# The effects of water-based exercise on body weight in people with type 2 diabetes

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**The aim of this systematic review was to evaluate the effect of water-based exercise on body weight in people with type 2 diabetes. Data from seven studies met the inclusion criteria and were analysed. Four of the seven studies reported a significant reduction in body weight with water-based exercise programmes, while slight but non-significant reductions were reported in two studies. Three out of five studies reported a significant reduction in HbA$_{1c}$ levels, two out of five reported a significant reduction in blood pressure and, finally, four reported a significant improvement in maximum oxygen uptake.**

O ne of the major causes of type 2 diabetes is obesity (Ndisang et al, 2017). The American Diabetes Association (2021) recommends maintaining a healthy diet and regular exercise to reduce body weight and, therefore, reduce the risk of developing type 2 diabetes and complications associated with the condition. The Global Burden of Disease 2015 Obesity Collaborators (2017) have investigated the impact of obesity and found that 604 million adults are obese worldwide.

A complication associated with obesity is considerable joint compression and inflammation, leading to musculoskeletal disorders causing joint pain and decreased movement within lower limb joints and the lower back (Onyemaechi et al, 2016). In these circumstances, performing exercise to reduce weight can exacerbate joint pain, impacting on quality of life and physical function (Shultz and Ambrose, 2017). To overcome these difficulties, water-based exercise interventions have been proposed, and a meta-analysis by Barker et al (2014) concluded that low-weight-bearing exercise such as water-based exercise reduced pain and increased range of joint motion, improving physical function and quality of life.

Williams et al (2016) performed a systematic review confirming the link between type 2 diabetes and musculoskeletal disorders. Within that review, the authors highlighted that people with type 2 diabetes are advised to carry out physical exercises regularly but that their pain and physical limitations are not being taken into consideration, impacting on their treatment and leading to further progression of both their diabetes and musculoskeletal disorders.

Water-based environments provide a safe and protective means to exercise due to water's buoyancy, and thus they reduce the risk of joint injury. This allows individuals who are overweight or obese with musculoskeletal complications to exercise at a high intensity that can generate weight loss and improve fitness levels which may not be achievable on land due to heavy joint loading (Becker, 2009).

Systematic reviews have assessed how water-based exercise programmes affect glycaemic control, vascular function and quality of life in people living with type 2 diabetes (Rees et al, 2017). However, no systematic review has yet been completed on the impact of water-based exercise on body weight in people with type 2 diabetes. Thus, this systematic

**Article points**

1. Water-based exercise offers overweight and obese people with type 2 diabetes the opportunity to partake in exercise with a lesser impact on joints and muscle than land-based exercise.

2. This review suggests that structured water-based exercise programmes can result in improvements in weight, HbA$_{1c}$, blood pressure and cardiorespiratory fitness.

3. The evidence is limited by small study sizes and high dropout rates, and more research into the longer-term effects of water-based exercise is needed.

