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Recommending swimming to people with low back pain: A scoping review

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ABSTRACT

Background: It is common practice for health professionals to recommend swimming to people with low back pain (LBP) despite limited evidence. The aim of this review was to gain an understanding of the current evidence base supporting the recommendation of swimming to people with LBP.
Methods: A scoping review was conducted searching five electronic databases, CINAHL, MEDLINE, PEDro, PubMed, and SPORTdiscus using the keywords back pain AND swim*. The studies were grouped by study design and the following uncertainties were considered; the impact of swimming on the spine and LBP, evidence of swimming increasing or reducing the risk of LBP and the use of swimming in LBP rehabilitation programmes.
Results: 25 studies met the eligibility criteria; including sixteen observational studies exploring the relationship between swimming and LBP, three biomechanical studies investigating the impact of swimming on the spine, and five interventional studies of which four integrated swimming into a rehabilitation programme and one used swimming to modify lumbar lordosis.
Conclusion: The review confirmed there is limited research and only low-level evidence to support the recommendation of swimming to people with LBP. Observational studies make up the greater proportion of research undertaken in the field; the data indicates that swimming is a low-risk form of exercise but not without risk. The findings from biomechanical research suggest that lumbar lordosis does not increase excessively when swimming breaststroke, but certain swimming techniques could negatively impact LBP and interventional trials illustrate that there are various ways to integrate swimming into a rehabilitation programme.

1. Introduction

Activity limiting low back pain (LBP) is very common; according to the 2015 global burden of disease study LBP is the number one cause of disability (Hoy et al., 2014). The NICE guidelines (2016) recommend aerobic, biomechanical and/or mind-body group exercise programmes as non-invasive treatments for people with LBP and sciatica. Aquatic therapy is one form of exercise offered to people with LBP by physiotherapists (Pires et al., 2015), it is also common practice for health professionals to recommend swimming to people with LBP despite limited evidence (Pocovi et al., 2022; Ribaud et al., 2013). Both swimming and aquatic therapy are low impact forms of exercise (Poyhonen et al., 2002; Waller, Lambeck and Daly 2009) which can be adapted for people with disabilities (Dunlap, 2009, p.130, Ethridge 2022). Swimming, however, differs to aquatic therapy in that it involves skill acquisition; the swimmer must learn how to propel the body through water, control their breath and float in a supine or prone position (Maglischo 1993; Tanaka 2009). Swimming offers several benefits, including cardiovascular and musculoskeletal training (Laughlin and Delves 2004, p.10); targeting some of the comorbidities associated with LBP such as obesity, cardiovascular disease, and diabetes (Connolly et al., 2016; Cox et al., 2010; Nualnim et al., 2012). It is important to note, however, that despite swimming being recommended to people with LBP swimming is not routinely delivered as a rehabilitation modality. Furthermore, there is limited guidance, based upon expert opinion, for aquatic physiotherapists integrating swimming in aquatic therapy (Cole et al., 1997, pp.86-99, Dunlap 2009, pp.172-173).

When recommending swimming to people with LBP, health professionals can encounter several uncertainties. First and foremost, it is not known which swimming strokes or combinations of strokes could be beneficial for someone with LBP and whether certain strokes such as breaststroke should be avoided (Hofling et al., 2003; Liyanage 2020, p.71). Furthermore, swimming ability and stroke technique can vary between individuals (Coleman et al. 2000; Newsome and Young 2012,

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p.121; YouGov 2016) and the impact of swimming and the swimming strokes on the spine and LBP is unknown (Ribaud et al., 2013). To date only two systematic reviews have been undertaken exploring the recommendation of swimming with people with LBP both reviews concluded that there was a scarcity of research in this field (Pocovi et al., 2022; Ribaud et al., 2013). In healthcare, systematic reviews are conducted to confirm or refute current practice, guidelines, or recommendations (Munn et al., 2108), whereas scoping reviews identify and map the current evidence, describing the types of methods used and highlighting gaps in knowledge (Peters et al., 2015). A scoping review exploring the current evidence base for the recommendation of swimming to people with LBP would help map the existing research in the field, helping guide health professionals when advising swimming and direct future research.

The aim of this scoping review was to review the current evidence base supporting the recommendation of swimming to people with LBP.

