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SHORT COMMUNICATION

AQUATIC CIRCUIT TRAINING INCLUDING AQUA-CYCLING IN PATIENTS WITH KNEE OSTEOARTHRITIS: A FEASIBILITY STUDY

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Background: **Aqua-cycling is easy to learn, acceptable, and safe for patients with knee osteoarthritis. It can therefore be an ideal component of aquatic circuit training.**
Objective: **To investigate the feasibility of a small group-based aquatic exercise programme including aqua-cycling.**
Design: **A feasibility study using quantitative (pre-post) and qualitative (cross-sectional) assessments.**
Participants: **A volunteer cohort of 10 women and men, age range 46–77 years, with knee osteoarthritis.**
Methods: **Focus group interviews explored participants' experience with the training. Pre- and post-exercise knee pain, attendance, progression in training, and adverse events were registered.**
Results: **Seventy percent of patients attended all sessions. Focus groups revealed high levels of satisfaction with the selection of exercises, and participants valued the immediate pain relief experienced. Participants progressed well. However, aqua-cycling in an out-of-the-saddle position was too demanding for most participants.**
Conclusion: **An aquatic circuit training that includes aqua-cycling is feasible for patients with knee osteoarthritis. Participants reported pain reduction and were positive about the diverse exercise programme. Aqua-cycling in a seated position is a safe and controlled type of movement.**

Key words: osteoarthritis; aquatic therapy; aqua-cycling; hydrotherapy.

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INTRODUCTION

Water-based exercise is frequently recommended for patients with knee osteoarthritis (OA), especially when land-based training is restricted by the experience of pain (1). The hydrostatic pressure, temperature and buoyancy of water result in relief of body weight, muscle relaxation, decreased joint compression, and pain reduction (2). Aqua-cycling is an upcoming fitness-trend in Europe and combines stationary cycling with the advantages of exercising in an aquatic environment. Previous research on rehabilitation after anterior cruciate ligament reconstruction and total knee surgery showed that aqua-cycling in addition to usual care resulted in greater improvement in range of motion (ROM) and more rapid reduction in knee joint swelling compared with standard care (3, 4). A small pre-post test study with 19 patients with rheumatic diseases showed a positive influence on well-being, strength and mobility after 10 weeks' aqua-cycling (5). Based on the results of previous studies it is hypothesized that participants with knee OA would also accept this type of exercise. However, aqua-bikes are expensive. Most therapy pools do not have enough space to store several aqua-bikes. We developed an aquatic circuit training for small groups of 3 participants consisting of aquatic exercises and aqua-cycling.

The present study aims to evaluate the feasibility of an 8-week aquatic circuit training in terms of adherence, possibility to progress in exercise level, occurrence of adverse events, operational aspects and patient acceptance.

METHODS

Design

A convergent mixed-methods design was used to describe different aspects of feasibility. The study was a proof of concept of a full-scale trial, which was approved by the local ethics committee (NL42617.068.12, NTR 3766).

Participants

Recruitment was carried out from February to April 2011 at Maastricht University Medical Centre. Participants were identified by their orthopaedic surgeon and signed a written informed consent. Eligible participants were diagnosed with knee OA and had an indication for conservative therapy including pharmacological and exercise treatment. Exclusion criteria were: a planned total knee arthroplasty; acute infection/inflammation; neuromuscular disease; and severe cardiorespiratory problems.

Measures and data collection procedure

Focus group interviews were chosen to explore participants' experiences with aquatic circuit training. The question guide (Table I) was based on typical questions for formative programme evaluation and included questions about positive and negative aspects of the training and aspects that should be changed, dropped or fine-tuned.

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Table I. *Focus group questions*

Introductory question:
1. What did you expect from the training?
Transition question:
2. Why did you participate?
Key questions:
3. If you compare this training with land-based training, what is the difference from land-based training?
4. What did you like best about the programme?
5. What did you like the least about the programme?
6. What should be changed?
7. What should be continued just as it is now?
8. What should be continued but fine-tuned?
9. What should be dropped?

The focus groups were recorded and documented in a transcript. Only the physiotherapist and the interviewer had access to the records and full transcripts. The statements of participants were separated from personal data by the following code: gender (male/female), age, and focus group number. The focus groups took place in a meeting room of Maastricht University. Both focus groups lasted for 1.5 h with a break after 45 min.

Quantitative data was collected on self-reported pre- and post-exercise knee pain on a numeric pain rating scale (NRS) (6, 7). Furthermore, attendance, progression in training and adverse events was registered. In addition to patient-relevant information the physiotherapist registered experiences with execution of the training and supervision of the groups and logistical aspects with the installation of the circuit training.

