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Selected Topics

David M. Morris, PT, PhD, FAPTA

Professor and Chair

UAB Department of PT

My Plan

- Research - Selected Topics
  - Balance Dysfunction
  - Hip and Knee Dysfunction
  - Edema control
  - Stroke
- Lifestyle Medicine and Physical Therapy
  - Physical Activity
  - Healthy Eating
  - Smoking Cessation
  - Sleep Health

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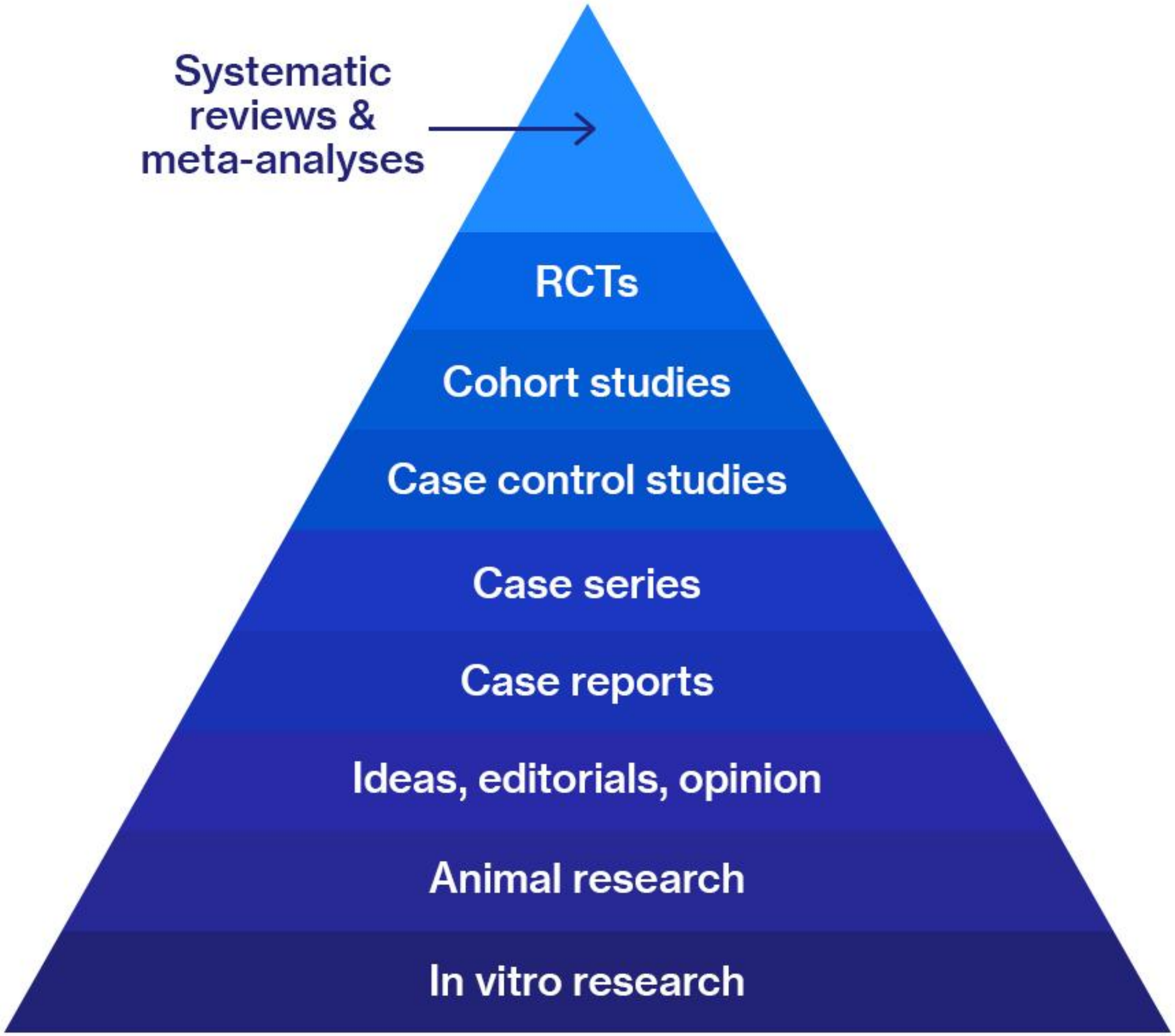
Research in Aquatics

David M. Morris, PT, PhD. FAPTA


Systematic reviews & meta-analyses
RCTs
Cohort studies
Case control studies
Case series
Case reports
Ideas, editorials, opinion
Animal research
In vitro research

Systematic Review Vs. Meta-nalysis

- Systematic Review - attempts to gather all available empirical research by using clearly defined, systematic methods to obtain answers to a specific question.
- A meta-analysis - the statistical process of analyzing and combining results from several similar studies.

Standard Mean Difference

- A summary statistic used when the studies in a meta-analysis assess the same outcome but measured it in different ways.

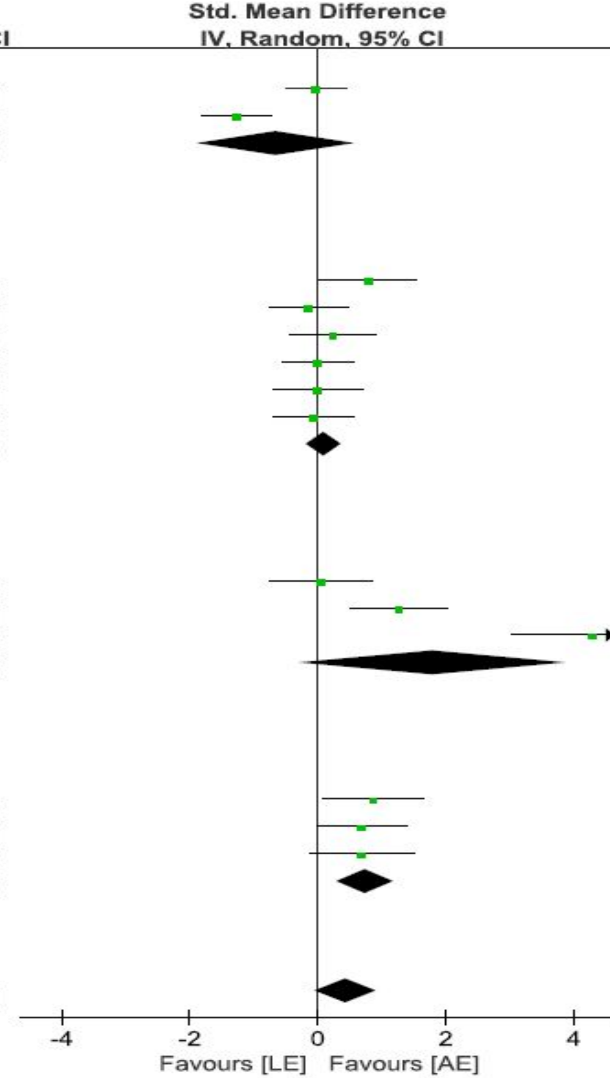
- Click here

Forest Plots

- Provides a quick graphical representation of the data coming from a meta-analysis, as well as numeric summaries to the left of the plot.
- Click here

B

Study or Subgroup	AE Mean	AE SD	AE Total	LE Mean	LE SD	LE Total	Weight	Std. Mean Difference IV, Random, 95% CI
2.2.1 Healthy population								
Oh 2015_TUGT	-4.91	0.69	34	-4.89	0.82	32	7.9%	-0.03 [-0.51, 0.46]
Oh 2021_TUGT	-7.42	1.26	34	-6.25	0.15	32	7.7%	-1.27 [-1.80, -0.74]
Subtotal (95% CI)			**68**			**64**	**15.6%**	**-0.64 [-1.86, 0.58]**
Heterogeneity: Tau² = 0.71; Chi² = 11.51, df = 1 (P = 0.0007); I² = 91%								
Test for overall effect: Z = 1.03 (P = 0.30)								
2.2.2 Nervous system diseases								
Kurt 2018_TUGT	-9.1	3.3	14	-11.5	2.6	15	7.0%	0.79 [0.03, 1.55]
Pérez 2017_TUGT	-14.19	4.86	20	-13.15	8.97	20	7.5%	-0.14 [-0.76, 0.48]
Pérez 2021_TUGT	-10.1	1.29	20	-10.7	3.46	15	7.3%	0.24 [-0.43, 0.91]
Silva 2020_TUGT	-11.51	3.21	24	-11.51	2.42	25	7.7%	0.00 [-0.56, 0.56]
Volpe 2014_TUGT	-9	1.4	17	-9	2.1	14	7.2%	0.00 [-0.71, 0.71]
Volpe 2017_TUGT	-15.1	9.5	19	-14.5	7.1	19	7.4%	-0.07 [-0.71, 0.57]
Subtotal (95% CI)			**114**			**108**	**44.1%**	**0.10 [-0.17, 0.36]**
Heterogeneity: Tau² = 0.00; Chi² = 4.37, df = 5 (P = 0.50); I² = 0%								
Test for overall effect: Z = 0.70 (P = 0.48)								
2.2.3 Musculoskeletal diseases								
Arnold 2010_TUGT	-11.5	2	13	-11.6	2.3	11	6.9%	0.05 [-0.76, 0.85]
Hale 2012_TUGT	-13.67	5.2	15	-20.24	4.9	17	7.0%	1.27 [0.50, 2.04]
Taglietti 2018_TUGT	-6.1	0.1	17	-6.8	0.2	18	5.4%	4.29 [3.03, 5.54]
Subtotal (95% CI)			**45**			**46**	**19.3%**	**1.81 [-0.27, 3.89]**
Heterogeneity: Tau² = 3.14; Chi² = 31.13, df = 2 (P < 0.00001); I² = 94%								
Test for overall effect: Z = 1.70 (P = 0.09)								
2.2.4 Cardiopulmonary diseases								
Adsett 2017_TUGT	-21.2	2.6	14	-23.6	2.8	14	7.0%	0.86 [0.08, 1.64]
de Castro 2020_TUGT	-11	2	17	-12.8	3	17	7.2%	0.69 [-0.01, 1.38]
Ferreira 2022_TUGT	-13.17	3.23	14	-15.58	3.65	11	6.8%	0.68 [-0.13, 1.50]
Subtotal (95% CI)			**45**			**42**	**21.1%**	**0.74 [0.30, 1.18]**
Heterogeneity: Tau² = 0.00; Chi² = 0.13, df = 2 (P = 0.93); I² = 0%								
Test for overall effect: Z = 3.32 (P = 0.0009)								
Total (95% CI)			**272**			**260**	**100.0%**	**0.44 [-0.04, 0.91]**
Heterogeneity: Tau² = 0.70; Chi² = 89.38, df = 13 (P < 0.00001); I² = 85%								
Test for overall effect: Z = 1.79 (P = 0.07)								
Test for subgroup differences: Chi² = 10.37, df = 3 (P = 0.02), I² = 71.1%								



PEDro Scale

- The PEDro scale is an instrument to assess randomized, controlled trials
  - “poor” (scores 0–4),
  - “fair” (4–5),
  - “good” (6–8), and
  - “excellent” (9–10)

PEDro scale

1.	eligibility criteria were specified	no ❑ yes ❑ where:
2.	subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	no ❑ yes ❑ where:
3.	allocation was concealed	no ❑ yes ❑ where:
4.	the groups were similar at baseline regarding the most important prognostic indicators	no ❑ yes ❑ where:
5.	there was blinding of all subjects	no ❑ yes ❑ where:
6.	there was blinding of all therapists who administered the therapy	no ❑ yes ❑ where:
7.	there was blinding of all assessors who measured at least one key outcome	no ❑ yes ❑ where:
8.	measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	no ❑ yes ❑ where:
9.	all subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat"	no ❑ yes ❑ where:
10.	the results of between-group statistical comparisons are reported for at least one key outcome	no ❑ yes ❑ where:
11.	the study provides both point measures and measures of variability for at least one key outcome	no ❑ yes ❑ where:

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Aquatic Therapy for Balance Dysfunction

David M. Morris, PT, PhD. FAPTA

Introduction

- No universal definition of posture and balance
- No agreement on the neural mechanisms underlying control of posture and balance
- Postural control emerges from interaction of individual with task and environment
- Postural control system is complex interaction of musculoskeletal and neural systems

Defining Postural Control

Postural control involves controlling body's position in space

- **Postural orientation** — ability to maintain appropriate relationship between body segments and between the body and environment for a task
- **Postural stability** — ability to control COM in relationship to the base of support

Postural Stability or Balance

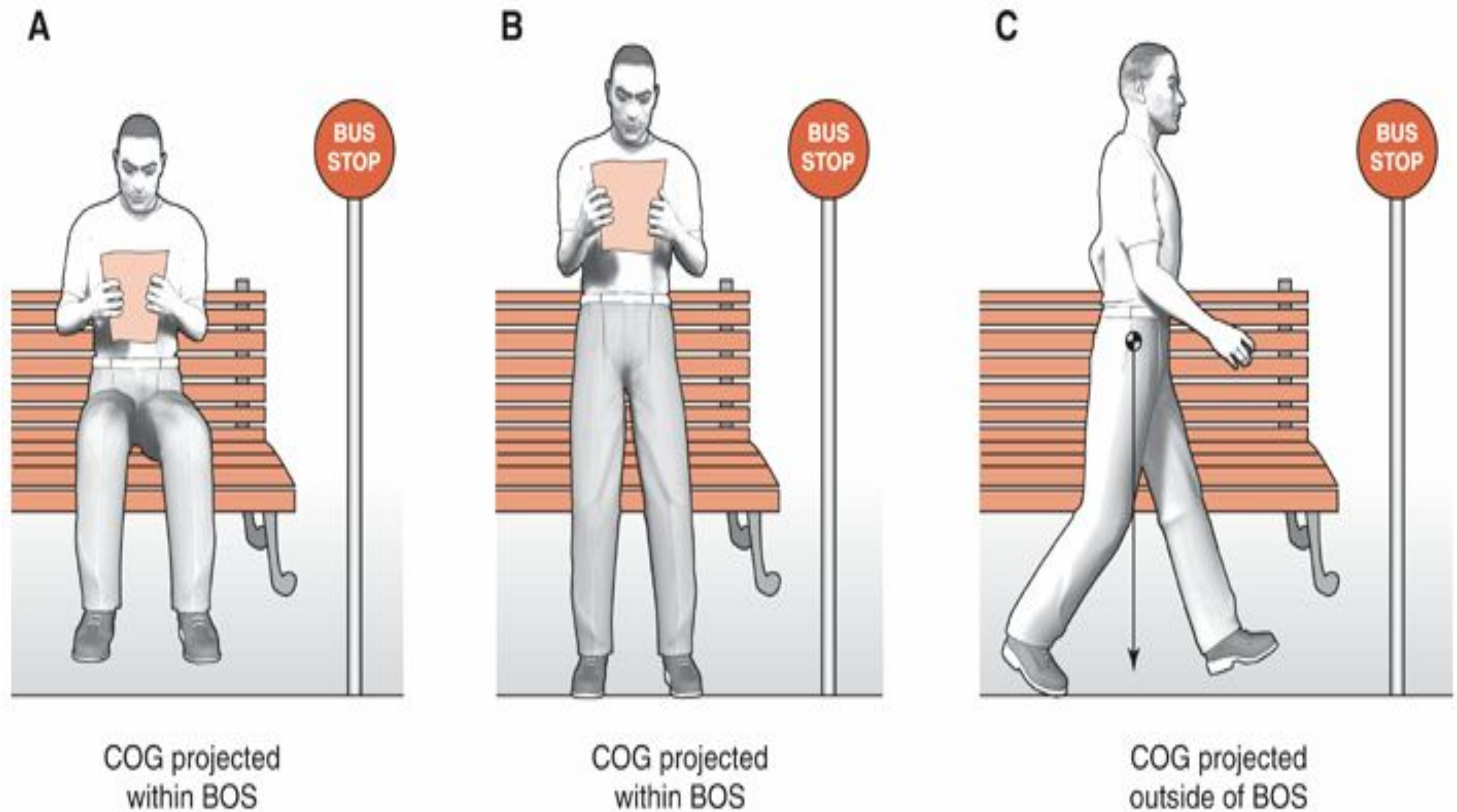
- Ability to maintain the Center of Mass (COM) over the base of support.
- Vertical projection of COM is the Center of Gravity (COG).
- Requires:
  - ✔ Ability to maintain a position (static balance).
  - ✔ Stabilize during voluntary activities (dynamic balance).
  - ✔ React to external perturbations (static and dynamic).

Balance: Related Terms

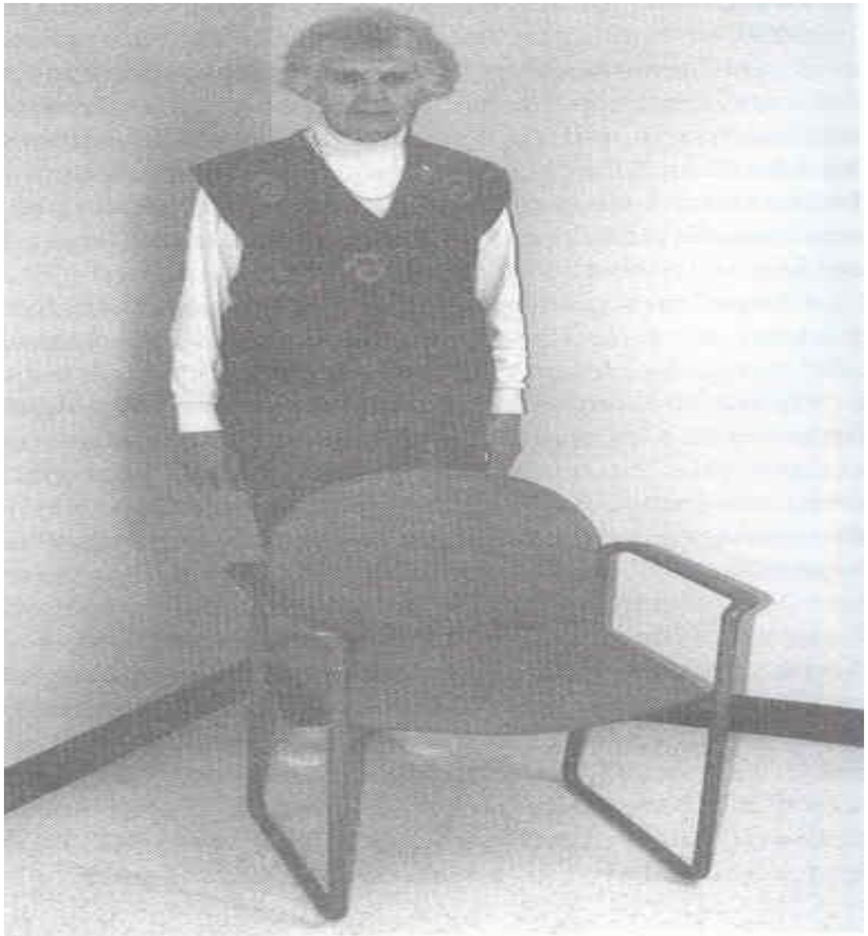
- Balance reactions
- Postural reactions
- Postural Control
- Posture
- Equilibrium

Postural Control Requirements Vary with the Task and Environment

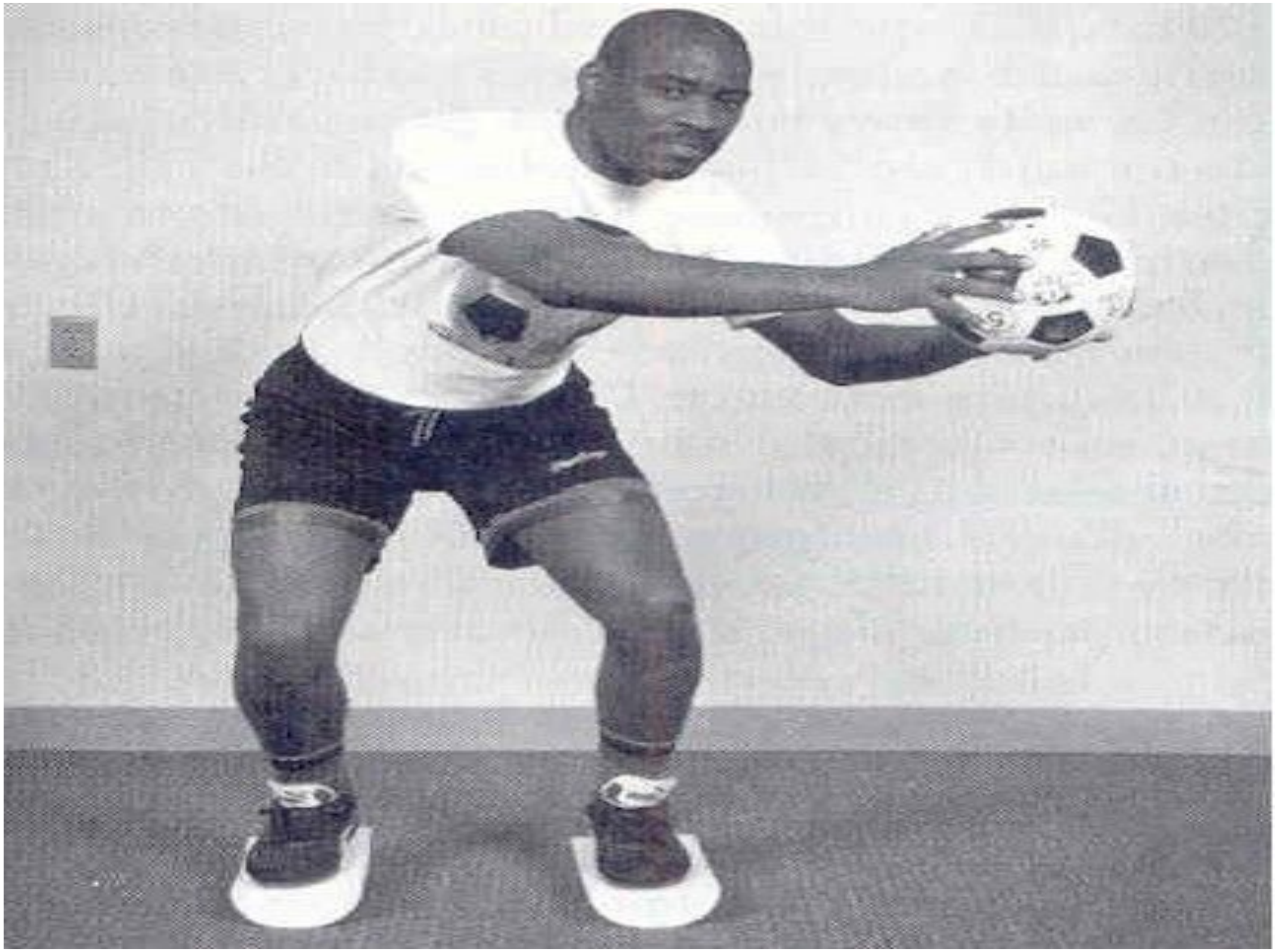
- Specific orientation and stability requirements vary according to task and environment
- Strategies used to accomplish postural control must adapt to varying task and environmental demands


A
B
C
BUS STOP
BUS STOP
BUS STOP
COG projected within BOS
COG projected within BOS
COG projected outside of BOS

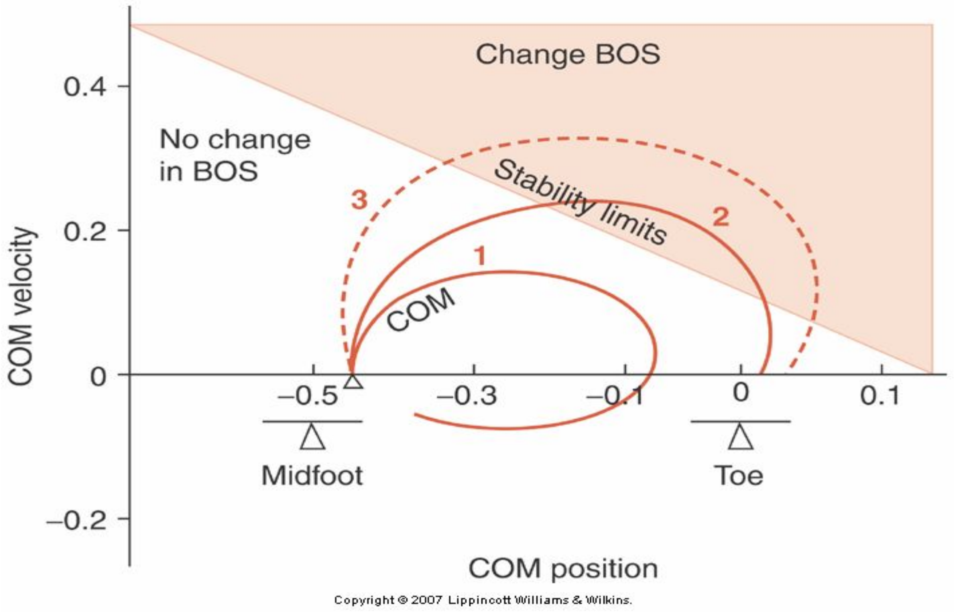
Low Level Task



High Level Task



Cone of Stability



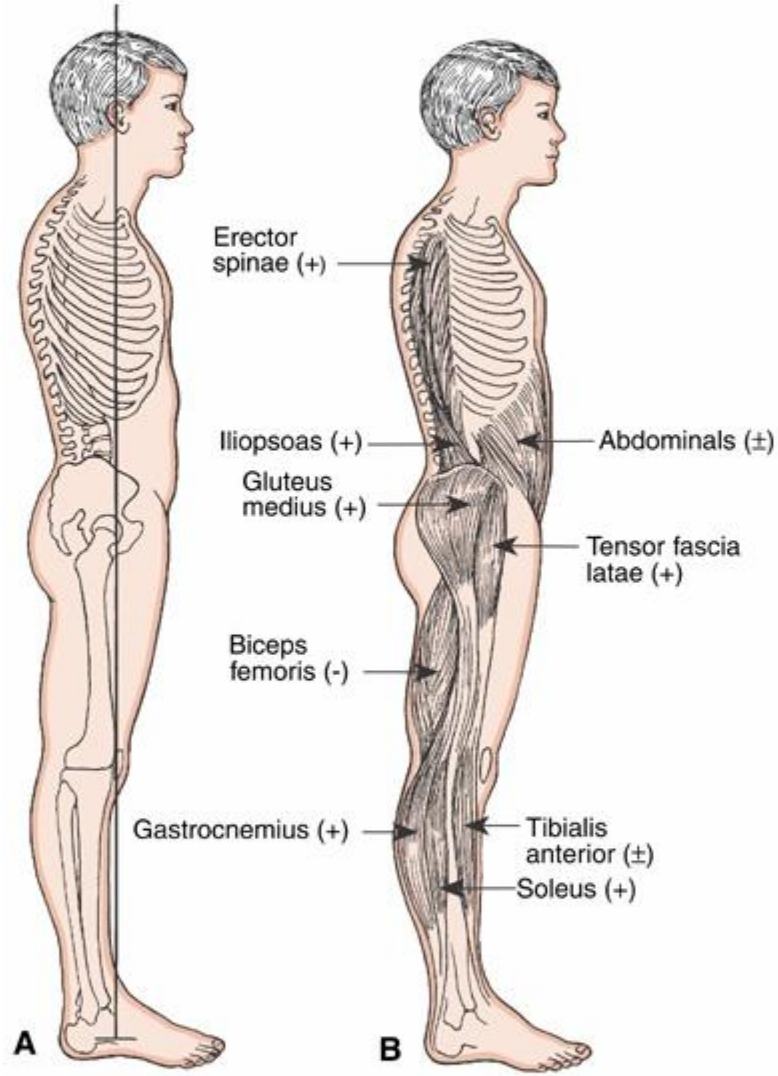
Motor Control of Quiet Stance

- Alignment

- Muscle tone
  - Intrinsic stiffness of muscles
  - Background muscle tone
  - Postural tone – activation of antigravity muscles during quiet stance