**Key words**

- Obesity, diet and lifestyle
- Type 2 diabetes
- Water-based exercise

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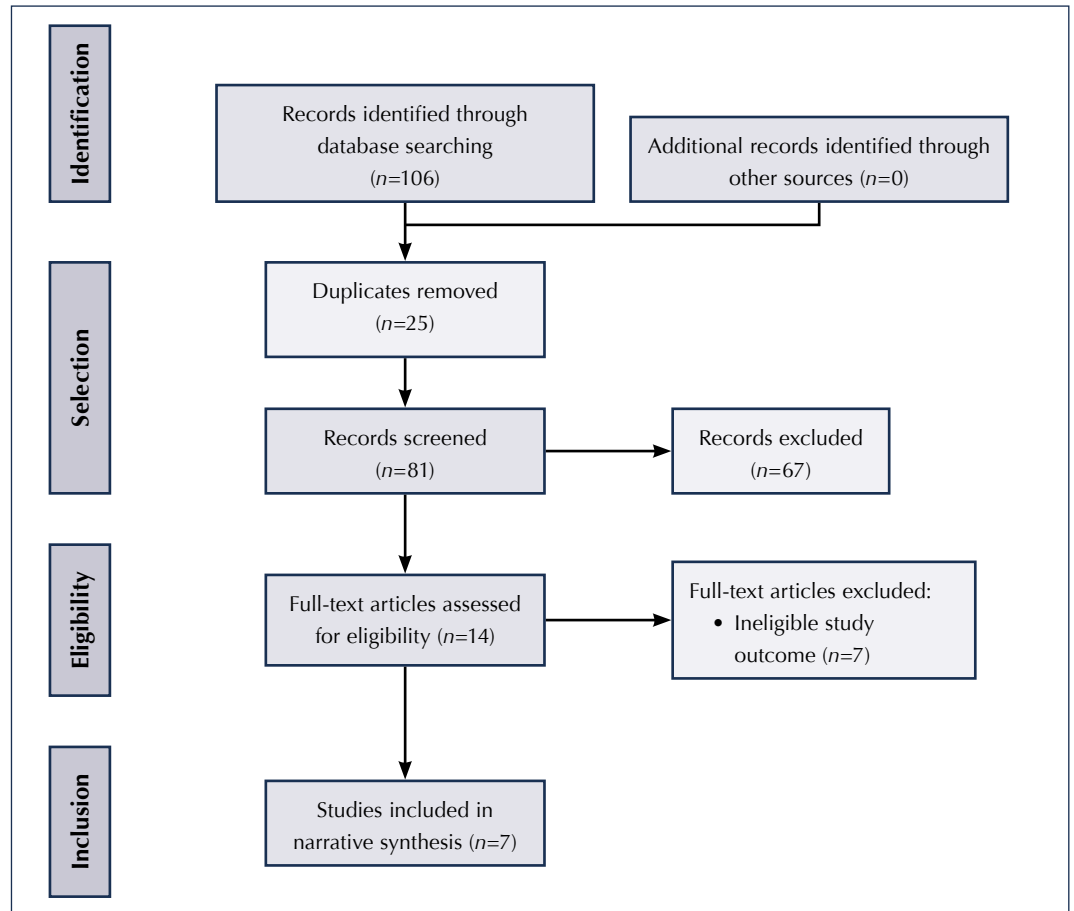
*Figure 1. PRISMA flowchart.*

review aims to address a gap in the research and our knowledge.

## Methods

### Aim

The aim of this systematic review was to examine the effect of water-based exercise programmes on body weight in people with type 2 diabetes.

### Inclusion criteria

Studies had to include participants over the age of 18 years with a diagnoses of type 2 diabetes. The intervention must have included a structured, water-based exercise programme with reported pre- and post-intervention body weight measurements. Only English-language articles were considered. Studies that did not report the primary or secondary outcomes were excluded.

### Search strategy

Using the search strategy guidelines of the *Cochrane*

*Handbook for Systematic Reviews of Interventions* (Higgins et al, 2022a), a systematic search was performed to ensure all relevant literature was included. Through use of the EBSCO host search engine, the MEDLINE, CINAHL Plus with Full Text, Health Business Elite, Information Science & Technology Abstracts and APA PsycInfo databases were searched, in addition to the individual PubMed, Google Scholar and Cochrane Library databases.

Key search terms as below were used in each of the databases, along with the Boolean operators "OR" and "AND":
- Diabetes mellitus type 2.
- Diabetes.
- Water-based exercise.
- Aquatic based exercise.
- Weight.
- Body mass.

*Figure 1* summarises the overall process of the comprehensive search that was undertaken.

