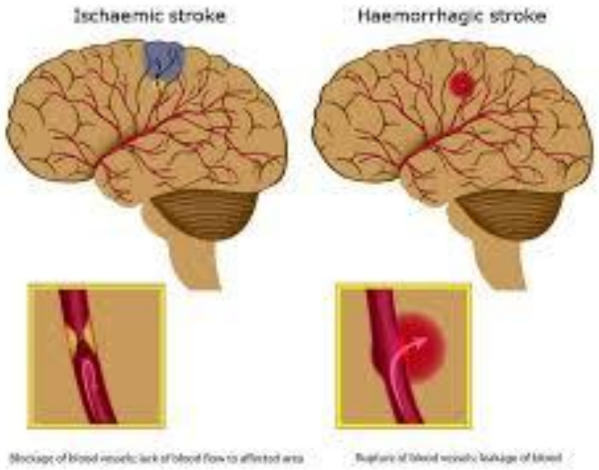
APTA
Academy of Aquatic Physical Therapy™

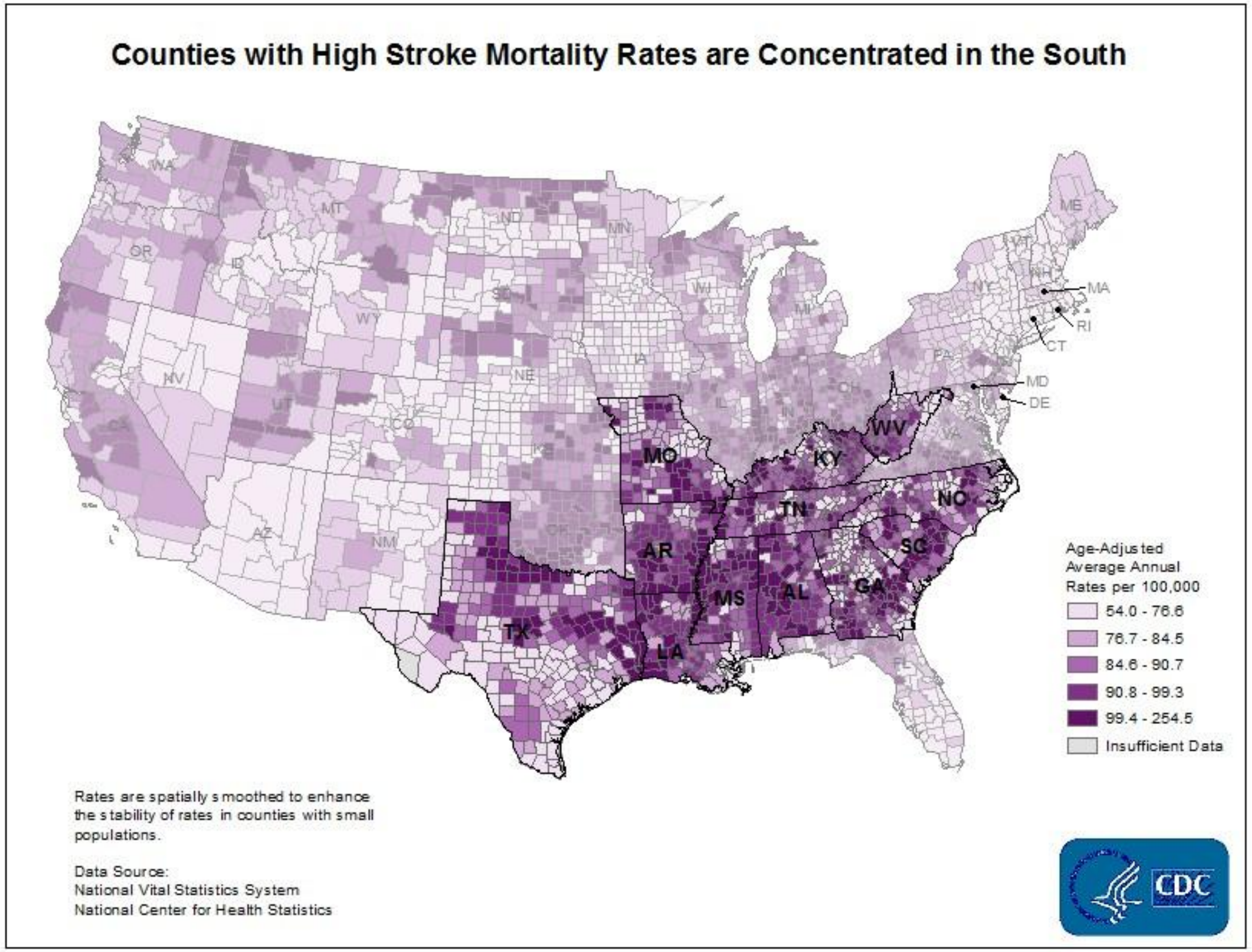
Aquatic Rehabilitation to Promote Stroke Recovery

David Morris, PT, PhD, FAPTA

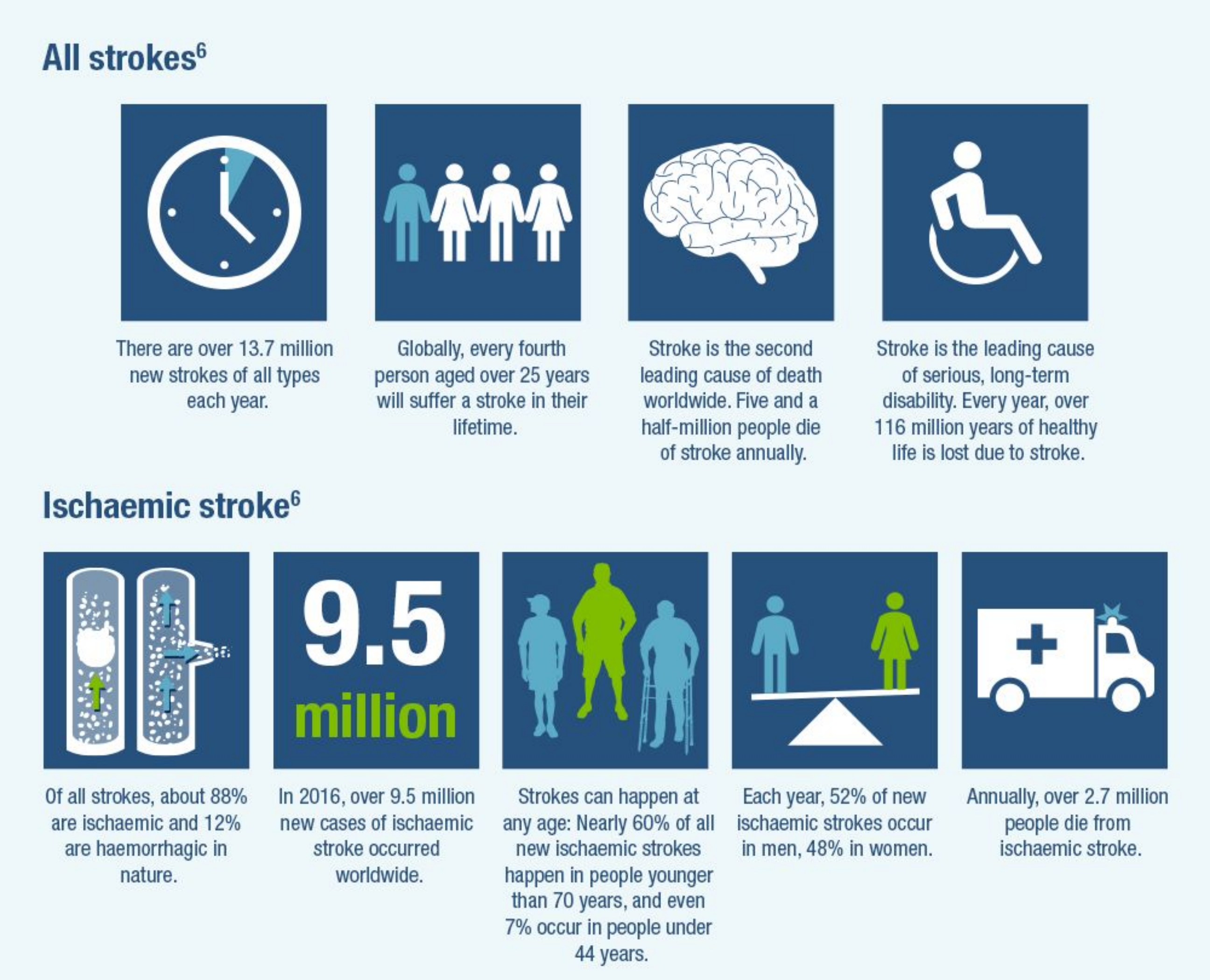
Stroke



Every year, more than **795,000 people** in the United States have a stroke. About 610,000 of these are first or new strokes.



