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# Effects of aquatic exercise on mood and anxiety symptoms: A systematic review and meta-analysis

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**Objective:** Exercise has beneficial effects on mood and anxiety symptoms. However, the impact of aquatic exercise on mood and anxiety symptoms has not been clearly confirmed. Therefore, this study aimed to synthesize and systematically analyze evidence available on boosting mental health through aquatic exercise.

**Method:** A systematic review and meta-analysis were conducted under the PRISMA 2020 guidelines. PubMed, BIOSIS Previews, PsycINFO, Medline, SPORTDiscus, Education Source, and Web of Science Core Collection (WoSCC) were searched in May 2022. The research included the influence of aquatic exercises on mood and anxiety symptoms. After assessing trial quality and completing data extraction, a meta-analysis was carried out through R software. The results were presented as a standardized mean difference (SMD) and the corresponding 95% confidence interval.

**Results:** A total of 18 original trials were included. People who received aquatic exercise intervention had a statistically significant reduction in mental disorder symptoms compared with before. The results were aquatic exercise [SMD = -0.77, 95% CI (-1.08, -0.47),  $I^2 = 77\%$ , P < 0.01], swimming [SMD = -0.51, 95% CI (-1.14, 0.12),  $I^2 = 78\%$ , P < 0.01], aquatic aerobics [SMD = -0.92, 95% CI (-1.32, -0.53),  $I^2 = 78\%$ , P < 0.01], moderate intensity [SMD = -0.75, 95% CI (-1.07, -0.43),  $I^2 = 67\%$ , P < 0.01], and low intensity [SMD = -1.07, 95% CI (-1.08, -0.47),  $I^2 = 85\%$ , P < 0.01].

**Conclusion:** Aquatic exercise could statistically significantly improve mental health. Light aquatic aerobics probably has a better effect on mood and anxiety symptoms. However, given the number and quality of included research, verifying the aforementioned conclusions requires a larger sample of high-quality studies.

#### KEYWORDS

swimming, mental health, anxiety, depression, aquatic exercise, mood

## Introduction

Mental health is critically important to everyone, everywhere (1). Mood and anxiety significantly diminish the quality of life and happiness of those who suffer from them (2). Some psychological problems become so severe that they can even lead to suicide. More than 90% of suicides in the West have been attributed to mood disorders (3). The prevalence of these conditions has a significant economic impact on society because of the difficulties they cause for affected individuals on a daily basis (4-6). One study from China found that in January and February 2020, 54% of subjects expressed psychological symptoms as severe or moderate, 29% of subjects reported moderate to serious anxiety, and approximately 17% of subjects reported moderate to severe depression (7). Therefore, finding some effective and acceptable intervention methods that can improve mood and anxiety symptoms is significant.

As a non-drug treatment for mental disorders, exercise has become the focus of more and more researchers' attention. Recent studies support that exercise, especially aerobic exercise (8) and physical activity, has beneficial effects on mental health (9). Exercise was promoted as the first level in the Canadian Clinical Guidelines 2016 emotional therapy (10).

Aquatic exercise, as a special aerobic exercise, has been shown to potentially benefit mood and anxiety (11–14). Aquatic exercise has many physiological benefits compared to landbased workouts because of the water's unique properties, such as buoyancy, pressure, resistance, and protection from skin irritation due to temperature and touch (15). As a result, when compared to other forms of exercise, aquatic exercise may prove to be the most effective in terms of its positive impact on mood. However, to our knowledge, no study has been conducted to synthesize the research on the psychological benefits of aquatic exercise. A systematic review of the studies and a meta-analysis are necessary to elaborate on the effect of aquatic exercise on mood and anxiety.

Furthermore, the effect of exercise on mental health is affected by many factors, including differences in individual characteristics and specific parameters of exercise intervention. Aging of both the body and mind may be associated with an increased probability of developing mood disorders (16). Exercise as an intervention to treat chronic diseases is associated with mood elevations in patients with various chronic diseases and disabilities (17). The type, intensity, and duration of exercise also affect the effect of exercise on mood. Specifically, longtime relaxing aerobic exercise may promote greater mood benefits (18–20). Although little evidence supports greater mood improvements in response to exercise among women, (21) some previous studies showed that exercise (dance, yoga, aerobic games, etc.) reduced depressive symptoms, with no moderating effect of sex (22–25). However, it is unclear whether there are differences in age, sex, disease, intensity, and duration in the impact of aquatic exercise on mood.

This study aimed to synthesize and systematically analyze the available evidence to determine the effect of aquatic exercise on mental health.

## Methods

The systematic review and meta-analysis followed the guidance of the PRISMA 2020 statement (26).

## Eligibility criteria

The eligibility and inclusion criteria of the article are as follows: 1) The study design must only include randomized controlled trials and quasi-experimental studies. 2) The article's full text must be available. 3) The article must be written in English. 4) It must only include peer-reviewed journal articles. 5) The subjects must be limited to humans. 6) Interventions must have included any type of aquatic exercise. 7) Mental health, mood, anxiety symptoms, depression, or related parameters in the study could be clearly extracted.

Aquatic exercise in the encyclopedia was defined as "an activity," and the activity site must be in the water, such as a pool, lake, or ocean (27). Based on this, all types of exercise in water (such as swimming, aquatic exercise, and floating in water) were included in this study. Additionally, demographic restrictions were waived.

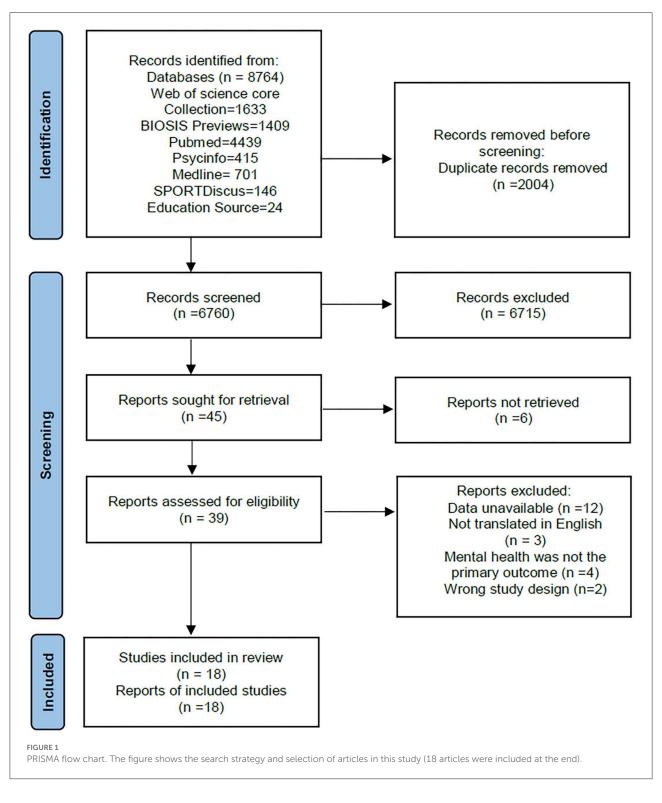
## Information sources and search strategy

PubMed, BIOSIS Previews, PsycINFO, Medline, SPORTDiscus, Education Source, and Web of Science Core Collection were searched on May 28, 2022, for studies using the following combination of terms: "mental health," "depression,"

TABLE 1 Search strategy in PubMed.

### Step Search strategies

#1	"swim" OR "aquatic" OR "water sport" [Mesh]
#2	"swim" OR "aquatic exercise" OR "water sport" [Text Word]
#3	#1 OR #2
#4	"mental health" OR "depression" OR "anxiety" OR "mood" [Mesh]
#5	"mental health" OR "depression" OR "anxiety" OR "mood" [Text Word]
#6	"POMS" OR "BDI" OR "BAI" [Text Word]
#7	#4 OR #5 OR #6
#8	#3 AND #7



"anxiety," "mood," "POMS," "BDI," "BAI" in combination with "swim," "aquatic," "water sport," and "aquatic exercise." Table 1 shows the search strategies used for database searches (e.g., PubMed).

## Study selection

All of the search results were imported into Endnote. The duplicate was searched by year, title, and author.

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									(WEEK)	(u/week)		(min)
1	1992	Berger and Owen. (28)	United States	39	College students	21	Swim	Profile of Mood State (POMS)	14	2	Moderate	40
2	1997	Berger et al. (29)	Australia	39	Swimmers	15	Swim	POMS	1	12	High	180
3	1999	Tanaka et al. (30)	United States	12	Obese subjects with stages 1 to 2 essential hypertension	48	Swim	POMS	10	3	Moderate	60
4	2001	Webb and Drummond. (31)	Australia	19	Beach swimming participants	26	Swim	Spielberger State-Trait Anxiety questionnaire	2	N/R <sup>a</sup>	Moderate	240
5	2002	Lindeman et al. (32)	Finland	25	Winter swimming	50	Winter swim	Crown Crisp Experimental Index (CCEI)	32	N/R	N/R	N/R
6	2004	Huttunen et al. (33)	Finland	36	Winter swimming	53	Winter swim	POMS	16	4	N/R	N/R
7	2015	Kim et al. (34)	Korea	25	Elderly women	72	Aquatic aerobics	POMS	24	3	Moderate	60
8	2016	Razazian et al. (35)	Switzerland		Female patients with multiple sclerosis	34	Aquatic aerobics	Beck's Depression Inventory (BDI)	8	3	Moderate	60
9	2018	Aidar et al. (36)	Brazil	19	Persons with stroke	52	Aquatic aerobics	StateTrait Anxiety Inventory & BDI	12	2	Moderate	60
10	2018	Da Silva et al. (37)	Brazil	29	Hypertensive adults & health adults	53	Aquatic aerobics	BDI & Beck's Anxiety Inventory (BAI)	12	2	light	45
11	2018	Delevatti et al. (38)	Brazil	17	Patients with type 2 diabetes	54	Aquatic aerobics	BDI	12	3	high	45
12	2019	da Silva et al. (39)	United States	30	Nondepression elderly & elderly with depression	58	Aquatic aerobics	BDI & BAI	12	2	light	45
13	2019	de Oliveira et al. (38)	Brazil	10	Elderly women	67	Swim	Geriatric Anxiety Inventory (GAI) & Perceived Stress Scale	12	2	light	45
14	2019	Perez et al. (40)	Brazil	10	Patients with Parkinson's disease	67	Aquatic aerobics	Short Geriatric Depression Scale	15	2	light	45
15	2019	Sahin et al. (14)	Turkey	30	People with osteoarthritis	63	Aquatic aerobics	Hospital Anxiety and Depression Scale (HAD)	3	5	Moderate	60
16	2020	Useros et al. (41)	Chile	15	People with cervical dystonia	48	Aquatic aerobics	BDI & State-Trait Anxiety Inventory (STAI)	4	1	light	50
17	2021	da Silva et al. (42)	United States	30	Health adults &people with Type 2 diabetes mellitus	64	Aquatic aerobics	BDI & BAI	12	0.5	light	41
18	2021	Lee et al. (43)	Korea	20	Pre-frailty elderly women	73	Aquatic aerobics	POMS	12	3	Moderate	60

Measurement tool

Country N Population characters Age Mode

TABLE 2 General characteristics.