## Table 1. Details of water-based exercise interventions.

| Study | Type of exercise | Sessions per week | Minutes per session | Facility used | Equipment used |
|-------|------------------|-------------------|---------------------|---------------|----------------|
| Reis Filho et al (2012) | Aqua aerobics | 3 times per week | 10 minutes warm-up; 40 minutes exercise; 10 minutes cool-down (total 60 minutes) | Swimming pool; temperature 27–30°C | Floats, dumbbells, rubber bands, batons |
| Nuttamonawarakul et al (2012) | Aqua aerobics | 3 times per week | 10 minutes warm-up; 30 minutes exercise; 10 minutes cool-down (total 50 minutes) | Swimming pool; temperature 34–36°C | Not stated |
| Sporis et al (2013) | Aqua aerobics | 3 times per week | 10 minutes warm-up; 40 minutes exercise; 10 minutes cool-down (total 60 minutes) | Swimming pool; temperature 26–28°C | Not stated |
| Cugusi et al (2015) | Water circuit training | 3 times per week | 10 minutes warm-up; 30 minutes exercise; 10 minutes cool-down (total 50 minutes) | Swimming pool; temperature 31–32°C | Aquatic equipment |
| Suntraluck et al (2017) | Water cycling | 3 times per week | 10 minutes warm-up; 15 minutes exercise; 10 minutes cool-down (total 35 minutes) | Water tank; temperature 36°C | Monark cycle ergometer 894e |
| Conners et al (2019) | Underwater treadmill walking | 3 times per week | Week 1, 30 minutes; gradual increase in duration; week 12, 60 minutes | Water tank; temperature 29–31°C | Ferno Aquatic underwater treadmill |
| Scheer et al (2020) | Water circuit training | 3 times per week | 5 minutes warm-up; 40 minutes exercise; 5 minutes cool-down (total 50 minutes) | Swimming pool; temperature 30°C | Paddles |

### Data extraction and quality appraisal

Accurate, relevant and standardised data were collated and presented using a bespoke data extraction table. The Evidence-Based Librarian critical appraisal checklist tool (Glynn, 2006) was used to assess the quality and validity of each selected study.

### Data analysis

It was initially attempted to run a meta-analysis using RevMan; however, this was not possible as the statistical heterogeneity of the combined studies, tested using the I² value, was 95%, indicating considerable heterogeneity. Therefore, a narrative analysis methodology was used.

## Results

### Description of included studies

Of the seven studies that met the inclusion criteria, two were based in Thailand and the other five were based in Italy, USA, Brazil, Croatia and Australia, respectively. The timeframe of the studies ranged from 2012 to 2020, and they were set predominantly in a community setting, with one study conducted in a hospital setting. One study did not state the setting.

### Study participants

All seven studies involved adults over the age of 18 years with a medical diagnosis of type 2 diabetes. No participants were on insulin and no change was made to any participant's medication or treatment during the course of any of the studies.

Four studies focused on adults over the age of 60 years (Reis Filho et al, 2012; Nuttamonwarakul et al, 2012; Suntraluck et al, 2017; Scheer et al, 2020). Cugusi et al (2015) enrolled participants aged 40–65 years, while the participants in Conners et al (2019) had a mean age of 58 years. In Sporis et al (2013), participants were aged between 39 and 73 years, with a mean age of 56 years. The study by Cugusi et al (2015) had male participants only; all other studies involved male and female participants. The smallest sample size was 18 (Cugusi et al, 2015) and the largest was 40 (Nuttamonwarakul et al, 2012).

### Description of water-based exercises

*Table 1* details the different types of water-based exercise and the elements that were involved in each study. Intensity levels of the exercises were measured differently throughout the studies, as seen in *Table 2* (overleaf). The Borg scale: Rating

| Table 2. Measurements of exercise intensity. | | |
|---|---|---|
| **Study** | **Intensity measurement** | **Rating** |
| Reis Filho et al (2012) | Borg scale rating | 11–13 RPE |
| Nuttamonawarakul et al (2012) | Borg scale rating and maximum heart rate | 10–16 RPE<br>70% of MHR |
| Sporis et al (2013) | Heart rate reserve | Month 1–2: 60% of HR<br>Month 3–4: 65% of HR<br>Month 5–6: 70% of HR |
| Cugusi et al (2015) | Maximum oxygen consumption ($VO_{2max}$) | 50–75% of $VO_{2max}$ |
| Suntraluck et al (2017) | Maximum heart rate | First 4 weeks: 50–60% of MHR for 35 minutes<br>Next 4 weeks: 60–70% of MHR for 40 minutes<br>Remaining 4 weeks: 60–70% of MHR for 50 minutes |
| Conners et al (2019) | Heart rate reserve | Week 1: 40–50%; gradually increased; Week 12: 50–70% |
| Scheer et al (2020) | Borg scale rating and maximum heart rate | 12–15 RPE<br>60–80% of MHR |