Postural Tone

- Results from sensory input from multiple sensory systems
    - Cutaneous input from soles of feet
    - Somatosensory inputs form neck
    - Vestibular input
- Many muscles are tonically active in quiet stance; core stability muscles
    - Soleus and gastrocnemius
    - Tibialis antierior
    - Gluteus medius
    - Iliopsoas
    - Thoracic erector spinae (with intermittent activity of abdominals)



Erector spinae (+)
Iliopsoas (+)
Abdominals (±)
Gluteus medius (+)
Tensor fascia latae (+)
Biceps femoris (-)
Gastrocnemius (+)
Tibialis anterior (±)
Soleus (+)
A
B

Systems Underlying Balance

- Biomechanical Factors
- Motor Coordination
- Sensory Organization

Biomechanical Factors

- Strength
- Range of Motion
- Flexibility
- Muscle tone

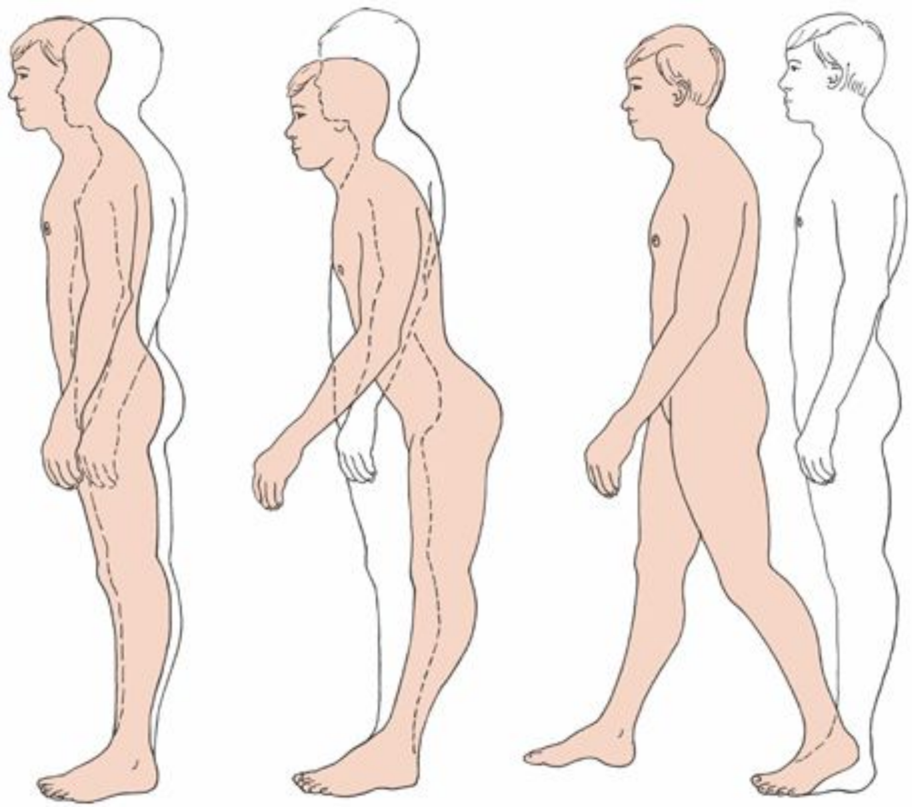
Motor Coordination

- Postural strategies (anteroposterior)
  - ✔ ankle, hip, stepping

- Synergies
  - ✔ coupling of groups of muscles so they act as a unit to produce strategies
  - ✔ Combined with fine tuning of individual muscles

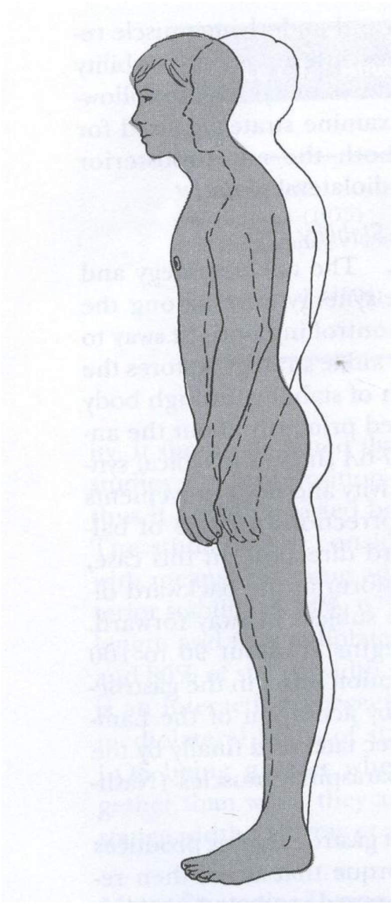
Anteroposterior Stability

- Ankle strategy
- Hip strategy
- Stepping strategy

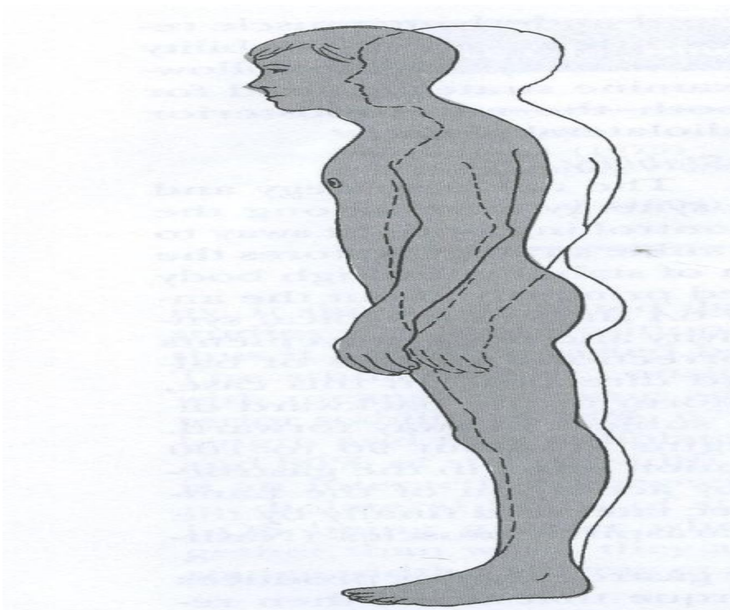


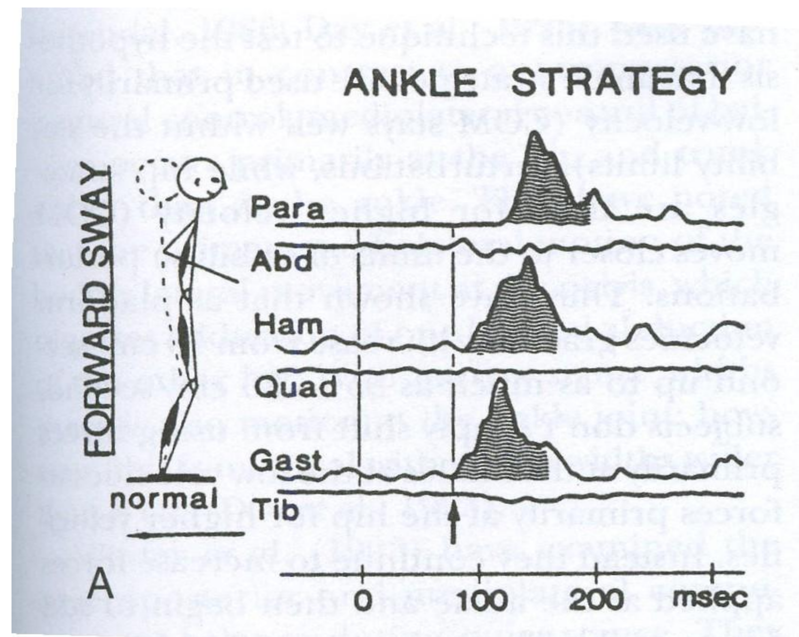
Ankle strategy

- Small perturbations
- Firm support surface



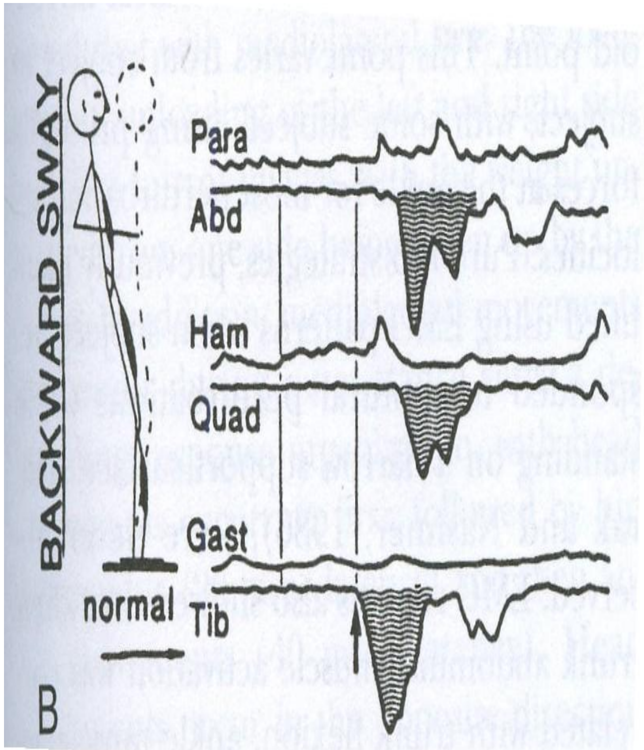
Ankle Strategy: Synergy





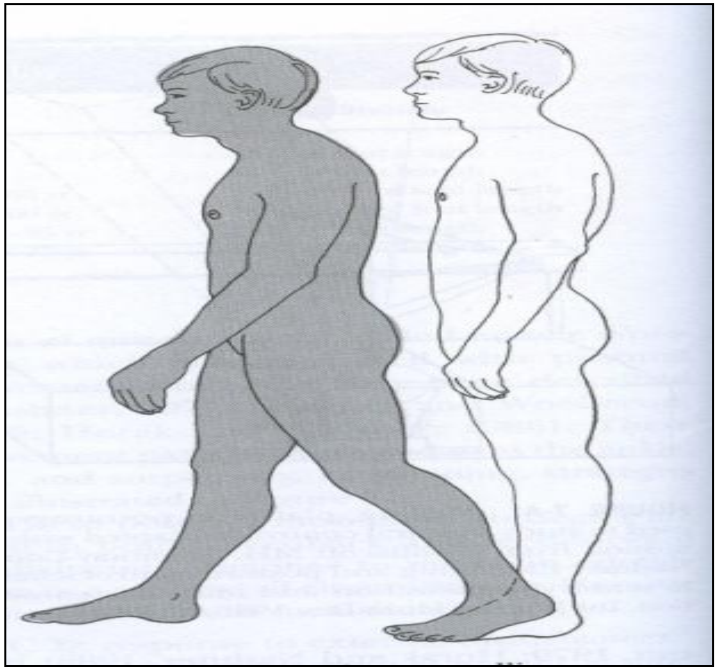
Hip Strategy

- Larger and faster perturbations
- Compliant surfaces
- Surfaces smaller than feet



Stepping Strategy

- When ankle or hip strategies are inadequate



Other postural strategies

- Mediolateral strategies
- Equilibrium responses
- Anticipatory Adjustments

Critical Characteristics of Motor Strategies

- Timing
- Sequence
- Reciprocal inhibition
- Force
- When and where used

Higher-Level Cognitive Aspects

- Cognitive ≠ Conscious
- **Adaptive postural control (Feedback)**–
  - involves modifying sensory and motor systems in response to changing task and environmental demands
  - Results from external perturbation
- **Anticipatory postural control (Feedforward)**
  - pre-tuned sensory and motor systems based on previous experience and learning
  - Made in anticipation of a voluntary movement that is expected to be destabilizing.

Anticipatory Adjustments

- Prior to movement
- adjust “set”, align COG
- adapts to task demands
- feedback & experience
  - Lets you know if it was successful
  - Allows you to fine tune for next movement

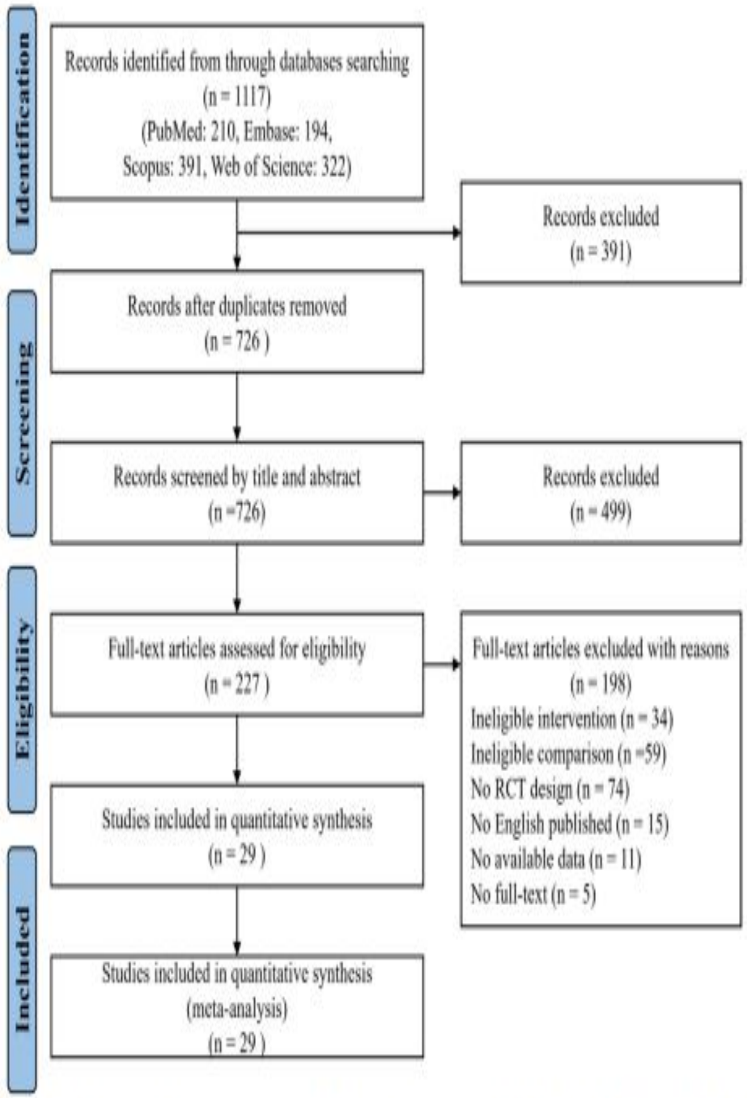


Fig. 1 Flow diagram of the study selection process according to Preferred Reporting Items for Systematic Reviews and meta-analysis (PRIAMA)

Deng et al., 2024

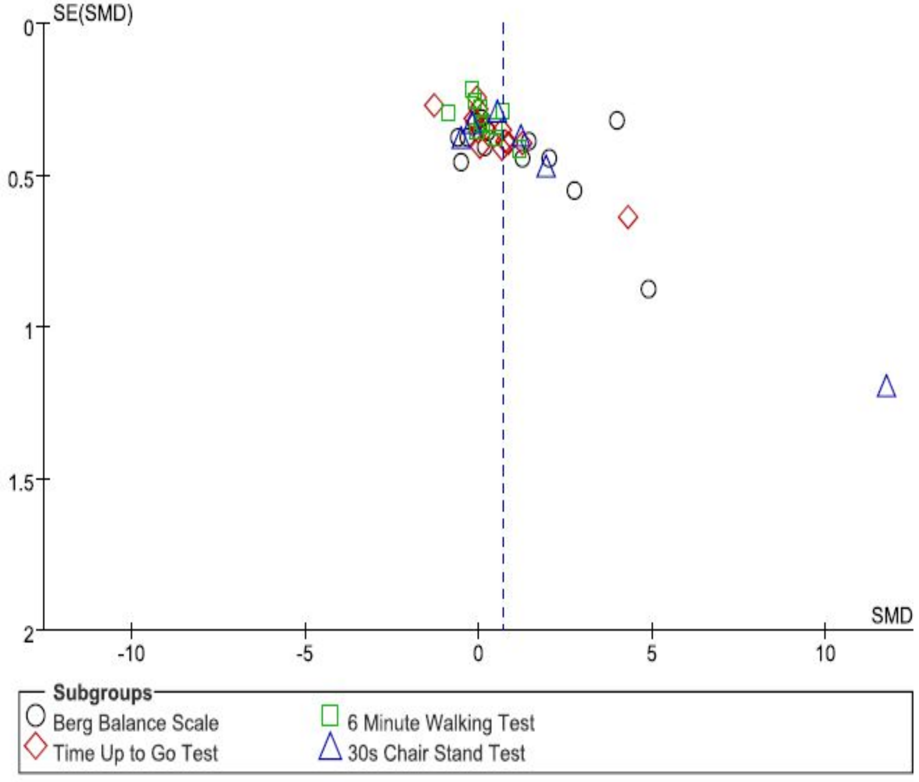


Fig.2 Funnel plot for all the meta-analyses

Inclusion Criteria

- Ages 60 and above
- Interventions involving AE with clear intervention details (duration, frequency, type and intensity)
- Control group was land-based
- Outcomes reported had at least 1 balance score and compared AE vs. LE
- RCTs
- In English

Table 1 Summary of Included studies

Study	Diagnosis		Intervention/ Comparison	Sample size pre (post)	Age (mean ± SD)
Bento et at, 2012	Healthy Populations	Healthy	AE LE	27 (24) 20 (14)	65.6 ± 4.2 65.6 ± 4.4
Bento-Torres et al, 2019		Healthy	AE LE	14 (14) 14 (14)	71.2 ± 4.4 71.7 ± 4.4
Bocalini et al, 2010		Healthy	AE LE	30 (27) 20 (18)	>62
Oh et al, 2015		Healthy	AE LE	40 (34) 40 (32)	74.7 ± 2.9 68.2 ± 4.4
Oh et al, 2021		Healthy	AE LE	40 (34) 40 (32)	74.7 ± 2.9 72.2 ± 4.4
Sanders et al, 2013		Healthy	AE LE	48 (43) 18 (17)	73.6 ± 13.5 72.8 ± 27.4
Vale et al, 2020		Sedentary Lifestyle	AE LE	28 (28) 26 (26)	67.3 ± 1.7 67.3 ± 1.7

Intervention Period

Study	Water Depth	T °C	Min/Session	Times/ Week	Total Duration (weeks)	Outcome Measures
Bento et at, 2012	Xiphoid Level	28-30	60	3	12	6 MWT / 30 CST
Bento-Torres et al, 2019	/	/	/	3	12	6 MWT / 30 CST
Bocalini et al, 2010	/	/	45	3	12	30 CST
Oh et al, 2015	1.2m	28	60	3	10	TUG
Oh et al, 2021	1.2m	28	60	3	10	TUG
Sanders et al, 2013	1.0-1.2m	28-29	45	3	16	30 CST
Vale et al, 2020	1.3 M	32	60	2	16	BBS

Study	Diagnosis		Intervention/ Comparison	Sample size pre (post)	Age (mean ± SD)
Kurt et al, 2018	Nervous system diseases	Parkinson	AE LE	20 (20) 20 (20)	62.4 ± 6.8 63.6 ± 7.2
Lee et al, 2018		Stroke	AE LE	19 (18) 18 (14)	57.6 ± 14.0 63.7 ± 11.3
Perez et al, 2017		Parkinson	AE LE	15 (14) 15 (15)	66.8 ± 5.3 67.5 ± 9.9
Perez et al, 2021		Stroke	AE LE	15 (15) 15 (17)	63.8 ± 13.6 62.7 ± 13.4
Silva et al, 2020	Nervous system diseases	Parkinson	AE LE	14 (14) 14 (11)	63.1 ± 13.6 64.2 ± 13.5
Volpe et al 2014		Parkinson	AE LE	17 (17) 17 (17)	68.0 ± 7.0 66.0 ± 8.0
Volpe et al 2017		Parkinson	AE LE	15 (13) 15 (11)	70.6 ± 7.8 67.3 ± 7.8

Intervention Period

Study	Water Depth	T °C	Min/Session	Times/ Week	Total Duration	Outcome Measures
Kurt et al, 2018	1.2	32	60	5		BBS / TUG
Lee et al, 2018	/	30-33	30		4	BBS
Perez et al, 2017	1.4-1.45 m	30	45	2	10	BBS / TUG
Perez et al, 2021	1.4m	34-36	45	2	12	BBS/ TUG
Silva et al, 2020	/	/	60	2	10	BBS/ TUG
Volpe et al, 2014	/	/	60	5	8	BBS/ TUG
Volpe et al, 2017	/	/	60	5	8	BBS/ TUG

Study	Diagnosis		Intervention/ Comparison	Sample size pre (post)	Age (mean ± SD)
Arnold et al, 2008	Musculoskeletal diseases	HOA	AE LE	21 (16) 20 (15)	68.6 ± 5.4 69.1 ± 6.3
Arnold et al, 2010		HOA	AE LE	27 (19) 27 (19)	74.4 ± 7.5 75.8 ± 6.2
Assar et al, 2020		KOA	AE LE	12 (12) 12 (12)	57.5± 6.9 63.8 ± 7.5
Hale et al, 2012		OA	AE LE	23 (20) 16 (15)	62.1± 6.4 61.7 ± 6.9
Kuptniratsaikul et al, 2019	Nervous system diseases	KOA	AE LE	40 (40) 40 (40)	62.1 ± 6.4 61.7 ± 6.9
Moreira, et al, 2020		Muscle Disorder	AE LE	75 (60) 70 (60)	70.6 ± 6.0 71.9 ± 7.0
Murtezani, et al, 2014		Osteoporosis	AE LE	33 (31) 31 (31)	59.8 ± 6.0 60.7 ± 7.6

Intervention Period

Study	Water Depth	T ℃	Min/Session	Time/ Week	Total Duration	Outcome Measures
Arnold et al, 2008	Shoulder to waist	30	50	3	20	BBS
Arnold et al, 2010	Chest Level	/	45	2	11	6 MWT / BBS/ TUG/ 30 CST
Assar et al, 2020	1.3	32	90	3	8	BBS
Hale et al, 2012	1.3	28	60	2	12	TUGT
Kuptniratsaikul et al, 2019	/	/	30	3	4	6 WMT
Moreira, et al, 2020	Xiphoid level	31	45	2	16	BBS
Murtezani, et al, 2014	Chest level	30	60	3	40	6 MWT / BBS

Study	Diagnosis		Intervention/ Comparison	Sample size pre (post)	Age (mean ± SD)
Taglietti et al, 2018	Musculoskeletal diseases	KOA	AE LE	31 (31) 29 (29)	67.3 ± 5.9 68.7 ± 6.7
Wang et al 2011		KOA	AE LE	28 (26) 28 (26)	66.7 ± 5.6 / 68.3 ± 5.6
Adset et al, 2017	Cardiopulmonary diseases	HF	AE LE	36 (29) 25 (22)	72.9 ± 8.4 68.3 ± 11.3
Caminti et al, 2011		HF	AE LE	11 (11) 10 (10)	67.0 ± 6.0 69.0 ± 8.0
de Castro et al, 2020		COPD	AE LE	27 (17) 23 (14)	64.0 ± 8.0 65.0 ± 8.0
Felcar, et al, 2018		COPD	AE LE	34 (20) 36 (16)	68.0 ± 8.0 69.0 ± 9.0
Ferreira et al, 2022		COVID-19	AE LE	26 (24) 26 (25)	70.2 ± 4.2 71.4 ± 4.6
Liu et al, 2021		COPD	AE LE	16 (14) 17 (15)	65.0 ± 11.0 65.0 ± 8.0