No. Year Author

<sup>a</sup> N/R, Not reported.

Duration

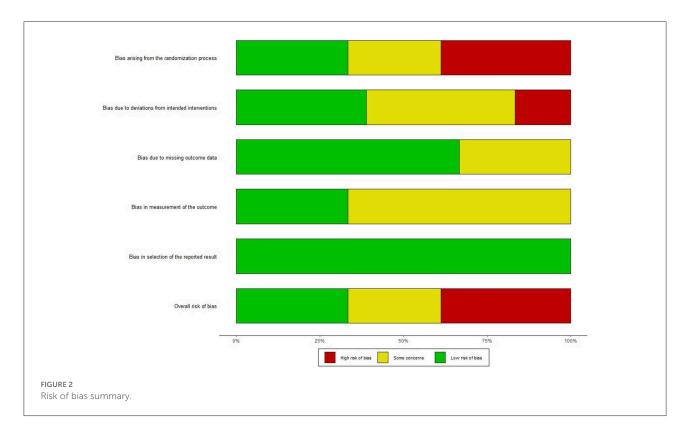
of sessions

Frequency Intensity

(d/week)

Duration

(week)



After removing duplicates, two authors (ZYT and JML) independently screened the studies based on the title and the abstract. Only experimental articles defining the effect of aquatic exercise on human mood and anxiety symptoms were included. Following the initial screening, two authors searched the full text and further evaluated the research according to the eligibility criteria. We resolved differences through discussion with another author (YW). The selection process of the study was exhibited by a PRISMA 2020 flow diagram.

# Assessment of trial quality and data extraction

Trial quality was assessed from the selected full-text articles by two authors—the studies' risk of bias was in accordance with the Cochrane Handbook for Systematic Reviews of Interventions. At the same time, the data for the article were extracted. The information from the included articles (author, date of publication, country, and study design), the characteristics of subjects (sample size, age, sex, health condition, etc.), and intervention (types of exercises, duration, frequency) were extracted from the included articles. Furthermore, outcomes measured (mean, SD) and measurement tools used (type of questionnaire) were extracted.

### Synthesis and analysis

The meta-analysis was performed by R 4.2.1 software ("meta" package). The Chi-square test was performed to determine whether or not there were statistically significant differences between the research results. Multiple similar homogenous studies were considered if  $P \ge 0.1$ ,  $I^2 < 50\%$ , and meta-analysis using a fixed-effect model. If P < 0.1,  $I^2 \ge 50\%$ , the random-effects model was used. Because of the different ranges and measurement methods of mental health in these studies, standardized mean difference (SMD) and a 95% confidence interval (CI) were used for continuous data.

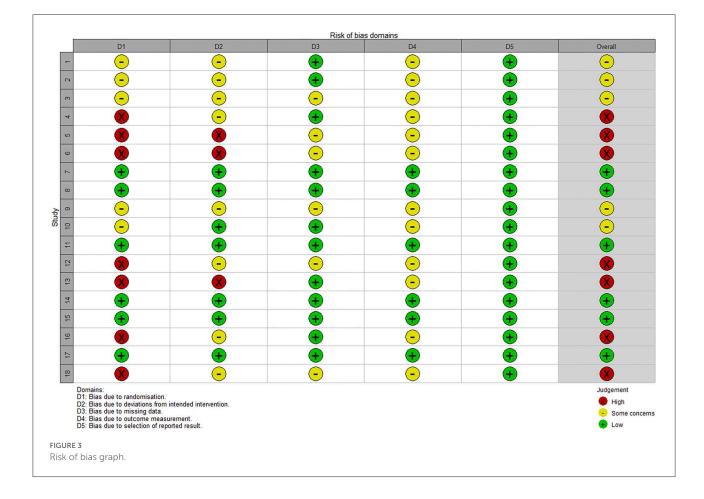
### Subgroup analysis

Subgroup analyses were grouped based on the following factors: age, disease, mode of exercise, type of mental health, duration of exercise, and intensity.

## Results

### Search strategy results

The PRISMA flow chart (Figure 1) shows the search strategy and details the selection of articles for this review. A total of 8,764 articles were retrieved on a database search. After



removing duplicates, 6,715 were removed through reviewing the title and abstract. Afterward, of the remaining 45 articles, through the full-text review, 27 were eliminated, and 18 were included.

## **Study characteristics**

Table 2 displays the general characteristics of the 18 articles, including the date of publication, the country, the study design, and the population of subjects.

## Quality of the evidence

The assessment of trial quality was performed independently by two authors, according to Version 2 of the Cochrane risk-of-bias tool for randomized trials (RoB 2) (44). All discrepancies were discussed or consulted with another author. After evaluating the risk of bias in studies, seven studies were considered to have a high bias risk arising from the randomization process, three studies were found to have an ambiguous bias risk due to deviations from intended interventions, and 12 studies were found to have complete data (Figure 2). Overall, six studies have low risk, five have some concerns, and seven have a high risk (Figure 3).

# Effects of aquatic exercise on mental health

According to meta-analysis, people who were treated with aquatic exercise showed a statistically significant reduction in mental disorder symptoms compared to pro-intervention [SMD = -0.77, 95% CI (-1.08, -0.47), I<sup>2</sup> = 77%, P < 0.01]. As depicted in Figure 4, aquatic exercise improves mood and anxiety symptoms.

## Subgroup analysis

### Subgroup: Age

Based on the age of the subjects, studies were divided into three groups, with an age range of <18 years, 18-64 years,

tudy	Total	Mean	erimental SD	Total	Mean	Control	Standardised Mean Difference	SMD	95%-CI	Weight (common)	Weigh (randon
tudy	Total	mean	30	Total	mean	30		SIND	33%-01	(common)	(randon
erger 1992	17	42.00		22	41.00		:1			0.0%	0.0
erger 1992	17	42.00		22	42.00		2			0.0%	0.0
erger 1997	39	1.86	2.5700	39	3.17	3.2700	<b>1</b>	-0.44	[-0.89; 0.01]	5.9%	3.2
erger 1997	39	2.47	2.7600	39	2.63	2.9100		-0.06	[-0.50; 0.39]	6.0%	3.2
anaka 1999	12	4.00	1.3000	12	3.60	1.5000	3- <del>1-</del>	0.28	[-0.53; 1.08]	1.8%	2.7
anaka 1999	12	5.20	1.5000	12	5.50	0.9000		-0.23	[-1.04; 0.57]	1.8%	2.7
/ebb 2001	19	27.50	2.5000	19	33.10	2.6000	<del></del>	-2.15	[-2.96; -1.34]	1.8%	2.7
/ebb 2001	21	32.00	2.6000	21	33.50	2.7000		-0.56	[-1.17; 0.06]	3.196	3.0
indeman 2002	25	2.00	1.4000	25	2.40	2.0000	· <del></del>	-0.23	[-0.78; 0.33]	3.8%	3.1
uttunen 2004	36	4.30	4.1000	36	4.80	5.7000	:=	-0.10	[-0.56; 0.36]	5.6%	3.2
uttunen 2004	36	2.10	1.8000	36	3.00	2.6000	<del></del>	-0.40	[-0.86; 0.07]	5.4%	3.2
im 2015	25	170.98	4.4100	25	171.68	4.9600		-0.15	[-0.71; 0.40]	3.8%	3.1
azazian 2016	18	4.78	3.4200	18	19.17	7.8300	i	-2.33	[-3.19; -1.46]	1.6%	2.7
idar 2018	19	12.20	7.1000	19	16.40	7.1000		-0.58	[-1.23; 0.07]	2.8%	2.9
idar 2018	19	43.10	6.9000	19	47.10	8.6000		-0.50	[-1.15; 0.14]	2.8%	3.0
a Silva 2018	16	8.30	2.7000	16	9.60	2.3000	······································	-0.51	[-1.21; 0.20]	2.4%	2.9
a Silva 2018	16	6.20	2.0000	16	15.80	2.1000	ii	-4.56	[-5.94; -3.19]	0.6%	2.0
a Silva 2018	13	4.20	1.9000	13	5.20	2.9000		-0.40	[-1.17; 0.38]	2.0%	2.8
a Silva 2018	13	4.50	0.7000	13	4.70	0.9000		-0.24	[-1.01; 0.53]	2.0%	2.8
elevatti 2018	17	8.40	1.6000	17	9.70	1.1000		-0.92	[-1.64; -0.21]	2.3%	2.9
a Silva 2019	14	4.20	1.9000	14	5.20	2,9000		-0.40	[-1.15; 0.35]	2.1%	2.8
a Silva 2019	14	4.50	0.7000	14	4.70	0.0900		-0.39	[-1.14; 0.38]	2.1%	2.8
a Silva 2019	16	8.30	2.7000	16	9.60	2.3000		-0.51	[-1.21; 0.20]	2.4%	2.9
a Silva 2019	16	6.20	2.0000	16	15.80	2,1000		-4.58	[-5.94; -3.19]	0.6%	2.0
e Oliveira 2019	10	4.50		10	9.00		3			0.0%	0.0
e Oliveira 2019	10	17.00		10	37.50		8			0.0%	0.0
erez 2019	15	3.00	2.1000	15	4.07	2.7000	4	-0.43	[-1.16; 0.29]	2.3%	2.9
ahin 2019	30	5.58	3.7100	30	8.96	4.5900		-0.80	[-1.33; -0.28]	4.3%	3.1
ahin 2019	30	6.03	2.8700	30	9.86	4.0600		-1.08	[-1.62; -0.53]	4.0%	3.1
ahin 2019	30	7.53	3.8300	30	10.13	4,4400	-	-0.62	[-1.14; -0.10]	4,4%	3.1
ahin 2019	30	7.90	3,7700	30	10.70	4.3900		-0.68	[-1.20; -0.15]	4.4%	3.1
seros-Olmo 2020	15	13.30	7.7400	15	17.40	9.8200		-0.45	[-1.18; 0.27]	2.3%	2.9
seros-Olmo 2020	15	60.67	34.0400	15	71.13	28,1400	<u></u>	-0.33	[-1.05; 0.40]	2.3%	2.9
a Silva 2021	14	5.66	3,1200	14	13.30	6.0700		-1.54	[-2.39; -0.68]	1.6%	2.7
a Silva 2021	14	8.20	2.1000	14	14.00	1.6000		-3.02	[-4.14; -1.89]	0.9%	2.3
a Silva 2021	18	5.50	5.6600	18	4.98	4.1300	3 <u>1  </u>	0.11	[-0.59; 0.80]	2.5%	2.9
a Silva 2021	16	4.20	4.0000	16	4.80	8.0000	<u></u>	-0.09	[-0.79; 0.60]	2.5%	2.9
unjae Lee 2021	20	9.20	1.4700	20	10.30	1.4200	- <u>+</u> -	-0.75	[-1.39; -0.10]	2.9%	3.0
unjae Lee 2021	20	7.35	1.0900	20	8.35	1.6300	1	-0.71	[-1.35; -0.07]	2.9%	3.0
onjae Lee 2021	20	1.55	1.0000	20	0.55	1.0500	3	-0.71	[1.55, 6.67]	2.370	5.0
ommon effect model	774			784				-0.58	[-0.69; -0.47]	100.0%	
andom effects model							<u> </u>	-0.77	[-1.08; -0.47]	-	100.0
eterogeneity: I <sup>2</sup> = 77%, -	= 0.6900	. p < 0.01					-4 -2 0 2 4				
GURE 4											