2. Method

A scoping review was undertaken based upon the PRISMA-ScR extension for scoping reviews, a protocol was written before undertaking the review (Peters et al., 2015; Tricco et al., 2018). The review protocol was not registered as it was conducted as part of a PhD.

2.1. Search strategy

A search of five electronic databases, CINAHL, MEDLINE, PEDro, PubMed, and SPORTdiscus, was carried out October 2022. The population included in the review were people with back pain, and the intervention was swimming. For the purpose of this review the term back pain included conditions characterised by marked discomfort or pain in the back region (ICD10Data.com 2023) and the term swimming referred to the activity of propelling the body through the water, not aquatic therapy. Boolean logic was used to increase search specificity; the following keywords were used: (back pain OR low back pain OR lumbar pain OR chronic low back pain) AND (swim OR swimmer OR swimming). The search included peer review articles and studies in human adults (>18 years) and excluded animal studies. Studies involving aquatic therapy and competitive swimmers were not excluded in the initial search. The key words were chosen based upon the research question and using the PICOS (Patient Intervention Comparison Outcome Study) framework (Costantino et al., 2015) which helps convert a research question into key words for a literature search. All physiotherapy modalities were considered as comparisons to swimming to broaden the search and the outcomes of interest were those commonly used in LBP research including pain, function, and quality of life. The search was expanded by reviewing the reference list of the included studies, searching the grey literature, and reviewing the program content of aquatic therapy studies which included people with LBP. The following study designs were considered in the review; observational studies exploring the relationship between LBP and swimming, biomechanical studies exploring the impact of swimming on the spine and interventional studies integrating swimming into a rehabilitation programme for LBP.

2.2. Data extraction and analysis

The following data was recorded during the screening process: records identified through database searching, additional records identified through other sources, total number of records screened by abstract and title, duplicates removed, full text articles assessed for eligibility, and total number of studies meeting the eligibility criteria. The number of records excluded was also documented and the reasons for the record not meeting the eligibility criteria. Reasons for papers not being eligible included the findings were only relevant to competitive swimmers, the study involved aquatic exercise not swimming, the study did not include swimming, LBP, or humans, it was not published in the English language, or the paper was a review paper or authors response. The data charting process was undertaken using Excel. The review process is presented in Fig. 1 as a PRISMA flow chart, showing the numbers of search results and the reasons for studies being excluded. The studies were reviewed and grouped by study design and the following uncertainties were considered. The impact of swimming on the spine and LBP, evidence of swimming increasing or reducing the risk of LBP and the use of swimming in a LBP rehabilitation programme. This search, data extraction and analysis was originally undertaken by the first author, who is a PhD candidate and then the process and papers were reviewed by the supervisory team (the second, third and fourth authors).

3. Results

The search strategy identified 344 citations, 167 duplicates were removed, 138 papers were removed after reading the title and abstract and a further 15 were excluded after reading the full text due to not meeting the eligibility criteria. 25 studies met the eligibility criteria.

3.1. Characteristics of included studies

The studies included sixteen observational studies exploring the relationship between swimming and LBP, three biomechanical studies investigating the impact of swimming on the spine, and five interventional studies of which four integrated swimming into a rehabilitation program and one used swimming to modify lumbar lordosis. The sample sizes for the observational studies ranged from 38 to 16,394 participants, the biomechanical studies from 19 to 46 participants and the interventional studies from 6 to 98 participants. The greatest number of publications occurred in Japan and the United States of America, 16% (n = 4), followed by Finland, 12% (n = 3).

3.2. Characteristics of participants

The observational studies included student athletes, college swimmers, competitive swimmers, master's swimmers, leisure/recreational swimmers, middle age and older adults, and non-athletic populations. The biomechanical studies included recreational swimmers without LBP, skilled breaststroke swimmers with LBP and college swimmers and the interventional studies recruited retired athletes with LBP, automotive workers with LBP and people with LBP.