Stroke


All strokes[6]
There are over 13.7 million new strokes of all types each year.
Globally, every fourth person aged over 25 years will suffer a stroke in their lifetime.
Stroke is the second leading cause of death worldwide. Five and a half-million people die of stroke annually.
Stroke is the leading cause of serious, long-term disability. Every year, over 116 million years of healthy life is lost due to stroke.
Ischaemic stroke[6]
9.5
million
Of all strokes, about 88% are ischaemic and 12% are haemorrhagic in nature.
In 2016, over 9.5 million new cases of ischaemic stroke occurred worldwide.
Strokes can happen at any age: Nearly 60% of all new ischaemic strokes happen in people younger than 70 years, and even 7% occur in people under 44 years.
Each year, 52% of new ischaemic strokes occur in men, 48% in women.
Annually, over 2.7 million people die from ischaemic stroke.

Common issues after stroke

Right brain controls:
Left body motor control
Spatial recognition
Insight and imagination

RIGHT CVA

Right hemiparesis

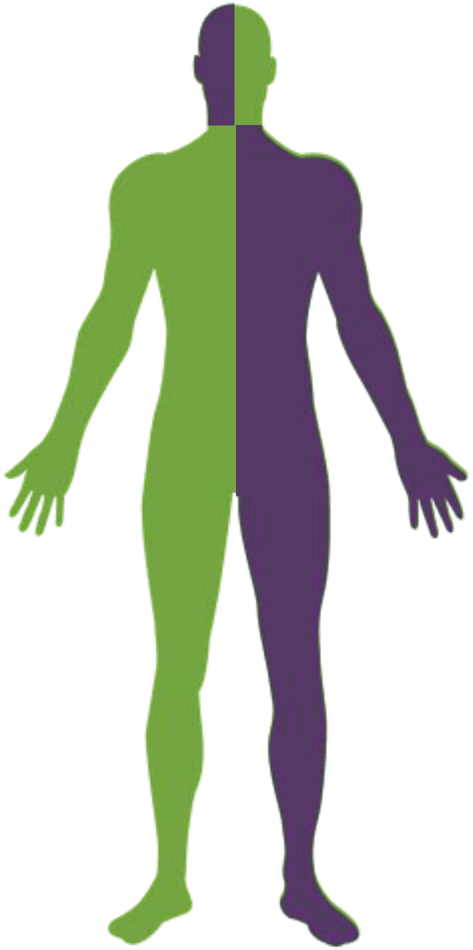
Speech-language deficits

Slow, cautious behavior

Impaired comprehension

Aware of deficits, depression, anxiety

Memory deficits



LEFT CVA

Left brain controls:
Right body motor control
Language and writing
Logic & reasoning

Left hemiparesis

Spatial-perceptual deficits

Quick impulsive behavior

Impaired judgement

Tends to minimize problems

Memory deficits

Movement Control Issues

- Hemiparesis
- 50% - long term muscle weakness influencing ability to move
- Limited fine, dexterous control of hand and fingers – limiting ADLs
- Up to 85% experience impaired proprioception and/or touch
- Movement and sensation damage extend beyond initial damage to the brain
  - Tightness, inelastic muscle properties
  - Limited ROM/Contractures
  - Over-excited reflex reactions
- Deconditioning is profound!

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REVIEW ARTICLE

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Aquatic therapy in stroke rehabilitation: systematic review and meta-analysis

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Abstract

The main object of this systematic review and meta-analysis is to collect the available evidence of aquatic therapy in stroke rehabilitation and to investigate the effect of this intervention in supporting stroke recovery. The PubMed, the Cochrane Central Register of Controlled Trials and the PEDro databases were searched from their inception through to 31/05/2020 on randomized controlled trials evaluating the effect of aquatic therapy on stroke recovery. Subjects´ characteristics, methodological aspects, intervention description, and outcomes were extracted. Effect sizes were calculated for each study and outcome. Overall, 28 appropriate studies ($N = 961$) have been identified. A comparison with no intervention indicates that aquatic therapy is effective in supporting walking, balance, emotional status and health-related quality of life, spasticity, and physiological indicators. In comparison with land-based interventions, aquatic therapy shows superior effectiveness on balance, walking, muscular strength, proprioception, health-related quality of life, physiological indicators, and cardiorespiratory fitness. Only on independence in activities of daily living the land- and water-based exercise induce similar effects. Established concepts of water-based therapy (such as the Halliwick, Ai Chi, Watsu, or Bad Ragaz Ring methods) are the most effective, aquatic treadmill walking is the least effective. The current evidence is insufficient to support this therapy form within evidence-based rehabilitation. However, the available data indicate that this therapy can significantly improve a wide range of stroke-induced disabilities. Future research should devote more attention to this highly potent intervention.

Previous Metanalyses/Reviews (at least 4)

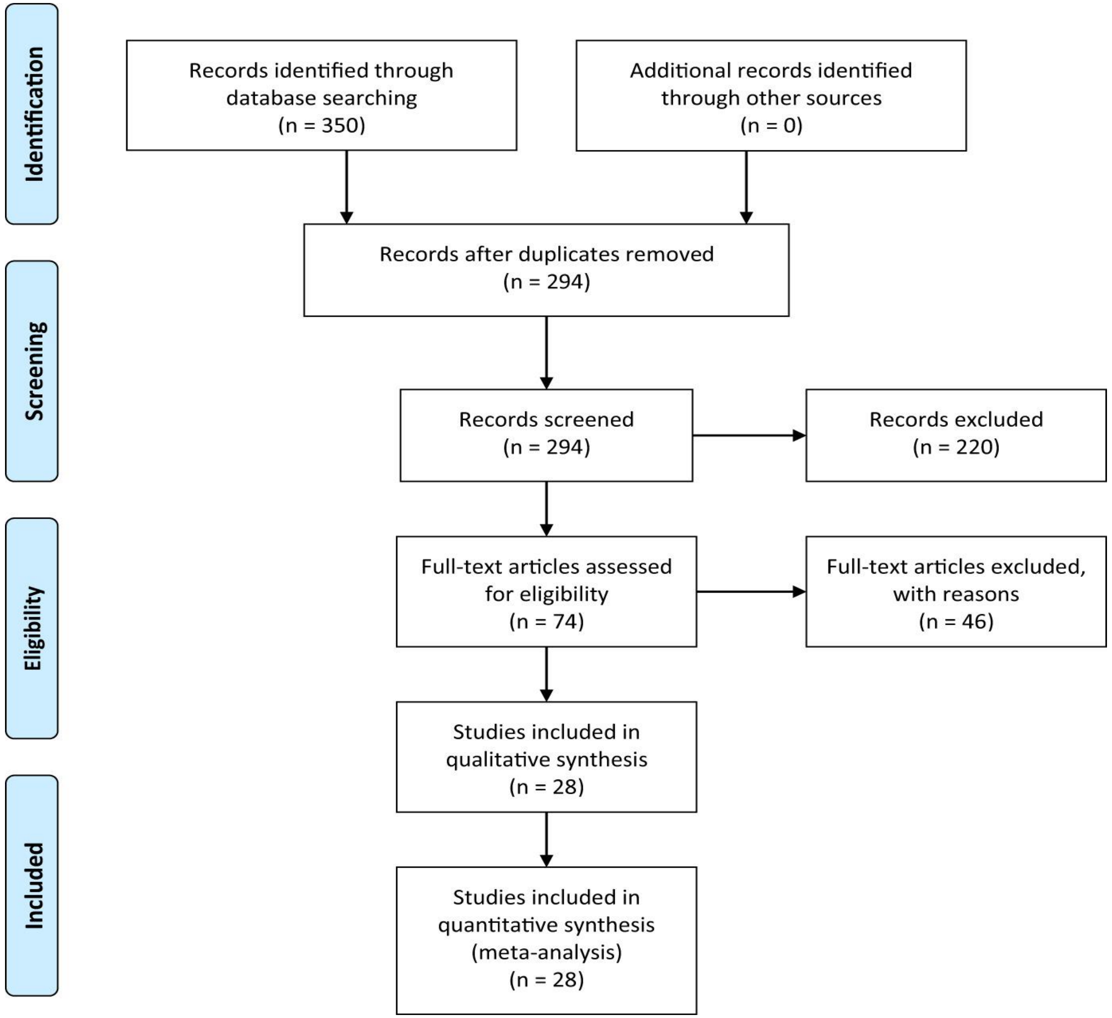
- Results indicated aquatic therapy is superior to land-based therapy in:
  - ✔ Gait
  - ✔ Balance
  - ✔ Independence with ADLs
  - ✔ Mobility
  - ✔ Muscular Strength
  - ✔ Aerobic Capacity
  - ✔ Body Structure and Function