Intervention Period

Study	Water Depth	T °C	Min/Session	Time/ Week	Total Duration	Outcome Measures
Taglietti et al, 2018	1.2m	32	60	2	8	TUG
Wang et al 2011	/	30	60	3	12	6 MWT
Adset et al, 2017	Chest Level	33-34	60	1	16	6 MWT/TUG
Caminti et al, 2011	Xiphoid level	31	60	3	24	6 MWT
de Castro et al, 2020	1m	33	60	3	12	6 MWT/TUG
Felcar, et al, 2018	1m	33	60	3	24	6 MWT
Ferreira et al, 2022	1.4	27-32	60	2	16	TUG
Liu et al, 2021	Xiphoid level	26-30	60	2	12	6 MWT / 30CST

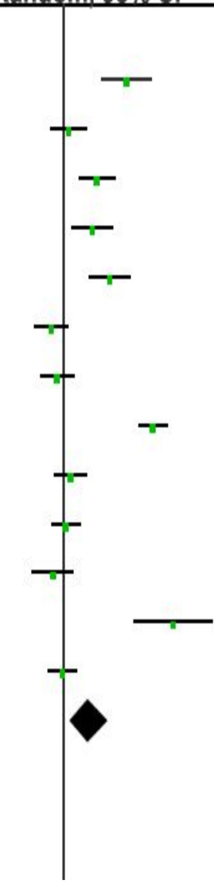
A

Study or Subgroup	AE Mean	AE SD	AE Total	LE Mean	LE SD	LE Total	Weight	Std. Mean Difference IV, Random, 95% CI
1.1.1 Berg Balance Scale								
Arnold 2008	49.4	3.8	14	37.9	4.2	14	2.1%	2.79 [1.71, 3.87]
Arnold 2010	50.2	4.6	13	49.2	5.1	11	2.3%	0.20 [-0.61, 1.01]
Assar 2020	51.2	3.1	17	43.9	6.1	17	2.3%	1.47 [0.70, 2.24]
Kurt 2018	49.62	4.01	14	42.91	6.35	11	2.2%	1.26 [0.38, 2.13]
Lee 2018	43.8	9.9	15	26.71	6.3	17	2.2%	2.04 [1.16, 2.91]
Moreira 2020	44.1	7.5	15	47.9	4.8	15	2.3%	-0.59 [-1.32, 0.15]
Murtezani 2014	21.5	3.94	15	22.73	3.6	14	2.3%	-0.32 [-1.05, 0.42]
Pérez 2017	52.1	3.3	60	41.3	1.9	60	2.4%	3.99 [3.36, 4.61]
Pérez 2021	39.74	15.05	18	35.67	13.16	14	2.3%	0.28 [-0.42, 0.98]
Silva 2020	41	18	20	40	5.5	20	2.4%	0.07 [-0.55, 0.69]
Vale 2020	45.9	5.2	10	48.7	5.2	10	2.2%	-0.52 [-1.41, 0.38]
Volpe 2014	52.55	4.88	12	33.83	1.88	12	1.6%	4.89 [3.18, 6.60]
Volpe 2017	30.5	5.1	19	30.9	3.8	19	2.4%	-0.09 [-0.72, 0.55]
Subtotal (95% CI)			**242**			**234**	**28.8%**	**1.13 [0.25, 2.00]**

Heterogeneity: $Tau^2 = 2.39$; $Chi^2 = 193.35$, df = 12 ($P < 0.00001$); $I^2 = 94\%$

Test for overall effect: Z = 2.53 (P = 0.01)

Std. Mean Difference
IV, Random, 95% CI

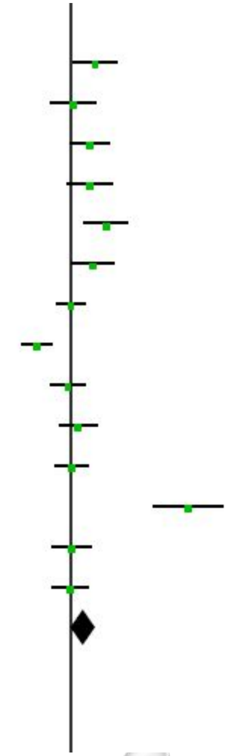


1.1.2 Time Up to Go Test

Adsett 2017	-21.2	2.6	14	-23.6	2.8	14	2.3%	0.86 [0.08, 1.64]
Arnold 2010	-11.5	2	13	-11.6	2.3	11	2.3%	0.05 [-0.76, 0.85]
de Castro 2020	-11	2	17	-12.8	3	17	2.3%	0.69 [-0.01, 1.38]
Ferreira 2022	-13.17	3.23	14	-15.58	3.65	11	2.3%	0.68 [-0.13, 1.50]
Hale 2012	-13.67	5.2	15	-20.24	4.9	17	2.3%	1.27 [0.50, 2.04]
Kurt 2018	-9.1	3.3	14	-11.5	2.6	15	2.3%	0.79 [0.03, 1.55]
Oh 2015	-4.91	0.69	34	-4.89	0.82	32	2.5%	-0.03 [-0.51, 0.46]
Oh 2021	-7.42	1.26	34	-6.25	0.15	32	2.4%	-1.27 [-1.80, -0.74]
Pérez 2017	-14.19	4.86	20	-13.15	8.97	20	2.4%	-0.14 [-0.76, 0.48]
Pérez 2021	-10.1	1.29	20	-10.7	3.46	15	2.3%	0.24 [-0.43, 0.91]
Silva 2020	-11.51	3.21	24	-11.51	2.42	25	2.4%	0.00 [-0.56, 0.56]
Taglietti 2018	-6.1	0.1	17	-6.8	0.2	18	1.9%	4.29 [3.03, 5.54]
Volpe 2014	-9	1.4	17	-9	2.1	14	2.3%	0.00 [-0.71, 0.71]
Volpe 2017	-15.1	9.5	19	-14.5	7.1	19	2.4%	-0.07 [-0.71, 0.57]
Subtotal (95% CI)			**272**			**260**	**32.3%**	**0.44 [-0.04, 0.91]**

Heterogeneity: $Tau^2 = 0.70$; $Chi^2 = 89.38$, df = 13 ($P < 0.00001$); $I^2 = 85\%$

Test for overall effect: Z = 1.79 (P = 0.07)

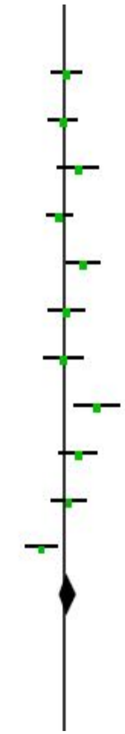


1.1.3 6 Minute Walking Test

Adsett 2017	386	75.8	26	381	70.4	26	2.4%	0.07 [-0.48, 0.61]
Arnold 2010	299.37	46.5	31	302.84	49.7	30	2.4%	-0.07 [-0.57, 0.43]
Beato 2012	486.07	78.52	14	451	62.09	15	2.3%	0.48 [-0.26, 1.22]
Bento-Torres 2019	308.8	81.6	40	325	79.5	40	2.5%	-0.20 [-0.64, 0.24]
Caminiti 2011	438.04	49.26	25	402.58	55.18	25	2.4%	0.67 [0.10, 1.24]
de Castro 2020	524	81	20	519	93	16	2.4%	0.06 [-0.60, 0.71]
Felcar 2018	527	83	17	532	71	14	2.3%	-0.06 [-0.77, 0.65]
Kuptniratsaikul 2019	568.8	111.1	14	457.5	64.8	14	2.3%	1.19 [0.37, 2.00]
Liu 2021	596.8	77.1	24	558.3	79.4	14	2.3%	0.48 [-0.19, 1.15]
Murtezani 2014	371.9	136.9	19	352.6	123.5	19	2.4%	0.14 [-0.49, 0.78]
Wang 2011	375.1	55.9	29	419.5	42	22	2.4%	-0.87 [-1.45, -0.29]
Subtotal (95% CI)			**259**			**235**	**26.1%**	**0.13 [-0.16, 0.43]**

Heterogeneity: $Tau^2 = 0.15$; $Chi^2 = 26.04$, df = 10 (P = 0.004); $I^2 = 62\%$

Test for overall effect: Z = 0.89 (P = 0.38)



1.1.4 30s Chair Stand Test								
Arnold 2010	14.06	3.95	43	12.18	1.44	17	2.4%	0.54 [-0.03, 1.11]
Beato 2012	16.86	4.96	14	19.2	4.4	15	2.3%	-0.49 [-1.23, 0.25]
Bento-Torres 2019	23	0.8	27	14.6	0.6	28	1.2%	11.74 [9.40, 14.08]
Bocalini 2010	18.4	3.7	14	12.8	1.4	14	2.2%	1.94 [1.02, 2.87]
Liu 2021	14.58	2.1	24	12.23	1.36	14	2.3%	1.23 [0.51, 1.95]
Sanders 2013	7.5	3.9	19	8.1	2.6	19	2.4%	-0.18 [-0.81, 0.46]
Subtotal (95% CI)			**141**			**107**	**12.7%**	**2.02 [0.50, 3.54]**

Heterogeneity: $Tau^2 = 3.33$; $Chi^2 = 112.17$, df = 5 ($P < 0.00001$); $I^2 = 96\%$

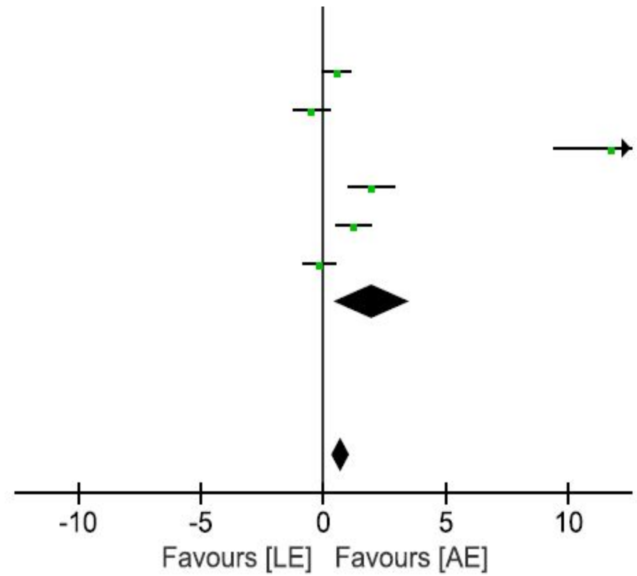
Test for overall effect: Z = 2.60 (P = 0.009)

Total (95% CI)			**914**			**836**	**100.0%**	**0.71 [0.37, 1.06]**

Heterogeneity: $Tau^2 = 1.19$; $Chi^2 = 462.55$, df = 43 ($P < 0.00001$); $I^2 = 91\%$

Test for overall effect: Z = 4.07 ($P < 0.0001$)

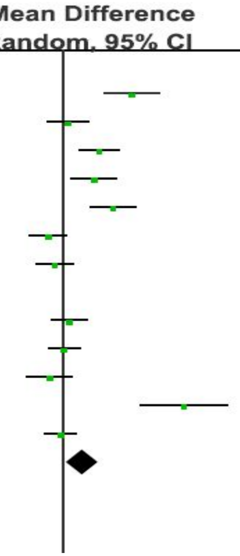
Test for subgroup differences: $Chi^2 = 9.81$, df = 3 (P = 0.02), $I^2 = 69.4\%$



Study or Subgroup	AE Mean	AE SD	AE Total	LE Mean	LE SD	LE Total	Weight	Std. Mean Difference IV, Random, 95% CI
1.1.1 Berg Balance Scale								
Arnold 2008	49.4	3.8	14	37.9	4.2	14	1.9%	2.79 [1.71, 3.87]
Arnold 2010	50.2	4.6	13	49.2	5.1	11	2.4%	0.20 [-0.61, 1.01]
Assar 2020	51.2	3.1	17	43.9	6.1	17	2.4%	1.47 [0.70, 2.24]
Kurt 2018	49.62	4.01	14	42.91	6.35	11	2.3%	1.26 [0.38, 2.13]
Lee 2018	43.8	9.9	15	26.71	6.3	17	2.3%	2.04 [1.16, 2.91]
Moreira 2020	44.1	7.5	15	47.9	4.8	15	2.5%	-0.59 [-1.32, 0.15]
Murtezani 2014	21.5	3.94	15	22.73	3.6	14	2.5%	-0.32 [-1.05, 0.42]
Pérez 2017	52.1	3.3	60	41.3	1.9	60	0.0%	3.99 [3.36, 4.61]
Pérez 2021	39.74	15.05	18	35.67	13.16	14	2.5%	0.28 [-0.42, 0.98]
Silva 2020	41	18	20	40	5.5	20	2.7%	0.07 [-0.55, 0.69]
Vale 2020	45.9	5.2	10	48.7	5.2	10	2.2%	-0.52 [-1.41, 0.38]
Volpe 2014	52.55	4.88	12	33.83	1.88	12	1.2%	4.89 [3.18, 6.60]
Volpe 2017	30.5	5.1	19	30.9	3.8	19	2.6%	-0.09 [-0.72, 0.55]
Subtotal (95% CI)			**182**			**174**	**27.5%**	**0.82 [0.17, 1.48]**

Heterogeneity: $Tau^2 = 1.15$; $Chi^2 = 87.48$, df = 11 ($P < 0.00001$); $I^2 = 87\%$

Test for overall effect: $Z = 2.46$ ($P = 0.01$)

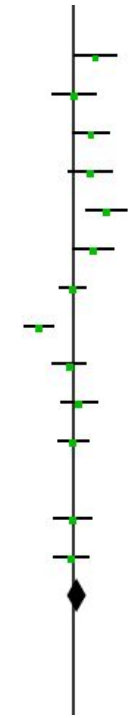


1.1.2 Time Up to Go Test

Adsett 2017	-21.2	2.6	14	-23.6	2.8	14	2.4%	0.86 [0.08, 1.64]
Arnold 2010	-11.5	2	13	-11.6	2.3	11	2.4%	0.05 [-0.76, 0.85]
de Castro 2020	-11	2	17	-12.8	3	17	2.5%	0.69 [-0.01, 1.38]
Ferreira 2022	-13.17	3.23	14	-15.58	3.65	11	2.4%	0.68 [-0.13, 1.50]
Hale 2012	-13.67	5.2	15	-20.24	4.9	17	2.4%	1.27 [0.50, 2.04]
Kurt 2018	-9.1	3.3	14	-11.5	2.6	15	2.4%	0.79 [0.03, 1.55]
Oh 2015	-4.91	0.69	34	-4.89	0.82	32	2.9%	-0.03 [-0.51, 0.46]
Oh 2021	-7.42	1.26	34	-6.25	0.15	32	2.8%	-1.27 [-1.80, -0.74]
Pérez 2017	-14.19	4.86	20	-13.15	8.97	20	2.7%	-0.14 [-0.76, 0.48]
Pérez 2021	-10.1	1.29	20	-10.7	3.46	15	2.6%	0.24 [-0.43, 0.91]
Silva 2020	-11.51	3.21	24	-11.51	2.42	25	2.8%	0.00 [-0.56, 0.56]
Taglietti 2018	-6.1	0.1	17	-6.8	0.2	18	0.0%	4.29 [3.03, 5.54]
Volpe 2014	-9	1.4	17	-9	2.1	14	2.5%	0.00 [-0.71, 0.71]
Volpe 2017	-15.1	9.5	19	-14.5	7.1	19	2.6%	-0.07 [-0.71, 0.57]
Subtotal (95% CI)			**255**			**242**	**33.4%**	**0.20 [-0.16, 0.57]**

Heterogeneity: $Tau^2 = 0.33$; $Chi^2 = 47.38$, df = 12 ($P < 0.00001$); $I^2 = 75\%$

Test for overall effect: $Z = 1.08$ ($P = 0.28$)



Sensitivity Analysis

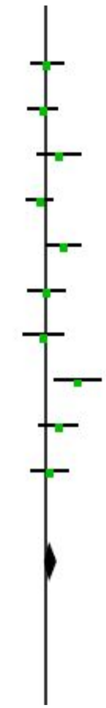
- Excluding trials with distinctly opposite direction change in each category

1.1.3 6 Minute Walking Test

Adsett 2017	386	75.8	26	381	70.4	26	2.8%	0.07 [-0.48, 0.61]
Arnold 2010	299.37	46.5	31	302.84	49.7	30	2.9%	-0.07 [-0.57, 0.43]
Beato 2012	486.07	78.52	14	451	62.09	15	2.5%	0.48 [-0.26, 1.22]
Bento-Torres 2019	308.8	81.6	40	325	79.5	40	2.9%	-0.20 [-0.64, 0.24]
Caminiti 2011	438.04	49.26	25	402.58	55.18	25	2.7%	0.67 [0.10, 1.24]
de Castro 2020	524	81	20	519	93	16	2.6%	0.06 [-0.60, 0.71]
Felcar 2018	527	83	17	532	71	14	2.5%	-0.06 [-0.77, 0.65]
Kuptniratsaikul 2019	568.8	111.1	14	457.5	64.8	14	2.4%	1.19 [0.37, 2.00]
Liu 2021	596.8	77.1	24	558.3	79.4	14	2.6%	0.48 [-0.19, 1.15]
Murtezani 2014	371.9	136.9	19	352.6	123.5	19	2.6%	0.14 [-0.49, 0.78]
Wang 2011	375.1	55.9	29	419.5	42	22	0.0%	-0.87 [-1.45, -0.29]
Subtotal (95% CI)			**230**			**213**	**26.5%**	**0.22 [-0.03, 0.47]**

Heterogeneity: $Tau^2 = 0.06$; $Chi^2 = 14.72$, df = 9 (P = 0.10); $I^2 = 39\%$

Test for overall effect: Z = 1.74 (P = 0.08)



1.1.4 30s Chair Stand Test								
Arnold 2010	14.06	3.95	43	12.18	1.44	17	2.7%	0.54 [-0.03, 1.11]
Beato 2012	16.86	4.96	14	19.2	4.4	15	2.5%	-0.49 [-1.23, 0.25]
Bento-Torres 2019	23	0.8	27	14.6	0.6	28	0.0%	11.74 [9.40, 14.08]
Bocalini 2010	18.4	3.7	14	12.8	1.4	14	2.2%	1.94 [1.02, 2.87]
Liu 2021	14.58	2.1	24	12.23	1.36	14	2.5%	1.23 [0.51, 1.95]
Sanders 2013	7.5	3.9	19	8.1	2.6	19	2.6%	-0.18 [-0.81, 0.46]
Subtotal (95% CI)			**114**			**79**	**12.6%**	**0.58 [-0.20, 1.36]**

Heterogeneity: $Tau^2 = 0.65$; $Chi^2 = 24.52$, df = 4 ($P < 0.0001$); $I^2 = 84\%$

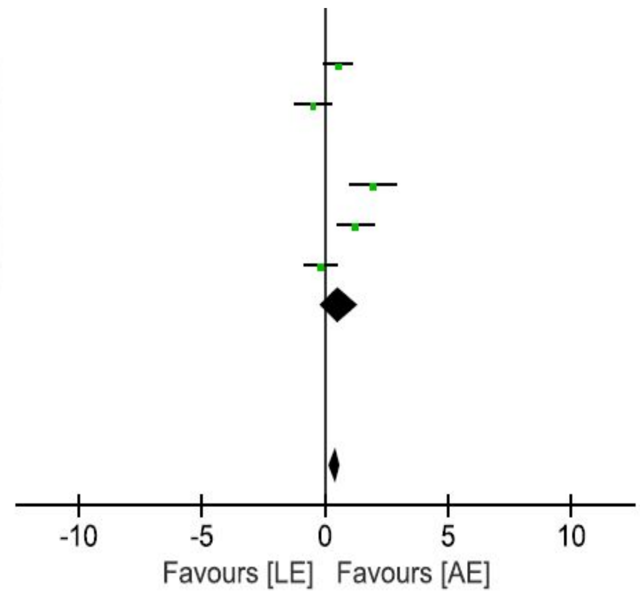
Test for overall effect: $Z = 1.46$ ($P = 0.15$)

Total (95% CI)			**781**			**708**	**100.0%**	**0.41 [0.17, 0.65]**

Heterogeneity: $Tau^2 = 0.44$; $Chi^2 = 183.79$, df = 39 ($P < 0.00001$); $I^2 = 79\%$

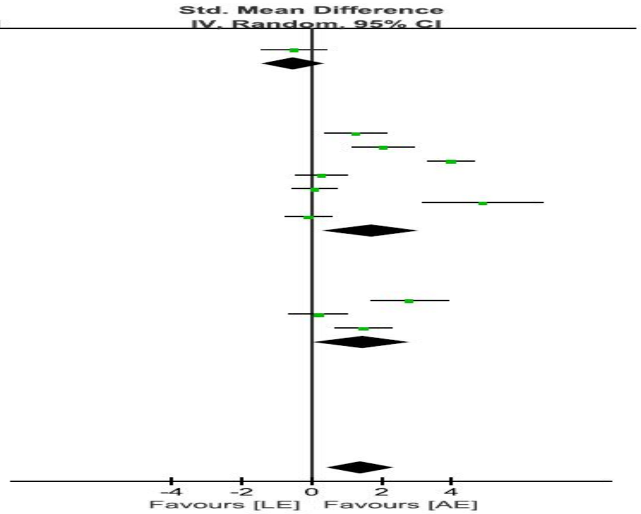
Test for overall effect: $Z = 3.41$ ($P = 0.0007$)

Test for subgroup differences: $Chi^2 = 3.60$, df = 3 ($P = 0.31$), $I^2 = 16.8\%$



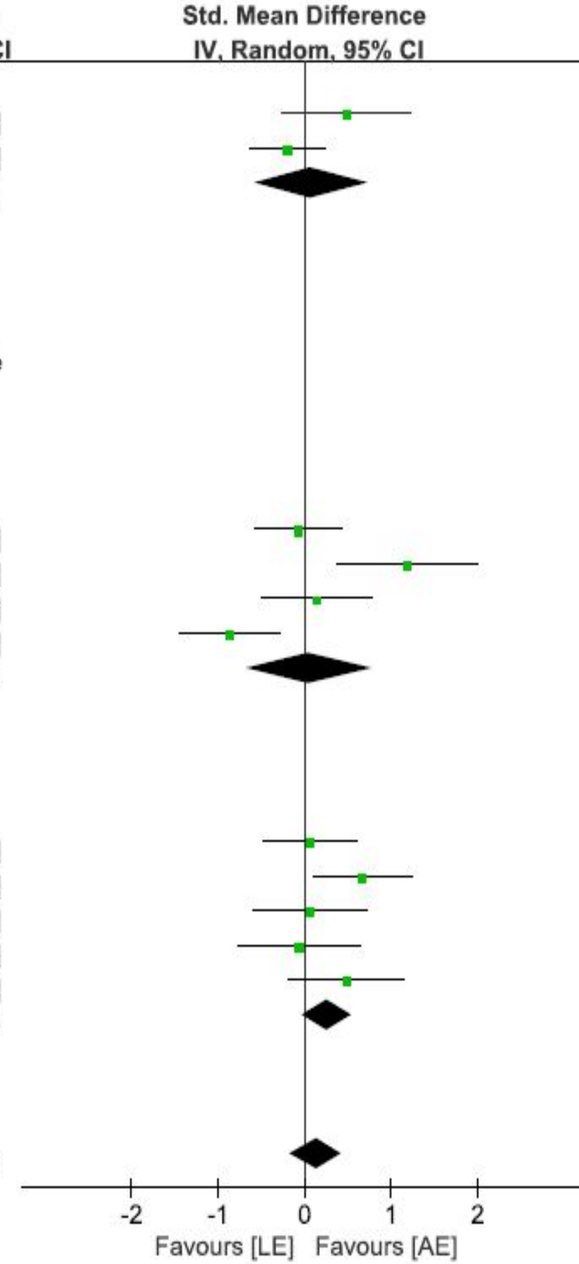
A

Study or Subgroup	AE Mean	AE SD	AE Total	LE Mean	LE SD	LE Total	Weight	Std. Mean Difference IV, Random, 95% CI
2.1.1 Healthy population								
Vale 2020_BBS	45.9	5.2	10	48.7	5.2	10	9.1%	-0.52 [-1.41, 0.38]
Subtotal (95% CI)			**10**			**10**	**9.1%**	**-0.52 [-1.41, 0.38]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.13 (P = 0.26)								
2.1.2 Nervous system diseases								
Kurt 2018_BBS	49.62	4.01	14	42.91	6.35	11	9.1%	1.26 [0.38, 2.13]
Lee 2018_BBS	43.8	9.9	15	26.71	6.3	17	9.1%	2.04 [1.16, 2.91]
Pérez 2017_BBS	52.1	3.3	60	41.3	1.9	60	9.5%	3.99 [3.36, 4.61]
Pérez 2021_BBS	39.74	15.05	18	35.67	13.16	14	9.4%	0.28 [-0.42, 0.98]
Silva 2020_BBS	41	18	20	40	5.5	20	9.5%	0.07 [-0.55, 0.69]
Volpe 2014_BBS	52.55	4.88	12	33.83	1.88	12	7.5%	4.89 [3.18, 6.60]
Volpe 2017_BBS	30.5	5.1	19	30.9	3.8	19	9.5%	-0.09 [-0.72, 0.55]
Subtotal (95% CI)			**158**			**153**	**63.6%**	**1.70 [0.35, 3.06]**
Heterogeneity: Tau² = 3.13; Chi² = 131.88, df = 6 (P < 0.00001); I² = 95%								
Test for overall effect: Z = 2.46 (P = 0.01)								
2.1.3 Musculoskeletal diseases								
Arnold 2008_BBS	49.4	3.8	14	37.9	4.2	14	8.8%	2.79 [1.71, 3.87]
Arnold 2010_BBS	50.2	4.6	13	49.2	5.1	11	9.2%	0.20 [-0.61, 1.01]
Assar 2020_BBS	51.2	3.1	17	43.9	6.1	17	9.3%	1.47 [0.70, 2.24]
Subtotal (95% CI)			**44**			**42**	**27.3%**	**1.45 [0.08, 2.81]**
Heterogeneity: Tau² = 1.25; Chi² = 14.62, df = 2 (P = 0.0007); I² = 86%								
Test for overall effect: Z = 2.08 (P = 0.04)								
2.1.4 Cardiopulmonary diseases								
Subtotal (95% CI)			**0**			**0**		**Not estimable**
Heterogeneity: Not applicable								
Test for overall effect: Not applicable								
Total (95% CI)			**212**			**205**	**100.0%**	**1.42 [0.46, 2.39]**
Heterogeneity: Tau² = 2.46; Chi² = 161.44, df = 10 (P < 0.00001); I² = 94%								
Test for overall effect: Z = 2.89 (P = 0.004)								
Test for subgroup differences: Chi² = 9.80, df = 2 (P = 0.007), I² = 79.6%								