3.3. Risk of bias

Only one randomised clinical trial was identified in the search (Weifen et al., 2013), this study was assessed for risk of bias in the systematic review and meta-analysis by Pocovi et al. (2022) using the RoB 2 tool (RiskofBias.info, 2019). The overall rating was 'some concerns'; the concerns were in the domains of outcome measurement and the selection of the reported results. Three of the interventional studies were single arm studies and the other study in the review included a control group but did not randomise the two groups (Manshouri and Rahnama, 2014). The risk of bias assessment using the ROBINS-I assessment tool (RiskofBias.info, 2016) for this study was rated as moderate risk of bias, suggesting that it would not be comparable to a well conducted randomised trial but provided sound evidence for a non-randomised trial. The areas of moderate risk of bias were selection of participants and selection of reported results.

The PRISMA flow chart can be found in Fig. 1 and the studies included in the review have been summarised documenting reference, country, participants, study design and main findings in Tables 1–3.

4. Discussion

The scoping review identified sixteen observational studies, three

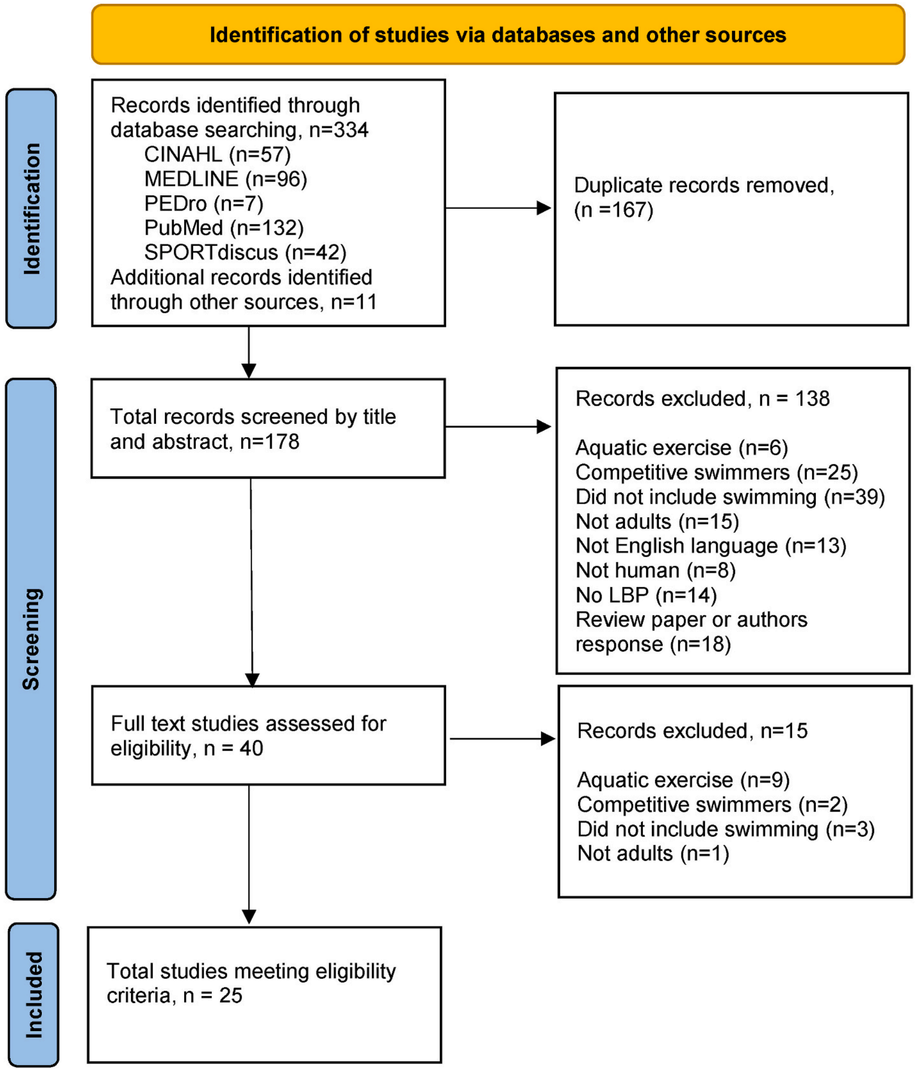

Fig. 1. PRIMSA flow chart of search results and study selection.

biomechanical studies and six interventional studies; these findings support the claim that there is limited research supporting the recommendation of swimming to people with LBP. It was already known, based upon the recent systematic review by Pocovi et al. (2022) that there has only been one randomised controlled trial conducted in the field of swimming and LBP. Only four additional interventional studies were identified in this review, of which three were single arm studies and one was an uncontrolled study. The greater proportion of research has been in the form of observational studies, which cannot be used establish causality. Due to swimming being a sport, most research has been undertaken with competitive swimmers. 27 papers were excluded in the screening section of the search due to the findings only being relevant to competitive swimmers. Although research involving competitive swimmers provides some understanding of the impact of swimming on the spine and LBP, the findings may not be transferable to leisure swimmers and people with comorbidities. This discussion section, grouped by study design, will summarise the studies, consider the implications for people with LBP and make further recommendations.