- No difference in Quality-of-Life Measures

Previous Metanalyses/Reviews (at least 4)

- Limitations/Gaps
  - ✔ No comparison of different forms of aquatic therapy
  - ✔ No information on non-physical deficits (e.g., depression)
  - ✔ No information on muscle tone/spasticity

Aquatic therapy in stroke rehabilitation: systematic review and meta-analysis



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Outcome Measures Used (N=28)

Categories	# Trials
Balance	22
Walking Ability	19
Muscular Strength	7
ADL Independence	5
Proprioception	3
HRQL (e.g., SF-36, EQ-5D)	5
Physiological Indicators (e.g., arterial stiffness, blood pressure, EMG)	2
Cardiorespiratory Fitness (e.g., Graded Treadmill testing, Max ergometer testing)	3
Spasticity	1

Effect Size

$$\text{Effect Size} = \frac{\text{Mean of experimental group - Mean of Control group}}{\text{Standard deviation}}$$

Small = .2

Medium = .5

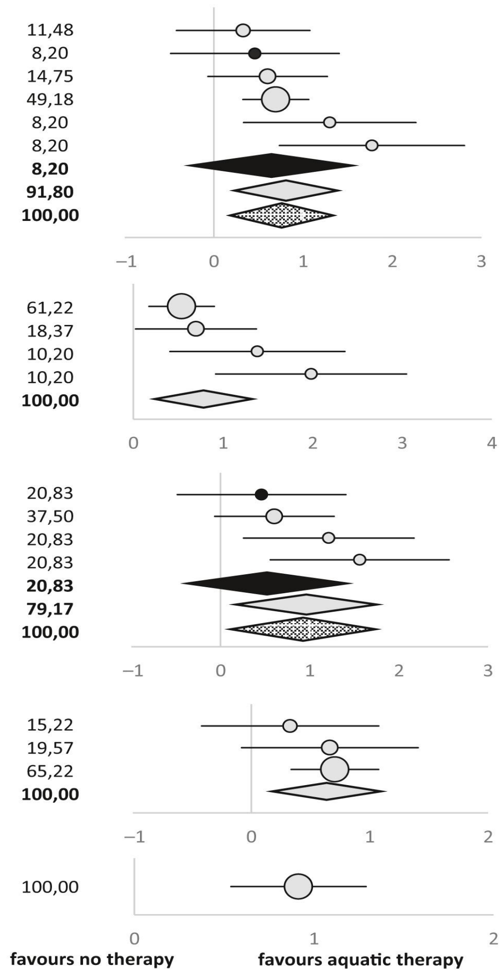
Large = .8

Comparison with no Intervention

- 6 Studies
- 244 participants
- 30 days – 3.6 years post stroke
- Aquatic Therapy is effective in:
  - ✔ Walking
  - ✔ Balance
  - ✔ Emotional status and HRQL
  - ✔ Spasticity
  - ✔ Physiological indicators

Aquatic therapy in stroke rehabilitation: systematic review and meta-analysis

	Aquatic therapy	Effect size	Lower limit	Upper limit	Relative weight
Overall (n = 251)					
Aidar et al., 2013	walking	0,33	−0,42	1,08	11,48
Park et al., 2014	treadmill	0,46	−0,48	1,40	8,20
Aidar et al., 2018	walking	0,60	−0,07	1,27	14,75
Matsumoto et al., 2016	walking	0,69	0,33	1,06	49,18
Kim et al., 2015a	walking	1,30	0,33	2,27	8,20
Kim et al., 2016	walking	1,77	0,74	2,81	8,20
Subtotal	**treadmill**	**0,46**	**−0,48**	**1,40**	**8,20**
Subtotal	**walking**	**0,78**	**0,21**	**1,36**	**91,80**
Total		**0,76**	**0,15**	**1,37**	**100,00**
Subgroup heterogeneity: I^2 = 64.9%					
Gait (n = 196)					
Matsumoto et al., 2016	walking	0,54	0,17	0,90	61,22
Aidar et al., 2018	walking	0,70	0,02	1,37	18,37
Kim et al., 2015a	walking	1,38	0,41	2,36	10,20
Kim et al., 2016	walking	1,98	0,91	3,06	10,20
Total		**0,80**	**0,25**	**1,36**	**100,00**
Subgroup heterogeneity: I^2= 86,5%					
Balance (n = 96)					
Park et al., 2014	treadmill	0,46	−0,48	1,40	20,83
Aidar et al., 2018	walking	0,60	−0,07	1,27	37,50
Kim et al., 2015a	walking	1,21	0,26	2,17	20,83
Kim et al., 2016	walking	1,56	0,56	2,56	20,83
Subtotal	**treadmill**	**0,46**	**−0,48**	**1,40**	**20,83**
Subtotal	**walking**	**1,02**	**0,18**	**1,85**	**79,17**
Total		**0,90**	**0,04**	**1,76**	**100,00**
Subgroup heterogeneity: I^2 = 81,9%					
Health related quality of life, emotional status (n = 184)					
Aidar et al., 2013	walking	0,33	−0,42	1,08	15,22
Aidar et al., 2018	walking	0,66	−0,08	1,41	19,57
Matsumoto et al., 2016	walking	0,71	0,34	1,08	65,22
Total		**0,64**	**0,14**	**1,14**	**100,00**
Subgroup heterogeneity: I^2 = 87.5%					
Spasticity (n = 120)					
Matsumoto et al., 2016	walking	0,91	0,54	1,29	100,00



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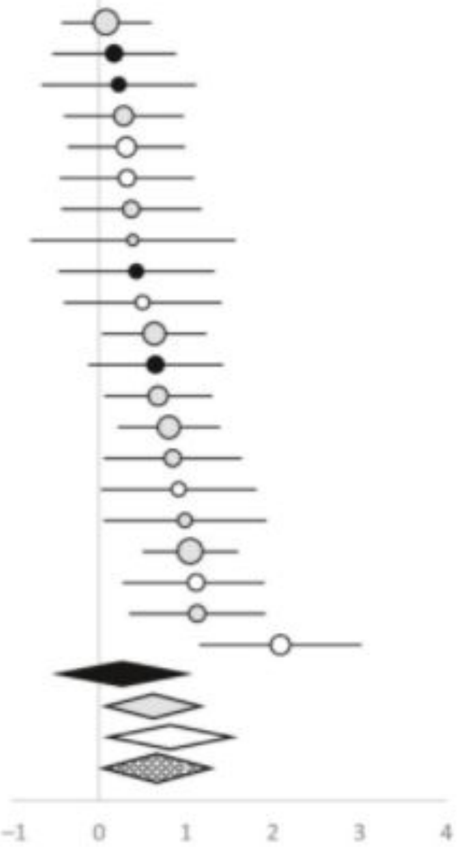
Comparison to Land-Based Interventions