and>64 years, respectively. Age groups were classified according to WHO standards (45). It can be observed that 18–64 years [SMD = -0.94, 95% CI (-1.34, -0.54), I<sup>2</sup> = 80%, P < 0.01] were statistically significant through the subgroup analysis (Figure 5). There was no statistical significance in other groups. There was a statistically significant subgroup effect (P = 0.02).

### Subgroup: Disease

Studies were divided into ten groups based on the subjects' physical health. It can be observed that the Health group [SMD = -0.64, 95% CI (-1.03,-0.25), I<sup>2</sup> = 74%, *P* < 0.01], Hypertension group [SMD = -1.20, 95% CI (-3.31, 0.91), I<sup>2</sup> = 92%, *P* < 0.01], and Depression group [SMD = -2.49, 95% CI (-6.47, 1.49), I<sup>2</sup> = 96%, *P* < 0.01] were statistically significant through the subgroup analysis (Figure 6). There was no statistical significance in other groups. There was a statistically significant subgroup effect (*P* = 0.02).

### Subgroup: Mode of exercise

Based on the exercise mode of intervention, studies were divided into three groups. The swimming group included swimming learning courses, leisure swimming, and swimming training. The aquatic aerobics group included water walking, water gymnastics, and any form of aerobic exercise in water, except swimming. It can be observed that swim [SMD = -0.51, 95% CI (-1.14, 0.12), I<sup>2</sup> = 78%, P < 0.01] and aquatic aerobics [SMD = -0.92, 95% CI (-1.32, -0.53), I<sup>2</sup> = 78%, P < 0.01] were statistically significant through the subgroup analysis (Figure 7). There was no statistical significance in the winter swim. There was a statistically significant subgroup effect (P = 0.02).

### Subgroup: Type of mental health

Based on the type of mental health intervention, studies were divided into three groups. It can be observed that anxiety [SMD = -1.28, 95% CI (-2.04, -0.53), I<sup>2</sup> = 87%, P < 0.01] and depression [SMD = -0.52, 95% CI (-0.74, -0.30), I<sup>2</sup> = 55%,

tudy	Total	Mean	erimental SD	Total	Mean	Control	Standardised Mean Difference	SMD	95% CI	Weight (common)	Weigh (random
udy	Iotal	mean	50	Iotal	Mean	50	Dimerence	SMD	35%-CI	(common)	(random
ge = <18							::				
erger 1997	39	1.86	2.5700	39	3.17	3.2700	កា	-0.44	[-0.89; 0.01]	5.9%	3.29
erger 1997	39	2.47	2.7600	39	2.63	2.9100		-0.06	[-0.50; 0.39]	6.0%	3.29
ommon effect model	78			78			l	-0.25	[-0.56; 0.07]	11.9%	
andom effects model								-0.25	[-0.62; 0.13]		6.49
eterogeneity: $I^2 = 30\%$ , $\pi^2$	<sup>2</sup> = 0.0222,	p = 0.23									
ge = 18-64							į				
erger 1992	17	42.00		22	41.00		5 I			0.0%	0.09
erger 1992	17	42.00		22	42.00		1			0.0%	0.0
ebb 2001	19	27.50	2.5000	19	33.10	2.6000		-2.15	[-2.96; -1.34]	1.8%	2.79
ebb 2001	21	32.00	2.6000	21	33.50	2.7000	<u>i  </u>	-0.58	[-1.17; 0.06]	3.196	3.0
azazian 2016	18	4.78	3.4200	18	19.17	7.8300	i ]	-2.33	[-3.19; -1.46]	1.6%	2.79
eros-Olmo 2020	15	60.67	34.0400	15	71.13	28.1400		-0.33		2.3%	2.9
							21		[-1.05; 0.40]		
anaka 1999	12	4.00	1.3000	12	3.60	1.5000	:1	0.28	[-0.53; 1.08]	1.8%	2.79
anaka 1999	12	5.20	1.5000	12	5.50	0.9000	31	-0.23	[-1.04; 0.57]	1.8%	2.79
seros-Olmo 2020	15	13.30	7.7400	15	17.40	9.8200	<del></del>	-0.45	[-1.18; 0.27]	2.3%	2.99
ndeman 2002	25	2.00	1.4000	25	2.40	2.0000	<u></u>	-0.23	[-0.78; 0.33]	3.8%	3.19
dar 2018	19	12.20	7.1000	19	16.40	7.1000		-0.58	[-1.23; 0.07]	2.8%	2.9
dar 2018	19	43.10	6.9000	19	47.10	8.6000	- <u>4</u> -	-0.50	[-1.15; 0.14]	2.8%	3.09
a Silva 2018	16	6.20	2.0000	16	15.80	2.1000	—— 罰	-4.58	[-5.94; -3.19]	0.6%	2.09
Silva 2018	13	4.50	0.7000	13	4.70	0.9000	<u></u>	-0.24	[-1.01: 0.53]	2.0%	2.89
a Silva 2018 Silva 2018		4.50		13	9.60	2,3000	<u></u>			2.0%	2.8
	16		2.7000				31	-0.51	[-1.21; 0.20]		
a Silva 2018	13	4.20	1.9000	13	5.20	2.9000	<u></u>	-0.40	[-1.17; 0.38]	2.0%	2.89
uttunen 2004	36	4.30	4.1000	36	4.80	5.7000	₩-	-0.10	[-0.56; 0.36]	5.6%	3.29
ttunen 2004	38	2.10	1.8000	36	3.00	2.6000		-0.40	[-0.86; 0.07]	5.4%	3.29
elevatti 2018	17	8.40	1.6000	17	9.70	1.1000		-0.92	[-1.64; -0.21]	2.3%	2.99
Silva 2019	14	4.50	0.7000	14	4.70	0.0900		-0.39	[-1.14; 0.36]	2,1%	2.89
Silva 2019	14	4.20	1.9000	14	5.20	2.9000		-0.40	[-1.15; 0.35]	2.1%	2.89
Silva 2019	16	6.20	2.0000	16	15.80	2.1000	il	-4.58	[-5.94; -3.19]	0.6%	2.09
Silva 2019	16	8.30	2.7000	16	9.60	2.3000	<u></u>	-0.51		2.4%	2.9
							-		[-1.21; 0.20]		
ahin 2019	30	6.03	2.8700	30	9.86	4.0600		-1.08	[-1.62; -0.53]	4.0%	3.19
ahin 2019	30	7.90	3.7700	30	10.70	4.3900		-0.68	[-1.20; -0.15]	4.4%	3.19
ahin 2019	30	5.56	3.7100	30	8.96	4.5900	- T	-0.80	[-1.33; -0.28]	4.3%	3.19
ahin 2019	30	7.53	3.8300	30	10.13	4.4400		-0.62	[-1.14; -0.10]	4.4%	3.19
a Silva 2021	14	8.20	2.1000	14	14.00	1.6000		-3.02	[-4.14; -1.89]	0.9%	2.3
Silva 2021	14	5.66	3.1200	14	13.30	6.0700		-1.54	[-2.39; -0.68]	1.6%	2.79
ommon effect model	564			574			<u> </u>	-0.69	[-0.82; -0.57]	71.3%	
andom effects model								-0.94	[-1.34; -0.54]		76.0
terogeneity: $I^2 = 80\%$ , $\tau^2$	= 0.9601	p < 0.01						0.04	[1.04, 0.04]		10.0
je = >64	10			10						0.54	
Silva 2021	16	4.20	4.0000	16	4.80	8.0000		-0.09	[-0.79; 0.60]	2.5%	2.99
Silva 2021	16	5.50	5.6600	16	4.98	4.1300		0.11	[-0.59; 0.80]	2.5%	2.99
Oliveira 2019	10	4.50		10	9.00		8			0.0%	0.09
Oliveira 2019	10	17.00		10	37.50		31			0.0%	0.09
erez 2019	15	3.00	2.1000	15	4.07	2.7000	- <del>2</del> -1-	-0.43	[-1.16; 0.29]	2.3%	2.9
m 2015	25	170.98	4.4100	25	171.68	4.9600	à.∔-	-0.15	[-0.71: 0.40]	3.8%	3.1
njae Lee 2021	20	7.35	1.0900	20	8.35	1.6300	÷	-0.71	[-1.35; -0.07]	2.9%	3.09
injae Lee 2021	20	9 20	1 4700	20	10.30	1.4200		-0.75	[-1.39; -0.10]	2.9%	3.05
		5.20	1.4700	132	10.30	1.4200				16.8%	3.01
ommon effect model	132			132				-0.34	[-0.61; -0.07]	10.0%	
andom effects model aterogeneity: $l^2 = 7\%$ , $\tau^2$	= 0.0087,	p = 0.37						-0.34	[-0.62; -0.06]	-	17.69
ommon effect model	774			784			3 I	-0.58	[-0.69; -0.47]	100.0%	
andom effects model							·	-0.77	[-1.08; -0.47]	-	100.09
eterogeneity: 1 <sup>2</sup> = 77%, τ			2				-4 -2 0 2 4				
st for subgroup difference st for subgroup difference											
URE 5											

P < 0.01] were statistically significant through the subgroup analysis (Figure 8). There was a statistically significant subgroup effect (P = 0.07).