4.1. *Observational studies involving LBP and swimming (n = 16)*

Four correlational studies were identified exploring the relationship between competitive swimming and LBP. A survey of musculoskeletal pain in competitive male swimmers, reported that 18.4% had LBP and there was a significant relationship between the time spent training each week and the number of years of training and musculoskeletal pain (Capaci et al., 2002). In contrast a cross-sectional survey of female student athletes competing in nine sports found that the swimmers had the lowest lifetime prevalence for LBP, 47.8% (Noormohammadpour et al., 2016). Likewise, a survey of undergraduate students reported that compared to the other sports the swimmers had the lowest prevalence of LBP, with only 1.6% of swimmers reporting LBP (Triki et al., 2015) and a retrospective study of elite and leisure swimmers found that the elite swimmers had a smaller lifetime and one year pain prevalence than leisure swimmers (Cabri et al., 2001). Two of these studies recruited a young athletic population (Noormohammadpour et al., 2016; Triki et al., 2015), both studies found that the swimmers had a lower lifetime prevalence of LBP when compared to other sports. The findings however might not be transferable to older leisure swimmers, as illustrated by the findings by Cabri et al. (2001) which reported different findings in the competitive and leisure swimmers, supporting the need for caution when using data from competitive swimmers to guide recommendations for leisure swimmers. Furthermore, one study found a relationship between training time and musculoskeletal pain (Capaci et al., 2002), again highlighting the significant differences between how swimming is practiced by competitive and leisure swimmers.

Four studies were identified which explored the relationship between leisure swimming and LBP. A prospective cohort study of 38-year-

Table 1
Observational studies (n = 16).

Reference	Country	Participants	Study design	Main findings
Almeida et al. (2015)	Brazil	257 elite swimmers	Cross-sectional survey	6.2% experienced LBP
Atilla et al. (2020)	Turkey	88 Male Masters swimmers (26–89 years)	Cross-sectional survey	27% experienced LBP
Cabri et al. (2001)	Portugal	146 elite swimmers and 119 leisure swimmers	Cross-sectional retrospective survey	Competitive swimmers had a smaller lifetime and one year pain prevalence than leisure swimmers
Capaci et al. (2002)	Turkey	38 competitive male swimmers	Survey	18.4% had LBP, there was a significant relationship between the time spent training each week and the number of years of training and musculoskeletal pain
Folkvardsen et al. (2016)	Finland	100 elite swimmers and 96 people not involved in sport	Cross-sectional comparative study	Incidence of degenerative disc disease was similar between the two groups. Lower levels of correlation between herniated discs and LBP in the swimmers (68.4%) than the people not involved in sport (90%)
Hangai et al. (2009)	Japan	308 university athletes to 71 non-athletic university students	Cross-sectional study	Swimmers who trained during their youth had a significantly greater proportion of degenerative changes when compared to non-athletes and that there was a relationship between lifetime LBP and disc degeneration.
Harreby et al. (1997)	Denmark	578 38-year-old women and men	Prospective cohort study	Being physically active for more than three times a week reduced the incidence of LBP. 68% of participants found that swimming improved their LBP and 16% of participants reported swimming aggravated their LBP.
Junqueira et al. (2014)	Australia	38 twin pairs	Cohort study	Moderate exercise such as gentle swimming was not associated with chronic LBP, whereas low level or more strenuous physical activity had a positive association.
Kaartinen et al. (2020)	Finland	4246 adults	Cross-sectional survey	More LBP in those who engaged in swimming and walking, but not significantly significant.
Kaneoka et al. (2007)	Japan	38 elite swimmers and 38 recreational swimmers	Case control study	Disc degeneration was greater in elite compared to leisure swimmers. They found no significant relationship between LBP symptoms, disc degeneration and swimming strokes.
Kovacs et al. (2003)	Mallorca	16,394 School children and parents	Cross-sectional population survey	Swimming was significantly associated with LBP, but not associated with the practice of other sports.
Mundt et al. (1993)	USA	155 people with disc herniation	Cross-sectional survey	Relative risk for swimming and disc herniation was close to 1.0, no increase in the risk of disc herniation
Noormohammaspour (2016)	Iran	1335 female university student athletes	Cross-sectional survey	Swimmers had the lowest lifetime prevalence for LBP, 47.8%
Suri et al. (2015)	USA	424 older adults	Cross-sectional study	No significant increased risk in lumbar zygapophyseal osteoarthritis in those who were swimming regularly
Triki et al. (2015)	Tunisia	5958 students	Cross-sectional survey	Swimmers had the lowest prevalence of LBP, with only 1.6% of swimmers reporting LBP
Wolf et al. (2009)	USA	94 Collegiate swimmers	Retrospective review	12.8% experienced LBP