- 21 Trials
- 691 participants
- 24 weeks - > 12 months
- Aquatic Therapy superior to Land-based
- Similar effects on Independence in ADLS
  - Balance
  - Walking
  - Muscular Strength
  - Proprioception
  - HRQL
  - Physiological Indicators
  - Cardiorespiratory fitness
- Water-based therapy concepts (Halliwick, Ai Chi, Bad Ragaz) - most effective
- Aquatic Treadmill – least effective

Overall

(A)	Aquatic therapy	Effect size	Lower limit	Upper limit	Relative weight
Overall (n = 691)					
Eyvaz et al., 2018	walking	0,09	−0,42	0,60	8,77
Lee et al., 2018	treadmill	0,18	−0,53	0,88	4,68
Park et al., 2012	treadmill	0,23	−0,65	1,11	2,92
Lee et al., 2010	walking	0,29	−0,39	0,97	4,97
Zhang et al., 2016	concept	0,32	−0,35	0,98	5,26
Tripp et al., 2014	concept	0,32	−0,44	1,09	3,95
Chan et al.,2017	walking	0,38	−0,42	1,17	3,65
Chu et al., 2004	walking	0,39	−0,78	1,57	1,75
Han et al., 2018	treadmill	0,43	−0,45	1,32	2,92
Noh et al., 2008	concept	0,51	−0,39	1,40	2,92
Park et al., 2011b	walking	0,64	0,04	1,23	6,73
Kum et al., 2017	treadmill	0,66	−0,11	1,42	4,09
Park et al., 2011a	walking	0,69	0,07	1,30	6,43
Saleh et al., 2019	walking	0,81	0,23	1,39	7,31
Zhu et al., 2016	walking	0,85	0,07	1,64	4,09
Cha et al., 2017	concept	0,92	0,04	1,81	3,22
Kim et al., 2015b	walking	0,99	0,06	1,92	2,92
Han et al., 2013	walking	1,05	0,52	1,59	9,06
Park et al., 2016	concept	1,12	0,28	1,90	4,09
Jung et al., 2014	walking	1,13	0,36	1,91	4,39
Funari et al., 2014	concept	2,09	1,17	3,02	5,85
Subtotal	**treadmill**	**0,37**	**−0,42**	**1,17**	**14,62**
Subtotal	**walking**	**0,66**	**0,01**	**1,31**	**60,09**
Subtotal	**concepts**	**0,96**	**0,13**	**1,77**	**25,29**
Total		**0,70**	**−0,02**	**1,41**	**100,00**

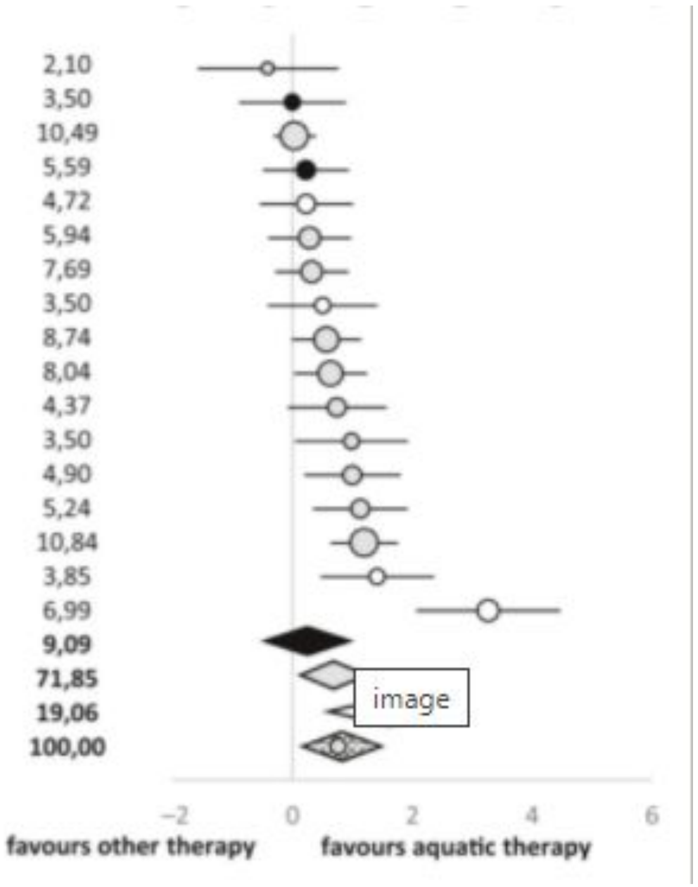
Subgroup heterogeneity: I^2 = 11.4%



Balance

Balance (n = 572)					
Chu et al., 2004	walking	–0,41	–1,57	0,75	2,10
Park et al., 2012	treadmill	0,00	–0,88	0,88	3,50
Eyvaz et al., 2018	walking	0,04	–0,30	0,37	10,49
Lee et al., 2018	treadmill	0,23	–0,48	0,93	5,59
Tripp et al., 2014	concept	0,23	–0,53	0,99	4,72
Lee et al., 2010	walking	0,29	–0,39	0,97	5,94
Park et al., 2011a	walking	0,32	–0,27	0,92	7,69
Noh et al., 2008	concept	0,50	–0,39	1,40	3,50
Saleh et al., 2019	walking	0,57	0,00	1,13	8,74
Park et al., 2011b	walking	0,64	0,04	1,23	8,04
Chan et al., 2017	walking	0,75	–0,06	1,56	4,37
Kim et al., 2015b	walking	0,99	0,06	1,92	3,50
Zhu et al., 2016	walking	1,00	0,21	1,79	4,90
Jung et al., 2014	walking	1,13	0,36	1,91	5,24
Han et al., 2013	walking	1,20	0,65	1,75	10,84
Cha et al., 2017	concept	1,42	0,48	2,35	3,85
Funari et al., 2014	concept	3,27	2,08	4,46	6,99
Subtotal	**treadmill**	**0,14**	**–0,63**	**0,91**	**9,09**
Subtotal	**walking**	**0,62**	**–0,01**	**1,24**	**71,85**
Subtotal	**concepts**	**1,64**	**0,66**	**2,62**	**19,06**
Total		**0,77**	**0,06**	**1,47**	**100,00**

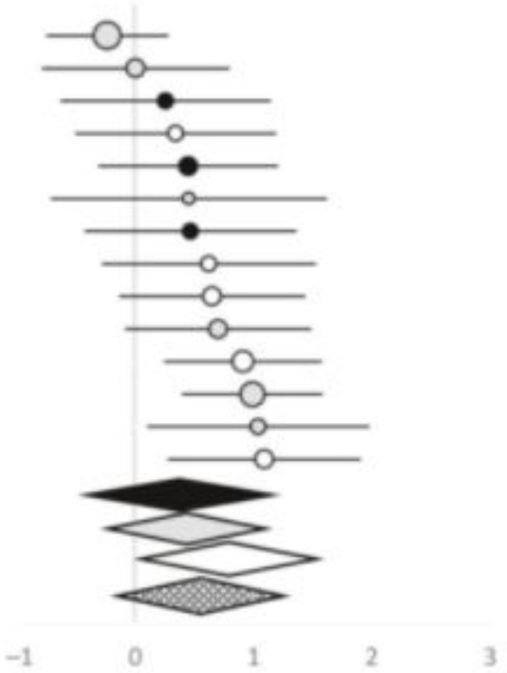
Subgroup heterogeneity: I^2 = 75.2%



Gait

(B)	Aquatic therapy	Effect size	Lower limit	Upper limit	Relative weight
Gait (n = 400)					
Eyvaz et al., 2018	walking	−0,24	−0,74	0,27	15,00
Chan et al.,2017	walking	0,00	−0,78	0,79	6,25
Park et al., 2012	treadmill	0,26	−0,63	1,14	5,00
Cha et al., 2017	concept	0,34	−0,50	1,18	5,50
Kum et al., 2017	treadmill	0,45	−0,31	1,20	7,00
Chu et al., 2004	walking	0,45	−0,71	1,62	3,00
Han et al., 2018	treadmill	0,47	−0,42	1,36	5,00
Noh et al., 2008	concept	0,62	−0,27	1,52	5,00
Tripp et al., 2014	concept	0,65	−0,13	1,43	6,75
Zhu et al., 2016	walking	0,70	−0,08	1,48	7,00
Funari et al., 2014	concept	0,91	0,25	1,57	10,00
Saleh et al., 2019	walking	0,99	0,40	1,58	12,50
Kim et al., 2015b	walking	1,04	0,11	1,97	5,00
Park et al., 2016	concept	1,09	0,28	1,90	7,00
Subtotal	**treadmill**	**0,40**	**−0,43**	**1,23**	**17,00**
Subtotal	**walking**	**0,42**	**−0,27**	**1,10**	**48,75**
Subtotal	**concepts**	**0,76**	**−0,01**	**1,54**	**34,25**
Total		**0,53**	**−0,21**	**1,27**	**100,00**