C

Study or Subgroup	AE Mean	AE SD	AE Total	LE Mean	LE SD	LE Total	Weight	Std. Mean Difference IV, Random, 95% CI
2.3.1 Healthy population								
Beato 2012_6 MWT	486.07	78.52	14	451	62.09	15	7.8%	0.48 [-0.26, 1.22]
Bento-Torres 2019_6 MWT	308.8	81.6	40	325	79.5	40	11.3%	-0.20 [-0.64, 0.24]
Subtotal (95% CI)			**54**			**55**	**19.1%**	**0.07 [-0.58, 0.73]**
Heterogeneity: Tau² = 0.14; Chi² = 2.42, df = 1 (P = 0.12); I² = 59%								
Test for overall effect: Z = 0.22 (P = 0.82)								
2.3.2 Nervous system diseases								
Subtotal (95% CI)			**0**			**0**		**Not estimable**
Heterogeneity: Not applicable								
Test for overall effect: Not applicable								
2.3.3 Musculoskeletal diseases								
Arnold 2010_6 MWT	299.37	46.5	31	302.84	49.7	30	10.5%	-0.07 [-0.57, 0.43]
Kuptniratsaikul 2019_6 MWT	568.8	111.1	14	457.5	64.8	14	7.0%	1.19 [0.37, 2.00]
Murtezani 2014_6 MWT	371.9	136.9	19	352.6	123.5	19	8.9%	0.14 [-0.49, 0.78]
Wang 2011_6 MWT	375.1	55.9	29	419.5	42	22	9.5%	-0.87 [-1.45, -0.29]
Subtotal (95% CI)			**93**			**85**	**36.0%**	**0.06 [-0.68, 0.79]**
Heterogeneity: Tau² = 0.46; Chi² = 16.86, df = 3 (P = 0.0008); I² = 82%								
Test for overall effect: Z = 0.16 (P = 0.88)								
2.3.4 Cardiopulmonary diseases								
Adsett 2017_6 MWT	386	75.8	26	381	70.4	26	10.0%	0.07 [-0.48, 0.61]
Caminiti 2011_6 MWT	438.04	49.26	25	402.58	55.18	25	9.7%	0.67 [0.10, 1.24]
de Castro 2020_6 MWT	524	81	20	519	93	16	8.6%	0.06 [-0.60, 0.71]
Felcar 2018_6 MWT	527	83	17	532	71	14	8.1%	-0.06 [-0.77, 0.65]
Liu 2021_6MWT	596.8	77.1	24	558.3	79.4	14	8.5%	0.48 [-0.19, 1.15]
Subtotal (95% CI)			**112**			**95**	**44.9%**	**0.26 [-0.02, 0.54]**
Heterogeneity: Tau² = 0.00; Chi² = 4.03, df = 4 (P = 0.40); I² = 1%								
Test for overall effect: Z = 1.82 (P = 0.07)								
Total (95% CI)			**259**			**235**	**100.0%**	**0.13 [-0.16, 0.43]**
Heterogeneity: Tau² = 0.15; Chi² = 26.04, df = 10 (P = 0.004); I² = 62%								
Test for overall effect: Z = 0.89 (P = 0.38)								
Test for subgroup differences: Chi² = 0.44, df = 2 (P = 0.80), I² = 0%								

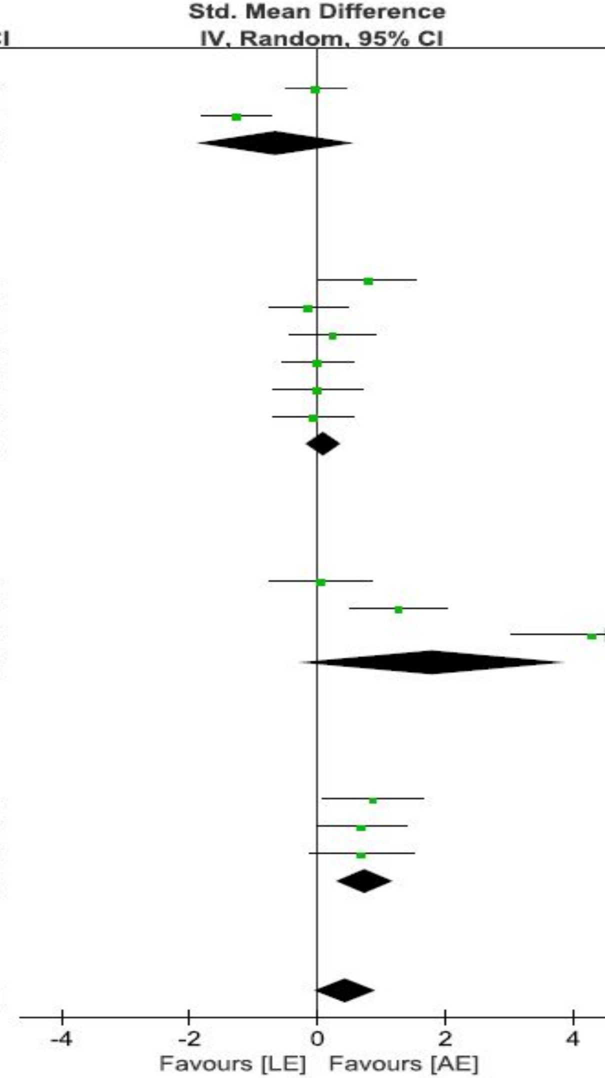


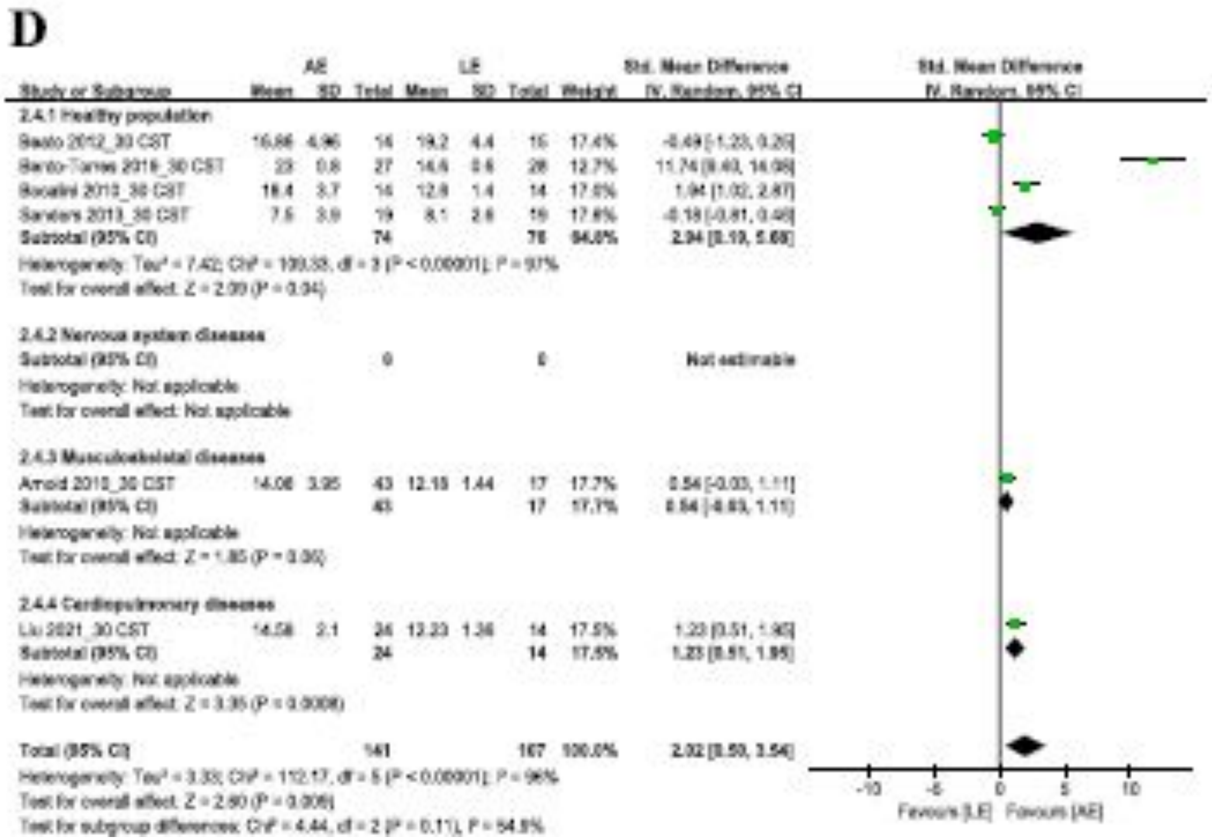
D

Study or Subgroup	AE Mean	AE SD	AE Total	LE Mean	LE SD	LE Total	Weight	Std. Mean Difference IV, Random, 95% CI
2.4.1 Healthy population								
Basto 2012_30 CST	16.66	4.96	16	19.2	4.4	16	17.4%	-0.49 [-1.23, 0.25]
Bento-Torres 2016_30 CST	23	0.8	27	14.6	0.6	28	12.7%	11.74 [9.40, 14.08]
Bocalini 2010_30 CST	18.4	3.7	16	12.8	1.4	14	17.6%	1.94 [1.02, 2.87]
Sanders 2013_30 CST	7.5	3.9	19	8.1	2.8	19	17.6%	-0.18 [-0.81, 0.45]
Subtotal (95% CI)			**74**			**76**	**64.8%**	**2.94 [0.19, 5.68]**
Heterogeneity: Tau² = 7.42; Chi² = 100.55, df = 3 (P < 0.00001); I² = 97%								
Test for overall effect: Z = 2.09 (P = 0.04)								
2.4.2 Nervous system diseases								
Subtotal (95% CI)			**0**			**0**		**Not estimable**
Heterogeneity: Not applicable								
Test for overall effect: Not applicable								
2.4.3 Musculoskeletal diseases								
Arnold 2010_30 CST	14.06	3.95	43	12.15	1.44	17	17.7%	0.54 [-0.03, 1.11]
Subtotal (95% CI)			**43**			**17**	**17.7%**	**0.54 [-0.03, 1.11]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.85 (P = 0.06)								
2.4.4 Cardiopulmonary diseases								
Liu 2021_30 CST	14.58	2.1	24	12.23	1.36	14	17.5%	1.23 [0.51, 1.95]
Subtotal (95% CI)			**24**			**14**	**17.5%**	**1.23 [0.51, 1.95]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 3.35 (P = 0.0008)								
Total (95% CI)			**141**			**167**	**100.0%**	**2.02 [0.50, 3.54]**
Heterogeneity: Tau² = 3.33; Chi² = 112.17, df = 5 (P < 0.00001); I² = 96%								
Test for overall effect: Z = 2.60 (P = 0.009)								
Test for subgroup differences: Chi² = 4.44, df = 2 (P = 0.11), I² = 54.9%								

B

Study or Subgroup	AE Mean	AE SD	AE Total	LE Mean	LE SD	LE Total	Weight	Std. Mean Difference IV, Random, 95% CI
2.2.1 Healthy population								
Oh 2015_TUGT	-4.91	0.69	34	-4.89	0.82	32	7.9%	-0.03 [-0.51, 0.46]
Oh 2021_TUGT	-7.42	1.26	34	-6.25	0.15	32	7.7%	-1.27 [-1.80, -0.74]
Subtotal (95% CI)			**68**			**64**	**15.6%**	**-0.64 [-1.86, 0.58]**
Heterogeneity: Tau² = 0.71; Chi² = 11.51, df = 1 (P = 0.0007); I² = 91%								
Test for overall effect: Z = 1.03 (P = 0.30)								
2.2.2 Nervous system diseases								
Kurt 2018_TUGT	-9.1	3.3	14	-11.5	2.6	15	7.0%	0.79 [0.03, 1.55]
Pérez 2017_TUGT	-14.19	4.86	20	-13.15	8.97	20	7.5%	-0.14 [-0.76, 0.48]
Pérez 2021_TUGT	-10.1	1.29	20	-10.7	3.46	15	7.3%	0.24 [-0.43, 0.91]
Silva 2020_TUGT	-11.51	3.21	24	-11.51	2.42	25	7.7%	0.00 [-0.56, 0.56]
Volpe 2014_TUGT	-9	1.4	17	-9	2.1	14	7.2%	0.00 [-0.71, 0.71]
Volpe 2017_TUGT	-15.1	9.5	19	-14.5	7.1	19	7.4%	-0.07 [-0.71, 0.57]
Subtotal (95% CI)			**114**			**108**	**44.1%**	**0.10 [-0.17, 0.36]**
Heterogeneity: Tau² = 0.00; Chi² = 4.37, df = 5 (P = 0.50); I² = 0%								
Test for overall effect: Z = 0.70 (P = 0.48)								
2.2.3 Musculoskeletal diseases								
Arnold 2010_TUGT	-11.5	2	13	-11.6	2.3	11	6.9%	0.05 [-0.76, 0.85]
Hale 2012_TUGT	-13.67	5.2	15	-20.24	4.9	17	7.0%	1.27 [0.50, 2.04]
Taglietti 2018_TUGT	-6.1	0.1	17	-6.8	0.2	18	5.4%	4.29 [3.03, 5.54]
Subtotal (95% CI)			**45**			**46**	**19.3%**	**1.81 [-0.27, 3.89]**
Heterogeneity: Tau² = 3.14; Chi² = 31.13, df = 2 (P < 0.00001); I² = 94%								
Test for overall effect: Z = 1.70 (P = 0.09)								
2.2.4 Cardiopulmonary diseases								
Adsett 2017_TUGT	-21.2	2.6	14	-23.6	2.8	14	7.0%	0.86 [0.08, 1.64]
de Castro 2020_TUGT	-11	2	17	-12.8	3	17	7.2%	0.69 [-0.01, 1.38]
Ferreira 2022_TUGT	-13.17	3.23	14	-15.58	3.65	11	6.8%	0.68 [-0.13, 1.50]
Subtotal (95% CI)			**45**			**42**	**21.1%**	**0.74 [0.30, 1.18]**
Heterogeneity: Tau² = 0.00; Chi² = 0.13, df = 2 (P = 0.93); I² = 0%								
Test for overall effect: Z = 3.32 (P = 0.0009)								
Total (95% CI)			**272**			**260**	**100.0%**	**0.44 [-0.04, 0.91]**
Heterogeneity: Tau² = 0.70; Chi² = 89.38, df = 13 (P < 0.00001); I² = 85%								
Test for overall effect: Z = 1.79 (P = 0.07)								
Test for subgroup differences: Chi² = 10.37, df = 3 (P = 0.02), I² = 71.1%								





D
AE
LE
Std. Mean Difference
Std. Mean Difference
Study or Subgroup
Mean
SD
Total
Mean
SD
Total
Weight
IV, Random, 95% CI
IV, Random, 95% CI
2.4.1 Healthy population
Basto 2012_30 CST 16.66 4.96 14 19.2 4.4 15 17.4% -0.49 [-1.23, 0.25]
Banto-Torres 2016_30 CST 23 0.8 27 14.6 0.6 28 12.7% 11.74 [9.40, 14.08]
Bocalini 2013_30 CST 18.4 3.7 14 12.8 1.4 14 17.0% 1.94 [1.02, 2.87]
Sanders 2013_30 CST 7.5 3.9 19 8.1 2.8 19 17.8% -0.18 [-0.81, 0.46]
Subtotal (95% CI) 74 76 64.8% 2.94 [0.19, 5.68]
Heterogeneity: Tau² = 7.42; Chi² = 109.35, df = 3 (P < 0.00001); I² = 97%
Test for overall effect: Z = 2.09 (P = 0.04)
2.4.2 Nervous system diseases
Subtotal (95% CI) 0 0 Not estimable
Heterogeneity: Not applicable
Test for overall effect: Not applicable
2.4.3 Musculoskeletal diseases
Arnold 2010_30 CST 14.06 3.95 43 12.15 1.44 17 17.7% 0.54 [-0.03, 1.11]
Subtotal (95% CI) 43 17 17.7% 0.54 [-0.03, 1.11]
Heterogeneity: Not applicable
Test for overall effect: Z = 1.85 (P = 0.06)
2.4.4 Cardiopulmonary diseases
Liu 2021_30 CST 14.58 2.1 24 12.23 1.36 14 17.5% 1.23 [0.51, 1.95]
Subtotal (95% CI) 24 14 17.5% 1.23 [0.51, 1.95]
Heterogeneity: Not applicable
Test for overall effect: Z = 3.35 (P = 0.0008)
Total (95% CI) 141 167 100.0% 2.02 [0.50, 3.54]
Heterogeneity: Tau² = 3.33; Chi² = 112.17, df = 5 (P < 0.00001); I² = 96%
Test for overall effect: Z = 2.60 (P = 0.009)
Test for subgroup differences: Chi² = 4.44, df = 2 (P = 0.11), I² = 54.9%
-10
-5
0
5
10
Favours [LE]
Favours [AE]

Other thoughts on balance recovery using water?

What are your "go to" strategies?

Any new ideas after seeing the research?

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

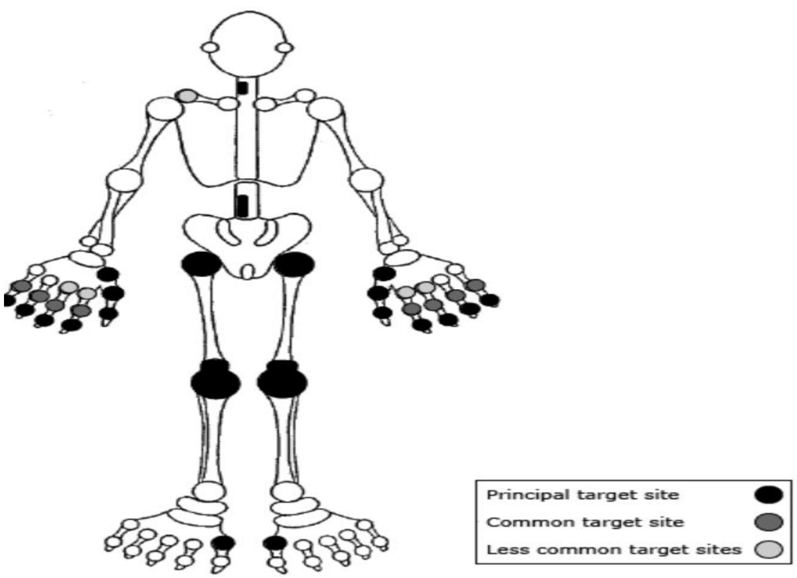
Aquatic Therapy for Hip and Knee Dysfunction with Osteoarthritis

David M. Morris, PT, PhD. FAPTA

Osteoarthritis

- Most common form of Arthritis
- Most frequently in hips, knees and hands
- Women > Men
- 10th on Disability Cause List
- 5th in US health care economic list
- All Guidelines STRONGLY recommend physical exercise

Most Affected Sites



Knee OA

- Worldwide – Most common single cause of lower limb disability in adults over 50
- Usually bilateral with one side more affected
- Pain
  - ✔ Anteromedial or more generalized on medial-compartment of tibiofemoral joint
  - ✔ Anterior in patellofemoral joint
  - ✔ Distal radiation
  - ✔ Rarely posterior unless popliteal (Baker's) cysts are present

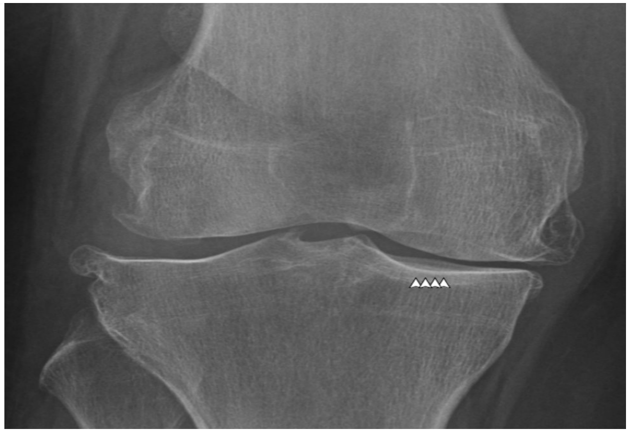
Knee OA - Symptoms

Category	Symptoms
Pain	• Affects one or a few joints at a time • Insidious onset - slow progression over years • Variable intensity • May be intermittent • Increased by joint use and relieved by rest • Night pain in severe osteoarthritis
Stiffness	Short-lived (<30 minutes) and early morning- or inactivity-related
Swelling	Some (eg, nodal osteoarthritis) patients present with swelling and/or deformity
Constitutional Symptoms	Absent

Knee OA – Physical Findings	
Appearance	• Swelling (bony overgrowth ± fluid/synovial hypertrophy) • Deformity • Muscle wasting (global - all muscles acting over the joint)
Palpation	• Absence of warmth • Swelling (effusion if present is usually small and cool) • Joint line tenderness • Periarticular tenderness (especially knee, hip)
Range of Motion	• Crepitus (knee, thumb bases) • Reduced range of movement • Weak local muscles

Knee OA – History Findings

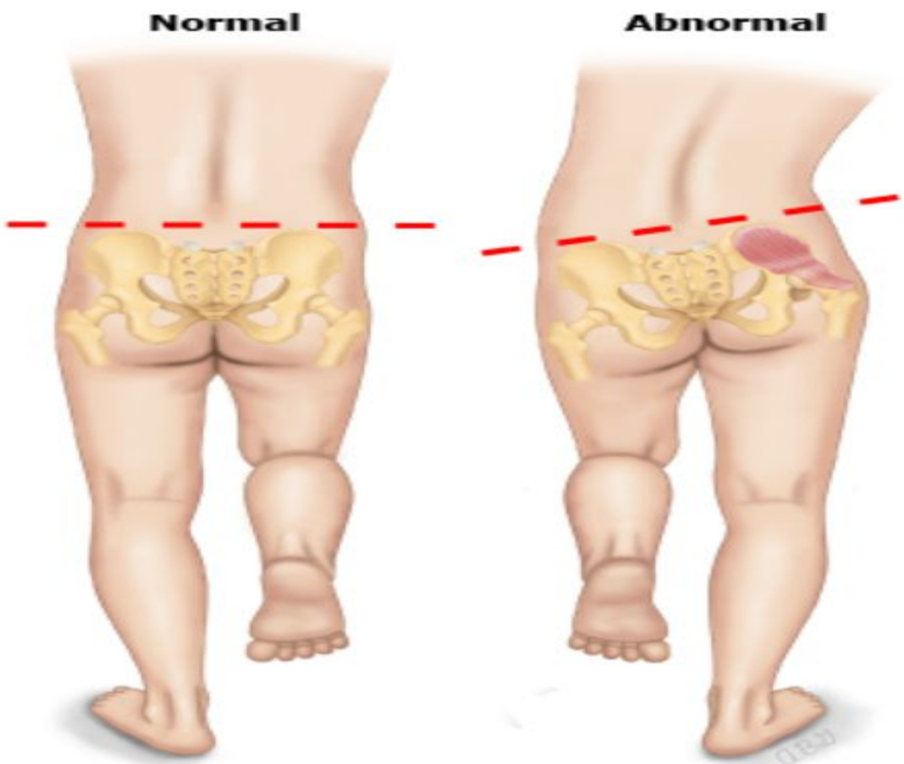
- Exacerbated by:
  - Prolonged sitting
  - Standing from a low chair
  - Climbing stairs or inclines (going down is often worse)
  - Persistent night pain – "keeps them awake"
- Reports of "giving way"

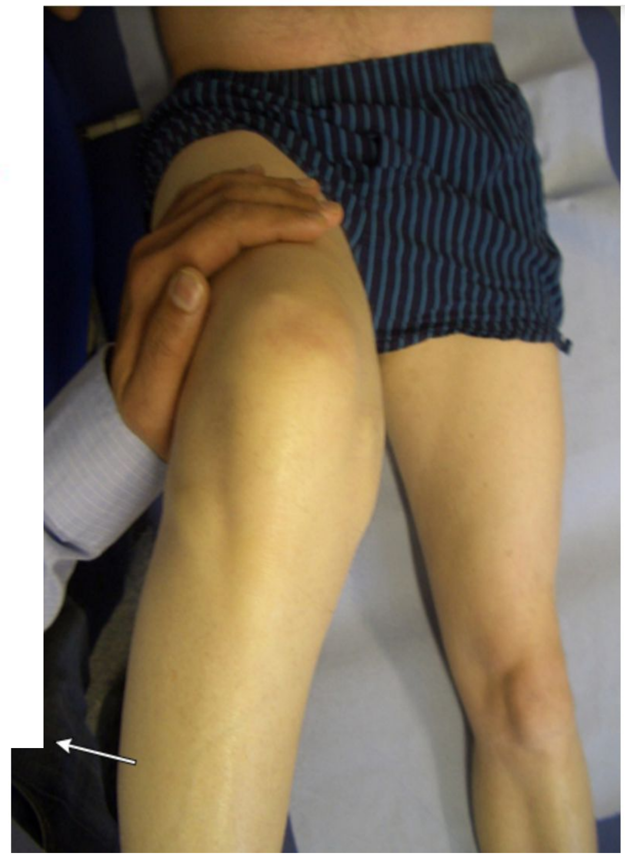


Patient with right hip OA, showing fixed flexion and external rotation deformity.