HR=heart rate; MHR=maximum heart rate; RPE=rating of perceived exertion.

of Perceived Exertion (Borg, 1982) was used in three studies to measure exercise intensity (Reis Filho et al, 2012; Nuttamonwarakul et al, 2012; Scheer et al, 2020). The Borg scale measures an individual's perception of the difficulty of an activity, with six being no exertion, and 20 meaning maximum exertion (Ritchie, 2012). Exercise intensity levels as a percentage of maximum heart rate (MHR) was recorded within three studies (Nuttamonwarakul et al, 2012; Suntraluck et al, 2017; Scheer et al, 2020). MRH is used in physical activity studies as an indicator of a participant's level of effort (Boer, 2017). It is determined and formulated by subtracting a participant's age from 220; for example, 220 (years) − 60 = 160 bpm MHR. Two studies measured intensity by monitoring heart rate reserve (Sporis et al, 2013; Conners et al, 2019). Heart rate reserve is found by subtracting a resting heart rate from a maximum heart rate. One study measured exercise intensity by monitoring maximum oxygen consumption ($VO_{2max}$; Cugusi

et al, 2015). This measurement is widely used to measure cardiorespiratory fitness (Chavarrias et al, 2020) and measures the maximum amount of oxygen consumed during exercise.

**Data collection methods**
The participants' weight was measured at the beginning of all seven studies. Different brands of scales were used to take measurements throughout the studies. One study obtained measurements on the first, sixth and final twelfth week of the study (Reis Filho et al, 2012). Sporis et al (2013) carried out measurements one week before the trial, at 3 months and at 6 months. All other studies obtained measurements on the first and last week of the trial.

**Outcomes measured**
The seven studies measured the effect of water-based exercise on a range of outcomes, including body weight, $HbA_{1c}$ levels, blood pressure measurements and maximum oxygen uptake. The data and information extracted from each study are represented in *Table 3* (overleaf).

**Primary outcome results: Body weight**
The form of water-based exercise and the measurement of intervention intensity varied throughout the seven studies. Because of the heterogeneous nature of the studies, a narrative analysis of the primary outcomes was carried out. In Reis Filho et al (2012), 12 weeks of water aerobics resulted in a significant body weight reduction within males (2.5 kg reduction; $P=0.01$), but not females (2.8 kg reduction; $P=0.09$).

Nuttamonwarakul et al (2012) reported a significant reduction (1.7 kg reduction; $P<0.05$) in the participants' body weight after 12 weeks of aqua aerobic exercise. Sporis et al (2013) reported a significant reduction of 2.64% after six months of aquatic aerobics. Cugusi et al (2015) reported a significant reduction (2.3 kg; $P<0.05$) in body weight after 12 weeks of water circuit training. Conners et al (2019) reported a mean body weight reduction of 2.99 kg (no $P$-value reported) after 12 weeks of underwater treadmill training sessions.

However, Scheer et al (2020) found no significant reduction (0.6 kg; $P=0.110$) in body weight measurements after 8 weeks of water circuit training, and Suntraluck et al (2012) observed an increase in