Intervention

Participants trained in small groups of maximal 3 participants, once a week for 45 min over an 8-week period. The aquatic circuit training was offered free to the patients; they only had to meet the cost of transport. The training was carried out in a heated therapy pool (32°C) of the physiotherapy department of Maastricht University Medical Centre, supervised by a physiotherapist who was also in the pool herself. The circuit training comprises aqua-cycling on the AquaCruiser, functional exercises, such as stepping and chair stands, ROM and strength exercises. Gait exercises were performed as a warm-up and cool-down. A detailed description of the content and goals of the exercises according to the framework from van Leeden et al. is given in Table II (8).

Data analysis

Focus group analysis was guided by the steps of framework analysis for descriptive accounts (9). The raw data was summarized per question from the interview guide and linked with illustrative quotes from the raw data. To enhance clarity, recurring themes additional to the questions were developed in regular discussion between the physiotherapist and the interviewer.

The Wilcoxon signed-rank test examined differences in pre- and post-exercise scores of knee pain. Results are presented as means and z-scores (z). Standard deviation (SD) and 95% confidence interval (CI) were calculated. A significance level of a 2-sided $p < 0.05$ was set.

RESULTS

Between February and April 2011 the orthopaedic surgeon identified 24 eligible patients, of whom 11 were willing to participate. One participant fell on her knee at home before signing the informed consent, which exacerbated her complaints and made it impossible for her to participate. The main reasons for not participating were: not interested, no specific reason given ($n = 8$); change of mind with respect to OA treatment, decided to stop conservative treatment and to undergo total knee surgery ($n = 2$); satisfied with physiotherapy twice a week ($n = 2$); and too occupied ($n = 1$).

The final cohort comprised 10 participants (7 women) aged between 46 and 77 years (mean 59.6 (SD 9.61)). The majority of the cohort was employed ($n = 6$), 3 participants were retired, and 1 participant was seeking work. Radiological assessment of the tibiofemoral joint showed Kellgren-Lawrence scores of 2 ($n = 2$), 3 ($n = 4$) and 4 ($n = 4$). In addition, 2 patients had grade 2 patellar OA. Elapsed time since diagnosis of knee OA ranged from 1 to 180 months (mean 62 months; SD 69.06). Treatment history varied from injections ($n = 5$), physiotherapy ($n = 5$), medical fitness training ($n = 4$) and pain medication ($n = 3$). Four people exercised regularly and continued their exercise routines (cycling on a home-trainer, exercises for the lower back and medical fitness) during the study period. Others had experiences with medical fitness ($n = 2$) and aquatic fitness ($n = 1$), but were not participating in these activities at the time of the study.

Feasibility of the training protocol

The adherence rate for all sessions was 70%. Two people missed 1 and 4 sessions, respectively, because of holidays. For work-related reasons 1 participant could only attend 5 sessions.

All the exercises in the conditioning section consisted of 3 levels. Except for 2 exercises, all patients could progress to level 3. Pushing the pool noodle underwater up and down was difficult for 2 participants because the buoyancy of the pool noodle raised their supporting leg from the floor. Based on the physiotherapists' judgement of a low exercise capacity ($n = 4$) and too few sessions or too long breaks between the sessions to progress ($n = 3$) all women remained at level 2 with the aqua-cycling exercise. Participants perceived resistance levels 2 and 3 as comfortable for pedalling, and scored aqua-cycling at an individual chosen pedalling frequency as light (men) to moderate (women) on the Borg scale independent from the resistance. Cycling in an out-of-the-saddle position (level 3) was evaluated as hard on the Borg scale.

One adverse event occurred during the cooling down section of 1 session. One participant's foot slipped during gait training, scoring 5 on the pain scale. Knee pain decreased quickly after the end of the session.

A swimming pool with an adjustable floor is preferable, because of the weight of the aqua-bike. Two people are needed to immerse the bike if the floor of the pool is not height-adjustable or has an entrance for disabled people.