Hip OA

- Hip OA presents with pain, aching, stiffness, and restricted movement
- Pain usually felt deep in the anterior groin but may involve the anteromedial or upper lateral thigh and occasionally the buttocks
- Distal radiation not uncommon-distal thigh and/or knee pain without any proximal symptoms
- Frequently unilateral
- Both active and passive hip movements are equally painful
- Internal rotation with the hip flexed is frequently the earliest and most affected movement


Normal
Abnormal



Hip OA

- Pain is exacerbated particularly by rising from a seated position and during the initial phases of ambulation
- Wasting of thigh muscles
- Positive Trendelenburg test
- Shortening of the affected extremity may also be present

Exercise in the Aquatic Environment for People With Primary Hip Osteoarthritis: A Systematic Review and Meta-analyses

Paula Richley Geigle, PT, MS, PhD; Anita Van Wingerden, PT, DPT; Marti Biondi, PT, DPT, CSCS; Janet Gangaway, PT, DPT, OCS, LAT; Stephen Modica, MLS; David Morris, PT, PhD, FAPTA; Yasser Salem, PT, PhD, PCS, NCS; Lori Thein Brody, PT, PhD, LAT, SCS

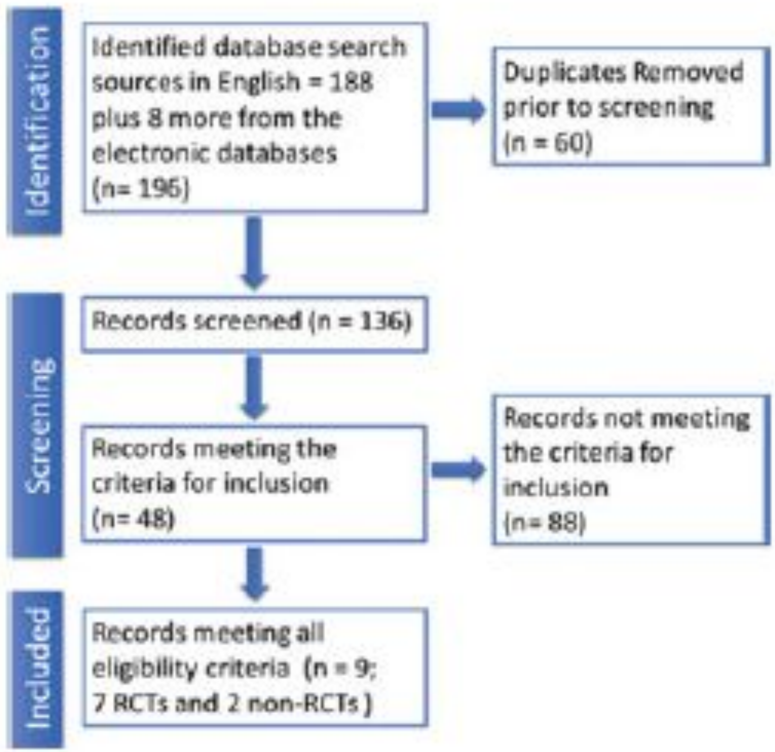


Fig. 1. Flow diagram of the article retrieval process. RCT indicates randomized controlled trials.

Inclusion Criteria

- People with Hip OA
- >18 years
- Reported AE interventions as main interventions
- Within last 15 years
- Included physical performance, functional performance, or health-related QOL

TABLE 3

PEDro Scores

	Score Out of 10
RCTs	
Arnold et al[10]	6
Cochrane et al[11]	7
Fransen et al[12]	7
Hale et al[13]	8
Hinman et al[14]	8
Wang et al[15]	8
Rahman et al[16]	7
Non-RCTs	
Wallis et al[17]	7
Lin et al[18]	7

Abbreviation: RCT, randomized controlled trial.

Table 2
Included Study Characteristics

			Intervention					Control	
Author	**Study Type**	**Year**	**n**	**Joint**	**Training Types**	**Training time/ wk,min**	**Training Duration, wk**	**n**	**Type**
Arnold et al	RCT	2011	28	Hip	AE+ Education	2 X 45	11	26	AE
Cochrane et al	RCT	2005	153	Hip & Knee	AE	2 X 60	52	159	none
Fransen et al	RCT	2007	55	Hip or Knee	AE	2 X 60	12	56 &41	Tai chi & wait-list
Hale et al	RCT	2012	23	Hip and/or Knee	AE	2 X 20-60	12	16	Computer Skills training
Hinman et al	RCT	2006	36	Hip or knee	Aquatic PT	2 X 45-60	6	35	None

LE Function Outcome

Author	ROM	Strength	Gait (Speed or Endurance)	LE Function	Balance	Pain	QOL
Arnold et al			6MWT	30sSTS	TUG, BBS, ABS, MCTSIB		
Cochrane et al		Isometric HS, Isometric Quads	8 –ft Walk Test	WOMAC, Function SF-36 Function Ascend 4 Stair (s) Decend 4 stair (s)		WOMAC pain, WOMAC Stiffness, SF-36 Pain	EQ Vas SF-36 All/Aggregat e
Fransen et al			50 Ft Walk Test	WOMAC Function Full Flight Stair Climb(s)	TUG	WOMAC Pain, WOMAC Stiffness	SF-12
Hale et al		PPA Strength		WOMAC Function	TUG, ABS, PPA- no strength, lateral Strep test	WOMAC Pain, WOMAC Stiffness	AIMS2-SF
Hinman et al		Isometric Quads, Isometric Hip Abs	6MWT	WOMAC Function, PASE Scale	TUG, Strep – Tap Test	VAS, WOMAC Pain, WOMAC Stiffness	AQL Scale

Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Statistics for each study						
Arnold et al., 2011	0.512	0.278	0.077	-0.032	1.056	1.843	0.065
Cochrane et al., 2005	0.117	0.113	0.013	-0.105	0.339	1.034	0.301
Fransen et al., 2007	0.397	0.194	0.038	0.017	0.777	2.048	0.041
Hale et al., 2012	0.310	0.320	0.103	-0.317	0.938	0.969	0.333
Hinman et al., 2007	0.368	0.241	0.058	-0.105	0.841	1.525	0.127
Rahmann et al., 2009	0.637	0.262	0.069	0.123	1.151	2.430	0.015
Wang et al., 2006	0.429	0.328	0.107	-0.213	1.072	1.311	0.190
Wallis et al., 2014	0.224	0.313	0.098	-0.391	0.838	0.713	0.476
Lin et al., 2004	0.353	0.206	0.042	-0.051	0.756	1.714	0.087
	0.294	0.070	0.005	0.157	0.432	4.187	0.000

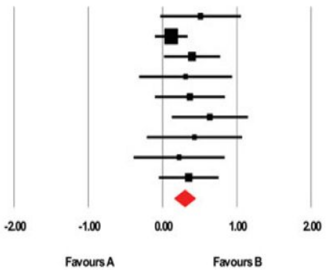


Fig. 2. Postintervention effect on overall outcomes (RCTs and non-RCTs). RCT indicates randomized controlled trial.

Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Statistics for each study						
Arnold et al., 2011	0.473	0.275	0.076	-0.067	1.012	1.716	0.086
Fransen et al., 2007	0.377	0.192	0.037	0.000	0.754	1.960	0.050
Hale et al., 2012	0.435	0.328	0.108	-0.208	1.079	1.327	0.185
Hinman et al., 2007	0.217	0.235	0.055	-0.244	0.678	0.923	0.356
Rahmann et al., 2009	0.578	0.258	0.066	0.073	1.083	2.245	0.025
	0.400	0.110	0.012	0.185	0.616	3.641	0.000

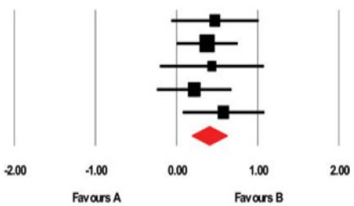


Fig. 3. Postintervention effect on balance.

Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Statistics for each study						
Cochrane et al., 2005	0.202	0.113	0.013	-0.019	0.423	1.787	0.074
Hale et al., 2012	0.177	0.311	0.096	-0.432	0.786	0.570	0.568
Hinman et al., 2007	0.258	0.234	0.055	-0.200	0.716	1.105	0.269
Rahmann et al., 2009	0.561	0.258	0.067	0.056	1.067	2.176	0.030
Wang et al., 2006	0.567	0.337	0.114	-0.094	1.228	1.683	0.092
Lin et al., 2004	0.301	0.205	0.042	-0.101	0.702	1.469	0.142
	0.278	0.080	0.006	0.120	0.435	3.455	0.001

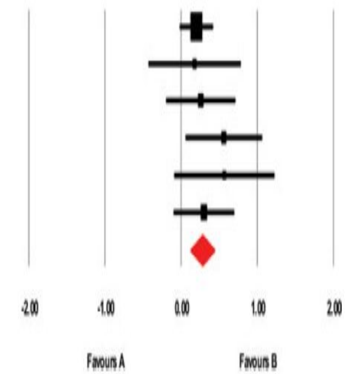


Fig. 4. Postintervention effect on muscle strength.

Study name	Statistics for each study						
	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Rahmann et al., 2009	0.713	0.265	0.070	0.193	1.233	2.687	0.007
Wang et al., 2006	0.328	0.320	0.103	-0.300	0.955	1.024	0.306
Lin et al., 2004	0.451	0.209	0.044	0.041	0.861	2.157	0.031
	0.505	0.146	0.021	0.218	0.791	3.455	0.001

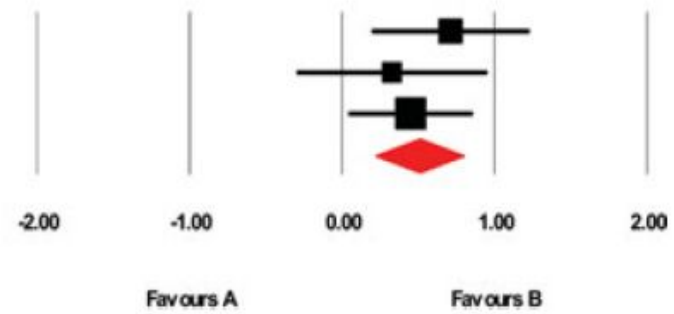


Fig. 5. Postintervention effect on range of motion.

Study name	Statistics for each study						
	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Cochrane et al., 2005	0.041	0.112	0.013	-0.178	0.261	0.369	0.712
Fransen et al., 2007	0.603	0.202	0.041	0.207	1.000	2.986	0.003
Hale et al., 2012	0.163	0.310	0.096	-0.446	0.771	0.524	0.600
Hinman et al., 2007	0.773	0.263	0.069	0.257	1.289	2.934	0.003
Wang et al., 2006	0.407	0.321	0.103	-0.222	1.036	1.269	0.204
Wallis et al., 2014	0.226	0.312	0.097	-0.386	0.838	0.725	0.469
Lin et al., 2004	0.348	0.205	0.042	-0.054	0.749	1.698	0.090
	0.339	0.116	0.013	0.113	0.566	2.933	0.003

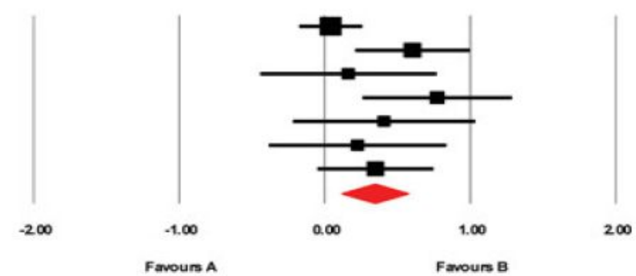


Fig. 6. Postintervention effect on pain (RCTs and non-RCTs). RCT indicates randomized controlled trial.

Study name	Statistics for each study						
	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Arnold et al., 2011	0.607	0.283	0.080	0.051	1.162	2.141	0.032
Cochrane et al., 2005	0.078	0.112	0.012	-0.140	0.297	0.702	0.482
Fransen et al., 2007	0.400	0.193	0.037	0.021	0.778	2.070	0.038
Hinman et al., 2007	0.237	0.233	0.054	-0.219	0.694	1.018	0.308
Rahmann et al., 2009	0.797	0.272	0.074	0.264	1.331	2.929	0.003
Wang et al., 2006	0.459	0.324	0.105	-0.176	1.094	1.416	0.157
Wallis et al., 2014	0.441	0.323	0.104	-0.191	1.074	1.367	0.172
Lin et al., 2004	0.189	0.201	0.040	-0.205	0.582	0.940	0.347
	0.319	0.090	0.008	0.143	0.494	3.561	0.000

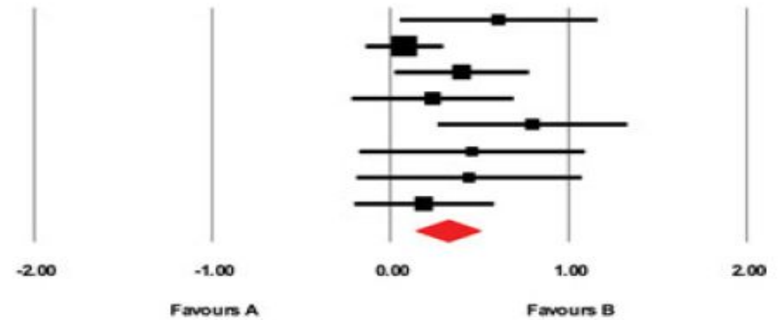


Fig. 7. Postintervention effect on gait (RCT and non-RCT). RCT indicates randomized controlled trial.

Study name	Statistics for each study						
	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Cochrane etal., 2005	0.091	0.114	0.013	-0.132	0.314	0.800	0.424
Fransen etal., 2007	0.267	0.190	0.036	-0.106	0.639	1.403	0.161
Hale etal., 2012	0.213	0.312	0.097	-0.398	0.824	0.683	0.495
Hinman etal., 2007	0.269	0.234	0.055	-0.189	0.728	1.152	0.250
Wang etal., 2006	0.000	0.308	0.095	-0.604	0.604	0.000	1.000
Wallis etal., 2014	0.089	0.309	0.095	-0.516	0.695	0.288	0.773
	0.145	0.080	0.006	-0.012	0.303	1.807	0.071

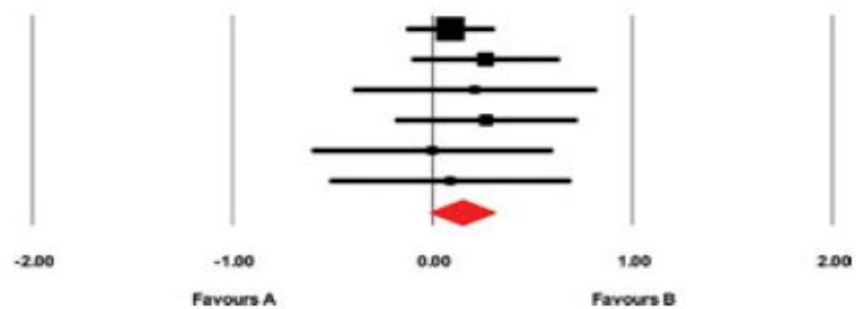


Fig. 8. Postintervention effect on quality of life (RCT and non-RCT). RCT indicates randomized controlled trial.

Study name	Statistics for each study						
	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Cochrane et al., 2005	0.143	0.113	0.013	-0.079	0.365	1.261	0.207
Fransen et al., 2007	0.433	0.195	0.038	0.051	0.815	2.224	0.026
Hale et al., 2012	0.085	0.309	0.095	-0.520	0.691	0.276	0.782
Hinman et al., 2007	0.247	0.237	0.056	-0.217	0.711	1.045	0.296
Wallis et al., 2014	0.248	0.313	0.098	-0.367	0.862	0.790	0.430
Lin et al., 2004	0.324	0.205	0.042	-0.078	0.725	1.581	0.114
	0.229	0.077	0.006	0.077	0.381	2.952	0.003

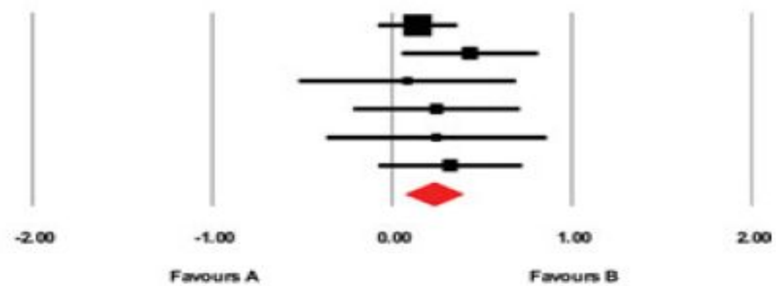


Fig. 9. Postintervention effect on self-reported function (RCT and non-RCT). RCT indicates randomized controlled trial.

Ma *et al.*
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Journal of Orthopaedic Surgery and Research

RESEARCH ARTICLE Open Access

Overall treatment effects of aquatic physical therapy in knee osteoarthritis: a systematic review and meta-analysis

Ji Ma[1], Xiaoyu Chen[2], Juan Xin[1], Xin Niu[1], Zhifang Liu[3*] and Qian Zhao[3*]

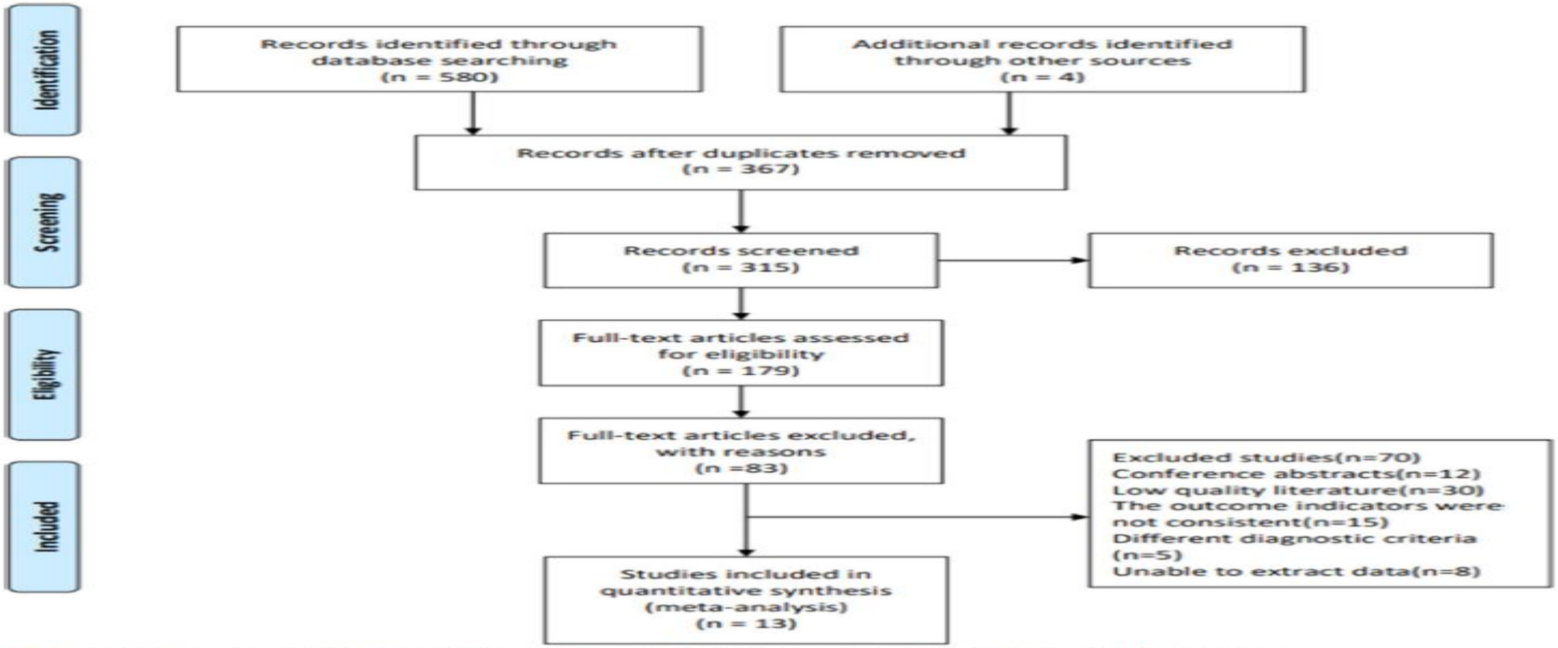


Fig. 1 Flow diagram based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement

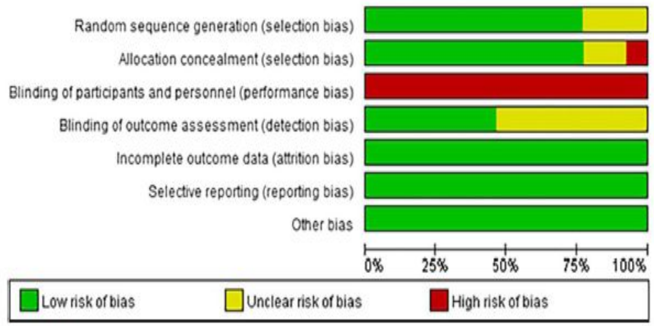


Fig. 2 Risk of bias graph

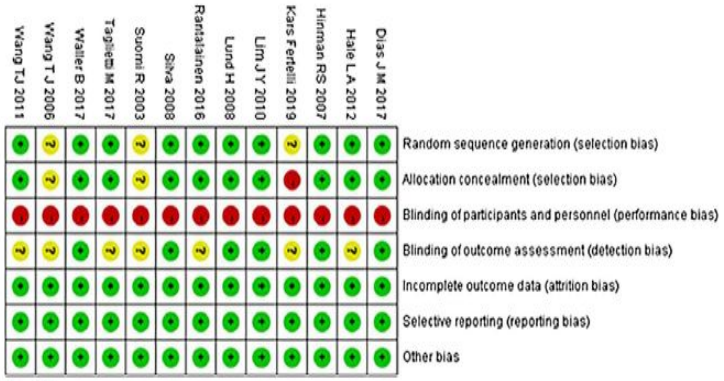


Fig. 3 Risk of bias summary

Inclusion Criteria

- People with Knee OA
- $\geq$ 40 years
- No medical conditions to prevent physical activity
- No organized exercise program in last 3 months
- RCT

Table 1 Characteristics of studies included in the meta- analysis

First Author	Country of study	*ne*1/*nc*1 *ne*2/*nc*2	Experimental Group (type of exercise)	Control Group (type of exercise)	Intervention Time	Outcome Measures
Dias	Brazil	33/32	Aquatic exercise and an educational Protocol	An educational Protocol	Six Weeks	WOMAC muscle strength Power and resistance
Silva	Brazil	32/32	Aquatic Physical Therapy	Land – Based Exercise	18 Weeks	Lequesne Index Scores WOMAC, VAS, 50FWT
Kars Fertelli	Turkey	60/60	Aquatic Physical Therapy	Not receive any intervention	8 Weeks	WOMAC, ASS Muscle strength
Hale	New Zealand	23/16	Aquatic Physical Therapy	Computer Skills Training	6 Weeks	Falls risk ratio Step test, TUGT, ABC Scale AIMS2-SF 26, WOMAC
Hinman	Australia	36/35	Aquatic Physical Therapy	Usual Care	8 Weeks	VAS, WOMAC, AQOL, PASE Muscle strength step test, TUGT, 6MWT

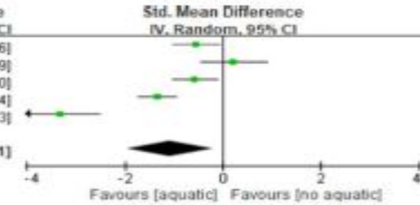
First Author	Country of study	*ne*1/*nc*1 *ne*2/*nc*2	Experimental Group (type of exercise)	Control Group (type of exercise)	Intervention Time	Outcome Measures
Lim	Korea	24/22 24/22	Aquatic Physical Therapy	Land-based exercise Home-based exercise	8 Weeks	Body weight, BMI, lean body mass, body fat mass, body fat proportion, abdominal fat, BPI WOMAC SF-36 Peak torque, knee extensor and flexor
Lund	Denmark	27/25 27/27	Aquatic Physical Therapy	Land-based exercise Not receive any intervention	8 Weeks	VAS KOOS
Rantalainen	Findland	60/60	Aquatic Physical Therapy	Usual Care	16 Weeks	T2 relaxation time, DGEMRIC index Cardiorespiratory fitness, force KOOS
Suomi	WI	10/10 10/10	Aquatic Physical Therapy	Land-based exercise Not receive any intervention	8 Weeks	Flexibility, hand–eye coordination Right arm curls, Left arm curls RSHab isometric, LSHab isometric, LHab isometric Functional capacity evaluation

First Author	Country of study	$ne1/nc1$ $ne2/nc2$	Experimental Group (type of exercise)	Control Group (type of exercise)	Intervention Time	Outcome Measures
Tagletti	Brazil	31/29	Aquatic Physical Therapy	Educational Program	8 Weeks	VAS, WOMAC, SF-36 Depression, TUGT
Waller	Finland	43/44	Aquatic Physical Therapy	Usual Care	4 Months	Walking speed, body mass, BMI, lean mass, fat mass KOOS
Wang	USA	20/18	Aquatic Physical Therapy	Usual Care	12 Weeks	Flexibility, muscle strength 6MWT, MDHAQ, VAS
Wang	Taiwan	26/26 26/26	Aquatic Physical Therapy	Land-based exercise Not receive any intervention	12 Weeks	KOOS, ROM, 6MWT

Comparison 1. WOMAC pain: aquatic physical therapy versus no aquatic physical therapy