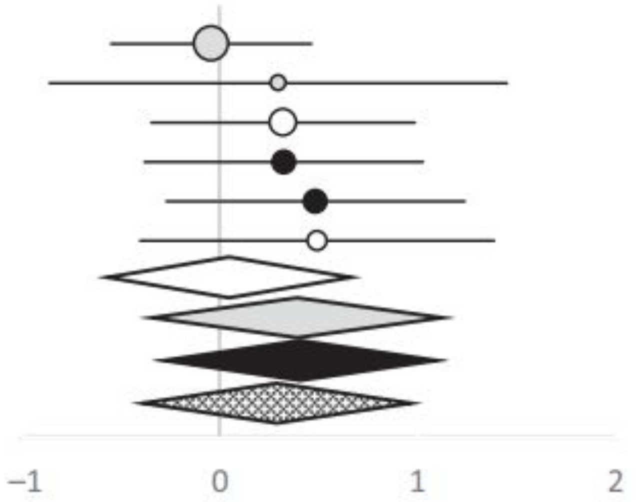
Subgroup heterogeneity: I^2 = 32.1%



Muscular Function/Strength

Muscular function/strength of lower limbs (n = 188)					
Eyvaz et al., 2018	walking	–0,04	–0,55	0,46	31,91
Chu et al., 2004	walking	0,29	–0,86	1,45	6,38
Zhang et al., 2016	concept	0,32	–0,35	0,98	19,15
Lee et al., 2018	treadmill	0,32	–0,38	1,03	17,02
Kum et al., 2017	treadmill	0,48	–0,27	1,24	14,89
Noh et al., 2008	concept	0,49	–0,40	1,39	10,64
Subtotal	**walking**	**0,01**	**–0,60**	**0,63**	**38,30**
Subtotal	**concepts**	**0,38**	**–0,37**	**1,13**	**29,79**
Subtotal	**treadmill**	**0,40**	**–0,33**	**1,13**	**31,91**
Total		**0,25**	**–0,45**	**0,94**	**100,00**

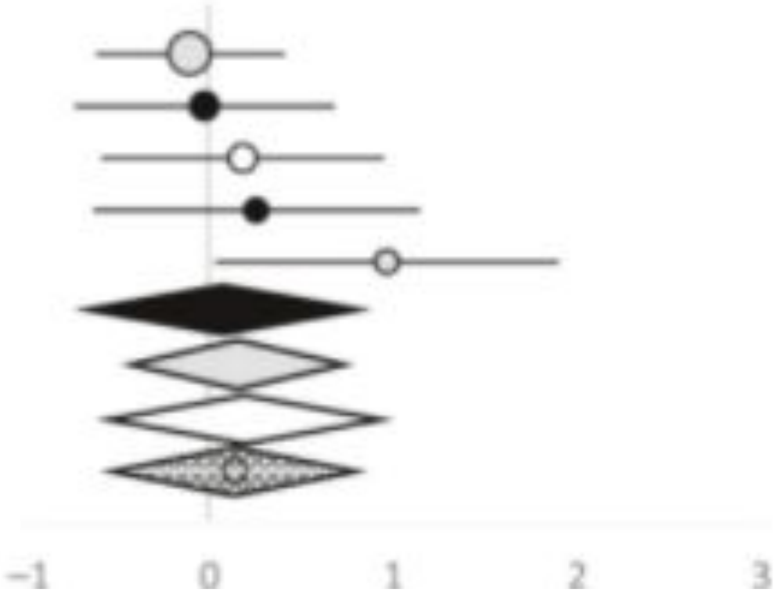
Subgroup heterogeneity: I^2 = 0.0%



ADL Independence

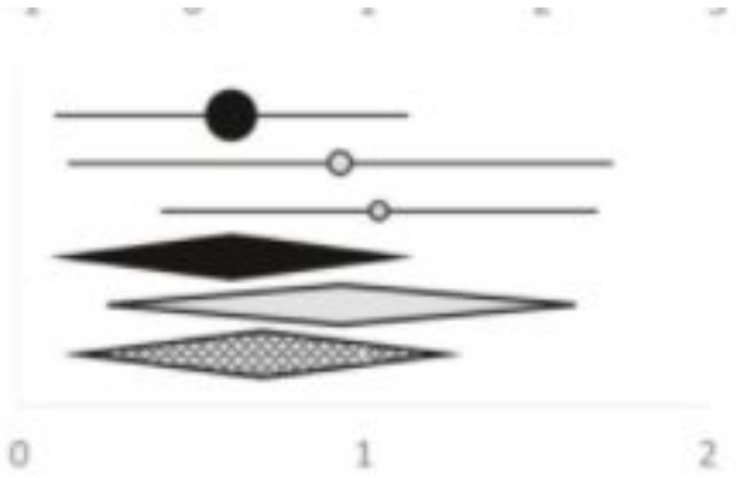
ADL independence (n = 159)					
Eyvaz et al., 2018	walking	−0,10	−0,61	0,40	37,74
Lee et al., 2018	treadmill	−0,02	−0,72	0,68	20,13
Tripp et al., 2014	concept	0,18	−0,58	0,94	16,98
Han et al., 2018	treadmill	0,26	−0,62	1,14	12,58
Kim et al., 2015b	walking	0,97	0,04	1,89	12,58
Subtotal	**treadmill**	**0,09**	**−0,68**	**0,85**	**32,70**
Subtotal	**walking**	**0,17**	**−0,45**	**0,78**	**50,31**
Subtotal	**concepts**	**0,18**	**−0,58**	**0,94**	**16,98**
Total		**0,14**	**−0,55**	**0,83**	**100,00**

Subgroup heterogeneity: I^2 = 65.4%



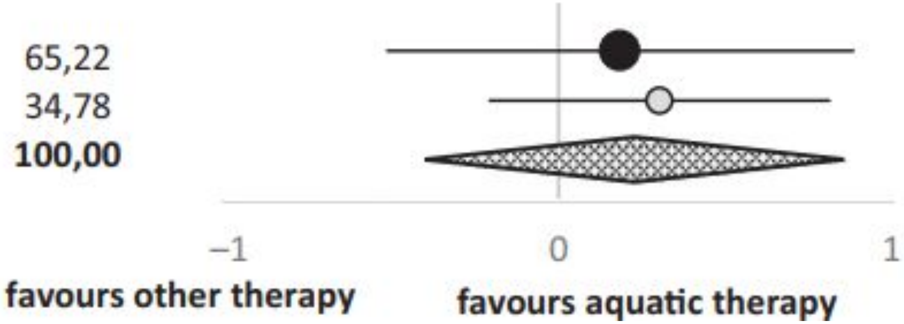
Proprioception (n = 124)					
Kum et al., 2017	treadmill	0,62	0,11	1,13	74,19
Park et al., 2011a	walking	0,93	0,15	1,72	16,13
Han et al., 2013	walking	1,05	0,42	1,68	9,68
Subtotal	**treadmill**	**0,62**	**0,11**	**1,13**	**74,19**
Subtotal	**walking**	**0,98**	**0,25**	**1,70**	**25,81**
Total		**0,71**	**0,14**	**1,28**	**100,00**