**Table 3. Details of water-based exercise interventions.**

| Author(s) and year | Country | Study setting | Study design | Population | Primary outcomes | Secondary outcomes |
|---|---|---|---|---|---|---|
| Reis Filho et al (2012) | Brazil | Community; Family Health Unit | 12 weeks aqua aerobics Experimental study | *N*=29 (intervention groups: 5 female, 10 male; control groups: 9 female, 5 male) | **Body weight (kg)** *Male intervention group* Baseline: 78.0±8.6 Follow-up: 75.5±8.5 (*P*=0.001) *Female intervention group* Baseline: 72.6±3.8 Follow-up: 69.8±6.0 (*P*=0.09) | |
| Nuttamon-warakul et al (2012) | Thailand | Community | 12 weeks aqua aerobics Randomised controlled trial | *N*=40 (intervention group *n*=20; control group *n*=20) | **Body weight (kg)** *Intervention group* Week 1: 62.8±8.6 Week 12: 61.1±8.3 (*P*<0.05) | **Systolic BP (mmHg)** Baseline: 117.6±15.0 Follow-up: 115.2±13.4 (*P*<0.05) **Diastolic BP (mmHg)** Baseline: 74.7±11.6 Follow-up: 71.7±8.3 (*P*<0.05) **HbA$_{1c}$ (DCCT %)** Baseline: 7.7±1.1% Follow-up: 6.6±0.7% (*P*<0.05) **VO$_{2max}$ (mL/kg/min)** Baseline: 23.6±0.5 Follow-up: 24.0±0.5 (*P*<0.05) |
| Sporis et al (2013) | Croatia | Community | 6 months aqua aerobics Observational study | *N*=24 | **Body weight (kg)** Pre-trial: 84.48±21.12 3 months: 83.42±20.95 6 months: 82.24±20.59 (*P*<0.05) | **HbA$_{1c}$ (DCCT %)** Pre-trial: 7.58±1.77 Post-trial: 7.05±1.45 (*P*<0.05) |
| Cugusi et al (2015) | Italy | Primary care | 12 weeks aquatic-based exercise programme Observational study | *N*=18 | **Body weight (kg)** Week 1: 89.11±18.03 Week 12: 86.83±17.94 (*P*<0.05) | **Systolic BP (mmHg)** Baseline: 130.66±17.45 Follow-up: 125.44±12.65 (*P*<0.05) **Diastolic BP (mmHg)** Baseline: 82.55±10.14 Follow-up: 77±6.54 (*P*<0.05) **HbA$_{1c}$ (DCCT %)** Baseline: 8.07±0.82 Follow-up: 7.56±0.9 (not significant; *P*-value not reported) **VO$_{2max}$ (mL/kg/min)** Baseline: 21.15±5.9 Follow-up: 24.1±4.9 (*P*<0.05) |
| Suntraluck et al (2017) | Thailand | Hospital | 12 weeks underwater cycling exercise training Randomised controlled trial | *N*=29 (water-based exercise group *n*=15; land-based exercise [control] group *n*=14) | **Body weight (kg)** *Water group* Week 1: 62.9±2.4 Week 12: 63.1±2.3 (not significant; *P*-value not reported) | **Systolic BP (mmHg)** Baseline: 140±5.7 Follow-up: 133±4.3 (not significant; *P*-value not reported) **Diastolic BP (mmHg)** Baseline: 79±3.4 Follow-up: 77±2.6 (not significant; *P*-value not reported) **HbA$_{1c}$ (mmol/mol)** Baseline: 62.4±3.5 Follow-up: 55.4±2.3 (*P*<0.05) **VO$_{2peak}$ (mL/min/kg)** Baseline: 15.7±1.0 Follow-up: 18.1±1.2 (*P*<0.05) |

(Table continues overleaf).

| **Table 3 (continued). Details of water-based exercise interventions.** | | | | | | |
|---|---|---|---|---|---|---|
| **Author(s) and year** | **Country** | **Study setting** | **Study design** | **Population** | **Primary outcomes** | **Secondary outcomes** |
| Conners et al (2019) | USA | Not stated | 12 weeks underwater treadmill training Randomised, treatment–control research design | *N*=26 (intervention group *n*=13; control group *n*=13) | **Body weight (kg)** Baseline: 94.96 Follow-up: 2.99 reduction (*P*-value not reported) | **Systolic BP (mmHg)** Baseline: 128.62 Follow-up: 120.93 (*P*-value not reported) **Diastolic BP (mmHg)** Baseline: 82.00 Follow-up: 76.00 (*P*-value not reported) **HbA$_{1c}$ (DCCT %)** Baseline: 7.25 Follow-up: 6.58 (*P*-value not reported) |
| Scheer et al (2020) | Australia | Community | 8 weeks upright water-based exercise training Quasi-experimental study | *N*=27 (intervention group *n*=13; control group *n*=14) | **Body weight (kg)** Week 1: 99.7±22.6 Week 8: 99.1±22.8 (*P*=0.110) | **Peak systolic BP (mmHg)** Baseline: 195±15 Follow-up: 197±21 (*P*=0.505) **Peak diastolic BP (mmHg)** Baseline: 94±6 Follow-up: 91±6 (*P*=0.067) **HbA$_{1c}$ (DCCT %)** Baseline: 7.33±0.97 Follow-up: 7.12±1.07 (*P*=0.076) **VO$_{2peak}$ (mL/kg/min)** Baseline: 18.5±4.3 Follow-up: 21.5±5.4 (*P*=0.02) |