### Subgroup: Duration

Based on the duration of the subjects, studies were divided into three groups, with an age range of <4 weeks,

4–12 weeks, and>12 weeks, respectively. It can be observed that <4 weeks [SMD = -0.74, 95% CI (-1.11, -0.37), I<sup>2</sup> = 70%, P < 0.01] and 4–12 weeks [SMD = -0.95, 95% CI (-1.45, -0.45), I<sup>2</sup> = 82%, P < 0.01] were statistically significant through the subgroup analysis (Figure 9). There was no statistical significance in the> 12-week group. There was a statistically significant subgroup effect (P = 0.01).

Study	Total	Mean	erimental SD	Total	Mean	Control SD	Standardised Mean Difference	SMD	95%-CI	Weight (common)	Weight (random)
disease = health							31				
Berger 1992	17	42.00		22	41.00		j j			0.0%	0.0%
Berger 1992	17	42.00		22	42.00		21			0.0%	0.0%
Berger 1997	39	1.86	2.5700	39	3.17	3.2700	······································	-0.44	[-0.89; 0.01]	5.9%	3.2%
Berger 1997	39	2.47	2.7600	39	2.63	2.9100	j <del>i</del> t .	-0.08	[-0.50; 0.39]	6.0%	3.2%
Webb 2001	19	27.50	2.5000	19	33.10	2.6000	<u> </u>	-2.15	[-2.96; -1.34]	1.8%	2.7%
Webb 2001	21	32.00	2.6000	21	33.50	2.7000	光	-0.58	[-1.17; 0.06]	3.1%	3.0%
Lindeman 2002	25	2.00	1.4000	25	2.40	2.0000	行士	-0.23	[-0.78; 0.33]	3.8%	3.1%
Huttunen 2004	36	4.30	4.1000	36	4.80	5.7000	;++	-0.10	[-0.56; 0.36]	5.6%	3.2%
Huttunen 2004	36	2.10	1.8000	36	3.00	2.6000	4-1	-0.40	[-0.86; 0.07]	5.4%	3.2%
Kim 2015	25	170.96	4.4100	25	171.68	4.9600	· · ·	-0.15	[-0.71: 0.40]	3.8%	3.196
Da Silva 2018	13	4.20	1.9000	13	5.20	2.9000	-#+	-0.40	[-1.17: 0.38]	2.0%	2.8%
Da Silva 2018	13	4.50	0.7000	13	4.70	0.9000	<del>강하</del> 는	-0.24	[-1.01; 0.53]	2.0%	2.8%
da Silva 2019	14	4.20	1.9000	14	5.20	2.9000		-0.40	[-1.15; 0.35]	2.1%	2.8%
da Silva 2019	14	4.50	0.7000	14	4.70	0.0900	·····································	-0.39	[-1.14; 0.38]	2.1%	2.8%
de Oliveira 2019	10	4.50		10	9.00		51		51 S S	0.0%	0.0%
de Oliveira 2019	10	17.00		10	37.50		:			0.0%	0.0%
da Silva 2021	14	5.66	3.1200	14	13.30	6.0700		-1.54	[-2.39; -0.68]	1.6%	2.7%
da Silva 2021	14	8.20	2.1000	14	14.00	1.6000	ji	-3.02	[-4.14; -1.89]	0.9%	2.3%
Common effect model	376			386			1.	-0.45	[-0.61; -0.29]	46.2%	
Random effects model							4	-0.64	[-1.03; -0.25]		40.7%
Heterogeneity: $I^2 = 74\%$ , $\tau^2$	= 0.4350	p < 0.01					<b>1</b>				
interestering in the terms of		. p					ŝ.				
disease = hypertension							31				
Tanaka 1999	12	4.00	1.3000	12	3.60	1.5000	j-}	0.28	[-0.53; 1.08]	1.8%	2.7%
Tanaka 1999	12	5.20	1.5000	12	5.50	0.9000	÷+-	-0.23	[-1.04; 0.57]	1.8%	2.7%
Da Silva 2018	18	8.30	2.7000	18	9.60	2.3000	光다	-0.51	[-1.21; 0.20]	2.4%	2.9%
Da Silva 2018	18	6.20	2.0000	16	15.80	2.1000	——————————————————————————————————————	-4.58	[-5.94; -3.19]	0.6%	2.0%
Common effect model	56			56				-0.60	[-1.02; -0.18]	6.7%	
Random effects model				30				-1.20	[-3.31; 0.91]	0.7 %	10.4%
Heterogeneity: $I^2 = 92\%$ , $\tau^2$	= 4 2.927	n < 0.01					ij		[	-	
	1,0001						21				
disease = Multiple Scle	rosis						<u>j</u> [				
Razazian 2016	18	4.78	3.4200	18	19,17	7.8300	i	-2.33	[-3.19; -1.46]	1.6%	2.7%
							2				
disease = post stroke							3				
Aidar 2018	19	12.20	7,1000	19	16.40	7,1000		-0.58	[-1.23; 0.07]	2.8%	2.9%
Aidar 2018	19	43.10	6.9000	19	47.10	8.6000	퓌	-0.50	[-1.15; 0.14]	2.8%	3.0%
Common effect model	38			38			*	-0.54	[-1.00: -0.08]	5.6%	
Random effects model							*	-0.54	[-1.00; -0.08]		5.9%
Heterogeneity: $I^2 = 0\%$ , $\pi^2 =$	= 0, p = 0	87					:				
							ä				
disease = type 2 diabete	25						:				
Delevatti 2018	17	8.40	1.6000	17	9.70	1.1000	-2	-0.92	[-1.64; -0.21]	2.3%	2.9%
da Silva 2021	16	5.50	5.6600	16	4.98	4.1300	i	0.11	[-0.59; 0.80]	2.5%	2.9%
da Silva 2021	16	4.20	4.0000	16	4.80	8.0000	÷.	-0.09	[-0.79; 0.60]	2.5%	2.9%
Common effect model	49			49				-0.29	[-0.70; 0.11]	7.3%	
Random effects model								-0.30	[-0.91; 0.32]	-	8.7%
Heterogeneity: $I^2 = 57\%$ , $\tau^2$	= 0.1675	p = 0.10									
							<sup>2</sup>				
disease = depression							i l				
da Silva 2019	16	8.30	2.7000	16	9.60	2.3000	÷ł	-0.51	[-1.21; 0.20]	2.4%	2.9%
da Silva 2019	16	6.20	2.0000	16	15.80	2.1000	!	-4.58	[-5.94; -3.19]	0.6%	2.0%
Common effect model	32			32				-1.35	[-1.98; -0.72]	3.0%	
Random effects model							the second se	-2.49	[-6.47; 1.49]		4.9%
Heterogeneity: $I^2 = 96\%$ , $\tau^2$	= 7.9225	p < 0.01									
disease = Parkinson dis	sease						8				
Perez 2019	15	3.00	2.1000	15	4.07	2.7000		-0.43	[-1.16; 0.29]	2.3%	2.9%
							3				
disease = osteoarthritis							ä				
Sahin 2019	30	5.56	3.7100	30	8.96	4.5900	4	-0.80	[-1.33; -0.28]	4.3%	3.1%
Sahin 2019	30	6.03	2.8700	30	9.86	4.0600		-1.08	[-1.62; -0.53]	4.0%	3.1%
Sahin 2019	30	7.53	3.8300	30	10.13	4.4400			[-1.14: -0.10]	4.4%	3.1%
Sahin 2019	30	7.90	3.7700	30	10.70	4.3900		-0.68	[-1.20; -0.15]	4.4%	3.1%
Common effect model	120			120			÷	-0.79	[-1.05; -0.52]	17.1%	-
Random effects model							<b>*</b>	-0.79	[-1.05; -0.52]		12.4%
Heterogeneity: $I^2 = 0\%$ , $\tau^2 =$	= 0, p = 0	.65					2				
							31				
disease = cervical dyst	onia						31				
Useros-Olmo 2020	15	13.30	7.7400	15	17.40	9.8200	÷+	-0.45	[-1.18: 0.27]	2.3%	2.9%
Useros-Olmo 2020	15	60.67	34.0400	15		28.1400	÷++-	-0.33	[-1.05; 0.40]	2.3%	2.9%
Common effect model	30			30			岩	-0.39	[-0.90; 0.12]	4.5%	
Random effects model								-0.39	[-0.90; 0.12]		5.7%
Heterogeneity: $I^2 = 0\%$ , $\tau^2 =$	0. n = 0	.81					81	5.00			
							21				
disease = pre-frailty							<u>51</u>				
Eunjae Lee 2021	20	9.20	1.4700	20	10.30	1.4200		-0.75	[-1.39; -0.10]	2.9%	3.0%
Eunjae Lee 2021	20	7.35	1.0900	20	8.35	1.6300	_iL	-0.71	[-1.35; -0.07]	2.9%	3.0%
Common effect model	40	1.50	1.0500	40	0.00	1.0300		-0.73	[-1.18; -0.27]	5.8%	3.0%
Random effects model	40			40						0.8%	5.9%
		02					1	-0.73	[-1.18; -0.27]	-	5.3%
Heterogeneity: $I^2 = 0\%$ , $\tau^2 =$	= 0, p = 0	.33					र्थ शाहक प्राय प्रति है जिसक प्राय प्रियोग के ∯जार ज				
Common effectives ? .	774			704			4	0.50	10.00 0.17	400.00	
Common effect model Random effects model	774			784			2	-0.58	[-0.69; -0.47]	100.0%	100.0%
nandom enects model								-0.77	[-1.08; -0.47]		100.0%
							-6 -4 -2 0 2 4 6				
	= 0.6900										
Heterogeneity: $I^2 = 77\%$ , $\tau^2$											
Heterogeneity: I <sup>*</sup> = 77%, τ <sup>*</sup> Test for subgroup differenc Test for subgroup differenc	es (comr										