Subgroup heterogeneity: I^2 = 44.0%



HRQOL

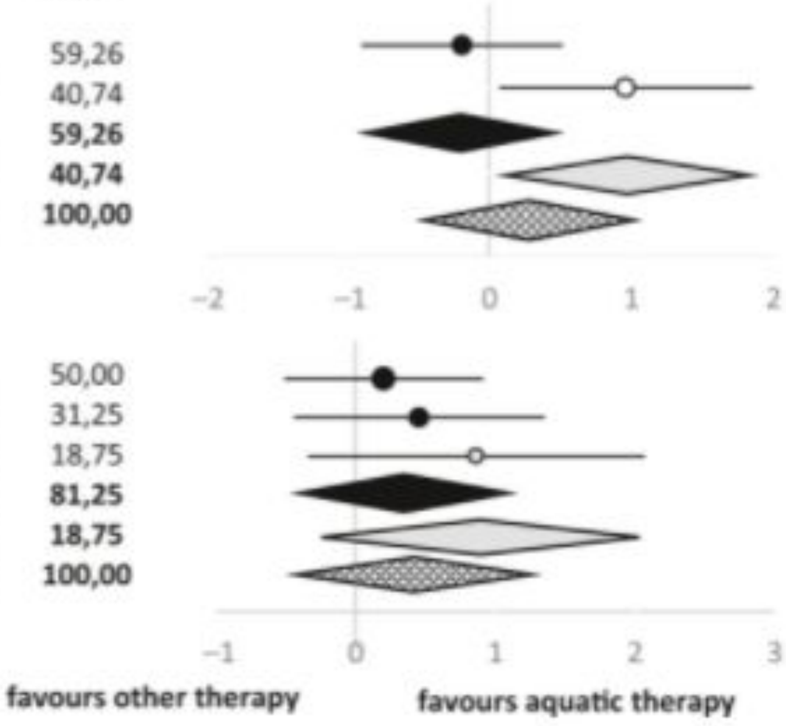
Health related quality of life (n = 92)					
Lee et al., 2018	treadmill	0,19	–0,51	0,89	65,22
Eyvaz et al., 2018	walking	0,30	–0,21	0,81	34,78
Total		**0,23**	**–0,41**	**0,86**	**100,00**
Subgroup heterogeneity: I^2 = 0.0%					



Physiological Factors/Cardiorespiratory Fitness

(C) image

	Aquatic therapy	Effect size	Lower limit	Upper limit	Relative weight
Physiological indicators (n = 61)					
Lee et al., 2018	treadmill	–0,19	–0,89	0,51	59,26
Cha et al., 2017	concept	0,96	0,08	1,84	40,74
Subtotal	**treadmill**	**–0,19**	**–0,89**	**0,51**	**59,26**
Subtotal	**walking**	**0,96**	**0,08**	**1,84**	**40,74**
Total		**0,28**	**–0,50**	**1,05**	**100,00**
Subgroup heterogeneity: I^2 = 96.9%					
Cardiorespiratory fitness (n = 64)					
Lee et al., 2018	treadmill	0,20	–0,50	0,91	50,00
Han et al., 2018	treadmill	0,46	–0,44	1,35	31,25
Chu et al., 2004	walking	0,86	–0,34	2,06	18,75
Subtotal	**treadmill**	**0,30**	**–0,48**	**1,07**	**81,25**
Subtotal	**walking**	**0,86**	**–0,34**	**2,06**	**18,75**
Total		**0,40**	**–0,45**	**1,26**	**100,00**
Subgroup heterogeneity: I^2 = 67.3%					



TOPICS IN STROKE REHABILITATION, 2017
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The effect of water-based exercises on balance in persons post-stroke: a randomized controlled trial

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ABSTRACT

Objective: Water-based exercises have been used in the rehabilitation of people with stroke, but little is known about the impact of this treatment on balance. This study examined the effect of water-based exercises compared to land-based exercises on the balance of people with sub-acute stroke.

Methods: In this single-blind randomized controlled study, 32 patients with first-time stroke discharged from inpatient rehabilitation at West Park Healthcare Centre were recruited. Participants were randomized into W (water-based + land; $n = 17$) or L (land only; $n = 15$) exercise groups. Both groups attended therapy two times per week for six weeks. Initial and progression protocols for the water-based exercises (a combination of balance, stretching, and strengthening and endurance training) and land therapy (balance, strength, transfer, gait, and stair training) were devised. Outcomes included the Berg Balance Score, Community Balance and Mobility Score, Timed Up and Go Test, and 2 Minute Walk Test.

Results: Baseline characteristics of groups W and L were similar in age, side of stroke, time since stroke, and wait time between inpatient discharge and outpatient therapy on all four outcomes. Pooled change scores from all outcomes showed that significantly greater number of patients in the W-group showed improvement post-training compared to the L-group ($p < 0.05$). More patients in W-group showed change scores exceeding the published minimal detectable change scores.

Discussion: A combination of water- and land-based exercises has potential for improving balance. The results of this study extend the work showing benefit of water-based exercise in chronic and less-impaired stroke groups to patients with sub-acute stroke.

KEYWORDS
Hydrotherapy; stroke; postural balance

Participants/Interventions

- 32 participants in sub-acute phase after stroke
- Water + Land (n=17)
  - ✔ 30 min/session water + 30 min/session land; 2x/week; 6 weeks
- Land only (n=18)
  - ✔ 60 min/session land; 2x/week; 6 weeks

Land Based Activities

Land-based exercises
Unsupported standing for 2 min
Weight shifting side to side for 2 min
Weight shifting in walk standing for 2 min
Reach to different directions for 2 min
Walk side steps for 20 ft
Walk backwards for 20 ft
Stand with one foot in front for 1 min
Stand on one foot for 30 s
Walk on spot on foam/mini-trampoline for 1 min
Tandem walk for 20 ft
Place alternate foot on stool for 8 times
Side steps with cross over for 20 ft
Walk on different surfaces (foam, mini-trampoline, 6 inches wooden block) for a length of 20 ft
Walk and pick up five bean-bags spread over 20 ft
Balance on rocker board for 30 s
180 degrees tandem pivot first towards right and then left
Lateral foot scooting for 10 ft
Walking and look away on command
Hop forward for 10 ft

Water-Based Activities

Water-based exercises
Unsupported standing with feet hip width apart for 10 s moving up to 2 min in deep water
Unsupported standing with feet together for 10 s moving up to 2 min in deep water
Tandem stance for 10 s moving up 2 min in deep water
Marching on the spot for 30 s moving up to 2 min in deep water – no hands on the bar
Side steps for 13 ft in deep water
Walk backwards for 13 ft in deep water
Stand on one foot for 10 s moving up to 1 min in deep water
Stand on one foot for 10 s moving up to 1 min in shallow water
Tandem walk for 13 ft in deep water
Tandem walk for 13 ft in shallow water
Side steps with cross over for 13 ft in deep water
Side steps with cross over for 13 ft in shallow water
Placing alternate foot on step 10 times
Tossing beach ball 10 times in deep water
Tossing beach ball 10 times in shallow water

Outcome Measures

- Berg Balance Scale
- Community Balance and Mobility Score
- Timed Up and Go
- 2-minute Walk Test

Figure 2 of 3

Figure 2. Average change in clinical scores post-both types of training.