Transportation of the aqua-bike inside and outside the pool is easy as it has 2 wheels at the front. The saddle height is easily adjustable by professionals or patients even when the bike is immersed. A difference in body height of more than 20 cm can result in suboptimal levels of immersion among participants. In order to ensure that participant's legs are underwater during cycling participants must be immersed to a minimum height of the navel and a maximum height of the xiphoid process. During shallow-water exercises immersion to chest height is

Table II. *Description of the aquatic circuit exercises*

Exercises: Water-based circuit training in groups of 3 patients, once a week, 45 min per session, supervised by 1 physiotherapist who is also in the pool.
Primary intervention goal:
- feasibility of aqua-cycling:
  - ease of learning of correct aqua-cycling techniques
  - exploring pedalling frequency and resistance during aqua-cycling

Secondary intervention goals (ICF):
- b770: gait pattern function (exercise 1)
- b710: mobility of joint functions (exercise 1, 2, 5, 7)
- b715: stability of joint functions (exercise 5, 3, 4, 9)
- b740: muscle endurance functions (exercise 2, 3, 5)
- b760: control of voluntary movement functions (exercise 1–9)
- b620: proprioceptive function (exercise 3, 4, 5, 6)

Level 1
1. Gait training (2–4 laps each direction):
   1.1. Forward = normal gait and step length and correct foot movement (heel to forefoot)
   1.2. Backward = reverse foot movement (forefoot to heel)
   1.3. Sideways= step to the left and bring right foot to the left v.v.
2. Aqua-cycling: cycling forward; move extended arms alternating forward/backward (10 min)
3. Stepping on an underwater step: step down and up
4. Squats
5. Flexion and extension of the unloaded knee (1-leg stance, bar work: 1-hand hold)
6. Hip abduction (bar work: 1-hand hold)
7. Cycle legs: Sitting on pool noodle or hanging on it (noodle in the back)
8. Stretching m. quadriceps, m. iliopsoas, adductors, hamstrings, calf (10 s, 3–4 reps)
9. Pool noodle balance: step over the immersed pool noodle, move the pool noodle around the body, sitting on the pool noodle

Level 2
1. Gait training (2–4 laps each direction):
   1.1. Forward = normal gait and step length correct foot movement (heel to forefoot), 1 lap heels up, 1 lap heels to buttock
   1.2. Backward = reverse foot movement (forefoot to heel)
   1.3. Sideways = step to the left and bring right foot to the left v.v.
2. Aqua-cycling: cycling forward/ backward, change pedalling direction after 2 min (total duration 10 min)
3. Stepping on an underwater step: step up then over, turn and repeat
4. Squats: go up and down in 3 steps (hold each position for 5 s)
5. Flexion and extension of the unloaded knee (1-leg stance, freestanding)
6. Hip abduction/adduction (bar work: 1-hand hold)
7. Cycle legs: sitting on pool noodle or hanging on it (noodle in the back)
8. Stretching m. quadriceps, m. iliopsoas, adductors, hamstrings, calf (10 s, 3–4 reps)
9. Pool noodle balance: step over the immersed pool noodle, move the pool noodle around the body, sitting on the pool noodle

Level 3
1. Gait training (2–4 laps each direction):
   1.1. Forward = normal gait and step length correct foot movement (heel to forefoot), 1 lap heels up, 1 lap heels to buttock
   1.2. Backward = reverse foot movement (forefoot to heel)
   1.3. Sideways= step to the left and bring right foot to the left v.v.
2. Aqua-cycling: cycling in sitting* and half-sitting** position, change position after 4 min*, 1 min**, 2 min*, 1 min**, 2 min*
3. Stepping: go up and down in sideways
4. Squats, while pushing and pulling a pool noodle with arms on shoulder height
5. Push pool noodle down (under the foot of the free leg) while extending knee and hip, let the pool noodle come up gently until hip and knee reach 90° flexion (bar work: 1-hand hold)
6. Lunge sideways
7. Cycle legs: sitting on pool noodle or hanging on it (noodle in the back)
8. Stretching m. quadriceps, m. iliopsoas, adductors, hamstrings, calf (10 s, 3–4 reps)
9. Pool noodle balance: step over the immersed pool noodle, move the pool noodle around the body, sitting on the pool noodle

General information
- Main focus on:
  - correct aqua-cycling technique
  - knee position (neutral knee alignment, active control of knee position) during the exercises
- Duration: warming-up: 5–10 min, exercise 1
  exercise 2–6: 10 min with individually chosen pedalling frequency and resistance
  exercise 3–6: 1 min (~15–20 repetitions) each with 1-min rest
  cooling-down: 5–10 min, exercise 1 (in uneven weeks), 7, 8, 9 (even weeks)
- Resting time between exercises: 1 min (including change of workstation)
- Intensity: exercise 1, 7–9: 7–10 on Borg scale
  exercise 2–6: 11–13 on Borg scale
- Progression to level 2 and 3 if:
  - knee pain during and after the exercises < 5 on a NRS for pain
  - patients performed the exercises with light to moderate exertion (Borg scale, no observation for any visible signs of overexertion)
  - patients performed the exercise with good quality of performance (based on the visual inspection of the physical therapist)
- Training devices:
  - Underwater step
  - Aqua bike "AquaCruiser" (placed at the bottom of a pool; participants needed to be immersed to xiphoid process level)

NRS: numeric rating scale; v.v.: vice versa.