Forest plot of disease. By subgroup analysis of the disease, the Health group [SMD = -0.64, 95% CI (-1.03, -0.25),  $|^2 = 74\%$ , P < 0.01], Hypertension group [SMD = -1.20, 95% CI (-3.31, 0.91),  $|^2 = 92\%$ , P < 0.01], and Depression group [SMD = -2.49, 95% CI (-6.47, 1.49),  $|^2 = 96\%$ , P < 0.01] were statistically significant.

			erimental			Control	Standardised Mean			Weight	Weigh
tudy	Total	Mean	SD	Total	Mean	SD	Difference	SMD	95%-CI	(common)	(randon
ode = Swim							:1				
erger 1992	17	42.00		22	41.00		j j			0.0%	0.0
erger 1992	17	42.00		22	42.00		21			0.0%	0.0
erger 1997	39	1.86	2.5700	39	3.17	3.2700	<u>4</u>	-0.44	[-0.89; 0.01]	5.9%	3.2
erger 1997	39	2.47	2.7600	39	2.63	2.9100	:L	-0.08	[-0.50; 0.39]	6.0%	3.2
anaka 1999	12		1.3000	12	3.60	1.5000	<u>:</u>				2.7
		4.00					<u>il</u>	0.28	[-0.53; 1.08]	1.8%	
anaka 1999	12	5.20	1.5000	12	5.50	0.9000		-0.23	[-1.04; 0.57]	1.8%	2.7
ebb 2001	19	27.50	2.5000	19	33.10	2.6000	i	-2.15	[-2.96; -1.34]	1.8%	2.7
ebb 2001	21	32.00	2.6000	21	33.50	2.7000	÷1	-0.56	[-1.17; 0.06]	3.1%	3.0
Oliveira 2019	10	4.50		10	9.00					0.0%	0.0
Oliveira 2019	10	17.00		10	37.50		: I			0.096	0.0
ommon effect model	196			206			-	-0.41	[-0.65; -0.17]	20.5%	
andom effects model								-0.51	[-1.14; 0.12]		17.6
eterogeneity: $I^2 = 78\%$ , $\pi^2$	= 0.5051	n < 0.01									
nerogeneny. 1 - 1070, c	0.0001	. p . 0.01					1				
ada = Mintar rusin							<b>3</b>				
ode = Winter swim	05	0.00	1 1000	-	0.40	0.0000		0.00	10 70 0 001	0.001	0.44
ndeman 2002	25	2.00	1.4000	25	2.40	2.0000	1 T	-0.23	[-0.78; 0.33]	3.8%	3.1
uttunen 2004	36	4.30	4.1000	36	4.80	5.7000		-0.10	[-0.58; 0.38]	5.6%	3.2
ittunen 2004	36	2.10	1.8000	36	3.00	2.6000	<u>i</u>	-0.40	[-0.86; 0.07]	5.4%	3.2
ommon effect model	97			97			3 <b>-</b> 1	-0.24	[-0.53; 0.04]	14.8%	
andom effects model							:*	-0.24	[-0.53; 0.04]		9.4
eterogeneity: $I^2 = 0\%$ , $\tau^2$	= 0, p = 0	.67									
ode = Aquatic Aerobio	25						21				
m 2015	25	170.98	4,4100	25	171.68	4,9800	i-	-0.15	[-0.71; 0.40]	3.8%	3.1
zazian 2016	18	4.78	3.4200	18	19.17	7.8300	#]				2.7
				0.00				-2.33	[-3.19; -1.46]	1.6%	
dar 2018	19	12.20	7.1000	19	16.40	7.1000		-0.58	[-1.23; 0.07]	2.8%	2.9
dar 2018	19	43.10	6.9000	19	47.10	8.6000	्रा	-0.50	[-1.15; 0.14]	2.8%	3.0
Silva 2018	16	8.30	2.7000	16	9.60	2.3000	<u></u>	-0.51	[-1.21; 0.20]	2.4%	2.9
a Silva 2018	16	6.20	2.0000	16	15.80	2.1000	<u>i</u>	-4.58	[-5.94; -3.19]	0.6%	2.0
a Silva 2018	13	4.20	1.9000	13	5.20	2.9000		-0.40	[-1.17; 0.38]	2.0%	2.8
a Silva 2018	13	4.50	0.7000	13	4.70	0.9000		-0.24	[-1.01; 0.53]	2.0%	2.8
elevatti 2018	17	8.40	1.6000	17	9.70	1,1000		-0.92	[-1.64; -0.21]	2.3%	2.9
Silva 2019	14	4.20	1,9000	14	5.20	2 9000		-0.40	[-1.15: 0.35]	2.1%	2.8
Silva 2019	14	4.50	0.7000	14	4.70	0.0900	<u>.</u>	-0.39	[-1.14; 0.36]	2.1%	2.8
a Silva 2019	16	8.30	2.7000	16	9.60	2.3000	51	-0.55		2.1%	2.9
									[-1.21; 0.20]		
a Silva 2019	16	6.20	2.0000	16	15.80	2.1000		-4.58	[-5.94; -3.19]	0.8%	2.0
arez 2019	15	3.00	2.1000	15	4.07	2.7000		-0.43	[-1.16; 0.29]	2.3%	2.9
ahin 2019	30	5.56	3.7100	30	8.96	4.5900		-0.80	[-1.33; -0.28]	4.396	3.1
ahin 2019	30	6.03	2.8700	30	9.86	4.0600		-1.08	[-1.62; -0.53]	4.0%	3.1
ahin 2019	30	7.53	3.8300	30	10.13	4.4400	÷-	-0.62	[-1.14; -0.10]	4.4%	3.1
ahin 2019	30	7.90	3.7700	30	10.70	4.3900	-i	-0.68	[-1.20; -0.15]	4.4%	3.1
eros-Olmo 2020	15	13.30	7.7400	15	17.40	9.8200	÷	-0.45	[-1.18; 0.27]	2.3%	2.9
eros-Olmo 2020	15	60.67	34.0400	15	71.13	28.1400	<u>11</u>	-0.33	[-1.05; 0.40]	2.3%	2.9
Silva 2021	14	5.66	3.1200	14	13.30	6.0700		-1.54	[-2.39; -0.68]	1.6%	2.7
Silva 2021	14	8.20	2.1000	14	14.00	1.6000	i	-3.02	[-4.14; -1.89]	0.9%	2.3
Silva 2021	16	5.50	5.6600	16	4.96	4.1300		0.11	[-0.59; 0.80]	2.5%	2.9
Silva 2021	16	4.20	4.0000	16	4.80	8.0000	<u>*</u> +-	-0.09	[-0.79; 0.60]	2.5%	2.9
njae Lee 2021	20	9.20	1.4700	20	10.30	1.4200		-0.75	[-1.39; -0.10]	2.9%	3.0
njae Lee 2021	20	7.35	1.0900	20	8.35	1.6300		-0.71	[-1.35; -0.07]	2.9%	3.0
ommon effect model	481			481			ÿ I	-0.71	[-0.85; -0.58]	64.7%	
andom effects model				100			🛶	-0.92	[-1.32; -0.53]		73.1
eterogeneity: $l^2 = 78\%$ , $\tau^2$	= 0.8908	, p < 0.01						-0.02			10.1
ommon effect model	774			784				-0.58	[-0.69; -0.47]	100.0%	
andom effects model							· · · · · · · · · · · · · · · · · · ·	-0.77	[-1.08; -0.47]	-	100.09
eterogeneity: / <sup>2</sup> = 77%, t	= 0.6900	0 < 0.01					-4 -2 0 2 4				
st for subgroup difference	es (comn	non effect):									
st for subgroup difference	es (rando	merrects):	X <sub>2</sub> = 7.01, 0	- 2 (p =	0.02)						
URE 7											

### Subgroup: Intensity

Intensity was one of the most important parameters of exercise intervention. Heart rate, as the main indicator of intensity, was measured in most studies. Based on the report of the American College of Sports Medicine, < 64% of the maximum was considered low intensity, 64-76% of the heart rate maximum was regarded as moderate intensity, and 77-95% of the heart rate maximum was considered high intensity

(46). However, a few studies did not report the measurement of intensity.