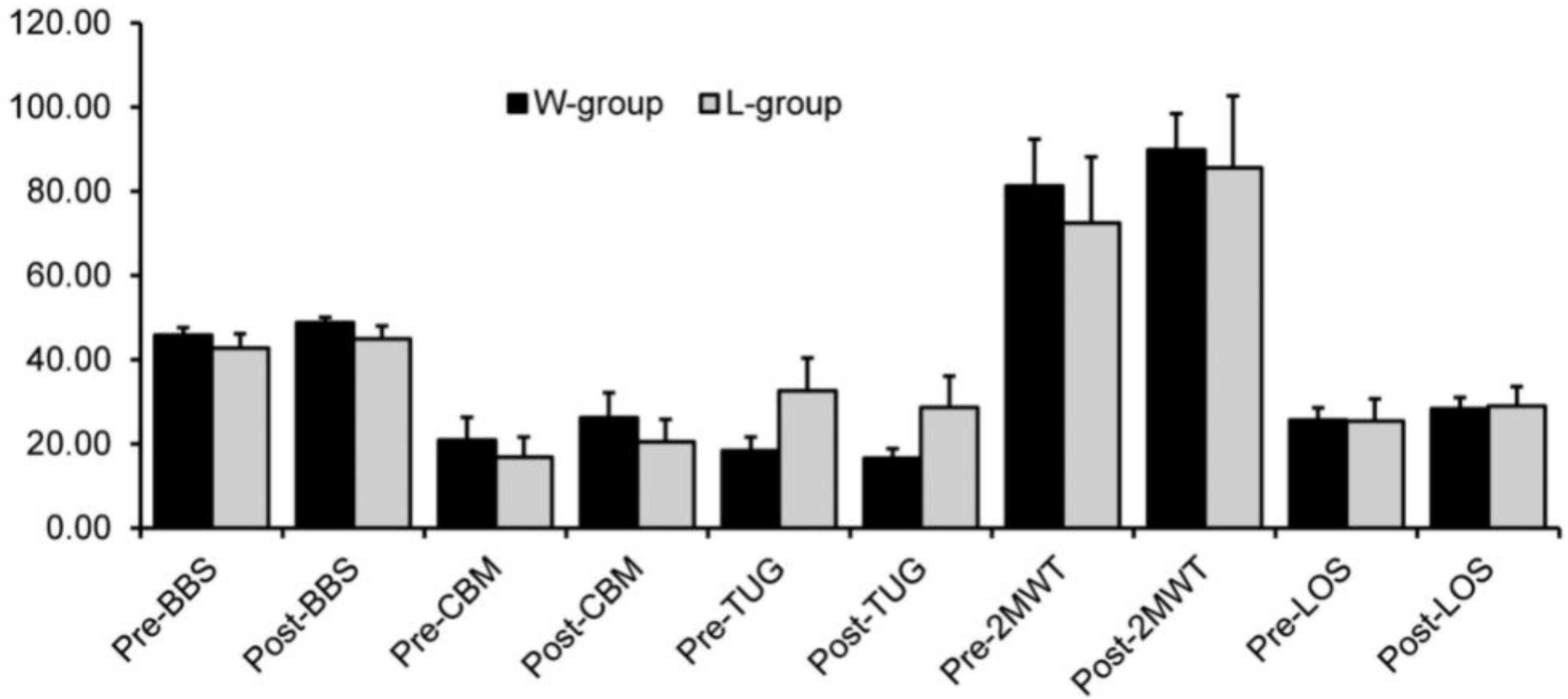
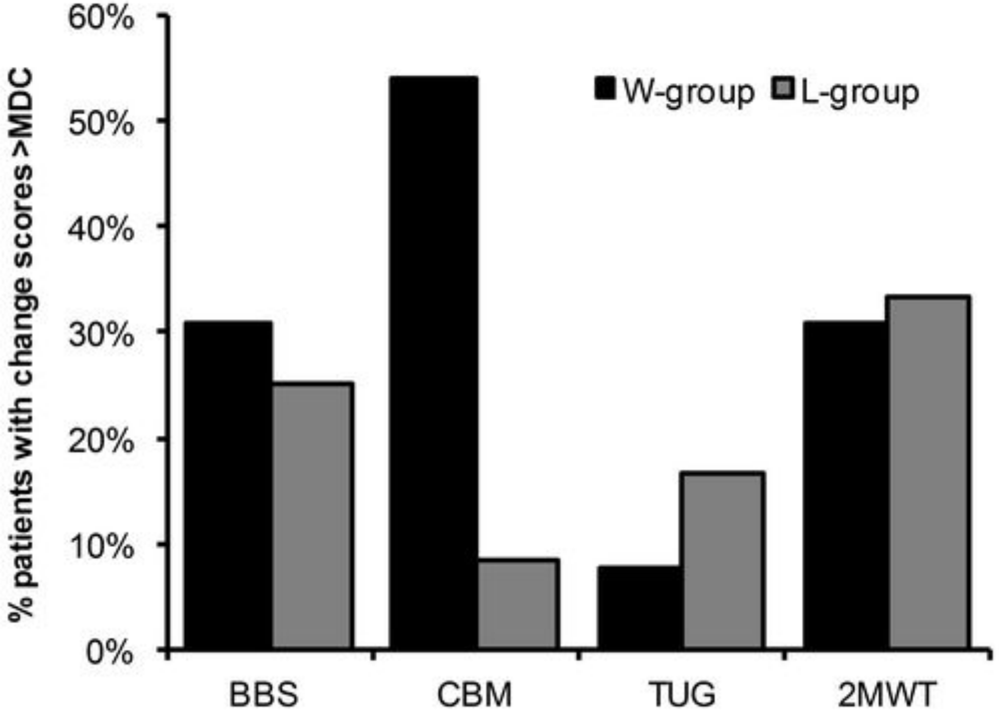


Figure 3. Percentage of patients with a clinically meaningful change score.



Results

- Water + Land Group –

✔ significantly better outcomes compared to land only - with more exceeding the published minimal detectable change scores

ORIGINAL RESEARCH ARTICLE

Aquatic Therapy Improves Outcomes for Subacute Stroke Patients by Enhancing Muscular Strength of Paretic Lower Limbs Without Increasing Spasticity

A Randomized Controlled Trial

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ABSTRACT

Zhang Y, Wang Y-Z, Huang L-P, Bai B, Zhou S, Yin M-M, Zhao H, Zhou X-N, Wang H-T: Aquatic therapy improves outcomes for subacute stroke patients by enhancing muscular strength of paretic lower limbs without increasing spasticity: a randomized controlled trial. Am J Phys Med Rehabil 2016;95:840–849.

Purpose: The aim of this study was to evaluate the effects of an aquatic exercise program designed to enhance muscular strength in paretic lower limbs in subacute stroke patients.

Method: Thirty-six subacute stroke patients were randomly divided to a conventional or an aquatic group ($n = 18$ each). Outcome measures were assessed at baseline and after 8 wks of training. For the paretic lower limbs, maximum isometric voluntary contraction strength of the rectus femoris and biceps femoris caput longus and the tibialis anterior and lateral gastrocnemius was measured. Cocontraction ratios during knee extension and flexion and ankle dorsiflexion and plantarflexion were calculated respectively. In addition, Modified Ashworth Scale, Functional Ambulation Category, and Barthel Index were assessed.

Participants/Interventions

- 36 in subacute phase of recovery (3-6 mos)
- Aquatic Intervention (n=18)
  - ✔ 40 min/session; 5x/week; 8 weeks
  - ✔ 5 minute warm-up
  - ✔ 35 min exercise
    - 5 min Halliwick activities
    - 6 exercises
- Control group (n=18)
  - ✔ 40 min/session; 5x/week; 8 weeks
  - ✔ Structured land-based exercises

Outcome Measures

- Maximum isometric contraction
- Co-contraction ratios
- Modified Ashworth Scale (hypertonicity)
- Functional Ambulation Category
- Barthel Index