old women and men found that being physically active for more than three times a week reduced the incidence of LBP (Harreby et al., 1997). The participants were asked about whether specific sports affected their LBP; 68% of participants found that swimming improved their LBP and 16% reported swimming aggravated their LBP. Similarly, a cohort study of twins found that moderate exercise such as gentle swimming was not associated with chronic LBP (Junqueira et al., 2014). Conversely another study of twins found that there was a higher rate of LBP in those who reported in engaging in swimming and walking when compared to other activities, but it was not statistically significant (Kaartinen et al., 2020). Likewise, a survey of parents reported that swimming was significantly associated with LBP, but not associated with the practice of other sports (Kovacs et al., 2003). It is important to note that it was not known in the studies where there was an association with swimming and LBP, whether swimming had contributed to the development of LBP or whether swimming was used by this population to help manage LBP and keep physically active. Without follow up qualitative data, it is impossible to draw conclusions, and this is one of the limitations of correlational research.

Five correlational studies were identified exploring the relationship between swimming and degenerative changes in the spine including, disc herniation, disc degeneration and zygapophyseal joint arthritis. A cross-sectional study examined the correlation between physical activity, including swimming, with lumbar zygapophyseal osteoarthritis in older adults, and found no significant increased risk in those who were swimming regularly (Suri et al., 2015). Likewise, a cross-sectional survey of people with disc herniation reported that the relative risk for swimming and disc herniation was close to 1.0, meaning that there was no increase in the risk of disc herniation for this form of exercise (Mundt et al., 1993). Furthermore, a comparative study found that the incidence of degenerative disc disease observed through MRI scans was similar between elite swimmers and those not involved in sport (Folkvardsen et al., 2016). The study discovered that there were lower levels of correlation between herniated discs and LBP in the swimmers (68.4%) than the people not involved in sport (90%). In contrast a cross-sectional study compared degenerative disc disease in university athletes to non-athletic university students (Hangai et al., 2009). They found that swimmers who trained during their youth had a significantly greater proportion of degenerative changes when compared to non-athletes and that there was a relationship between lifetime LBP and disc degeneration. Similar findings were found in a case control study of elite and recreational swimmers, they found that disc degeneration was greater in elite compared to leisure swimmers (Kaneoka et al., 2007), however they found no significant relationship between LBP symptoms, disc degeneration and swimming strokes. The review also identified three studies which reported different rates of LBP injuries in swimmers; ranging from 6.2% in elite swimmer (Almeida et al., 2015), to 12.8% in collegiate swimmers (Wolf et al., 2009), and 27% in male Masters swimmers (Atilla et al., 2020). The higher rates of injuries in the Masters swimmers could reflect the older age range sampled in this study.

Correlational studies are used to explore relationships between two variables; in this case swimming and LBP but cannot establish causality and findings should be interpreted with caution (Argyrous 2012 p.232, Hung et al., 2017). The studies had mixed findings with regards to relationship to LBP and degenerative changes in the spine. The studies illustrated that swimmers are a heterogenous population ranging from elite competitive swimmers to leisure swimmers and that correlations found for one swimming stroke, swimming style or swimming volume may not be transferable to other situations. It was evident from this section of the review that the majority of swimming research has been carried out with elite swimmers; however due to much greater training volumes it is unlikely that this form of swimming and the research

Table 2
Biomechanical studies (n = 3).