Study or Subgroup	Aquatic exercise Mean	SD	Total	No aquatic exercise Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Dias J M 2017	37.7	16.5	33	48.6	22.1	32	20.5%	-0.55 [-1.05, -0.06]
Hale L A 2012	7.8	3.91	20	7.1	1.84	15	19.4%	0.21 [-0.46, 0.89]
Hinman RS 2007	143	79	36	198	108	35	20.6%	-0.58 [-1.05, -0.10]
Kars Fertelli 2019	7	4.44	60	14.43	6.4	60	21.0%	-1.34 [-1.74, -0.94]
Taglietti M 2017	4.2	0.7	31	8.1	1.5	29	18.6%	-3.33 [-4.12, -2.53]
Total (95% CI)			**180**			**171**	**100.0%**	**-1.09 [-1.97, -0.21]**

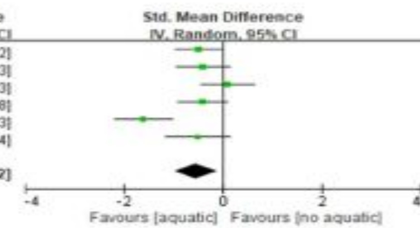
Heterogeneity: $Tau^2 = 0.92$; $Chi^2 = 54.17$, df = 4 ($P < 0.00001$); $I^2 = 93\%$
Test for overall effect: Z = 2.42 (P = 0.02)



Comparison 2. VAS: aquatic physical therapy versus no aquatic physical therapy

Study or Subgroup	Aquatic exercise Mean	SD	Total	No aquatic exercise Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Hinman RS 2007	4	2	36	5	2	35	17.9%	-0.49 [-0.97, -0.02]
Lund H 2008	20.3	16.64	27	27.2	16.64	27	16.8%	-0.41 [-0.95, 0.13]
Lund H 2008	20.3	16.64	27	18.8	16.5	25	16.7%	0.09 [-0.46, 0.63]
Silva 2008	26.7	23.1	32	37.3	27.5	32	17.5%	-0.41 [-0.91, 0.08]
Taglietti M 2017	2.9	0.5	31	3.8	0.6	29	16.0%	-1.61 [-2.20, -1.03]
Wang T J 2006	43.5	18.6	20	54.9	25.2	18	15.0%	-0.51 [-1.16, 0.14]
Total (95% CI)			**173**			**166**	**100.0%**	**-0.55 [-0.98, -0.12]**

Heterogeneity: $Tau^2 = 0.21$; $Chi^2 = 18.46$, df = 5 ($P = 0.002$); $I^2 = 73\%$
Test for overall effect: Z = 2.53 (P = 0.01)



Comparison 3. KOOS pain: aquatic physical therapy versus no aquatic physical therapy

Study or Subgroup	Aquatic exercise Mean	SD	Total	No aquatic exercise Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Lund H 2008	60.2	12.48	27	60.3	12.48	27	13.4%	-0.10 [-6.76, 6.56]
Lund H 2008	60.2	12.48	27	62	12.5	25	12.9%	-1.80 [-8.59, 4.99]
Rantalainen 2016	84	9.91	42	83	9.91	42	33.0%	1.00 [-3.24, 5.24]
Waller B 2017	84.3	10.5	43	83.3	11.7	44	27.2%	1.00 [-3.67, 5.67]
Wang TJ 2011	72	18	26	68	18	26	6.2%	4.00 [-5.78, 13.78]
Wang TJ 2011	72	18	26	76	15	26	7.3%	-4.00 [-13.01, 5.01]
Total (95% CI)			**191**			**190**	**100.0%**	**0.31 [-2.12, 2.75]**

Heterogeneity: $Chi^2 = 2.00$, df = 5 ($P = 0.85$); $I^2 = 0\%$
Test for overall effect: Z = 0.25 (P = 0.80)

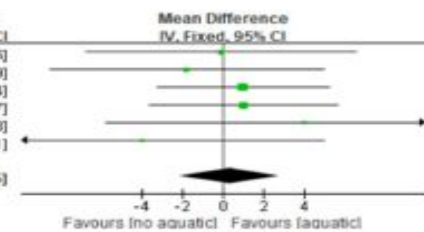
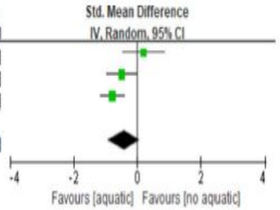


Fig. 4 Forest plot of aquatic physical therapy versus no aquatic physical therapy interventions in pain

Comparison 1. WOMAC stiffness: aquatic physical therapy versus no aquatic physical therapy

Study or Subgroup	Aquatic exercise Mean	SD	Total	No aquatic exercise Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Hale L A 2012	3.7	1.47	20	3.4	1.45	15	26.6%	0.20 [-0.47, 0.87]
Hinman RS 2007	73	45	36	95	44	35	34.5%	-0.49 [-0.96, -0.02]
Kars Fertelli 2019	2	2.13	60	5.52	5.87	60	38.9%	-0.79 [-1.16, -0.42]
Total (95% CI)			**116**			**110**	**100.0%**	**-0.42 [-0.94, 0.09]**

Heterogeneity: $Tau^2 = 0.14$; $Chi^2 = 6.48$, $df = 2$ ($P = 0.04$); $I^2 = 69\%$
Test for overall effect: $Z = 1.62$ ($P = 0.10$)



Comparison 2. KOOS symptoms: aquatic physical therapy versus no aquatic physical therapy

Study or Subgroup	Aquatic exercise Mean	SD	Total	No aquatic exercise Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Lund H 2008	64.6	12	27	61.4	11.96	27	17.4%	3.20 [-3.19, 9.59]
Lund H 2008	64.6	12	27	66.9	11.5	25	17.4%	-2.30 [-8.69, 4.09]
Rantalainen 2016	81	11.57	42	77	11.57	42	29.0%	4.00 [-0.95, 8.95]
Waller B 2017	80.9	12.1	43	77.5	14.9	44	21.9%	3.40 [-2.30, 9.10]
Wang TJ 2011	69	20	26	61	17	26	7.0%	8.00 [-2.09, 18.09]
Wang TJ 2011	69	20	26	71	16	26	7.3%	-2.00 [-11.84, 7.84]
Total (95% CI)			**191**			**190**	**100.0%**	**2.47 [-0.19, 5.14]**

Heterogeneity: $Chi^2 = 4.61$, $df = 5$ ($P = 0.47$); $I^2 = 0\%$
Test for overall effect: $Z = 1.82$ ($P = 0.07$)

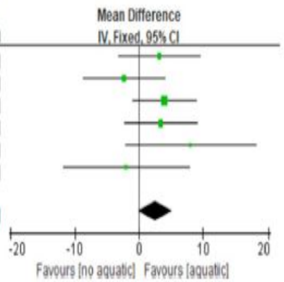
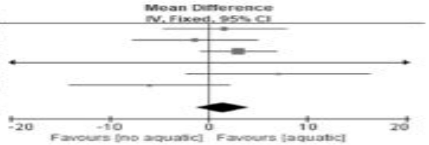


Fig. 5 Forest plot of aquatic physical therapy versus no aquatic physical therapy interventions in symptoms of joints

Comparison 1. KOOS ADL: aquatic physical therapy versus no aquatic physical therapy

Study or Subgroup	Aquatic exercise Mean	SD	Total	No aquatic exercise Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Lund H 2008	62.7	11.96	27	61.1	11.44	27	17.9%	1.60 [-4.64, 7.84]
Lund H 2008	62.7	11.96	27	64.1	11.5	25	17.1%	-1.40 [-7.78, 4.98]
Rantalainen 2016	88	9.91	42	85	8.29	42	45.6%	3.00 [-0.91, 6.91]
Waller B 2017	87.7	97	43	86	14.6	44	0.8%	1.70 [-27.61, 31.01]
Wang TJ 2011	76	16	26	69	18	26	8.1%	7.00 [-2.26, 16.26]
Wang TJ 2011	76	16	26	82	14	26	10.4%	-6.00 [-14.17, 2.17]
Total (95% CI)			**191**			**190**	**100.0%**	**1.37 [-1.27, 4.01]**

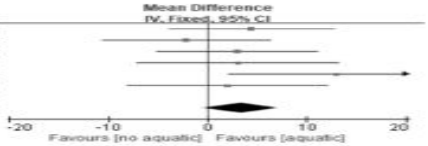
Heterogeneity: $Chi^2 = 5.94$, df = 5 (P = 0.31); $I^2 = 16\%$
Test for overall effect: Z = 1.02 (P = 0.31)



Comparison 2. KOOS sport/recreation: aquatic physical therapy versus no aquatic physical therapy

Study or Subgroup	Aquatic exercise Mean	SD	Total	No aquatic exercise Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Lund H 2008	26.2	15.6	27	21.8	15.6	27	20.2%	4.40 [-3.92, 12.72]
Lund H 2008	26.2	15.6	27	28.4	15.5	25	19.6%	-2.20 [-10.66, 6.26]
Rantalainen 2016	71	19.84	42	68	18.18	42	21.1%	3.00 [-5.14, 11.14]
Waller B 2017	70.6	21.7	43	67.6	26.5	44	13.5%	3.00 [-7.17, 13.17]
Wang TJ 2011	70	20	26	57	20	26	11.8%	13.00 [2.13, 23.87]
Wang TJ 2011	70	20	26	68	17	26	13.7%	2.00 [-8.09, 12.09]
Total (95% CI)			**191**			**190**	**100.0%**	**3.31 [-0.43, 7.05]**

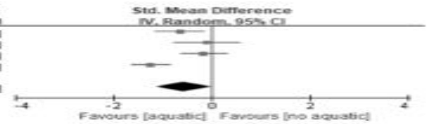
Heterogeneity: $Chi^2 = 4.82$, df = 5 (P = 0.44); $I^2 = 0\%$
Test for overall effect: Z = 1.74 (P = 0.08)



Comparison 3. WOMAC physical function: aquatic physical therapy versus no aquatic physical therapy

Study or Subgroup	Aquatic exercise Mean	SD	Total	No aquatic exercise Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Dias J M 2017	36.3	19	33	50.2	22.7	32	25.2%	-0.66 [-1.16, -0.16]
Hale L A 2012	24	8.89	20	24.9	7.14	15	21.8%	-0.11 [-0.78, 0.56]
Hinman RS 2007	598	316	36	656	373	35	25.8%	-0.17 [-0.63, 0.30]
Kars Fertelli 2019	26.1	15.59	60	46.9	17.22	60	27.2%	-1.26 [-1.65, -0.87]
Total (95% CI)			**149**			**142**	**100.0%**	**-0.57 [-1.14, -0.01]**

Heterogeneity: $Tau^2 = 0.27$; $Chi^2 = 15.81$, df = 3 (P = 0.001); $I^2 = 81\%$
Test for overall effect: Z = 1.98 (P = 0.05)



Comparison 4. SF-36 physical function: aquatic physical therapy versus no aquatic physical therapy

Study or Subgroup	Aquatic exercise Mean	SD	Total	No aquatic exercise Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Lim J Y 2010	38.8	7.7	24	40.4	7.9	22	32.9%	-1.60 [-6.12, 2.92]
Lim J Y 2010	38.8	7.7	24	36.9	9.6	20	32.2%	1.90 [-3.31, 7.11]
Taglietti M 2017	74.3	2.9	31	61.5	4.1	29	34.8%	12.80 [10.99, 14.61]
Total (95% CI)			**79**			**71**	**100.0%**	**4.54 [-5.60, 14.69]**

Heterogeneity: $Tau^2 = 76.02$; $Chi^2 = 43.84$, df = 2 (P < 0.00001); $I^2 = 95\%$
Test for overall effect: Z = 0.88 (P = 0.38)

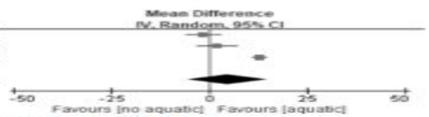


Fig. 6 Forest plot of aquatic physical therapy versus no aquatic physical therapy interventions in physical function

Comparison 1. KOOS QOL: aquatic physical therapy versus no aquatic physical therapy

Study or Subgroup	Aquatic exercise Mean	SD	Total	No aquatic exercise Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Lund H 2008	43	12.48	27	43.1	11.96	27	17.7%	-0.10 [-6.62, 6.42]
Lund H 2008	43	12.48	27	43.8	12.5	25	16.3%	-0.80 [-7.59, 5.99]
Rantalainen 2016	72	13.22	42	74	14.88	42	20.7%	-2.00 [-8.02, 4.02]
Waller B 2017	72.6	18.1	43	74.1	23.1	44	9.9%	-1.50 [-10.21, 7.21]
Wang TJ 2011	73	12	26	67	13	26	16.2%	6.00 [-0.80, 12.80]
Wang TJ 2011	73	12	26	74	11	26	19.2%	-1.00 [-7.26, 5.26]
Total (95% CI)			**191**			**190**	**100.0%**	**0.07 [-2.67, 2.81]**

Heterogeneity: $Chi^2 = 3.68$, $df = 5$ ($P = 0.60$); $I^2 = 0\%$
Test for overall effect: $Z = 0.05$ ($P = 0.96$)

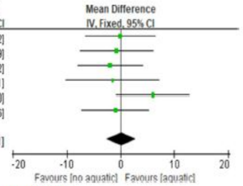
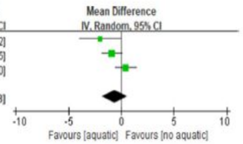


Fig. 7 Forest plot of aquatic physical therapy versus no aquatic physical therapy interventions in quality of life

Comparison 1. Joint ROM of knee extension: aquatic physical therapy versus no aquatic physical therapy

Study or Subgroup	Aquatic exercise Mean	SD	Total	No aquatic exercise Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Wang TJ 2006	1.2	2.6	20	3.2	3.5	18	21.9%	-2.00 [-3.98, -0.02]
Wang TJ 2011	2.4	2.2	26	3.3	1.1	26	39.6%	-0.90 [-1.85, 0.05]
Wang TJ 2011	2.4	2.2	26	2	1.4	26	38.5%	0.40 [-0.60, 1.40]
Total (95% CI)			**72**			**70**	**100.0%**	**-0.64 [-1.86, 0.58]**

Heterogeneity: $Tau^2 = 0.74$; $Chi^2 = 5.99$, $df = 2$ ($P = 0.05$); $I^2 = 67\%$
Test for overall effect: $Z = 1.03$ ($P = 0.30$)



Comparison 2. Joint ROM of knee flexion: aquatic physical therapy versus no aquatic physical therapy

Study or Subgroup	Aquatic exercise Mean	SD	Total	No aquatic exercise Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Wang TJ 2006	122.4	6.5	20	125.6	13.9	18	72.9%	-3.20 [-10.22, 3.82]
Wang TJ 2011	125	42	26	122.3	5.6	26	13.6%	2.70 [-13.59, 18.99]
Wang TJ 2011	125	42	26	125	6.1	26	13.5%	0.00 [-16.31, 16.31]
Total (95% CI)			**72**			**70**	**100.0%**	**-1.97 [-7.97, 4.03]**

Heterogeneity: $Chi^2 = 0.49$, $df = 2$ ($P = 0.78$); $I^2 = 0\%$
Test for overall effect: $Z = 0.64$ ($P = 0.52$)

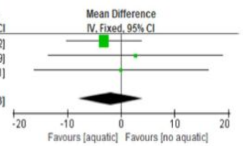
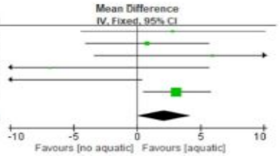


Fig. 8 Forest plot of aquatic physical therapy versus no aquatic physical therapy interventions in flexibility

Comparison 1. Knee extension muscle strength: aquatic physical therapy versus no aquatic physical therapy

Study or Subgroup	Aquatic exercise Mean	SD	Total	No aquatic exercise Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Dias J M 2017	64.5	14.4	33	61.7	15.4	32	8.3%	2.80 [-4.45, 10.05]
Hinman RS 2007	25.7	10.6	36	24.9	10.3	35	18.5%	0.80 [-4.06, 5.66]
Kars Fertelli 2019	70.8	24.71	41	64.84	18.23	42	5.0%	5.96 [-3.40, 15.32]
Lim J Y 2010	50.4	19.3	24	57.3	23.7	22	2.8%	-6.90 [-19.46, 5.66]
Lim J Y 2010	50.4	19.3	24	63.1	24.1	20	2.6%	-12.70 [-25.78, 0.38]
Wang T J 2006	16	4.5	20	12.9	3.8	18	62.8%	3.10 [0.46, 5.74]
Total (95% CI)			**178**			**169**	**100.0%**	**2.11 [0.02, 4.20]**

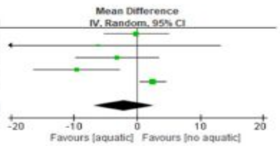
Heterogeneity: Chi² = 8.40, df = 5 (P = 0.14); I² = 41%
Test for overall effect: Z = 1.98 (P = 0.05)



Comparison 2. Knee flexion muscle strength: aquatic physical therapy versus no aquatic physical therapy

Study or Subgroup	Aquatic exercise Mean	SD	Total	No aquatic exercise Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Dias J M 2017	25.9	9.6	33	26.1	11.3	32	23.8%	-0.20 [-5.30, 4.90]
Kars Fertelli 2019	52.75	13.01	41	58.94	62.48	42	5.1%	-6.19 [-25.50, 13.12]
Lim J Y 2010	24.3	11.6	24	27.5	11.1	22	20.2%	-3.20 [-9.76, 3.36]
Lim J Y 2010	24.3	11.6	24	33.9	11.2	20	19.8%	-9.60 [-16.36, -2.84]
Wang T J 2006	12.1	3.8	20	9.6	2.5	18	31.0%	2.50 [0.47, 4.53]
Total (95% CI)			**142**			**134**	**100.0%**	**-2.14 [-6.91, 2.63]**

Heterogeneity: Tau² = 18.06; Chi² = 13.87, df = 4 (P = 0.008); I² = 71%
Test for overall effect: Z = 0.88 (P = 0.38)



Comparison 3. Hip abduction muscle strength: aquatic physical therapy versus no aquatic physical therapy

Study or Subgroup	Aquatic exercise Mean	SD	Total	No aquatic exercise Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
6.3.1 Left								
Hinman RS 2007	22.2	8.5	36	21	8	35	43.5%	1.20 [-2.64, 5.04]
Suomi R 2003	72.8	26.5	10	61.8	34.8	10	0.9%	11.00 [-16.11, 38.11]
Suomi R 2003	72.8	26.5	10	74.3	20.3	10	1.5%	-1.50 [-22.19, 19.19]
Subtotal (95% CI)			**56**			**55**	**45.9%**	**1.30 [-2.44, 5.04]**
Heterogeneity: Chi² = 0.56, df = 2 (P = 0.75); I² = 0%								
Test for overall effect: Z = 0.68 (P = 0.50)								
6.3.2 Right								
Hinman RS 2007	22.7	8.3	36	20.3	6.8	35	51.6%	2.40 [-1.13, 5.93]
Suomi R 2003	72.9	23.9	10	72.9	22.4	10	1.6%	0.00 [-20.30, 20.30]
Suomi R 2003	72.9	23.9	10	63.5	32.7	10	1.0%	9.40 [-15.70, 34.50]
Subtotal (95% CI)			**56**			**55**	**54.1%**	**2.46 [-0.98, 5.90]**
Heterogeneity: Chi² = 0.35, df = 2 (P = 0.84); I² = 0%								
Test for overall effect: Z = 1.40 (P = 0.16)								
Total (95% CI)			**112**			**110**	**100.0%**	**1.93 [-0.60, 4.46]**

Heterogeneity: Chi² = 1.12, df = 5 (P = 0.95); I² = 0%
Test for overall effect: Z = 1.49 (P = 0.14)
Test for subgroup differences: Chi² = 0.20, df = 1 (P = 0.65), I² = 0%

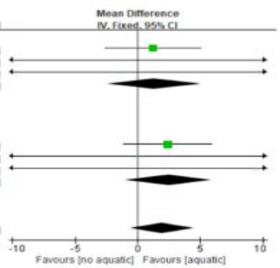
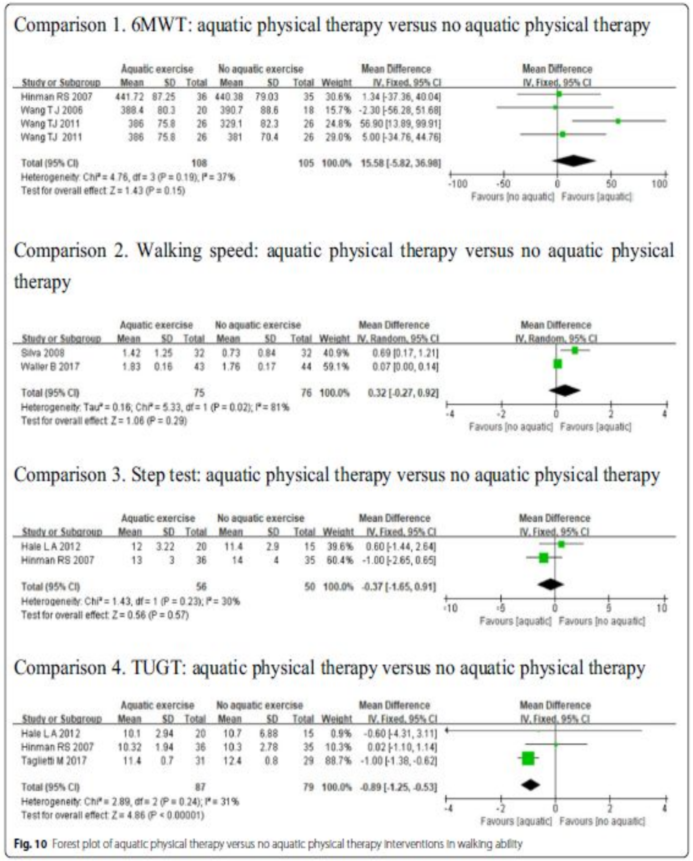


Fig. 9 Forest plot of aquatic physical therapy versus no aquatic physical therapy interventions in muscle strength



Comparison 1. 6MWT: aquatic physical therapy versus no aquatic physical therapy

	Aquatic exercise			No aquatic exercise				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Hinman RS 2007	441.72	87.25	36	440.38	79.03	35	30.6%	1.34 [-37.36, 40.04]
Wang T J 2006	388.4	80.3	20	390.7	88.6	18	15.7%	-2.30 [-56.28, 51.68]
Wang TJ 2011	386	75.8	26	329.1	82.3	26	24.8%	56.90 [13.89, 99.91]
Wang TJ 2011	386	75.8	26	381	70.4	26	29.0%	5.00 [-34.76, 44.76]
Total (95% CI)			108			105	100.0%	15.58 [-5.82, 36.98]

Heterogeneity: Chi² = 4.76, df = 3 (P = 0.19); I² = 37%
Test for overall effect: Z = 1.43 (P = 0.15)

Comparison 2. Walking speed: aquatic physical therapy versus no aquatic physical therapy

	Aquatic exercise			No aquatic exercise				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Silva 2008	1.42	1.25	32	0.73	0.84	32	40.9%	0.69 [0.17, 1.21]
Waller B 2017	1.83	0.16	43	1.76	0.17	44	59.1%	0.07 [0.00, 0.14]
Total (95% CI)			75			76	100.0%	0.32 [-0.27, 0.92]

Heterogeneity: Tau² = 0.16; Chi² = 5.33, df = 1 (P = 0.02); I² = 81%
Test for overall effect: Z = 1.06 (P = 0.29)

Comparison 3. Step test: aquatic physical therapy versus no aquatic physical therapy

	Aquatic exercise			No aquatic exercise				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Hale L A 2012	12	3.22	20	11.4	2.9	15	39.6%	0.60 [-1.44, 2.64]
Hinman RS 2007	13	3	36	14	4	35	60.4%	-1.00 [-2.65, 0.65]
Total (95% CI)			56			50	100.0%	-0.37 [-1.65, 0.91]

Heterogeneity: Chi² = 1.43, df = 1 (P = 0.23); I² = 30%
Test for overall effect: Z = 0.56 (P = 0.57)

Comparison 4. TUGT: aquatic physical therapy versus no aquatic physical therapy

	Aquatic exercise			No aquatic exercise				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Hale L A 2012	10.1	2.94	20	10.7	6.88	15	0.9%	-0.60 [-4.31, 3.11]
Hinman RS 2007	10.32	1.94	36	10.3	2.78	35	10.3%	0.02 [-1.10, 1.14]
Taglietti M 2017	11.4	0.7	31	12.4	0.8	29	88.7%	-1.00 [-1.38, -0.62]
Total (95% CI)			87			79	100.0%	-0.89 [-1.25, -0.53]

Heterogeneity: Chi² = 2.89, df = 2 (P = 0.24); I² = 31%
Test for overall effect: Z = 4.86 (P < 0.00001)

Fig. 10 Forest plot of aquatic physical therapy versus no aquatic physical therapy interventions in walking ability

Comparison 1. Body mass index and fat mass: aquatic physical therapy versus no aquatic physical therapy

Study or Subgroup	Aquatic exercise Mean	SD	Total	No aquatic exercise Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
8.1.1 BMI								
Lim J Y 2010	27.13	1.82	24	27	1.59	22	40.6%	0.13 [-0.86, 1.12]
Lim J Y 2010	27.13	1.82	24	27.71	2.16	20	27.7%	-0.58 [-1.77, 0.61]
Waller B 2017	26.2	3.9	43	27.1	3.6	44	15.8%	-0.90 [-2.48, 0.68]
Subtotal (95% CI)			**91**			**86**	**84.1%**	**-0.30 [-0.98, 0.39]**
Heterogeneity: Chi² = 1.50, df = 2 (P = 0.47); I² = 0%								
Test for overall effect: Z = 0.85 (P = 0.39)								
8.1.2 Fat Mass								
Lim J Y 2010	21.8	4.4	24	21.22	3.6	22	7.4%	0.58 [-1.74, 2.90]
Lim J Y 2010	21.8	4.4	24	23.5	4.7	20	5.4%	-1.70 [-4.41, 1.01]
Waller B 2017	24.8	8.8	43	26.4	8.1	44	3.1%	-1.60 [-5.16, 1.96]
Subtotal (95% CI)			**91**			**86**	**15.9%**	**-0.62 [-2.20, 0.96]**
Heterogeneity: Chi² = 1.93, df = 2 (P = 0.38); I² = 0%								
Test for overall effect: Z = 0.77 (P = 0.44)								
Total (95% CI)			**182**			**172**	**100.0%**	**-0.35 [-0.98, 0.28]**
Heterogeneity: Chi² = 3.57, df = 5 (P = 0.61); I² = 0%								
Test for overall effect: Z = 1.09 (P = 0.28)								
Test for subgroup differences: Chi² = 0.14, df = 1 (P = 0.71), I² = 0%								