Variable		Conventional Group			Aquatic Group			Pretreatment Comparison Between-Groups *P* Value	Posttreatment Comparison Between-Groups *P* Value
		Pretreatment	Posttreatment	*P*	Pretreatment	Posttreatment	*P*		
Knee	Extension torque, N m	15.8 ± 4.8 (12.37–19.17)	16.9 ± 5.1 (13.21–20.50)	0.207	15.8 ± 3.8 (13.02–18.49)	20.8 ± 4.9 (17.30–24.26)	0.000[a]	0.993	0.002[b]
	Flexion torque, N m	9.4 ± 3.6 (6.82–11.95)	10.4 ± 3.6 (7.82–12.95)	0.035[a]	9.5 ± 2.8 (7.49–11.43)	10.4 ± 2.6 (8.56–12.26)	0.027[a]	0.962	0.936
	Extension CR, %	25.9 ± 9.5 (19.10–32.71)	24.3 ± 9.7 (17.40–31.23)	0.081	28.6 ± 9.9 (21.52–35.72)	17.1 ± 6.3 (12.57–21.56)	0.000[a]	0.540	0.000[b]
	Flexion CR, %	32.2 ± 11.3 (24.12–40.28)	27.5 ± 9.1 (21.01–34.01)	0.441	29.1 ± 8.3 (23.14–34.96)	24.4 ± 7.4 (19.18–29.70)	0.158	0.487	0.991
Ankle	Dorsiflexion torque, N m	3.4 ± 1.1 (2.58–4.20)	3.8 ± 0.9 (3.11–4.40)	0.042[a]	3.4 ± 1.1 (2.66–4.20)	3.8 ± 1.3 (2.82–4.69)	0.036[a]	0.938	0.841
	Plantarflexion torque, N m	8.2 ± 2.6 (6.38–10.11)	7.3 ± 2.4 (5.63–9.04)	0.074	8.1 ± 3.9 (5.36–10.93)	10.1 ± 3.3 (7.72–12.39)	0.014[a]	0.946	0.002[b]
	Dorsiflexion CR, %	15.3 ± 4.8 (11.87–18.71)	13.5 ± 5.2 (9.70–17.21)	0.347	16.6 ± 5.8 (12.50–20.74)	14.1 ± 4.8 (10.68–17.56)	0.352	0.582	0.835
	Plantarflexion CR, %	45.3 ± 17.0 (33.15–57.50)	39.2 ± 16.0 (27.75–50.71)	0.349	44.3 ± 16.0 (32.82–55.73)	38.6 ± 10.4 (31.19–46.01)	0.250	0.889	0.958

Data are presented as mean ± SD (95% CI).

[a]Significant difference between pretreatment and posttreatment in each group.

[b]Significant difference between the aquatic group and the conventional group posttreatment.

CI indicates confidence interval.

MIVC torque and CR of knee extension and flexion and ankle dorsiflexion and plantar flexion at baseline and after 8 wks of treatment

Results

- Aquatic Intervention group
  - ✔ Higher knee extension and ankle plantarflexion torque
  - ✔ Lower knee extension co-contraction ratio
  - ✔ Functional Ambulation Category scores
  - ✔ Barthel Index
  - ✔ **Modified Ashworth Scale scores – did not change**

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The effects of Ai Chi for balance in individuals with chronic stroke: a randomized controlled trial

Pei-Hsin Ku[1], Szu-Fu Chen[2], Yea-Ru Yang[1], Ta-Chang Lai[3*] & Ray-Yau Wang[1*]

This study investigated the effectiveness of Ai Chi compared to conventional water-based exercise on balance performance in individuals with chronic stroke. A total of 20 individuals with chronic stroke were randomly allocated to receive either Ai Chi or conventional water-based exercise for 60 min/time, 3 times/week, and a total of 6 weeks. Balance performance assessed by limit of stability (LOS) test and Berg balance scale (BBS). Fugl-Meyer assessment (FMA) and gait performance were documented for lower extremity movement control and walking ability, respectively. Excursion and movement velocity in LOS test was significantly increased in anteroposterior axis after receiving Ai Chi ($p = 0.005$ for excursion, $p = 0.013$ for velocity) but not conventional water-based exercise. In particular, the improvement of endpoint excursion in the Ai Chi group has significant inter-group difference ($p = 0.001$). Both groups showed significant improvement in BBS and FMA yet the Ai Chi group demonstrated significantly better results than control group ($p = 0.025$). Ai Chi is feasible for balance training in stroke, and is able to improve weight shifting in anteroposterior axis, functional balance, and lower extremity control as compared to conventional water-based exercise.

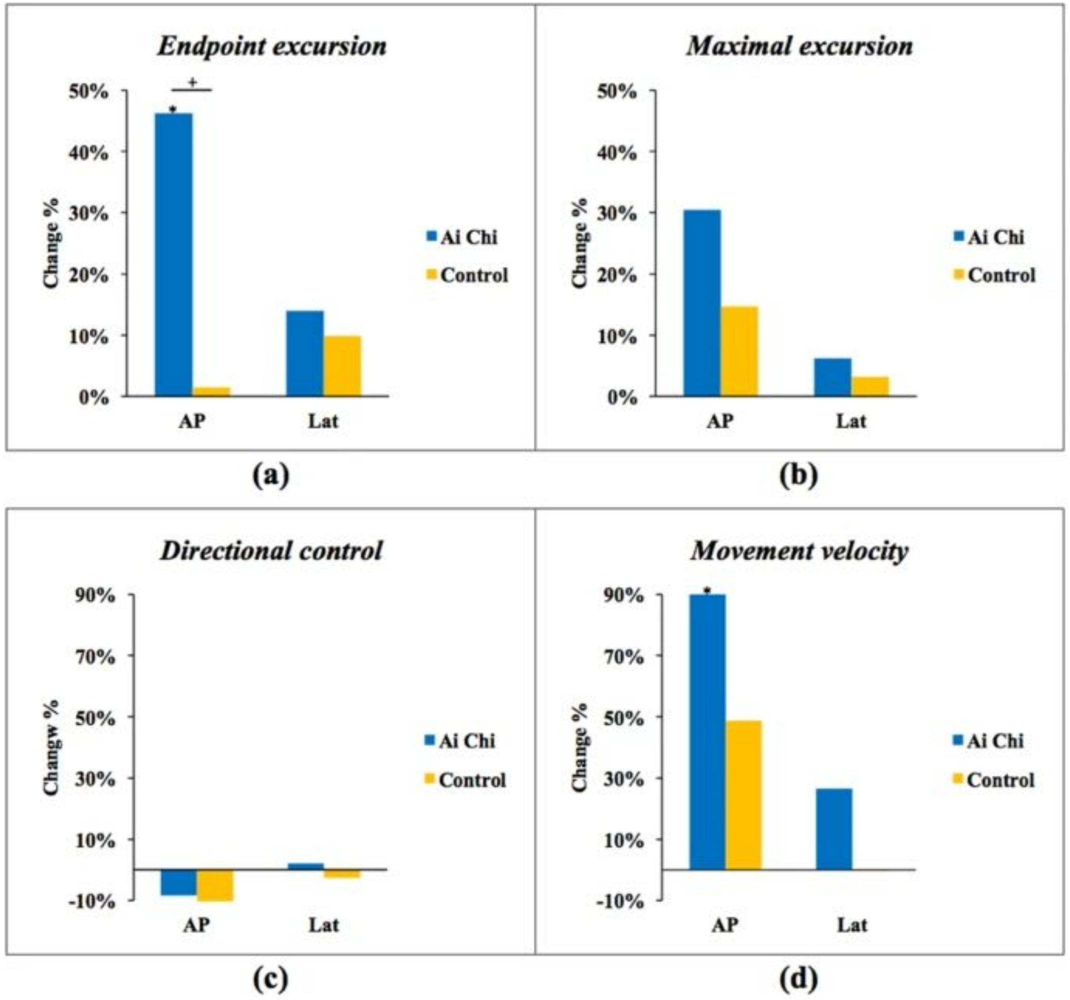
Participants

- 20 in chronic phase of recovery (> 6 mos)
- 60 min/session; 3x/week; 6 weeks
- Ai Chi (n=10)
  - ✔ 3 Katas – warm up
  - ✔ 3-4 Katas; 10-15 repetitions
  - ✔ Gait training for 15 minutes
- Conventional Aquatic Exercise (n=10)
  - ✔ Stretching
  - ✔ Resistance
  - ✔ Gait training

Outcome Measures

- Limits of Stability – SMART Balance System
- Berg Balance Scale
- GaitRite System
- Fugl-Meyer Assessment

Figure 2



Change of LOS in anteroposterior (AP) and lateral (Lat) direction in Ai Chi and Control group: (**a**) endpoint excursion (**b**) maximal excursion (**c**) directional control (**d**) movement velocity.

Results

- Limits of Stability – SMART Balance System
  - ✔ Ai Chi group significantly improved
- Berg Balance Scale
  - ✔ Both groups improved with AI Chi group improving more
- GaitRite System
  - ✔ Ai Chi group improved with speed and stride length
  - ✔ Conventional group improved in stride length
- Fugl-Meyer Assessment
  - ✔ Both groups improved with AI Chi group improving more

Other thoughts on stroke recovery using water?