According to the intensity of the subjects, studies were divided into three groups, light, moderate, and high, respectively. It can be observed that moderate [SMD = -0.75, 95% CI (-1.07, -0.43), I<sup>2</sup> = 67%, P < 0.01] and light [SMD = -1.07, 95% CI (-1.08, -0.47), I<sup>2</sup> = 85%, P < 0.01] were statistically significant through the subgroup analysis

			erimental	-		Control	Standardised Mean			Weight	Weigh
tudy	Total	Mean	SD	Total	Mean	SD	Difference	SMD	95%-CI	(common)	(random
pe = Anxiety							51				
dar 2018	19	12.20	7.1000	19	16.40	7.1000		-0.58	[-1.23; 0.07]	2.8%	2.99
a Silva 2018	16	6.20	2.0000	16	15.80	2.1000	<u> </u>	-4.58	[-5.94; -3.19]	0.6%	2.09
Silva 2018	13	4.50	0.7000	13	4.70	0.9000	护士	-0.24	[-1.01; 0.53]	2.0%	2.8
Silva 2019	14	4.50	0.7000	14	4.70	0.0900		-0.39	[-1.14; 0.36]	2.1%	2.8
Silva 2019	16	6.20	2.0000	16	15.80	2.1000	!	-4.58	[-5.94; -3.19]	0.6%	2.0
Oliveira 2019	10	4.50		10	9.00		3			0.0%	0.0
eros-Olmo 2020	15	60.67	34.0400	15	71.13	28,1400	4	-0.33	[-1.05; 0.40]	2.3%	2.9
Silva 2021	14	8.20	2.1000	14	14.00	1.6000	ü	-3.02	[-4.14; -1.89]	0.9%	2.3
Silva 2021	16	4.20	4.0000	16	4.80	8.0000		-0.09	Charl shares in the second	2.5%	2.9
							_8_		[-0.79; 0.60]		
injae Lee 2021	20	7.35	1.0900	20	8.35	1.6300	ī	-0.71	[-1.35; -0.07]	2.9%	3.0
ebb 2001	19	27.50	2.5000	19	33.10	2.6000		-2.15	[-2.96; -1.34]	1.8%	2.7
ebb 2001	21	32.00	2.6000	21	33.50	2.7000		-0.58	[-1.17; 0.06]	3.1%	3.09
ahin 2019	30	6.03	2.8700	30	9.86	4.0600		-1.08	[-1.62; -0.53]	4.0%	3.19
ahin 2019	30	7.90	3.7700	30	10.70	4.3900		-0.68	[-1.20; -0.15]	4.4%	3.19
erger 1992	17	42.00		22	41.00		<u>;</u> ]			0.096	0.0
ndeman 2002	25	2.00	1.4000	25	2.40	2.0000	부수	-0.23	[-0.78; 0.33]	3.8%	3.19
ommon effect model	295			300			4	-0.83	[-1.02; -0.65]	33.9%	
andom effects model								-1.28	[-2.04; -0.53]	-	38.59
eterogeneity: $I^2 = 87\%$ , $\tau^2$	= 1,9078	p < 0.01					:				
	1.0010	10.01					5				
ne = Depression											
pe = Depression anaka 1999	10	4.00	1.3000	10	3.60	1.5000	;ı	0.00	10 50 1000	4.00	2.79
	12			12				0.28	[-0.53; 1.08]	1.8%	
anaka 1999	12	5.20	1.5000	12	5.50	0.9000		-0.23	[-1.04; 0.57]	1.8%	2.79
zazian 2016	18	4.78	3.4200	18	19.17	7.8300	<u> </u>	-2.33	[-3.19; -1.46]	1.6%	2.79
dar 2018	19	43.10	6.9000	19	47.10	8.6000		-0.50	[-1.15; 0.14]	2.8%	3.09
Silva 2018	16	8.30	2.7000	16	9.60	2.3000		-0.51	[-1.21; 0.20]	2.4%	2.99
Silva 2018	13	4.20	1.9000	13	5.20	2.9000		-0.40	[-1.17; 0.38]	2.0%	2.8
levatti 2018	17	8.40	1.6000	17	9.70	1.1000	- <u>÷</u> -	-0.92	[-1.64; -0.21]	2.3%	2.9
Silva 2019	14	4.20	1.9000	14	5.20	2.9000		-0.40	[-1.15; 0.35]	2.1%	2.89
Silva 2019	16	8.30	2,7000	16	9.60	2.3000	<u> </u>	-0.51	[-1.21; 0.20]	2.4%	2.9
eros-Olmo 2020	15	13.30	7,7400	15	17.40	9.8200	_ <u>i</u>	-0.45	[-1.18; 0.27]	2.3%	2.9
Silva 2021	14	5.66	3.1200	14	13.30	6.0700		-1.54	[-2.39; -0.68]	1.8%	2.79
Silva 2021	16	5.50	5.6600	16	4.98	4.1300		0.11	[-0.59; 0.80]	2.5%	2.9
	20	9.20	1.4700	20			<u> </u>			2.9%	3.09
unjae Lee 2021					10.30	1.4200		-0.75	[-1.39; -0.10]		
erger 1997	39	1.86	2.5700	39	3.17	3.2700	<u>با</u>	-0.44	[-0.89; 0.01]	5.9%	3.29
erger 1997	39	2.47	2.7600	39	2.63	2.9100	_i	-0.06	[-0.50; 0.39]	6.0%	3.29
ahin 2019	30	5.56	3.7100	30	8.96	4.5900		-0.80	[-1.33; -0.28]	4.3%	3.19
ahin 2019	30	7.53	3.8300	30	10.13	4.4400		-0.62	[-1.14; -0.10]	4.4%	3.19
erger 1992	17	42.00		22	42.00		i i			0.0%	0.09
uttunen 2004	36	4.30	4.1000	36	4.80	5.7000	<u>14</u>	-0.10	[-0.56; 0.36]	5.6%	3.29
erez 2019	15	3.00	2.1000	15	4.07	2.7000		-0.43	[-1.16; 0.29]	2.3%	2.9
ommon effect model	408			413				-0.48	[-0.62; -0.33]	56.9%	
andom effects model							<b>*</b>	-0.52	[-0.74; -0.30]		55.3
terogeneity: $I^2 = 55\%$ , $z^2$	= 0.1281	n < 0.01					2				
	0.1201	10.01					2				
pe = Stress							5 I I I I I I I I I I I I I I I I I I I				
	10	17.00		10	07.50					0.02	0.01
Oliveira 2019	10	17.00		10	37.50		<u>j</u> [			0.0%	0.0
and Takal Manual Di	da na seco						ŝ				
e = Total Mood Distu					10000		<u></u>	100 100			
uttunen 2004	36	2.10	1.8000	36	3.00	2.6000	Ξ <u>μ</u>	-0.40	[-0.86; 0.07]	5.4%	3.29
m 2015	25	170.96	4.4100	25	171.68	4.9600		-0.15	[-0.71; 0.40]	3.8%	3.19
ommon effect model	61			61			:+	-0.30	[-0.65; 0.06]	9.3%	
indom effects model							1	-0.30	[-0.65; 0.06]		6.2
eterogeneity: $I^2 = 0\%$ , $\tau^2$	= 0, p = 0	.50					31				
1000							5 L				
ommon effect model	774			784			*	-0.58	[-0.69; -0.47]	100.0%	
andom effects model							<b>*</b>	-0.77	[-1.08; -0.47]		100.09
che ors model											
tomonophic 12 - 778	- 0 -00	0 < 0.01					-4 -2 0 2 4				
eterogeneity: $I^2 = 77\%$ , $\tau^2$			2	11-01	10.00						
st for subgroup difference											
st for subgroup difference	es (rando	m effects):	$\chi_2 = 5.38$ , d	r = 2 (p =	: 0.07)						
IURE 8											

(Figure 10). There was no statistical significance in the high group. There was a statistically significant subgroup effect (P = 0.04).

## **Publication bias**

The funnel plot indicates the possible publication bias (Figure 11). Furthermore, the Egger method was

used for analysis. When the linear regression test was P < 0.01, the publication bias of studies was statistically significant.

A sensitivity analysis was also conducted. A leave-oneout meta-analysis was used to test the publication bias of a single study (Figure 12). After sequentially removing each study, no studies affecting heterogeneity were found ( $I^2 = 72\%-78\%$ ). This analysis confirmed the stability of the results.