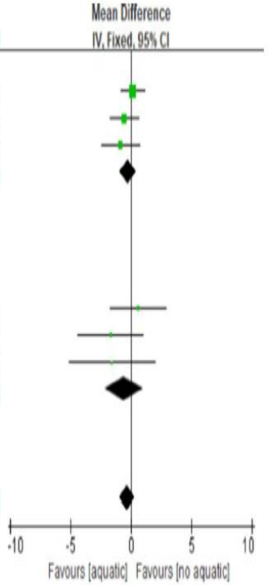


Fig. 11 Forest plot of aquatic physical therapy versus no aquatic physical therapy interventions in body composition

REVIEW

Effects of Aquatic Therapy and Land-Based Therapy versus Land-Based Therapy Alone on Range of Motion, Edema, and Function after Hip or Knee Replacement: A Systematic Review and Meta-analysis

Alison J. Gibson, BPhys;[*] Nora Shields, PhD, BSc (Hons), Grad Dip Stats, Grad Cert Higher Education[†]

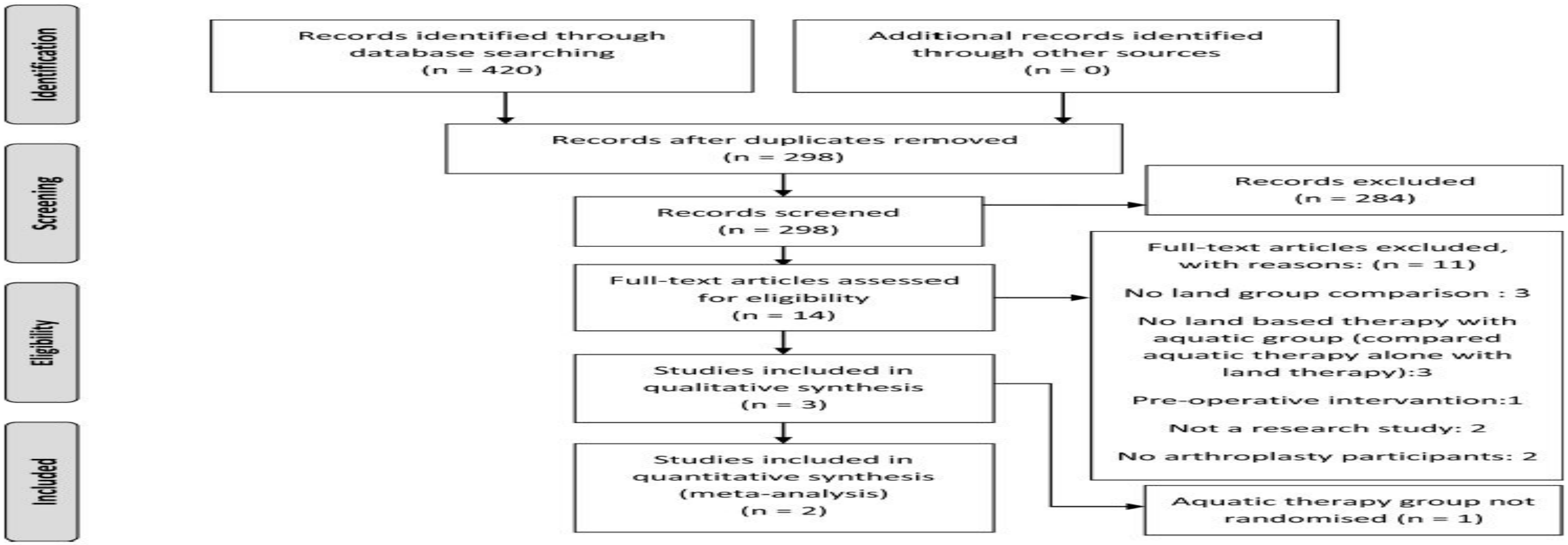


Figure 1 Study selection process to identify eligible articles for inclusion in the review.

Table 1 Summary of Studies

Author (Date)	PEDro score	Design	Setting	Arthroplasty type	Aquatic:land No. of respondents	Aquatic:land Sex, % male	Aquatic:land Mean age, y
McAvoy (2009)[13]	6	RCT	Outpatient	TKA	30 (15:15)	–	–
Stockton & Mengersen (2009)[14]	4	Controlled trial	Acute inpatient	THA	48 (21:27)	48.0:48.0	65.5:62.8
Rahmann, Brauer, & Nitz (2009)[15]	6	RCT	Acute inpatient	THA:TKA (15:20)	35 (18:17)	56.0: 29.4	69.4:70.4

RCT = randomized controlled trial; TKA = total knee arthroplasty; THA = total hip arthroplasty.

Inclusion Criteria

- Participants had undergone any type of hip or knee arthroplasty
- > 18 years
- Study compared AE and LE (comparison group completed LE alone)
- RCT
- English only

Table 2 Summary of Intervention Characteristics

	Aquatic therapy			Land-based therapy			Outcome	
Author	Frequency	Duration	Delivery	Frequency	Duration	Delivery	Impairment	Activity
McAvoy (2009)[13]	30 min, 2 × /wk	6 wk	Group	60 min, 2 × /wk	6 wk	Group	Edema Knee AROM & PROM Pain	KOOS
Stockton & Mengersen (2009)[14]	Daily Mean LOS = 7.9 (SD 1.6) d	Postoperative day 4–discharge Mean LOS = 8.1 (SD 2.6) d	1:1	Daily	Postoperative day 1–discharge	1:1	–	Iowa Level of Assistance
Rahmann, Brauer, & Nitz (2009)[15]	Daily Mean LOS = 7.4 (SD 1.6) d	Postoperative day 4–discharge Mean LOS = 8.3 (SD 1.9) d	1:1	Daily	Postoperative day 1–discharge	1:1	Edema Knee AROM Strength: quads, hams, hip abductors	WOMAC 10MW TUG PSFS

AROM = active range of motion; PROM = passive range of motion; KOOS = Knee Injury and Osteoarthritis Outcome Score; LOS = length of stay; WOMAC = Western Ontario and McMaster Universities Arthritis Index; 10MW = 10-metre walk test; TUG = timed up-and-go test; PSFS = Patient Specific Functional Scale.

	Aquatic adjunct			Land				Std. Mean Difference	Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
McAvoy 2009	75.3	16.7	15	68.3	13.6	15	47.4%	0.45 [-0.28, 1.17]	
Rahmann 2009	-37	13.3	17	-46.3	16.5	17	52.6%	0.61 [-0.08, 1.30]	
Total (95% CI)			**32**			**32**	**100.0%**	**0.53 [0.03, 1.03]**	

Heterogeneity: Tau² = 0.00; Chi² = 0.10, df = 1 (P = 0.76); I² = 0%

Test for overall effect: Z = 2.08 (P = 0.04)

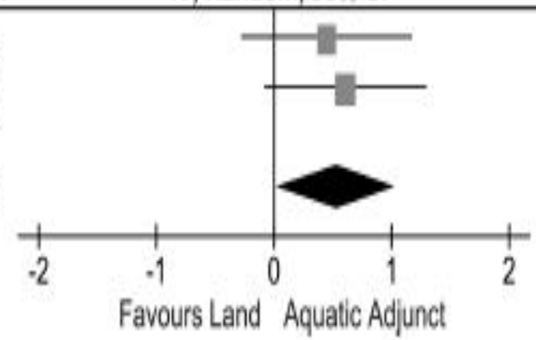


Figure 2 Knee range of motion

Standardised mean difference (95% CI) for the effect of aquatic physical therapy on range of motion for hip and knee arthroplasty by pooling data from two trials ($n = 64$).

IV = inverse variance; Std = standardised.

Table 3 Quality Assessment of Meta-Analyses for Aquatic Therapy as an Adjunct versus Land-Based Therapy Alone

Intervention	No. of trials	No. of participants	Outcome	SMD (95% CI), I^2	Quality of evidence (GRADE)
Activities of daily living	2[13,15]	64	KOOS Iowa Level of Assistance WOMAC	0.53 (0.03–1.03), 0%	Moderate*
ROM	2[13,15]	64	ROM in degrees	0.78 (0.27–1.29), 0%	Moderate*
Edema	2[13,15]	64	Lower limb circumference measurement	0.66 (0.15–1.16), 0%	Moderate*

*Reason for downgrade: large CI (>0.8).

SMD = standardized mean difference; GRADE = Grading of Recommendations Assessment, Development and Evaluation working group grades of evidence (see footnote); KOOS = Knee Injury and Osteoarthritis Outcome Score; WOMAC = Western Ontario and McMaster Universities Arthritis Index; ROM = range of motion.

Other thoughts on using water hip and knee dysfunction?

What are your “go to” strategies?

Any new ideas after seeing the research?

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

Aquatic Therapy for Edema Management

David M. Morris, PT, PhD. FAPTA

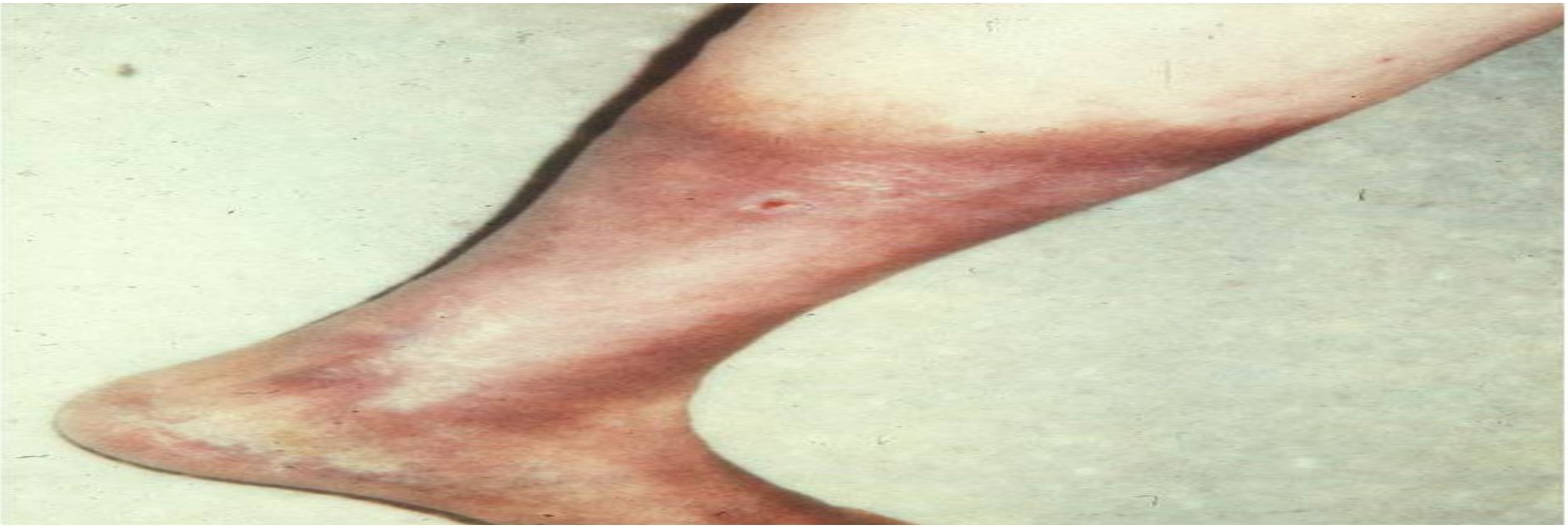
Chronic Venous Disease

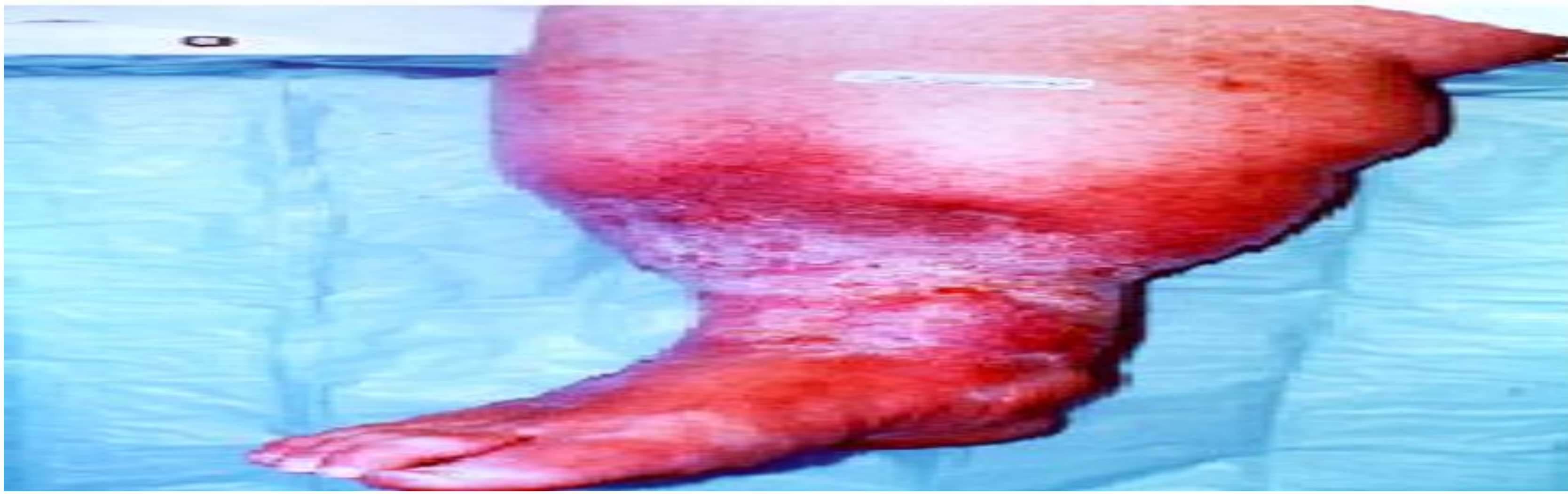
- Common medical problem that can result in significant morbidity and mortality. The clinical presentation spans a spectrum from:

✔ Asymptomatic but cosmetically troublesome small ectatic veins (spider veins and reticular veins)

✔ Varicosities and edema

✔ Severe skin changes including fibrosing panniculitis, dermatitis, and ulceration.



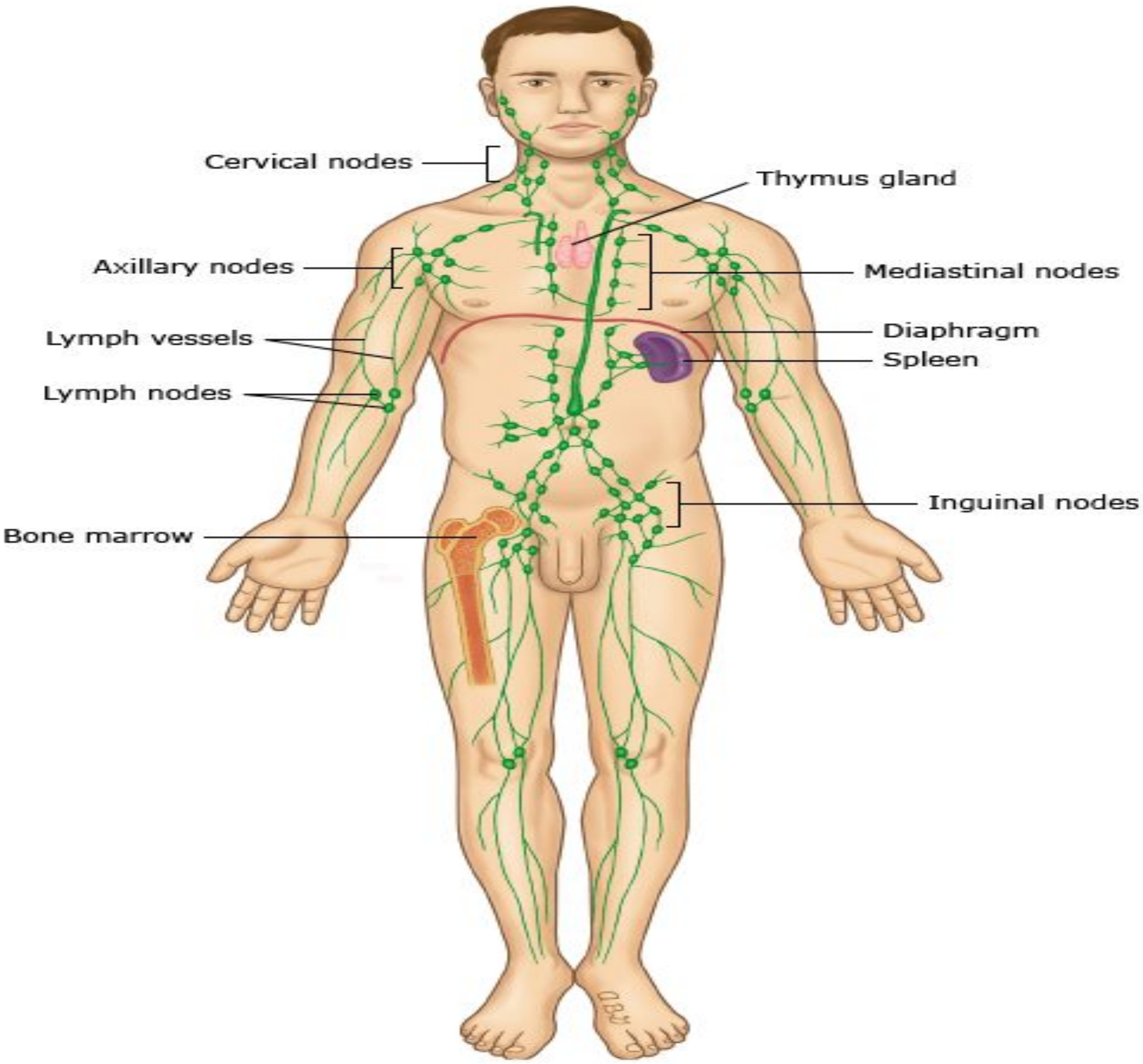


Advanced Lipodermatosclerosis

Skin changes of Chronic Venous Insufficiency

Clinical classification	
C_1	Telangiectasias, reticular veins
C_2	Varicose veins
C_{2r}	Recurrent varicose veins
C_3	Edema
C_4	Changes in skin and subcutaneous tissue secondary to chronic venous disease
C_{4a}	Pigmentation or eczema
C_{4b}	Lipodermatosclerosis or atrophie blanche
C_{4c}	Corona phlebectatica
C_5	Healed
C_6	Active venous ulcer
C_{6r}	Recurrent active venous ulcer
S	With symptoms attributable to venous disease
A	Absence of symptoms attributable to venous disease
Etiology classification	
E_p	Primary
E_s	Secondary
E_{si}	Secondary (intravenous)
E_{se}	Secondary (extravenous)
E_c	Congenital
E_n	No cause identified
Anatomy classification*	
A_s	Superficial veins (Tel, Ret, GSV_a, GSV_b, SSV, AASV, NSV)
A_d	Deep veins (IVC, CIV, IIV, EIV, PELV, CFV, DFV, FV, POPV, TIBV, PRV, ATV, PTV, MUSV, GAV, SOV)
A_p	Perforator veins (TPV, CPV)
A_n	No venous anatomic location identified

CEAP Classification

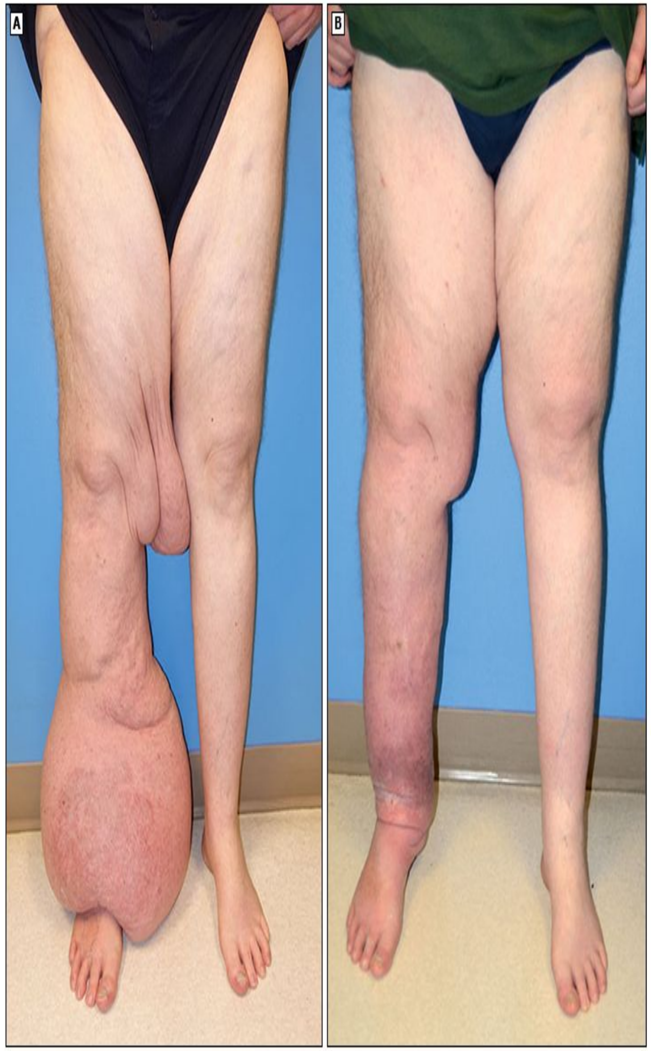


Lymphedema

- Abnormal accumulation of interstitial fluid and fibroadipose tissues resulting from reduced lymph transport because of injury, infection, cancer/cancer-related treatment, or congenital abnormalities of the lymphatic system
- Can be primary or secondary – depending on etiology and presentations

Risk Factors

- Hereditary syndromes
- Genetic mutations
- Malignancy and its treatment
- Obesity
- Infection
- Trauma



(A) Patient with severe fibrotic primary lower extremity lymphedema with 14.2 liter volume excess.

(B) Outcome following first-stage direct excision using a modification of Homan's technique with indocyanine green fluorescent lymphography to preserve functional lymphatics.

Measurement – Limb Circumference

For the upper extremity:

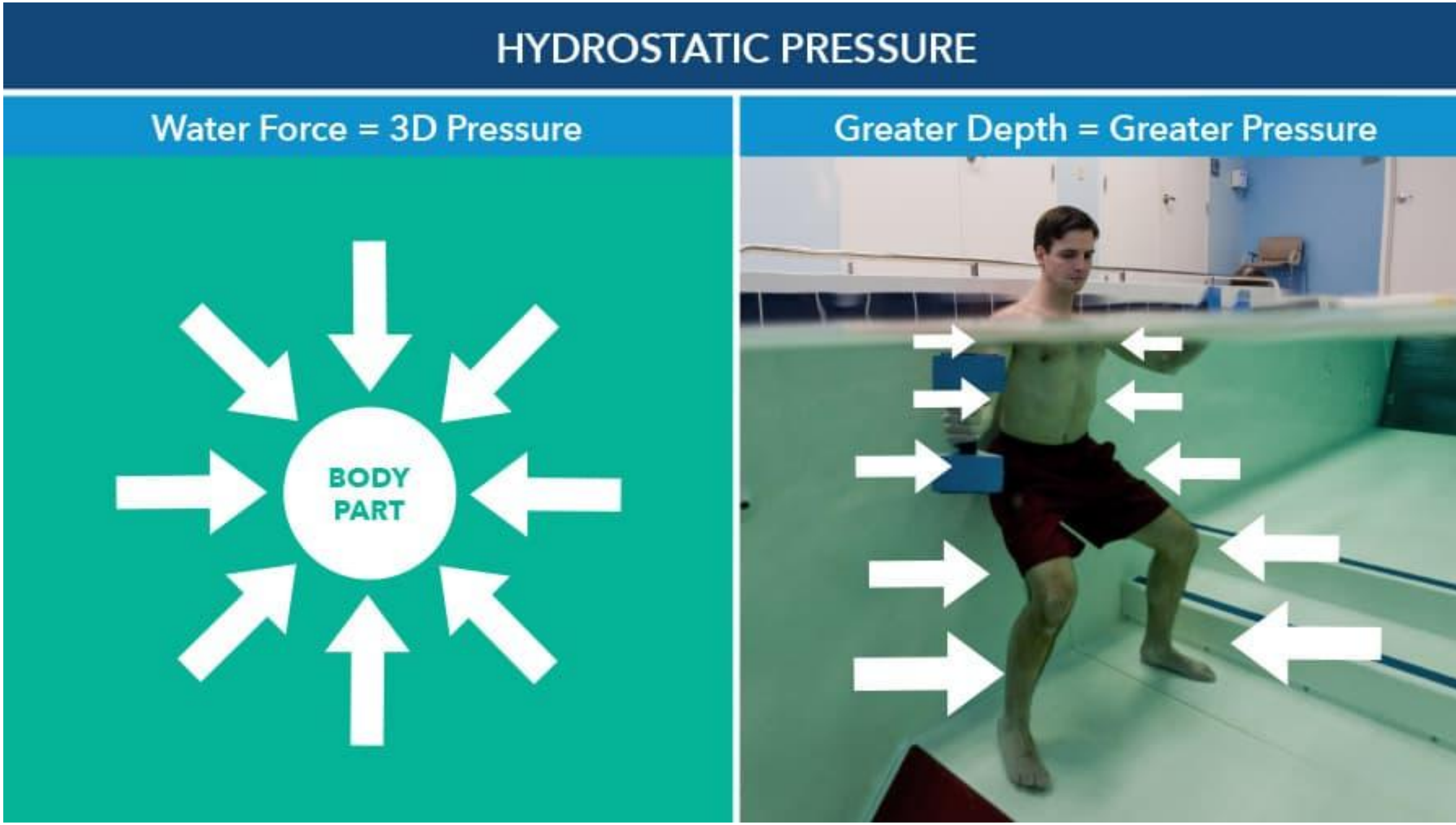
- ✔ At the metacarpal-phalangeal joints (if edematous)
- ✔ Around the wrist
- ✔ 10 cm below the olecranon process
- ✔ 10 cm above the olecranon process

In the lower extremity:

- ✔ At the metatarsal-phalangeal joints (if edematous)
- ✔ 2 cm superior to the medial malleolus
- ✔ 10 cm above the superior pole of the patella
- ✔ 10 cm below the inferior pole of the patella

Measurement - Other

- Limb Volume
- Bioimpedence spectroscopy
- Functional status
- Other manifestations


HYDROSTATIC PRESSURE
Water Force = 3D Pressure
Greater Depth = Greater Pressure
BODY
PART

With Immersion

Increase in blood flow:

- ✔75% to thorax
- ✔25% to cardiac chamber
- ✔15% to brain

Randomized controlled trial on Dryland And Thermal Aquatic standardized exercise protocol for chronic venous disease (DATA study)

Erica Menegatti, PhD,[a] Stefano Masiero, MD,[b] Paolo Zamboni, MD,[a] Giampiero Avruscio, MD,[c] Mirko Tessari, PhD,[a] Anselmo Pagani, BS,[a] *and* Sergio Gianesini, MD, PhD,[a,d] *Ferrara, Padua, and Padova, Italy; and Bethesda, Md*

Table I. Demographics and clinical characteristics of the study participants at baseline

	TW group (17 patients)	DL group (17 patients)	*P* value
Age, years	61.4 ± 10.8	60.1 ± 10.1	.7583
Sex (male/female)	5/12	4/13	.9999
BMI	26.8 ± 4.9	26.5 ± 3.3	.8507
Main symptom			
Heaviness	9/17	8/17	.9999
Achiness	3/17	2/17	.9999
Swelling	6/17	7/17	.9999
VCSS	9.5 ± 3.3	9.1 ± 3.2	.3342

BMI, Body mass index; *DL*, dryland; *TW*, thermal water; *VCSS*, Venous Clinical Severity Score.

