overaige") OD TITLE ADS VEV	
18		IIILE-ABS-KEY (training, exercise) OR IIILE-ABS-KEY	
19		("trainings, exercise")))))OR(((IIILE-ABS-KEY("water aerobics"))	
20 21		OR TITLE-ABS-KEY ("waterobics ") OR TITLE-ABS-KEY	
22		("aquarobics ") OR TITLE-ABS-KEY ("aquatic fitness ") OR TITLE-	
23		ABS-KEY ("aquafitness ") OR TITLE-ABS-KEY ("aquafit") OR	
24		TITLE-ABS-KEY (" aqua zumba") OR TITLE-ABS-KEY (" water	
25		voga") OR TITLE-ABS-KEY ("aqua aerobics") OR TITLE-ABS-KEY	
26		("aqua iog"))))	
27		(uquu jog))))	
29			1204
30	Ine	#1 MeSH descriptor: [Randomized Controlled Trials as Topic] explode	1284
31	Cochrane	all trees	
32	Library	#2 MeSH descriptor: [Randomized Controlled Trial] explode all trees	
33		#3 " controlled trial"	
35		#4 "randomized controlled study "	
36		#5 "Clinical Trials, Randomized"	
37		#6 "Trials, Randomized Clinical"	
38		#7 "Controlled Clinical Trials Randomized"	
39		#7 Controlled Chinear Thats, Randonized	
+0 11		#8 #1 OK #2 OK #5 OK #4 OK #5 OK #0 OK #7	
12		#9 MeSH descriptor: [Obesity] explode all trees	
13		#10 MeSH descriptor: [Fats] explode all trees	
14		#11 obese	
15		#12 MeSH descriptor: [Overweight] explode all trees	
16 17		#13 #9 OR #10 OR #11 OR #12	
+/ 18		#14 "water aerobics "	
19		#15 waterobics	
50		#16 aquarobics	
51		#17 "aquatic fitness "	
52		π_1 aquate functs	
53		#18 aquantness	
55 55		#19 aquafit	
55		#20 " aqua zumba"	
57		#21 " water yoga"	
58		#22 "aqua aerobics"	
59		#23 " aqua jog"	
50		- 1 J*O	

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3		#24 #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR	
4		#22 OR #23	
5		#25 MeSH descriptor: [Water] explode all trees	
7		#26 MaSH descriptor. [Evancial curlede all trace	
8		#20 MeSH descriptor: [Exercise] explode all trees	
9		#27 Exercises	
10		#28 cycling	
11		#29 "Physical Activity"	
12		#30 "Activity, Physical"	
14		#31 "Exercise, Physical"	
15		#32 "Exercises, Physical"	
16		#33 "Physical Exercise"	
17		#34 "Physical Exercises"	
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19 20		#35 Acute Exercise	
21		#36 "Acute Exercises"	
22		#37 "Exercise, Acute"	
23		#38 "Exercises, Acute"	
24		#39 "Exercise, Isometric"	
25		#40 "Exercises, Isometric"	
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31		#44 Actobic Exercise	
32		#45 "Aerobic Exercises"	
34		#46 "Exercises, Aerobic"	
35		#47 "Exercise Training"	
36		#48 "Exercise Trainings"	
37		#49 "Training, Exercise"	
38		#50 "Trainings, Exercise"	
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41		#34 OR #35 OR #36 OR #37 OR #38 OR #39 OR #40 OR #41 OR #42	
42		OP #42 OP #44 OP #45 OP #46 OP #47 OP #48 OP #40 OP #50	
43		450 425 AND 451	
44		#52 #25 AND #51	
45 46		#53 #24 OR #52	
40 47		#54 #8 AND #13 AND #53	
48			
49	Web of	((((((((((((((((((((((((((((((((((((
50	science	TS=(cycling)) OR TS=("Physical Activity")) OR TS=("Activities,	
51		Physical")) OR TS=("Activity, Physical")) OR TS=("Physical	
52 53		Activities")) OR TS=("Exercise Physical")) OR TS=("Exercises	
54		Physical")) OR TS=("Physical Exercise")) OR TS=/"Physical	
55		Evergises")) OP TC=("A outo Evergises")) OP TC=("A outo Evergises"))	
56		Exercises)) OR $15-($ Acute Exercise)) OR $15-($ Acute Exercises)) OD $TS=($ "Exercise Acute")) OD $TS=($ "Exercise A (")) OD	
57		OK 1S=("Exercise, Acute")) OK 1S=("Exercises, Acute")) OK	
58		TS=("Exercise, Isometric")) OR TS=("Exercises, Isometric")) OR	
59 60		TS=("Isometric Exercises")) OR TS=("Isometric Exercise")) OR	

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TS=("Exercise, Aerobic")) OR TS=("Aerobic Exercise")) OR
TS=("Aerobic Exercises")) OR TS=("Exercises, Aerobic")) OR
TS=("Exercise Training")) OR TS=("Exercise Trainings")) OR
TS=("Training, Exercise")) OR TS=("Trainings, Exercise")) AND
TS=(water)
OR ((((((((TS=("water aerobics ")) OR TS=("waterobics ")) OR
TS=("aquarobics ")) OR TS=("aquatic fitness ")) OR TS=("aquafitness "))
OR TS=("aquafit")) OR TS=(" aqua zumba")) OR TS=(" water yoga"))
OR TS=("aqua aerobics")) OR TS=(" aqua jog") AND
((((((TS=("Randomised controlled trial ")) OR TS=("Randomized
Controlled Trials as Topic")) OR TS=(" controlled trial")) OR TS=("
randomized controlled study ")) OR TS=("Clinical Trials, Randomized"))
OR TS=("Trials, Randomized Clinical")) OR TS=("Controlled Clinical
Trials, Randomized")AND (((TS=(obesity)) OR TS=(fat)) OR
TS=(obese)) OR TS=(Overweight)

ND (, /erweight)