Association IATF
Expert opinion statement

Enhancing the quality of aquatic therapy for subacute and chronic stroke patients

Johan Lambeck & Urs N. Gamper February 2022

Introduction

Stroke is the leading cause of death and disability globally with 116 million years of healthy life lost each year to the disease[1]. Almost two-thirds of stroke survivors receive rehabilitation, but will experience long lasting deficits with independence due to locomotor disability.
''Due to the ageing of e.g., the European population and the strong association between stroke risk and age, the number of people having a stroke continues to rise. Using data from the Global Burden of Disease study 2015, and demographic projections obtained from Eurostat, statistical office of the European Union (EU), a 34% increase in total number of stroke events in the EU between 2015 and 2035 is predicted"[2].

Goal: appraisal of aquatic research in stroke patients in order to formulate important elements for clinical practice and future research. The goal is not to write a narrative review and therefore we largely refrain from descriptions of specific methodological details in the trials.

Terminology: Clinical trials and systematic reviews use various terms for the intervention in water, like water-based exercise, pool therapy, aquatic therapy, aquatic rehabilitation, water-based therapy. To simplify terminology the acronym TAE refers to Therapeutic Aquatic Exercise and includes all the above terms. Land-based therapy is referred to as LT.

Aquatic therapy plays a role in the rehabilitation protocols for patients affected by stroke and has, for example, been included in the Dutch KNGF guidelines stroke[3]. Until around 2010, only a few publications were available and appraised in a Cochrane review by Mehrholz et al, 2011[4], concluding that: "This review of four trials, which included 94 participants, found there is not enough evidence to decide if water-based exercises may reduce disability after stroke. There is a lack of hard evidence for water-based exercises after stroke. More research is therefore needed".

Data sources

Since 2010, an exponential increase occurred of publications at various levels of evidence. Nine (9) systematic reviews with meta-analysis[5,6,7,8,9,10,11,12,13], published between 2017 and 2020, appraised a total of 33 randomized clinical trials (RCT's). The appraised RCT's were published between 2004 and 2018, included 1087 patients, and focused on balance, functionality, strength, mobility, lower limb function or gait parameters.

The nine systematic reviews contained a quantitative and a qualitative section. Not all authors came to the same conclusion regarding where to place an article (quantitative meta-analysis or qualitative appraisal). Where a certain author chose to include a trial in the quantitative assessment, another author chose to include the same trial in the qualitative appraisal. Reasons were not given.

Results

The findings of our synthesis indicate that all studies reported positive outcomes for the role of aquatic exercise in post-stroke rehabilitation. The general message is that, despite heterogeneity (chronic and subacute patients), all authors conclude the same: TAE (alone or in combination with LT) is as least as effective as LT for all the included outcomes. As an example, edited author's conclusions for balance are:

Chae et al[5]	In particular, TAE for patients with chronic stroke was statistically more effective on the Berg Balance Scale (BBS) compared with LT
Veldema & Jansen[6]	TAE is highly effective - and superior to LT in supporting gait and balance
Nayak et al[7]	TAE may be used to improve balance and gait after stroke; however, the evidence to support its use is still low
Giuriati et al[8]	The integration of TAE with LT may represent an optimal approach
Nascimento et al[9]	Moderate-quality evidence indicates that TAE significantly increases walking speed and balance, compared with LT
Ghayour et al[10]	TAE is effective for improving mobility, walking speed, and balance
Saquetto et al[11]).	There is moderate quality evidence that TAE versus LT should be considered an effective method of improving balance and mobility
Iliesco et al[12]	There is strong evidence that TAE is more effective than LT alone for improving aspects of mobility and balance
Iatridou et al[13]	There is Level I evidence that TAE is superior to LT program regarding postural balance

However, conclusions and size of measured effect of the authors are not consistent even when 22 clinical trials have been appraised in more than one review. This led us to qualitatively appraise all the clinical trials included in the different reviews. Twenty (20) trials only included chronic (> 6 months up to several years), six (6) trials included subacute patients and seven (7) trials included mixed subacute and chronic patients.

Trial designs
Two designs were detected in all trials:
- comparison water with land (intervention or waiting list).
- comparison land + water with land (conventional therapy/rehab + additional land intervention (1 publication water as additional intervention which gave a double dose).

Modes of exercise
Mode of exercise that were described:
- methods like Water Specific Therapy (WST)-Halliwick, Ai Chi, Bad Ragaz Ring Method (BRRM) and Aquatic PNF.
- exercise sets focused on walking, balancing, stretching, and strengthening variations.
- forward or backward treadmill walking.
- swimming.
- walking with weights.