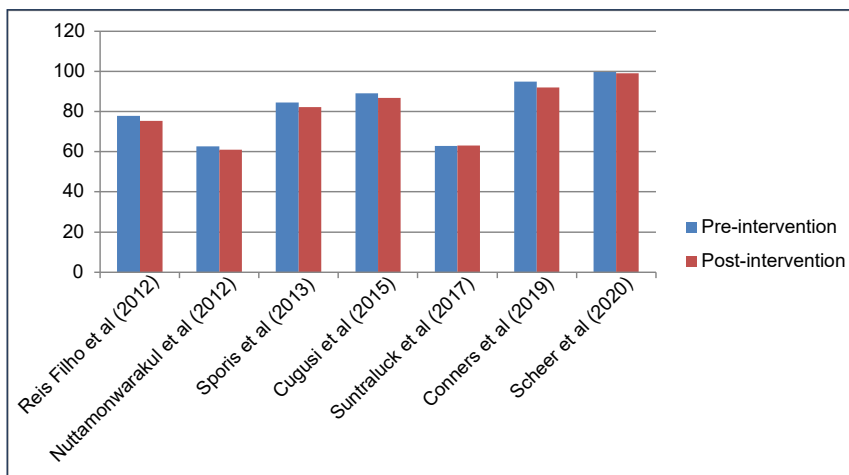BP=blood pressure; DCCT=Diabetes Control and Complications Trial



*Figure 2. Body weight measurements before and after water-based exercise.*

body weight after 12 weeks of a water cycling training programme (0.2 kg; no *P*-value reported).

*Table 3* presents the mean body weight measurements reported in the studies, and *Figure 2* is a visual representation of the primary outcome findings.

**Secondary outcome results**

**Blood pressure**

Four of the seven studies measured the effect of water-based exercise on resting systolic and diastolic blood pressure (BP) readings (see *Table 3*). Nuttamonwarakul et al (2012) reported a significant reduction (*P*<0.05) in resting blood pressure, both systolic (2.4 mmHg) and diastolic (3.0 mmHg), amongst the participants after 12 weeks of aqua aerobics. Cugusi et al (2015) observed significant (*P*<0.05) reductions in systolic (5.22 mmHg) and diastolic BP (5.55 mmHg) after 12 week of aqua aerobics. Suntraluck et al (2017) reported a reduction in BP after 12 weeks of underwater cycling; however, this was not a significant difference and no *P*-value was reported. Resting systolic and diastolic BP readings were also reported by Conners et al (2019). Systolic BP dropped by 7.69 mmHg and diastolic BP by 6.00 mmHg after 6 months of underwater treadmill training. It was not indicated whether this was a significant reduction.

## HbA$_{1c}$ levels

Six of the seven studies reported the effect of water-based exercise on HbA$_{1c}$ levels (see *Table 3*). After 12 weeks of aquatic aerobics, Nuttamonwarakul et al (2012) reported a significant reduction in HbA$_{1c}$ (1.1%; *P*<0.05). Sporis et al (2013) also reported a significant reduction (0.53%; *P*<0.05) after 6 months of aqua aerobics. Suntraluck et al (2017) reported a significant reduction (7 mmol/mol; *P*<0.05) following 12 weeks of water cycling. Conners et al (2019) reported a reduction of 0.67% following a 12-week underwater treadmill exercise programme; however, a *P*-value was not reported. Both Cugusi et al (2015) and Scheer et al (2020) reported no significant change to HbA$_{1c}$ levels post-intervention.