Table III. *Illustrative quotes from the focus group interviews*

What did you expect from the training?
- "I expected it could do no harm and I thought: Let's see!" (Male 57, group 2)
- "I thought: it is for my knee and if it is not helping, it could at least do no harm." (Female 58, group 1)

Why did you participate?
- "…they said to me that cycling is a knee-friendly sport." (Male 54, group 2)
- "We need to stay active in order to control pain and stiffness…" (Male 57, group 2)
- "I try to go to the gym every morning. I am motivated to do this because otherwise my (health) condition will deteriorate over a few years…" (Female 58, group 1)

What is the difference with land-based training?
- "Exercising in water is easier." (Female 59, group 2)
- "While doing medical fitness I always keep a certain tension in my knee. This isn't changing throughout the whole workout. This training aims to strengthen your muscles. I didn't feel this during the water-based training that was a relief." (Male 54, group 2)
- "Training in water aims to improve and keep your flexibility." (Male 57, group 2)

Comparison with land-based exercise/cycling
- "Pedalling is harder than on a usual bike, but at the same time it feels smoother." (Female 58, group 1)
- "It is easier than normal cycling, it feels effortlessly." (Female 77, group 1)
- "I often take the bike…but especially when I am cycling with a tempo of during uphill cycling I feel a certain pain under my patella. I never had this with aqua-cycling even pedalling is more tiring." (Male 54, group 2)

What did you like best about the programme?

Pain reduction
- "I could move with almost no pain." (Female 58, group 1)
- "After the training I always felt better. The improvement depended of course on how I was doing during the day, but it always improved." (Male 57, group 2)
- "I have noticed the positive effects of the training. Sometimes you move your leg in certain ways that it causes knee pain. You cannot prevent this during everyday life. On those days I knew that the pain would be reduced after the AquaCruiser training." (Male 54, group 2)
- "It reduced the pain, but the day after the pain was back." (Female 60, group 1)
- "…the pain reducing effect lasted a little while after the training…" (Male 57, group 2)

Water temperature
- "The warm water felt very good." (Female 58, group 1)
- "It is wonderful in that water." (Female 60, group 1)

Selection of exercises
- "I came with pleasure to every session. It was fun to do the exercises" (Male 54, group 2)
- "The exercises in combination with the warmth of the water gave a good feeling." (Female 58, group 1)
- "I really liked the combination of exercises." (Female 59, group 2)
- "I would like to do aqua-cycling at the beginning and in the end, but always in combination with the other exercises."
- "It is a total body workout." (Female 77, group 1)

What did you like the least about the programme?
- "Everything was fine, it was really great!" (Female 58, group 1)

What should be changed?
- "Nothing! I am afraid of water and for me it really was an overcoming. In the beginning I needed much assistance, but this got better with every session." (Female 77, group 1)

Motivation to continue the training
- "I would like to know where I can continue this type of training." (Female 77, group1)
- "I looked up information about aqua spinning classes, but I am not sure if this matches my exercise level." (Female 51, group 2)

What should be continued but fine-tuned?
- "The training was scheduled around dinnertime. I would prefer to come in the morning or around noon." (Female 58, group 1)
- "I think it would be even better to exercise two times a week." (Female 60, group 1)
- "I experienced pain reduction that lasted a little while after the training, but I did it only once a week. I think you need to exercise more often to be able to evaluate its effectiveness." (Male 57, group 2)
- "A display with more information about training parameters during aqua-cycling like tempo, pedalling frequency would be useful for feedback and to guide progression." (Male 54, group 2)

What should be dropped?

No suggestions were made.

preferred so that participants can perform all exercises, such as squatting without immersing their head.

Participants could step on and off the aqua-bike without assistance and were able to start exercising with minimal instruction. In addition, the combination of arm movements and cycling was easy to learn and participants needed no assistance during hand-free cycling. Because the cycling part lasted longer than the other exercises only 2 participants changed workstations at the same time, which allowed time for tailored feedback.

Qualitative evaluation

Two focus group interviews were conducted, with 4 and 3 participants, respectively. Two people could not attend the interviews because they were on holiday; another participant had other appointments ($n = 1$) on the day the focus groups were held.