Total time dosage
From 240 min to 2160 min. In one trial, the duration of the intervention was two weeks, in six trials four, in sixteen six, in four eight and in six trials twelve weeks. The duration of each intervention varied from 20 minutes to one hour.

Dose per session
- in 22 studies not mentioned.
- in the others either, treadmill speed + time, RPE (Rating of Perceived Exertion), repetitions and/or sets.
- 1 treadmill research out of 7 did not mention dose.
- The 2 swimming trials mentioned dose, RPE and time.
- 4 methods studies mention dose (RPE, % additional weight).

Measurement instruments
Most used instruments were 19 BBS/POMA (Berg Balance Test/Performance Oriented Mobility Assessment), 7 FRT (Functional Reach Test), 13 TUG (Timed up and go Test)
Others: 2 one leg stance, 2 FAC (Functional Ambulation Categories), 2 %VO_2 max. (maximum oxygen uptake), 10 strength tests, 6 gait speed/distance, 6 MWT (6 Minute Walk Test), 14 times 10 meter Walk Test ,11 Lab force platform ML/AP (medio-lateral/anterio-posterior sway).

- We did not look at outcome measures of quality of life, depression, pain etc.
- We did not see any reference to guidelines to support the choice for an outcome measure.
- We saw that comfortable speed was commonly used as outcome parameter. In chronic stroke, a low comfortable speed is mostly related to the high energy cost of walking, which can be changed with intensive endurance training. It is assumed, based on experience, that interventions tend to be not intensive enough

to reach the threshold of change, therefore comfortable speed might not be an outcome measure with proper effect size.

- When patients already achieve norm values at an instrument, clinical important change might not occur.
- Instruments measuring multiple domains like the Barthel Index are less sensitive to change when included in a motor ability forest plot / as a measure of balance and gait.

Statistics and psychometric properties

Only 6 articles used effect size (Cohen's d) to measure clinical differences between groups, where most articles only used inferential statistics. Only 3 articles used psychometric properties as Minimal Detectable Change (MDC) of Minimal Clinical Important Difference (MCID).

Follow up

None of the trials had follow up measurements. All of them were pre-post designs.

Description of the intervention

The description often was poor, especially in multimodal programs with a variety of exercises. As an example: walking forward was reported often. But we never read about corrections in terms of non-use of hands, adaptations of the swing leg, adaptations of the stance leg (in general: kinematic corrections).

Conclusions

What we observed is what authors of reviews also stated in their discussion: big differences in dosage, outcome measures, intervention concepts and time since the stroke. However, in general patients were able to walk (on a treadmill), do balance exercises, strengthen lower limbs and even swim. The included patients seem to be rather homogeneous in that respect.

Suggestions

To our expert opinion, we also observed issues that might be of importance for future therapy and research.

Therapy

- choose an appropriate water depth (for patient and therapist). Mostly we saw hip depth, but also 1.50m or popliteal depth. For walking purposes, water should be between iliac crest and xyphoid. For fast walking, depth should be at iliac crest or even lower.
- Describe dosage and intensity parameters, which might make replication easier in clinical practice and research. To our opinion, many interventions were underdosed, especially when no treadmill was used. By now we know that brain health intervention "prescribes" aerobic levels at which patients at least get moderately tired, even at the start of the session.
- Strength (intermuscular coordination) training needs high speeds against turbulence, as fast and as hard as you can, which was not described anywhere.

- None of the articles included clearly described perquisites for balance and gait like trunk stability exercises, changing the learned non-use of the affected leg or compensatory training of the non-affected leg.
- Use proper patterns of exercise. Some studies used the Bad Ragaz Ring Method, but pattern description showed significant mistakes.
- Describe kinematic exercise parameters in such a way that they can be replicated.
- Do not use general concepts like sagittal/transversal/longitudinal rotation control.
- What we also missed were activities in which gait adaptability, agility, reactive strategies, unexpected perturbations, limits of reaching, obstacle negotiation (apart from 1 trial), executive movement functions, power training for leg muscles (e.g. plantar flexors). These outcomes are listed in current recommendations for stroke rehabilitation.

Research

- Use of measurement instruments from guidelines, referring to their psychometric properties in relation to stroke (as e.g., BBS, FRT, TUG).
- Use of measures as effect size, MDC, MCID.
- Prevent a mismatch between measurements and intervention. As example: BBS has been used twice or a treadmill walking intervention in which hands were on the bars. Another treadmill trial used a force platform as an outcome measure. BBS will not change much when the intervention is supported walking. Also control of the center of gravity on a force platform does not match a walking intervention.
- Prevent ceiling effects when choosing outcome instruments.
- Future interventions and research should include appropriate measures for the above-mentioned activities. Gait adaptability, agility, power of leg muscles, reactive strategies on unexpected perturbations, obstacle negotiation, executive movement functions, multiple tasks (as e.g. mini-BEST, Dynamic Gait Index, T-test, Push and Release, Dual Task Walking test, Stroop).
- Include follow up measurements after 3 or 6 months.