Reference	Country	Participants	Study design	Main findings
Coleman et al. (2000)	Belgium	25 skilled breaststroke swimmers with LBP	Video biomechanical analysis of breaststroke	Stroke analysis found seven abnormal phases in the stroke which could cause LBP. The stroke abnormalities either related to hyperextension in the spine or poor body balance.
Du et al. (2016)	Japan	19 college swimmers	Biomechanical analysis using electromagnetic tracking measuring three-dimensional movement of torso during tethered front crawl swimming	Range of extension in front crawl was much less than the available range of spinal movement and there was no difference in the range of torso extension when breathing was added to the stroke cycle.
Hofling et al. (2003)	Finland	46 recreational swimmers without LBP	Video biomechanical analysis of lumbar lordosis and thoracic kyphosis during breaststroke and backstroke	Lumbar lordosis was less when swimming than when standing and less when swimming backstroke than breaststroke.

findings are transferable to leisure swimmers. It has been suggested that physical activity and its correlation with LBP is U shaped; meaning that too little and too much can result in an increased incidence of LBP (Heneweer et al., 2009). It is important to acknowledge in correlational research that other variables and factors will contribute; for example, in the case of elite swimmers, they would probably not have other risk factors for LBP such as being a smoker (Green et al., 2016).

4.2. Biomechanical research (n = 3)

Researchers in sports biomechanics seek to gain an understanding of the relationship of the kinetics of an activity, pain, and the area of injury (Eillott, 1999). In the field of LBP and swimming, the area of interest is the motion and position of the lumbar spine, either during swimming or as a consequence of swimming. The search identified three biomechanical studies exploring the impact of swimming on the spine. The first study analysed the spine during backstroke and breaststroke in recreational swimmer without LBP (Hofling et al., 2003). The rationale for the study was that often backstroke is recommended for people with LBP, but breaststroke is not advised due to the theoretical assumption that lumbar lordosis increases during breaststroke. They found that lordosis is less when swimming than when standing and less when swimming backstroke than breaststroke. The findings demonstrated that although lordosis increases in breaststroke, it does not increase excessively; suggesting that there are no grounds for advising against breaststroke. Another study involving breaststroke was undertaken to identify variants during the stroke associated with LBP (Coleman et al., 2000). Three variants of breaststroke were identified in a group of skilled breaststroke swimmers: a flat variant, keeping the head above the water variant, and an undulating variant. Following stroke analysis of the swimmers with LBP, the researchers found seven abnormal phases in the stroke which could cause LBP. The stroke abnormalities either related to hyperextension in the spine or poor body balance. The study

Table 3
Interventional studies and systematic reviews and meta-analysis (n = 6).

Reference	Country	Participants	Study design	Main findings
Ariyoshi et al. (1999)	Japan	35 people with LBP (25 female and 10 male)	Single arm study, land-based exercise, aquatic exercise, and swimming	Significant improvement in physical scores and swimming ability, more the 90% of participants felt they had improved after 6-months
Kim et al. (2008)	Korea	13 male automotive workers with LBP	Single arm study, land-based exercise, hill walking and swimming	No change in body composition, significantly reduced C reactive protein levels, indicating a reduction in inflammation and improvement in strength and flexibility.
Manshouri and Rahnama (2014)	Iran	98 females with hyper lumbar lordosis	Comparative study, comparing swimming backstroke, walking in water and stretches to a control group	Significant reduction in lumbar lordosis in the experimental group when compared to the control group
Pocovi et al. (2022)	Australia	19 trials 2362 participants	Systematic review and meta-analysis	Only one RCT (Weifen et al. (2013) identified in review involved swimming
Weifen et al. (2013)	China	38 retired athletes with LBP (21 male 17 female)	RCT comparing four interventions (swimming, jogging, backwards walking, and Tai Chi) plus physical therapy	Swimming and physical therapy was more effective at reducing pain at 3 months and 6 months than no treatment and had better outcomes than jogging and backward walking but had similar changes in the intensity of pain to Tai Chi.
Winter (2002)	USA	6 people with LBP (3 male and 3 female)	Single arm study, aquatic exercise, and swimming	Activity of daily living scores improved, and pain scores reduced.

recommended that swimming and health professionals should use biomechanical assessment of the stroke to prevent injuries.