## Maximum oxygen uptake (VO$_{2max}$)

The effects of water-based exercise on maximum oxygen uptake (VO$_{2max}$) was measured in four of the seven studies (see *Table 3*). VO$_{2max}$ is widely used to measure cardiorespiratory fitness, and is the rate at which oxygen is used during intense exercise (Grant et al, 1995). Nuttamonwarakul et al (2012) reported a significant increase in participants' VO$_{2max}$ levels (0.4 mL/kg/min; *P*<0.05) after 12 weeks of aqua aerobics. A significant improvement (2.95 mL/kg/min; *P*<0.05) was also reported by Cugusi et al (2015) after 12 weeks of aquatic exercise. Scheer et al (2020) reported a significant improvement (3.0 mL/kg/min; *P*=0.02) following eight weeks of water circuit training. Suntraluck et al (2017) reported a significant improvement (2.4 mL/kg/min; *P*<0.05) following 12 weeks of underwater cycling exercise training.

## Quality appraisal

The Evidence-Based Librarian critical appraisal checklist was completed on each of the seven studies. *Table 4* gives an overview of the validity score of each study. Six studies had a validity score over 75%. One study, by Cugusi et al (2015), scored 73.91%. It was unclear in this study whether the researcher was also involved in delivering a service to the target population. Three studies reported small sample sizes (Cugusi et al, 2015; Suntraluck et al, 2017; Scheer et al, 2020). Confounding variables were only identified in one study (Reis Filho et al, 2012) and were not reported in the other six

| Table 4. Evidence-Based Librarian critical appraisal checklist results. | | | | | |
|---|---|---|---|---|---|
| **Study** | **Population** | **Data collection** | **Study design** | **Results** | **Overall validity score** |
| Reis Filho et al (2012) | 100% | 85.71% | 100% | 100% | **91.7%** |
| Nuttamonawarakul et al (2012) | 85.71% | 85.71% | 80% | 66% | **80.0%** |
| Sporis et al (2013) | 100% | 85.71% | 80% | 66.66% | **82.6%** |
| Cugusi et al (2015) | 60% | 85.71% | 60% | 83.33% | **73.9%** |
| Suntraluck et al (2017) | 85.71% | 85.71% | 100% | 66.66% | **84.0%** |
| Conners et al (2019) | 100% | 85.71% | 100% | 83.33% | **92.0%** |
| Scheer et al (2020) | 50% | 85.71% | 100% | 83.33% | **76.9%** |

studies. The study by Cugusi et al (2015) only involved male participants and so this created a risk of population bias. In addition, the study did not report approval from an ethics committee; however, the researchers did report obtaining informed consent from participants. Lastly, three studies did not make any recommendations on further research (Nuttamonwarakul et al, 2012; Sporis et al, 2013; Suntraluck et al, 2017).

## Discussion

The primary aim of this systematic review was to review the evidence on the effect of water-based exercise on body weight in people with type 2 diabetes. The secondary outcomes that were focused on were blood pressure, HbA$_{1c}$ levels and maximum oxygen uptake.

In relation to the primary outcome, it was found that water-based exercise was effective in four of the seven studies in reducing body weight in participants with type 2 diabetes. Six of the seven studies reported the BMI of the participants, with all being either overweight or obese. The fact that all studies involved participants who were either overweight or obese adds strength to this systematic review as it is capturing the demographic profile of those who are most at risk of developing both cardiovascular and musculoskeletal complications associated with obesity and type 2 diabetes. In a one-year observational study, Wing et al (2011) recommended a weight loss of 5–10% to reduce the risk of cardiovascular complications; however, they

stated that as little as 2–5% weight loss can have a positive effect on cardiovascular risk factors by stabilising glycaemic control. Although a significant difference was not found in three of the studies, it can be considered that even a minimum amount of weight loss can reduce the risk of complications in an individual with type 2 diabetes.