Acknowledgements
Our special thanks go to Ben Waller and Caroline Barmatz for their constructive review of this statement.

Disclaimer
The Association IATF has based its statement on the best available information. IATF excludes any liability for any direct, indirect, incidental damages or any other damages that would result from, or be connected with the use of the information presented in this document.

References

1. https://www.world-stroke.org/world-stroke-day-campaign/why-stroke-matters/learn-about-stroke. Website accessed at November 7, 2021

2. https://strokeeurope.eu/executive-summary. Websites accessed at November 7, 2021

3. KNGF clinical practice guideline for physical therapy in patients with stroke. KNGF 2014

4. Mehrholz J, Kugler J, Pohl M. Water-based exercises for improving activities of daily living after stroke. Cochrane Database Syst Rev. 2011(1):CD008186. doi: 10.1002/14651858.CD008186.pub2.

5. Chae CS, Jun JH, Im S, Jang Y, Park GY. Effectiveness of hydrotherapy on balance and paretic knee strength in patients with stroke: a systematic review and meta-analysis of randomized controlled trials. Am J Phys Med Rehabil. 2020;99(5):409-419. doi: 10.1097/PHM.0000000000001357.

6. Veldema J, Jansen P. Aquatic therapy in stroke rehabilitation: systematic review and meta-analysis. Acta Neurol Scand. 2021;143(3):221-241. doi: 10.1111/ane.13371.

7. Nayak P, Mahmood A, Natarajan M, Hombali A, Prashanth CG, Solomon JM. Effect of aquatic therapy on balance and gait in stroke survivors: a systematic review and meta-analysis. Complement Ther Clin Pract. 2020;39:101-110. doi: 10.1016/j.ctcp.2020.101110.

8. Giuriati S, Servadio A, Temperoni G, Curcio A, Valente D, Galeoto G. The effect of aquatic physical therapy in patients with stroke: a systematic review and meta-analysis. Top Stroke Rehabil. 2021;28(1):19-32. doi: 10.1080/10749357.2020.1755816.

9. Nascimento LR, Louise C, Flores LC, de Menezes KKP, Teixeira-Salmela LF. Water-based exercises for improving walking speed, balance, and strength after stroke: a systematic review with meta-analyses of randomized trials. Physiotherapy. 2020;107:100-110. doi: 10.1016/j.physio.2019.10.002.

10. Ghayour Najafabadi M, Shariat A, Dommerholt J, Hakakzadeh A, Nakhostin-Ansari A, Selk-Ghaffari M, Ingle L, Cleland JA. Aquatic therapy for improving lower limbs function in post-stroke survivors: a systematic review with meta-analysis. Top Stroke Rehabil. 2021;Jun 19:1-17. doi: 10.1080/10749357.2021.1929011.

11. Saquetto MB, da Silva CM, Martinez BP, Sena CC, Pontes SS, da Paixão MTC, Neto MG. Water-based exercise on functioning and quality of life in post-stroke persons: a systematic review and meta-analysis.
J Stroke Cerebrovasc Dis. 2019;28(11):104341. doi: 10.1016/j.jstrokecerebrovasdis.2019.104341.

12. Iliescu AM, McIntyre A, Wiener J, Iruthayarajah J, Lee A, Caughlin S, Teasell R. Evaluating the effectiveness of aquatic therapy on mobility, balance, and level of functional independence in stroke rehabilitation: a systematic review and meta-analysis. Clin Rehabil. 2020;34(1):56-68. doi: 10.1177/0269215519880955.

13. Iatridou G, Pelidou HS, Varvarousis D, Stergiou A, Beris A, Panagiotis Givissis P, Ploumis A. The effectiveness of hydrokinesiotherapy on postural balance of hemiplegic patients after stroke: a systematic review and meta-analysis. Clin Rehabil. 2018;32(5):583-593. doi: 10.1177/0269215517748454.

14. Reisman DS, Binder-MacLeod S, Farquhar WB. Changes in metabolic cost of transport following locomotor training post-stroke. Top Stroke Rehabil. 2013;20(2):161-170. doi: 10.1310/tsr2002-161.

- References to the 33 appraised RCT's can be found in the reference lists of reviews 5-13.