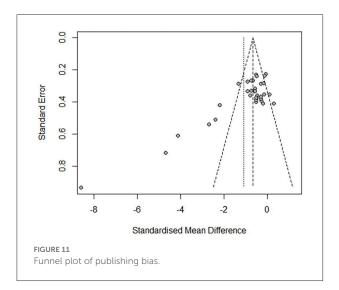
Study			erimental	-		Control	Standardised Mean			Weight	Weig
	Total	Mean	SD	Total	Mean	SD	Difference	SMD	95%-CI	(common)	(randor
uration = >12											
lerger 1992	17	42.00		22	41.00		5			0.0%	0.0
erger 1992	17	42.00		22	42.00					0.0%	0.0
indeman 2002	25	2.00	1.4000	25	2.40	2.0000	2-ch-	-0.23	[-0.78; 0.33]	3.8%	3.1
luttunen 2004	36	4.30	4.1000	36	4.80	5.7000	i+	-0.10	[-0.56; 0.36]	5.6%	3.2
luttunen 2004	36	2.10	1.8000	36	3.00	2.6000		-0.40	[-0.86; 0.07]	5.4%	3.2
(im 2015	25	170.96	4.4100	25	171.68	4.9600	<u> </u>	-0.15	[-0.71; 0.40]	3.8%	3.1
erez 2019	15	3.00	2.1000	15	4.07	2.7000	-#	-0.43	[-1.16; 0.29]	2.3%	2.9
Common effect model	171	0.00	2.1000	181	1.01	2.1000	2.	-0.25	[-0.48; -0.01]	20.9%	2.0
landom effects model							1.	-0.25	[-0.48; -0.01]		15.3
Heterogeneity: $I^2 = 0\%$ , $\tau^2 =$	= 0, p = 0.	88						-0.20	[10.40, 10.01]		10.0
duration = <4							3				
Berger 1997	39	1.86	2.5700	39	3.17	3.2700	÷-	-0.44	[-0.89; 0.01]	5.9%	3.2
Berger 1997	39	2.47	2.7600	39	2.63	2.9100	9 <u>1</u>	-0.08	[-0.50; 0.39]	6.0%	3.2
Vebb 2001	19	27.50	2.5000	19	33.10	2.6000	i l	-2.15	[-2.96; -1.34]	1.8%	2.7
Vebb 2001	21	32.00	2.6000	21	33.50	2,7000	- <u>+</u> -	-0.58	[-1.17; 0.06]	3.196	3.0
Sahin 2019	30	5.56	3,7100	30	8.96	4.5900	<u>_</u>	-0.50	[-1.33; -0.28]	4.3%	3.1
Sahin 2019	30	6.03	2.8700	30	9.86	4.0600		-1.08	[-1.62; -0.53]	4.0%	3.1
Sahin 2019	30	7.53	3.8300	30	10.13	4.4400		-0.62	[-1.14; -0.10]	4.4%	3.1
Sahin 2019 Sahin 2019	30	7.90	3.8300	30	10.13	4.4400	i		•	4.4%	3.1
		1.50	3.7700		10.70	4.3900	3	-0.68	[-1.20; -0.15]		3.1
Common effect model Random effects model Heterogeneity: $I^2 = 70\%$ , $\tau^2$	238	n < 0.01		238				-0.65 -0.74	[-0.83; -0.46] [-1.11; -0.37]	33.8%	24.4
	- 0.2036,	p < 0.01					i l				
iuration = 4-12							il.				
Fanaka 1999	12	4.00	1.3000	12	3.60	1.5000	: <u>-</u>	0.28	[-0.53; 1.08]	1.8%	2.7
Fanaka 1999	12	5.20	1.5000	12	5.50	0.9000	<u>9</u>	-0.23	[-1.04; 0.57]	1.8%	2.7
Razazian 2016	18	4.78	3.4200	18	19.17	7.8300		-2.33	[-3.19; -1.46]	1.6%	2.7
Aidar 2018	19	12.20	7.1000	19	16.40	7.1000		-0.58	[-1.23; 0.07]	2.8%	2.9
Aidar 2018	19	43.10	6.9000	19	47.10	8.6000	<del></del>	-0.50	[-1.15; 0.14]	2.8%	3.0
Da Silva 2018	16	8.30	2.7000	16	9.60	2.3000		-0.51	[-1.21; 0.20]	2.4%	2.9
Da Silva 2018	16	6.20	2.0000	16	15.80	2.1000	?	-4.58	[-5.94; -3.19]	0.6%	2.0
Da Silva 2018	13	4.20	1.9000	13	5.20	2.9000		-0.40	[-1.17; 0.38]	2.0%	2.8
Da Silva 2018	13	4.50	0.7000	13	4.70	0.9000		-0.24	[-1.01; 0.53]	2.0%	2.8
Delevatti 2018	17	8.40	1.6000	17	9.70	1,1000		-0.92	[-1.64; -0.21]	2.3%	2.9
a Silva 2019	14	4.20	1.9000	14	5.20	2,9000		-0.40	[-1.15; 0.35]	2,1%	2.8
la Silva 2019	14	4.50	0.7000	14	4.70	0.0900		-0.39	[-1.14; 0.36]	2.1%	2.8
la Silva 2019	16	8.30	2.7000	16	9.60	2.3000		-0.51	[-1.21; 0.20]	2.4%	2.9
a Silva 2019	16	6.20	2.0000	16	15.80	2.1000		-4.58	[-5.94; -3.19]	0.6%	2.0
de Oliveira 2019	10	4.50	2.0000	10	9.00	2.1000	2	4.00	[-0.04, -0.10]	0.0%	0.0
de Oliveira 2019	10	17.00		10	37.50		Î			0.0%	0.0
			7 7400			0 0000	<u></u>	0.45	1 4 40. 0 071		
Jseros-Olmo 2020	15	13.30	7.7400	15	17.40	9.8200	Ĩ	-0.45	[-1.18; 0.27]	2.3%	2.9
Jseros-Olmo 2020	15	60.67	34.0400	15	71.13	28.1400		-0.33	[-1.05; 0.40]	2.3%	2.9
la Silva 2021	14	5.66	3.1200	14	13.30	6.0700	<u> </u>	-1.54	[-2.39; -0.68]	1.6%	2.7
la Silva 2021	14	8.20	2.1000	14	14.00	1.6000	iL	-3.02	[-4.14; -1.89]	0.9%	2.3
la Silva 2021	16	5.50	5.6600	16	4.96	4.1300		0.11	[-0.59; 0.80]	2.5%	2.9
la Silva 2021	16	4.20	4.0000	16	4.80	8.0000	<u>è</u> +-	-0.09	[-0.79; 0.60]	2.5%	2.9
Eunjae Lee 2021	20	9.20	1.4700	20	10.30	1.4200	一	-0.75	[-1.39; -0.10]	2.9%	3.0
Longae Lee 2021	20	7.35	1.0900	20	8.35	1.6300		-0.71	[-1.35; -0.07]	2.9%	3.0
Eunjae Lee 2021	365			365			3	-0.69	[-0.85; -0.53]	45.2%	
Eunjae Lee 2021 Common effect model	000							-0.95	[-1.45; -0.45]		60.3
Eunjae Lee 2021	000										
Eunjae Lee 2021 Common effect model		p < 0.01					5 J				

## Discussion

This meta-analysis included 423 people who received a quatic exercise intervention; 18 studies synthesized the benefits of a quatic exercise, and the results revealed that a quatic exercise could statistically significantly improve mood and anxiety symptoms. The overall SMD = -0.77, [95% CI (-1.08, -0.47), I<sup>2</sup> = 77%, P < 0.01]. Ten different states of physical health are included in this review. Few comparable studies of a particular disorder made it difficult to determine which states would reap the most benefits from aquatic exercise. Nevertheless, this review found that aquatic exercise may be effective for general states of physical health observed, especially depression and hypertension. It is possible that the exercise increases the secretion of the related release of b-endorphin and dopamine and provides a soothing effect (47), while the muscular resistance of the

			erimental			Control	Standardised Mean			Weight	Weigh
tudy	Total	Mean	SD	Total	Mean	SD	Difference	SMD	95%-CI	(common)	(random
tensity = Moderate							2				
erger 1992	17	42.00		22	41.00		2			0.0%	0.09
erger 1992	17	42.00		22	42.00		2			0.0%	0.09
anaka 1999	12	4.00	1.3000	12	3.60	1.5000	;	0.28	[-0.53; 1.08]	1.8%	2.79
anaka 1999	12	5.20	1.5000	12	5.50	0.9000		-0.23	[-1.04; 0.57]	1.8%	2.79
ebb 2001	19	27.50	2.5000	19	33.10	2.6000	i	-2.15	[-2.96; -1.34]	1.8%	2.79
ebb 2001	21	32.00	2.6000	21	33.50	2.7000	<del></del>	-0.56	[-1.17; 0.08]	3.1%	3.09
m 2015	25	170.96	4.4100	25	171.68	4.9600	and the second se	-0.15	[-0.71; 0.40]	3.8%	3.19
zazian 2016	18	4.78	3.4200	18	19.17	7.8300		-2.33	[-3.19; -1.46]	1.6%	2.79
dar 2018	19	12.20	7.1000	19	16.40	7.1000	_ <u>+</u> +	-0.58	[-1.23; 0.07]	2.8%	2.99
dar 2018	19	43.10	6.9000	19	47.10	8.6000	ᅶᆤ	-0.50	[-1.15; 0.14]	2.8%	3.09
ahin 2019	30	5.56	3.7100	30	8.96	4.5900	-+-	-0.80	[-1.33; -0.28]	4.3%	3.19
ahin 2019	30	6.03	2.8700	30	9.86	4.0600		-1.08	[-1.62; -0.53]	4.0%	3.19
ahin 2019	30	7.53	3.8300	30	10.13	4.4400	1	-0.62	[-1.14; -0.10]	4.4%	3.19
ahin 2019	30	7.90	3.7700	30	10.70	4.3900	-ii-	-0.68	[-1.20; -0.15]	4.4%	3.19
	20	9.20	1.4700	20	10.30	1.4200		-0.08		2.9%	3.09
injae Lee 2021							<u>.</u>		[-1.39; -0.10]		
unjae Lee 2021	20 339	7.35	1.0900	20 349	8.35	1.6300		-0.71	[-1.35; -0.07]	2.9%	3.09
ommon effect model andom effects model	339			349			<u>.</u>	-0.72	[-0.88; -0.55]	42.5%	41.19
eterogeneity: $l^2 = 67\%$ ,	<sup>2</sup> = 0.2579	, <i>p</i> < 0.01					┨┱╌╾╌╾ <mark>┿</mark> ╺╖┝╼┝╌╪╌╪╴	-0.75	[-1.07; -0.43]	-	41.15
tensity = High							i l				-
erger 1997	39	1.86	2.5700	39	3.17	3.2700		-0.44	[-0.89; 0.01]	5.9%	3.29
erger 1997	39	2.47	2.7600	39	2.63	2.9100	24	-0.06	[-0.50; 0.39]	6.0%	3.29
elevatti 2018	17	8.40	1.6000	17	9.70	1.1000	- <u></u>	-0.92	[-1.64; -0.21]	2.3%	2.99
ommon effect model	95			95			1	-0.36	[-0.65; -0.07]	14.2%	
andom effects model terogeneity: $l^2 = 54\%$ ,	<sup>2</sup> = 0.0831	, p = 0.11						-0.41	[-0.85; 0.03]	-	9.29
tensity = N/R											
ndeman 2002	25	2.00	1.4000	25	2.40	2.0000	51	-0.23	[-0.78; 0.33]	3.8%	3.19
uttunen 2004	36	4.30	4.1000	36	4.80	5.7000	jul-	-0.10	[-0.56; 0.36]	5.6%	3.29
uttunen 2004	36	2.10	1.8000	36	3.00	2.6000		-0.40	[-0.86; 0.07]	5.4%	3.29
ommon effect model	97			97			1. The second	-0.24	[-0.53; 0.04]	14.8%	
andom effects model eterogeneity: $l^2 = 0\%$ , $\tau^2$ tensity = Light		.67						-0.24	[-0.53; 0.04]		9.49
a Silva 2018	18	8.30	2.7000	16	9.60	2.3000		-0.51	[-1.21; 0.20]	2.4%	2.99
Silva 2018	16	6.20	2.0000	16	15.80	2.1000	I	-4.58	[-5.94; -3.19]	0.6%	2.09
a Silva 2018	13	4.20	1.9000	13	5.20	2.9000		-0.40	[-1.17: 0.38]	2.0%	2.89
a Silva 2018	13	4.50	0.7000	13	4.70	0.9000		-0.24	[-1.01: 0.53]	2.0%	2.89
Silva 2019	14	4.20	1.9000	14	5.20	2.9000	-#	-0.40	[-1.15: 0.35]	2.1%	2.89
Silva 2019	14	4.50	0.7000	14	4.70	0.0900	÷-	-0.39	[-1.14; 0.36]	2.1%	2.89
Silva 2019	16	8.30	2.7000	16	9.60	2.3000	44	-0.51	[-1.21; 0.20]	2.4%	2.99
Silva 2019	16	6.20	2.0000	16	15.80	2.1000		-4.58	[-5.94; -3.19]	0.6%	2.09
Oliveira 2019	10	4.50	2.0000	10	9.00	2.1000		-4.00	[-0.04, -0.10]	0.0%	0.09
Oliveira 2019	10	17.00		10	37.50					0.0%	0.09
rez 2019	15	3.00	2.1000	15	4.07	2.7000		-0.43	[-1.16; 0.29]	2.3%	2.99
	15						II.				
eros-Olmo 2020 eros-Olmo 2020	15	13.30	7.7400	15	17.40	9.8200	盐	-0.45	[-1.18; 0.27]	2.3%	2.99
		60.67	0.000.000	15	71.13			-0.33	[-1.05; 0.40]	2.3%	
Silva 2021	14	5.66	3.1200	14	13.30	6.0700		-1.54	[-2.39; -0.68]	1.6%	2.79
Silva 2021	14	8.20	2.1000	14	14.00	1.6000	<u>!</u>	-3.02	[-4.14; -1.89]	0.9%	2.39
Silva 2021	16	5.50	5.6600	16	4.96	4.1300		0.11	[-0.59; 0.80]	2.5%	2.99
Silva 2021	16	4.20	4.0000	16	4.80	8.0000		-0.09	[-0.79; 0.60]	2.5%	2.99
ommon effect model	243			243			5	-0.67	-	28.5%	
andom effects model eterogeneity: $l^2 = 85\%$ , $\cdot$		, p < 0.01						-1.07	[-1.80; -0.34]	-	40.39
ommon effect model andom effects model	774			784				-0.58 -0.77	[-0.69; -0.47] [-1.08; -0.47]	100.0%	100.09
terogeneity: $l^2 = 77\%$ , st for subgroup different st for subgroup different st for subgroup different	ces (comm	non effect):					-4 -2 0 2 4				
URE 10											
	ntoreit	of and		auk au		Jucio of H	ne disease, moderate [SMD $= -0.75$ , 9	E9/ C1/ 4	07 0 471 12	670/ 0	. 0.041