The final study measured three-dimensional movement of the torso during tethered front crawl swimming in college swimmers (Du et al., 2016). The range of extension observed was much less than the available range of spinal movement and there was no difference in the range of torso extension when breathing was added to the stroke cycle. The data from this study led the authors to reject their hypothesis that repetitive hyperextension of the torso in front crawl is a major cause of LBP. People with LBP often have a directional preference to repeated movements of the spine or a spinal posture (Long et al., 2008; May, 2011); the findings from these biomechanical studies would be of interest to people with

LBP who find their pain is affected by lumbar extension. The studies included in this review considered three swimming strokes: front crawl, backstroke, and breaststroke. Front crawl and backstroke are predominantly long axis strokes, whereby the body rolls longitudinally (Newsome and Young, 2012, p.61, Swim England, 2019, pp.262; 285) whereas breaststroke is a short axis stroke which could impact the lumbar spine due to the body rotating around the horizontal axis (Cole et al., 1997, pp.95-96, Swim England, 2019, p.274). Although it is common practice to advise people with poor tolerance of lumbar extension against swimming breaststroke (Dunlap 2009, p.172), the findings from the study by Hofling et al. (2003) suggested that there are no grounds for this advice. The study by Coleman et al. (2000) found that certain methods of swimming breaststroke could have a negative impact on LBP; highlighting that even within strokes there is a great deal of variability in technique which could impact the spine. The study by Du et al. (2016) did not observe hyperextension of the spine during front crawl swimming, but the findings may not be transferable to recreational and older swimmers, who may adopt a different technique due to differences in swimming ability, loss of muscle strength and flexibility. Further biomechanical studies should be carried out to understand more about the impact of the swimming strokes on the spine and LBP, recruiting a combination of skilled swimmers, recreational swimmers, and swimmers with LBP.

4.3. Interventional studies integrating swimming into a rehabilitation programme for LBP (n = 5)

One systematic review and meta-analysis was identified in the search; the review identified only one RCT evaluating swimming for the treatment of non-specific LBP (Pocovi et al., 2022). The double blinded RCT included in the review by Pocovi et al. (2022) compared four interventions plus physical therapy; swimming, jogging, backward walking, tai chi, and just physical therapy in retired athletes with chronic LBP (Weifen et al., 2013). The participants in the swimming group were simply advised to take up swimming five days a week for 30 min each day for 6-months. The paper did not provide any details of the swimming undertaken, such as which strokes were swum. The study found that swimming was more effective at reducing pain at 3 months and 6 months than no treatment and had better outcomes than jogging and backward walking but had similar changes in the intensity of pain to Tai Chi. Although these findings suggest that swimming could be an effective form of exercise for reducing LBP, the findings may not be transferable to less able swimmers and people who do not have an athletic background. A non-randomised controlled study was identified in the search, which compared swimming to a control group in females with hyper lumbar lordosis (Manshouri and Rahnama 2014). The swimming programme included backstroke, walking in water and stretches and was delivered for 8-weeks, 3 times a week, for 50–90 min each week. The study found there was a significant reduction in lumbar lordosis when compared to the control group, suggesting that if hyper lordosis was a contributing factor to LBP, swimming could be utilised as a modality to modify posture.

Three single arm studies were identified in the review which delivered swimming in addition to other exercise to people with LBP. The first study evaluated a 6-month combined program of land-based exercise, aquatic exercise, and swimming for people with LBP (Ariyoshi et al., 1999). The aquatic exercise section included stretches, walking, jogging, front, back and side leg raise, bobbing and jumping and 25 m swimming front crawl or backstroke. This program was repeated three or four times during the session, once, twice or three times per week for 6-months. There was a significant improvement in the physical scores and swimming ability; 90% of the participants reported that they had improved after completing this program. The people who undertook the program 2–3 times a week had a more significant improvement in their physical scores than those who did the program once a week.