Only two of five studies reported a significant reduction in BP following water-based exercise. Lowering BP levels in people with type 2 diabetes reduces cardiovascular risk, including stroke, and retinopathy (Emdin et al, 2015). However, it must be noted that the literature reports inconsistent BP targets for individuals with type 2 diabetes, making it difficult to set an optimum goal (Grossman and Grossman, 2017; Shen et al, 2019).

The effect of water-based exercise on maximum oxygen uptake showed a significant overall positive result, with four studies reporting a significant improvement in cardiopulmonary fitness in the participants. There is a link associated between $VO_{2max}$ and insulin sensitivity; if $VO_{2max}$ is improved then it can have a positive effect on insulin sensitivity, reducing insulin resistance and therefore lowering blood glucose levels (Leite et al, 2009).

Water-based exercise was reported to significantly decrease $HbA_{1c}$ levels in three studies. Reducing $HbA_{1c}$ levels by 11 mmol/mol (1.0%) is associated with a 14% reduction in myocardial infarction risk and a 21% reduction in diabetes-related mortality (Najafipour et al, 2017). Any improvement in BP, $VO_{2max}$ and $HbA_{1c}$ levels may have substantial effects on an individual basis.

Water-based exercise performed in warm water environments can increase leg muscle strength and endurance, reduce muscle pain and spasms, and is perceived to be more enjoyable, improving quality of life for people with musculoskeletal disorders (Foley et al, 2003; Cadmus et al, 2010; Kargarfard et al, 2012; Rees et al, 2017). Silva et al (2008) highlighted that water-based exercise was effective in reducing pain in people with osteoarthritis compared to land-based exercise.

Nam et al (2011) have reported pain to be one of the barriers in diabetes management. Due to these findings and limited studies in this topic, research into water-based exercise and pain management in people with type 2 diabetes could be considered for future research and could have beneficial findings

on how to treat individuals with type 2 diabetes who are obese and have musculoskeletal pain.

Finally, as diabetes is a long-standing, progressive disorder and the studies involved were conducted over a short period of time, ranging from 8 weeks to 6 months, it is recommended that more research be carried out involving long-term water-based exercise programmes and their long-term effects on people living with type 2 diabetes.

### Study strength and limitations

The sample sizes were relatively small in all studies. In three studies the authors recognised this as a limitation. Dropout rates were discussed by Reis Filho et al (2012), with a 17.5% dropout rate; Suntraluck et al (2017), with a 19.5% dropout rate; and Scheer et al (2020), with 30% of participants not completing the 8-week exercise programme. Both the small sample sizes and high dropout rates could have had an impact on the power of the studies' results and increase the risk of bias due to missing outcome data (Higgins et al, 2022b).

Three studies declared a limitation in that they had no control group to minimise the effect of variables. However, Suntraluck et al (2017) argued that it was deemed unethical to have a control group providing no intervention to the participants, so the authors compared water-based to land-based exercise.

To enhance the strength of this systematic review, it was noted that all seven studies performed water-based exercises that were structured and according to a programme. Intensity levels were reported and monitored closely in each study. These programmes can be easily replicated for use in future treatment interventions; however, strength also lies in the precision and accuracy of the intervention execution reported by each study, which ensures uniform data collection for each session. Contributing to the strength of this review, six of the seven studies scored over 75% when critically appraised.

### Conclusion

The primary aim of this systematic review was to investigate how water-based exercise affects body weight in people with type 2 diabetes. Overall findings suggested that water-based exercise significantly decreases body weight. Secondary outcome results showed that two articles reported

a significant reduction in BP, three reported a reduction in $HbA_{1c}$ levels and four reported improved $VO_{2max}$ levels. However, due to small sample sizes and high dropout rates, the overall results should be considered with caution. The global population of people living with type 2 diabetes is growing rapidly and, therefore, the need to research different treatments and interventions is much needed to ensure there are different and effective interventions available to fit all medical needs. ∎

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