Illustrative quotes from both interviews are shown in Table III. Initially participants were asked about their expectations. Participants answered that they were motivated to try-out the training because exercise was known as a means to control symptoms of OA. They knew that cycling and aquatic exercises are frequently recommended to people with knee OA because of their low impact on the knee joints. Participants described the training as a total body workout with the focus on joint mobility and a light to moderate exercise intensity. In comparison with land-based training the pain relief effect was highlighted. Other reported effects were release of a certain

tension around the knee and higher self-efficacy about physical functioning. Participants believed that the warmth and buoyancy of the water had a great impact on the reduction of pain, initiation and maintenance of movements. They felt that they could perform the cycling movements in the water more easily, although they experienced pedalling on the AquaCruiser as more tiring. The participants were very positive about the selection of, and variety of, exercises. With regard to the aqua-cycling section participants stated that they would have liked to cycle for longer than 10 min on the AquaCruiser. Nevertheless, cycling alone with no other exercises would be too monotonous. Participants evaluated the training as suitable for their needs and exercise capabilities. Even someone with fear of water could participate without problems. Participants only had few suggestions for further optimization of the training. Participants who were not employed suggested scheduling the training in the morning. Furthermore, all participants would opt for a higher exercise frequency and a display on the aqua-bike with information about performance to make the training more efficient.

Quantitative evaluation; self-reported pre- and post-exercise knee pain

The self-reported pain scores were significantly lower after the training compared with the scores before the training, $z = -2.524$, $p < 0.05$, $r = -0.21$. Participants had a mean pre-exercise pain score of 4.09 (SD 1.45; 95% CI 3.05–5.12). After the training sessions participants had a mean pain value of 3.18 (SD 1.33; 95% CI 2.23–4.13).

DISCUSSION

This study investigated the feasibility of group-based aquatic circuit training for patients with knee OA. The training consisted of gait training, shallow-water toning exercises, flexibility exercises for the lower limbs, and aqua-cycling. Due to the set-up of the training only one aqua-bike was needed.

Seventy percent of the participants attended all 8 sessions. The short time-period for the research project, summer holidays and limited access hours to the therapy pool made it difficult to reschedule sessions for participants who were not able to attend sessions due to holidays and work time. Participants perceived the training as a total body workout, focusing on flexibility. They were positive about the immediate pain reduction and the fact that movements felt smoother. Also, self-reported pain showed a 1-point reduction immediately after the training. Evidence suggests that the decompressing effect, the warm temperature and the massage effect due to the hydrostatic pressure in combination with the exercises may explain pain relief (2, 10).

The intensity of aqua-cycling was rated as light to moderate, although participants experienced underwater pedalling as more tiring than on a normal bike or home-trainer. Only 3 patients, based on the physiotherapists' judgement, progressed to an out-of-the-saddle cycling position and perceived this as moderate to hard due to the fact that cycling in an out-of-saddle-position is less controlled and less stable. It might be that more training is needed before out-of-saddle movements are possible. A good technique is crucial to hold a stable posture with the knees in line with feet and hips. For instance, Moser developed an aqua-cycling programme for patients with rheumatic diseases and was able to introduce cycling in out-of the saddle position, but not before week 7 of a 10-week programme (5). These findings suggest that 10 min of aqua-cycling is probably too short a time to achieve progression, and that cycling in a seated position is preferable during early aquatic circuit training. Moreover, the perception of patients, that aqua-cycling was effortless in the seated position, might be explained by the fact that participants in the present study cycled at a self-selected pace. Previous research on underwater treadmill walking in patients with knee OA showed that walking at a self-selected and comfortable pace resulted in lower energy expenditure than land-based walking (11). This might be explained by the fact that during slow underwater walking buoyancy dominates and the water resistance is not sufficient to raise the heart rate.

Thus, participants should first progress their pedalling pace before cycling in a standing position. Cycling in a seated position is a controlled movement and few instructions are needed, which creates more time for tailored feedback for patients at other workstations. However, if the period of aqua-cycling is extended variation is needed to prevent monotony, which may require more supervision.

In conclusion, aquatic circuit training including aqua-cycling is feasible for patients with OA. Aqua-cycling in a seated position is a safe and controlled movement that enables the physiotherapist to spend more time on supervision of other patients. Therefore, aqua-cycling is easy to incorporate in circuit training and enables institutions to provide small group trainings even with 1 aqua-bike. Further research is needed to investigate patient acceptance of a higher exercise frequency of 2 or 3 sessions weekly and its impact on symptoms of knee OA. The feasibility and effects on knee OA of exercise programmes incorporating more time spent aqua-cycling have not yet been investigated.

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