water is more than ten times higher than the resistance of land. Hence, it requires more activation of the motor cortex in the elderly (39). Besides, people with type 2 diabetes are usually not sufficiently active. Activation of the brain and mood improvement are potentially important motivators for exercise (48). For patients with hypertension, the levels of the cytokines (TNF- $\alpha$  and IL-6) could be reduced by participating in the aquatic exercise program, suggesting the inhibitory effect of aquatic exercise on the production of pro-inflammatory cytokines (37).



Aquatic exercise is particularly effective in reducing anxiety. Comparing the results of this study with other studies, a meta-analysis conducted by Song (49) found the effect of land-based aerobic exercise on anxiety (SMD:-0.50), traditional Chinese exercise (SMD:-0.03), and meditation (SMD: -0.15). The above three exercises are lower than aquatic exercises (SMD: -1.28). Several studies have also shown that aquatic exercise can boost mood (35, 40, 50). However, those studies were relatively narrow, focusing primarily on relatively menial land aerobic exercise. The effect of aquatic exercise is different from that of land exercise and needs further research.

Compared with land-based aerobic exercise, aquatic exercise shows its particularity. The sensation of water flowing through the skin when moving in water is difficult to obtain when moving on land. Several studies indicated that touch could reduce stress and improve mood (51–54). The reduction in gravity also reduces the load on the spine, knees, and other pain-prone areas. In addition to physical factors, aquatic exercises are difficult for some people, especially in the sea and other special environments; thus, "confronting challenges" was key to the impact of mood (55). Moreover, aquatic exercise serves to connect and convey a sense of nature. With the function of re-orientating and changing the sense of body, space, and gravity, people can expand their perspectives (56).

Regarding the intervention type of exercise, aquatic aerobics (SMD: -0.92) is better than swimming (SMD: -0.51), but these studies lack consistency. Swimming includes swim-learning programs (28, 38), swimming training for competition (29, 57), and leisure swimming (31, 58, 59). Swimming in different situations affects people's moods differently. Similarly, aquatic

aerobics includes various forms. This may be one of the reasons for the high heterogeneity of research. In general, most of the aquatic aerobics' subjects are older or have ordinary diseases. Regarding safety and feasibility, older individuals prefer light, easy, and fun exercises over hard and stressful exercises (60). Therefore, they are more likely to benefit from water aerobics for their mental health than young, healthy adults. However, the trials in this study are insufficient for comparison. The specific impact needs further comparative study through similar samples. Winter swimming has little effect on improving mental health, which may be because the temperature stimulus of cold water is too strong, and then the body tends to remain tense (32, 33). For this reason, winter swimming may not be an effective way to improve mental health.

Based on the results of this study, the low intensity of aquatic exercise causes greater benefits for mental health. It may be that lower intensity makes people more relaxed (49). However, the acceptability of people of different ages and disease conditions to the intensity should also be considered, making it necessary to judge the research results carefully.

The influence of age and sex is not fully reflected in this study. In this study, the impact of exercise on the moods of the elderly was not statistically significant. The influence of age on the effect of exercise intervention is still controversial. A study of land-based exercise intervention shows that there were no significant differences in the amount of improvement between the younger and older exercise groups (61). However, some researchers find that exercise has greater distinct effects on brain activity and mood improvement in young people than in older people (62). Although the trials included in this investigation indicated the sex of the subjects, most studies were not classified by sex in the results, making sex-specific subgroup analysis challenging. Although some research (19, 25, 63, 64) suggests no difference in the positive effects of exercise based on sex, some evidence suggests that males may get greater advantages from exercise on their mood than females (65). Thus, more study is required to determine whether aerobic exercise has different effects on mood depending on gender and age.

There are a few limitations to this study. First, the betweenstudy heterogeneity is significant, and our subgroup and sensitivity analyses cannot entirely account for it. Second, this study only selected articles published in English to limit the risk of bias. There may be influential publications written in languages other than English that were not included. Finally, non-randomized controlled trials were included, which may lead to selection bias. Given the limitations in our review, more large-scale research should be conducted in the future.

Study	Standardised Mean Difference	SMD	95%-CI	P-value	Tau2	Tau	Ľ
mitting Person 1002		0.50	[-0.69; -0.47]	- 0.01	0 6000	0.0207	770
Dmitting Berger 1992 Dmitting Berger 1992	- <u> </u>		[-0.69; -0.47]			0.8307	
						0.8542	
Dmitting Berger 1997	and a second sec		[-0.70; -0.48]				
Omitting Berger 1997	NAME OF TAXABLE OF TAX		[-0.73; -0.50]			0.8414	
Omitting Tanaka 1999	and a second sec		[-0.71; -0.49]			0.8276	
Dmitting Tanaka 1999	and the second se		[-0.70; -0.48]			0.8476	
Omitting Webb 2001			[-0.66; -0.44]			0.7938	
Dmitting Webb 2001	and a second sec		[-0.69; -0.47]			0.8547	
Dmitting Lindeman 2002			[-0.71; -0.48]				
Dmitting Huttunen 2004	100		[-0.72; -0.50]			0.8434	
mitting Huttunen 2004			[-0.70; -0.48]			0.8532	
Dmitting Kim 2015	<u> </u>		[-0.71; -0.49]			0.8456	
mitting Razazian 2016			[-0.66; -0.44]				
mitting Aidar 2018			[-0.69; -0.47]			0.8546	
mitting Aidar 2018			[-0.69; -0.47]			0.8538	
Dmitting Da Silva 2018	- <u>-</u>		[-0.69; -0.47]			0.8534	
Omitting Da Silva 2018			[-0.67; -0.45]			0.6271	
Dmitting Da Silva 2018		-0.59	[-0.70; -0.48]	< 0.01	0.7245	0.8512	789
Dmitting Da Silva 2018		-0.59	[-0.70; -0.48]	< 0.01	0.7190	0.8479	789
mitting Delevatti 2018		-0.57	[-0.68; -0.46]	< 0.01	0.7279	0.8532	789
mitting da Silva 2019		-0.59	[-0.70; -0.48]	< 0.01	0.7249	0.8514	789
mitting da Silva 2019			[-0.70; -0.48]		0.7247	0.8513	789
mitting da Silva 2019	- <u></u>		[-0.69; -0.47]			0.8534	
Dmitting da Silva 2019			[-0.67; -0.45]			0.6271	
Omitting de Oliveira 2019			[-0.69; -0.47]			0.8307	
Omitting de Oliveira 2019			[-0.69; -0.47]			0.8307	
Omitting Perez 2019	- <del></del>		[-0.70; -0.47]			0.8522	
mitting Sahin 2019	- <u>+</u> -		[-0.68; -0.46]				
Dmitting Sahin 2019			[-0.67; -0.45]			0.8518	
mitting Sahin 2019			[-0.69; -0.47]			0.8560	
mitting Sahin 2019	- <u>T</u>		[-0.69; -0.47]			0.8562	
mitting Useros-Olmo 2020	- <u>-</u>		[-0.69; -0.47]				
mitting Useros-Olmo 2020	<u>-</u>		[-0.70; -0.48]			0.8502	
mitting da Silva 2021			[-0.68; -0.46]			0.8351	
mitting da Silva 2021			[-0.67; -0.45]			0.7387	
mitting da Silva 2021	- 100 - 100		[-0.71; -0.49]				
mitting da Silva 2021			[-0.70; -0.48]				
Dmitting Eunjae Lee 2021		-0.58	[-0.69; -0.47]	< 0.01	0.7313	0.0002	700
Omitting Eunjae Lee 2021		-0.58	[-0.69; -0.47]	< 0.01	0.7314	0.8552	187
common effect model	<b>*</b>	-0.58	[-0.69; -0.47]	< 0.01	0.6900	0.8307	779
	-0.6 -0.4 -0.2 0 0.2 0.4 0.6	5					

Sensitivity analysis plot. A leave-one-out meta-analysis was used to test the publication bias of a single study. No studies affecting heterogeneity were found ( $l^2 = 72-78\%$ ).

# Conclusion

Aquatic exercise could statistically significantly improve mental health. Light aquatic aerobics may have a better effect on mood and anxiety symptoms. However, given the number and quality of included research, verifying the above conclusions requires a larger sample size of highquality studies.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

# Author contributions

ZT and YW conceived of the idea and designed the study protocol. YL conducted statistical analysis. ZT and JL drafted the manuscript. ZT, YW, JL, and YL participated in the revision of the manuscript of the study. All authors contributed to the article and approved the submitted version.

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# **Conflict of interest**

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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