Another study using a more intensive program of exercise and swimming was undertaken with automotive workers with LBP. The program included land-based resistance exercise, a flexibility program for 1 h, five times a week, hiking once a week including hills and swimming 40 min three times a week. For the swimming section of the program the participants swam freestyle, swimming 9 repetitions of 50 m with a minute between these repetitions. They found no change in body composition, but significantly reduced C reactive protein levels, indicating a reduction in inflammation and improvement in strength and flexibility (Kim et al. 2008).

In contrast the final study identified in the review involving people with chronic LBP was carried out in a more controlled environment, trialling a protocol of aquatic exercise and swimming for 40 min, twice a week for 12 weeks (Winter and McCauley-Callagy, 2002). The programme was designed to improve lumbar stabilisation and strength, and the goals of the session were to decrease pain, increase lumbar mobility and progress the exercises. The exercises included walking, lower limb exercises, seated exercises, deep water exercises such as jogging, and supine and prone modified swimming. The participants were encouraged to maintain a neutral spine position during the exercises, floats and snorkels were used for the swimming and modified strokes were taught. The study found that activity of daily living scores improved, and pain scores reduced with this exercise program.

These interventional studies describe heterogeneous treatment programs which include swimming alongside other exercise and physiotherapy modalities. The studies illustrate several ways swimming could be integrated into a LBP rehabilitation programme. They provide some evidence that swimming can be tolerated by people with LBP, alongside aquatic and land-based exercise, and other physiotherapy modalities. A range of outcomes were collected; the studies found that swimming, alongside a multi-modal physiotherapy treatment, resulted in a significant reduction in inflammation and pain, change in posture and improvements in swimming ability, function, strength, and flexibility. Despite these positive outcomes only limited conclusions can be drawn and the findings should be interpreted with caution due to there being a small number of participants and no control group (Gilmartin-Thomas et al., 2018). The swimming component to these programs varied considerably in intensity from the low-level adaptive swimming program used by Winter and McCauley-Callagy (2002) to the much higher-level interval freestyle program used by Kim et al. (2008). Only one study (Winter and McCauley-Callagy, 2002) focused on the position of the spine when swimming, encouraging the participants to maintain a neutral spine position, the other studies simply advised swimming. The studies included either front crawl or front crawl and backstroke, this choice could be due to the common view that breaststroke should not be advised to people with LBP (Hofling et al., 2003). The time spent swimming was unclear in the studies which combined swimming with aquatic exercise, however in the other studies the time ranged between 30 and 90 min. The frequency of the sessions ranged from once a week to five times a week, with one study finding better outcomes with 2–3 times a week. The information provided in the methods sections of these studies could provide some initial guidance for future research studies involving swimming but should not exclude other protocols being explored.

4.4. Limitations

The review did not include research involving adolescent competitive swimmers due to the difference in training volume and the impact of puberty and growth. It is recommended that a second scoping review is undertaken in this age group, as the review had identified one study which found an increased risk of spinal deformity and higher prevalence of LBP in females and another series of case study studies reporting spondylolysis and LBP in adolescent swimmers (Nyska et al., 2000; Zaina et al., 2015).

5. Conclusions

The scoping review has confirmed that there is limited research supporting the recommendation of swimming to people with LBP and that observational studies make up the greater proportion of research in this field. The data from the observational studies indicates that swimming is a low-risk form of exercise but not without risk and the findings from biomechanical studies suggest that lumbar lordosis does not increase excessively when swimming breaststroke, backstroke, or front crawl but certain swimming techniques could negatively impact LBP. Interventional trials illustrate that there are various ways to integrate swimming into a rehabilitation programme, providing some initial data on the impact of swimming on LBP and function. Although further research is required in this field, guidelines could be developed for recommending swimming to people with LBP, consulting all stakeholder whilst recognising the uncertainties within the current evidence base.

6. Clinical Relevance

- There is limited research supporting the recommendation of swimming for back pain
- Swimming is a low-risk form of exercise for back pain but is not without risk
- Stroke and technique should be considered when advising swimming for back pain
- There are several ways swimming could be integrated into back pain rehabilitation

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CRediT authorship contribution statement

Helen Oakes: Data curation, Conceptualization, Funding acquisition, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. **Marlize de Vivo:** Supervision, Writing – original draft, Writing – review & editing. **Hayley Mills:** Supervision, Writing – original draft, Writing – review & editing. **David Stephensen:** Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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