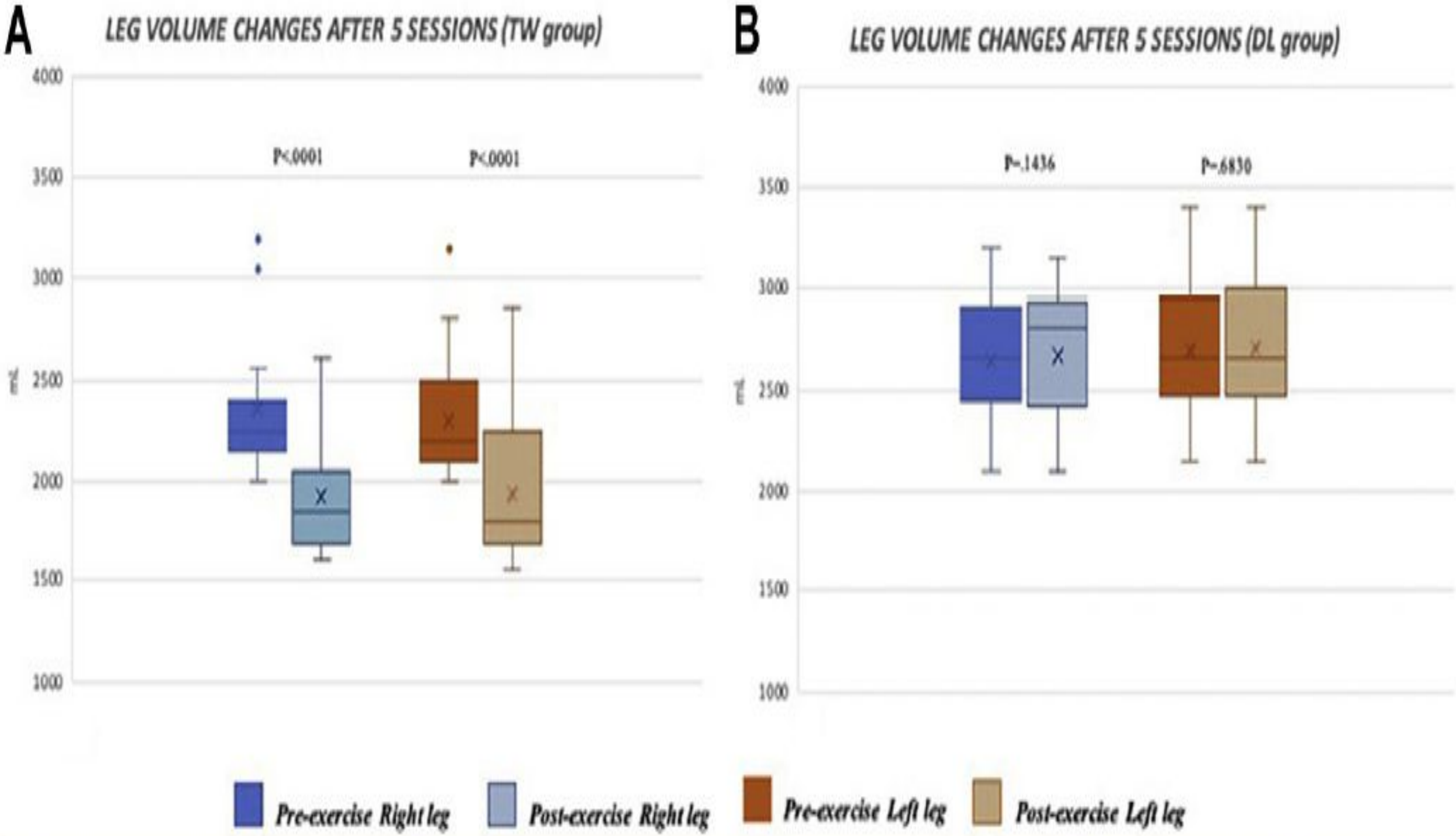


Fig 2. A, Leg volume decreases after five exercise sessions in the thermal water (*TW*) immersion. **B,** Leg volume remains constant after five sessions of dryland (*DL*) exercises.

groups

Session	TW group Baseline, mL	TW group End, mL	TW group *P* intragroup	DL group Baseline, mL	DL group End, mL	DL group *P* intragroup	*P* intergroup
1_R	2355.9 ± 326.9	2088.2 ± 386.3	<.0001	2638.2 ± 324.3	2644 ± 328.3	.4308	<.0001
2_R	2270.5 ± 328.9	2038.2 ± 351.6	<.0001	2661.8 ± 324.3	2667.6 ± 340	.6081	<.0001
3_R	2232.4 ± 312.2	2029.4 ± 358.8	<.0001	2650 ± 306.8	2658 ± 305.5	.4553	<.0001
4_R	2220.6 ± 334.5	2014.7 ± 359.6	<.0001	2661.8 ± 297.7	2673.5 ± 319.2	-2156	<.0001
5_R	2173.5 ± 306.8	1923.5 ± 293.2	<.0001	2670.6 ± 328.4	2664.2 ± 337.6	.5794	<.0001
1_L	2291.2 ± 312.4	2070.6 ± 396.9	<.0001	2694.1 ± 334.1	2700.0 ± 353.1	.4962	<.0001
2_L	2217.6 ± 303.6	2026.5 ± 334.1	<.0001	2723.5 ± 351.8	2735 ± 351.2	.3321	<.0001
3_L	2241.2 ± 360.2	2017.6 ± 384.0	<.0001	2714.7 ± 342.7	2723.5 ± 346.5	.4553	<.0001
4_L	2211.8 ± 354.7	2008.8 ± 393.0	<.0001	2711.8 ± 350.2	2717.6 ± 355.7	.5794	<.0001
5_L	2170.6 ± 324.5	1932.4 ± 363.1	<.0001	2688.2 ± 365.9	2700.0 ± 63.1	.2156	<.0001

DL, Dryland; *L*, Left leg; R, right leg; *TW*, thermal water.

Exercise Protocol

- Warm-up cycling
- Tip-toe exercises (4 x 10 reps)
- Hip flex-ext (4 x 10 reps)
- Tip-toe on step (4 x 10 reps
- Forward/backward walking (5 min)
- Cycling-like single push in standing(5 min)
- Ankle flex-ext with knee bent to 90(4 x 10 reps)
- Cool-down cycling

Table III. Subcutaneous thickness measurements changes from baseline to the end of the exercise protocol and comparison between the study groups

	TW group			DL group			
Point	Baseline, mm	End, mm	*P* intragroup	Baseline, mm	End, mm	*P* intragroup	*P* intergroup
A_R	16.1 ± 4.5	12.0 ± 4.8	<.0001	17.0 ± 4.3	16.9 ± 4.3	.1410	<.0001
B_R	11.9 ± 4.9	8.9 ± 3.5	<.0001	13.7 ± 4.3	13.5 ± 4.3	.0879	<.0001
C_R	9.5 ± 4.2	7.0 ± 2.3	<.0001	10.9 ± 4.0	11.0 ± 3.8	.6775	<.0002
A_L	15.4 ± 4.2	11.4 ± 4.1	<.0001	16.5 ± 3.4	16.4 ± 3.4	.4921	<.0001
B_L	11.4 ± 4.5	8.3 ± 3.4	<.0001	13.2 ± 4.0	13.3 ± 3.9	.2156	<.0001
C_L	9.6 ± 4.5	7.1 ± 3.1	<.0001	10.8 ± 4.2	10.9 ± 4.1	.1642	<.0001

DL, Dryland; *L*, Left leg; R, right leg; *TW*, thermal water.
Point A is 10 cm below the inguinal skin crease, point B is 10 cm above the superior margin of the knee, and point C is 5 cm below the inferior margin of the knee.

The randomized, controlled ATLANTIS trial of aquatic therapy for chronic venous insufficiency

Mohsen Sharifi, MD,[a,b] R. Curtis Bay, PhD,[c] Kaveh Karandish, MD,[a] Farnaz Emrani, RN,[a] Robert Snyder, AAS,[a] *and* Siddharth D'Silva, BS,[a] for the ATLANTIS Trial, *Mesa, Ariz*

Sharafi et al., 2020

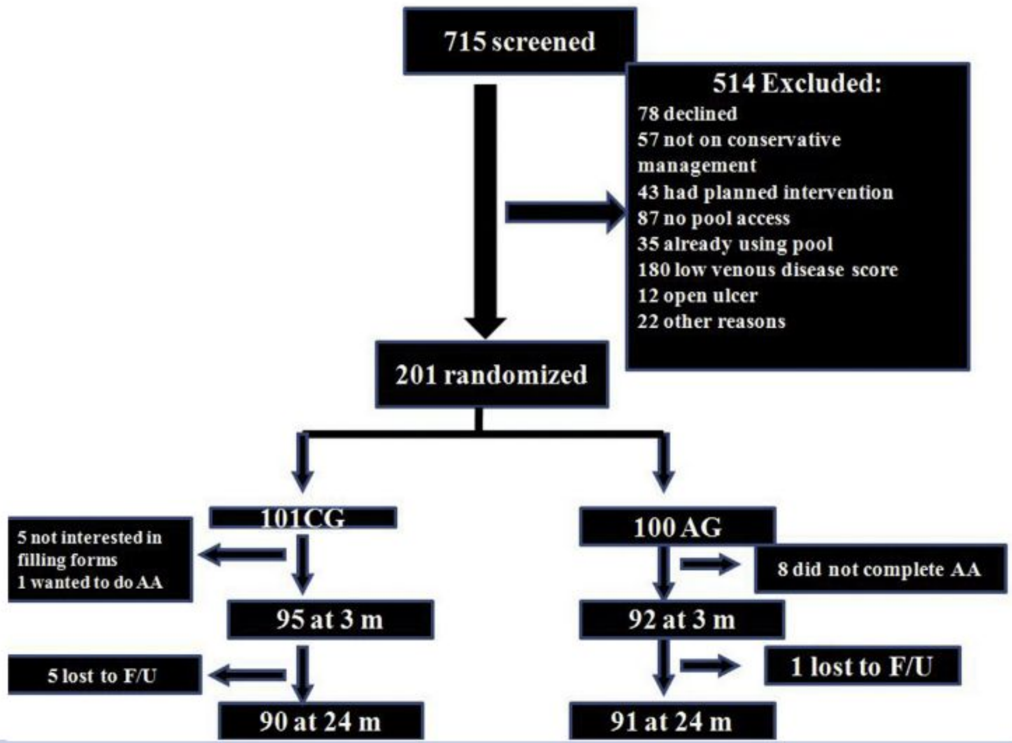


Fig 1. Flowchart of patients according to recommendations of the Consolidated Standards of Reporting Trials. *AA*, Aquatic activity; *AG*, Aquatic Group; *CG*, Control Group; *F/U*, follow-up.

Table II. Secondary efficacy end points with interval differences

	Baseline		3 months		2 years
	AG	CG	AG	CG	AG
Thigh, mean ± SD, cm	65.07 ± 5.03	63.58 ± 5.20	62.10 ± 4.43	63.34 ± 4.73	61.67 ± 4.09
Between-group comparison	NA*		$P = .069$		$P = .393$
Within-group comparison	NA		NA		NA
Leg, mean ± SD, cm	44.38 ± 1.58	44.06 ± 1.70	43.33 ± 1.35	44.04 ± 1.43	43.11 ± 1.35
Between-group comparison	NA*		$P = .001$		$P = .013$
Within-group comparison	NA		NA		NA
VCSS, mean ± SD	10.29 ± 2.73	9.18 ± 1.64	6.93 ± 1.80	8.92 ± 1.27	6.21 ± 1.39
Between-group comparison	NA*		$P < .001$		$P < .001$
Within-group comparison	NA		NA		NA
Vialtta, mean ± SD	9.05 ± 3.20	8.42 ± 1.66	5.56 ± 1.77	8.37 ± 1.31	5.05 ± 1.10
Between-group comparison	NA*		$P < .001$		$P < .001$
Within-group comparison	NA		NA		NA
SF36-PHC, mean ± SD	44.34 ± 2.55	46.12 ± 1.17	47.79 ± 1.45	46.27 ± 1.09	48.16 ± 1.51
Between-group comparison	NA*		$P < .001$		$P < .001$
Within-group comparison	NA		NA		NA
VEINES-QOL, mean ± SD	46.19 ± 2.27	46.62 ± 1.34	49.48 ± 1.41	46.67 ± 1.14	49.54 ± 1.38
Between-group comparison	NA*		$P < .001$		$P < .001$
Within-group comparison	NA		NA		NA
VEINES-Sym, mean ± SD	45.31 ± 2.18	45.60 ± 1.33	48.46 ± 1.29	45.53 ± 1.25	48.84 ± 1.34
Between-group comparison	NA*		$P < .001$		$P < .001$
Within-group comparison	NA		NA		NA
Subjective Index, median (IQR)	NA		2.(2, 2)	1 (0, 1)	1 (0, 1)
Between-group comparison	NA*		$P < .001$		$P = .001$
Within-group comparison	NA		NA		NA

AG, Aquatic Group; *CG*, Control Group; *IQR*, interquartile range; *NA*, not applicable; *NA**, not applicable because differences at baseline in a randomized trial are considered due to chance; *SD*, standard deviation; *SF36-PHC*, Physical Health Component of the 36-Item Short Form Health Survey; *VCSS*, modified Venous Clinical Severity Score; *VEINES-QOL*, Venous Insufficiency Epidemiological and Economic Study Quality of Life score; *VEINES-Sym*, Venous Insufficiency Epidemiological and Economic Study Symptom score.

Table III. Secondary efficacy end points between patients receiving 24 months vs 3 months of aquatic therapy

	3 months		2 years		Difference (2 years minus 3 months)	
	AG-24	AG-3	AG-24	AG-3	AG-24	AG-3
Thigh, mean ± SD, cm	62.54 ± 4.39	60.0 ± 4.15	61.88 ± 4.11	60.69 ± 4.0	−0.67 ± 1.09	0.69 ± 1.01
Between-group comparison	$P = .036$		$P = .292$		$P < .001$	
Within-group comparison	NA		NA		$P < .001$	$P = .016$
Leg, mean ± SD, cm	43.39 ± 1.43	43.06 ± 0.85	43.05 ± 1.44	43.38 ± 0.72	−0.33 ± 0.83	0.31 ± 0.79
Between-group comparison	$P = .386$		$P = .388$		$P = .005$	
Within-group comparison	NA		NA		$P = .001$	$P = .136$
VCSS, mean ± SD	7.01 ± 1.84	6.56 ± 1.59	6.23 ± 1.39	6.13 ± 1.46	−0.79 ± 1.20	−0.44 ± 0.81
Between-group comparison	$P = .366$		$P = .793$		$P = .271$	
Within-group comparison	NA		NA		$P < .001$	$P = .048$
Viallta, mean ± SD	5.64 ± 1.87	5.19 ± 1.22	5.13 ± 1.08	4.69 ± 1.14	−0.51 ± 1.40	−0.50 ± 0.97
Between-group comparison	$P = .356$		$P = .142$		$P = .986$	
Within-group comparison	NA		NA		$P = .002$	$P = .056$
SF36-PHC, mean ± SD	47.71 ± 1.47	48.19 ± 1.33	48.15 ± 1.57	48.25 ± 1.24	0.44 ± 1.19	0.06 ± 0.77
Between-group comparison	$P = .230$		$P = .806$		$P = .228$	
Within-group comparison	NA		NA		$P = .002$	$P = .751$
VEINES-QOL, mean ± SD	49.51 ± 1.50	49.38 ± 0.89	49.57 ± 1.45	49.38 ± 0.96	0.07 ± 1.08	0.00 ± 0.97
Between-group comparison	$P = .642$		$P = .604$		$P = .820$	
Within-group comparison	NA		NA		$P = .595$	$P = 1.0$
VEINES-Sym, mean ± SD	48.44 ± 1.36	48.56 ± 0.96	48.89 ± 1.42	48.56 ± 0.89	0.45 ± 0.93	0.00 ± 0.82
Between-group comparison	$P = .733$		$P = .374$		$P = .076$	
Within-group comparison	NA		NA		$P < .001$	$P = 1.0$
Subjective Index, median (IQR)	2.(2, 2)	2 (2, 2)	1 (0, 1)	0 (−1, 0)	−1 (−2, −1)	−2 (−3, −2)
Between-group comparison	$P = .726$		$P < .001$		$P < .001$	
Within-group comparison	NA		NA		$P < .001$	$P < .001$

AG-24, Aquatic Group patients completing 24 months of aquatic therapy n = 75; *AG-3*, Aquatic Group patients completing 3 months of aquatic therapy n = 16; *IQR*, interquartile range; *NA*, not applicable; *SD*, standard deviation; *SF36-PHC*, Physical Health Component of the 36-Item Short Form Health Survey; *VCSS*, modified Venous Clinical Severity Score; *VEINES-QOL*, Venous Insufficiency Epidemiological and Economic Study Quality of Life score; *VEINES-Sym*, Venous Insufficiency Epidemiological and Economic Study Symptom score.

LYMPHATIC RESEARCH AND BIOLOGY
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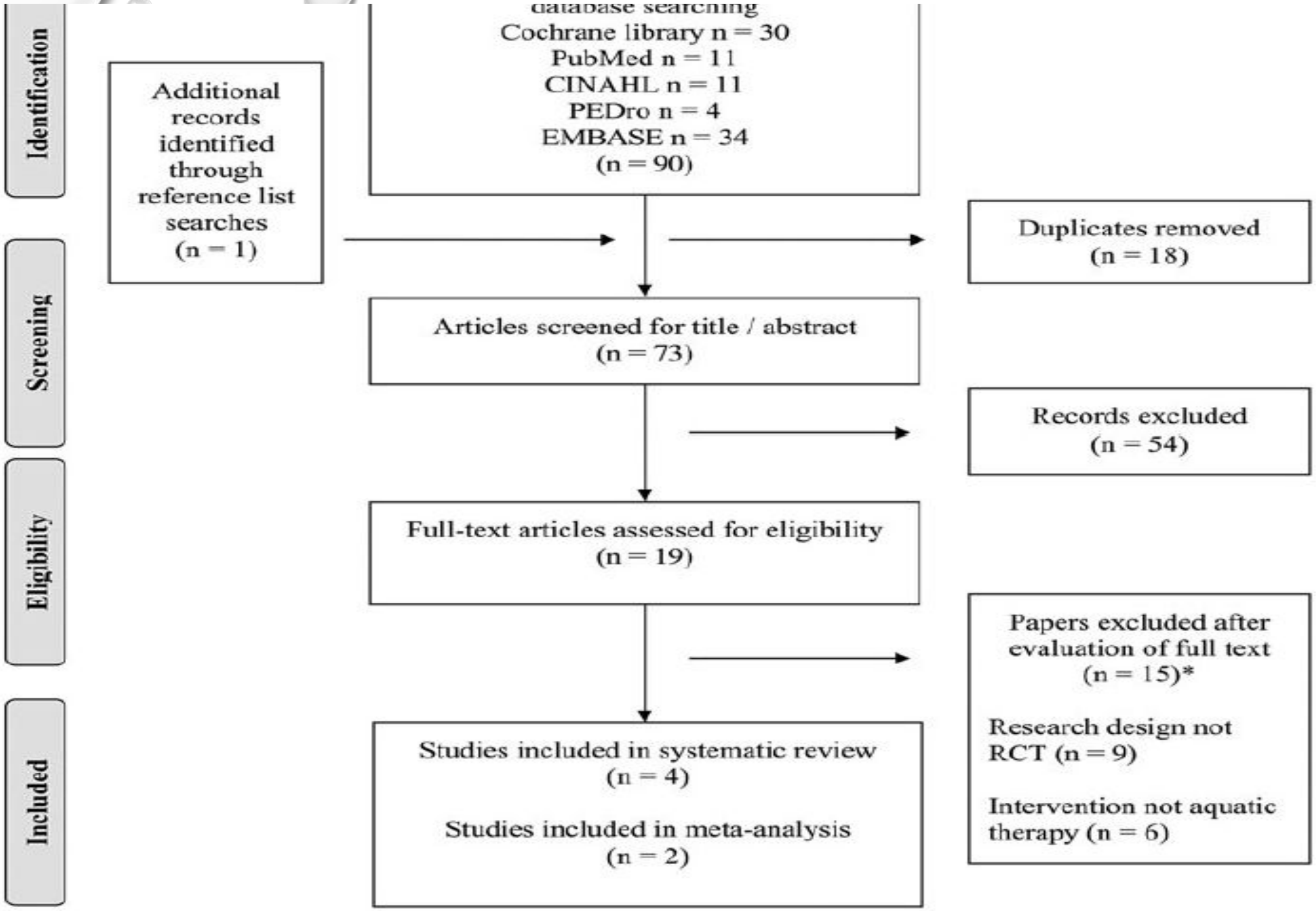
Aquatic Therapy for People with Lymphedema: A Systematic Review and Meta-analysis

Wai Yeung, MPhty[1] and Adam I Semciw, PhD, BAPPLSci(Physio, Hons)[1–3]



*Studies may have been excluded for failing to meet more than one inclusion criterion.

FIG. 1. Flow of studies through the review.

	Aqua Lymphatic Therapy			Standard care				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Letellier (2014)	20.4	12.8	10	22.5	22.9	8	29.7%	-0.11 [-1.04, 0.82]
Tidhar (2010)	34	13.8	16	39.2	15.5	32	70.3%	-0.34 [-0.95, 0.26]
Total (95% CI)			**26**			**40**	**100.0%**	**-0.27 [-0.78, 0.23]**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.17$, df = 1 (P = 0.68); $I^2 = 0\%$

Test for overall effect: Z = 1.06 (P = 0.29)

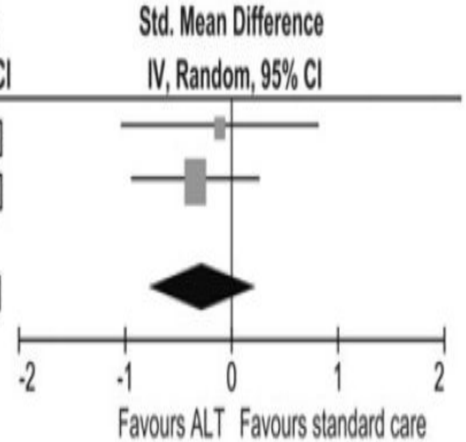


FIG. 3. SMD (95% CI) of effect of aquatic therapy after 3 months of training on UL physical function by pooling data from two studies and presented as an SMD (95% CI). UL, upper limb.

Study or Subgroup	Aqua Lymphatic Therapy Mean	SD	Total	Standard care Mean	SD	Total	Weight	Std. Mean Difference IV, Fixed, 95% CI
2.1.1 ALT vs standard care (short term)								
Letellier (2014)	18.9	11.3	10	16.7	10.1	8	29.3%	0.19 [-0.74, 1.13]
Tidhar (2010)	14	23.9	16	11.8	15.3	32	70.7%	0.12 [-0.48, 0.72]
Subtotal (95% CI)			**26**			**40**	**100.0%**	**0.14 [-0.37, 0.64]**
Heterogeneity: Chi² = 0.02, df = 1 (P = 0.89); I² = 0%								
Test for overall effect: Z = 0.54 (P = 0.59)								

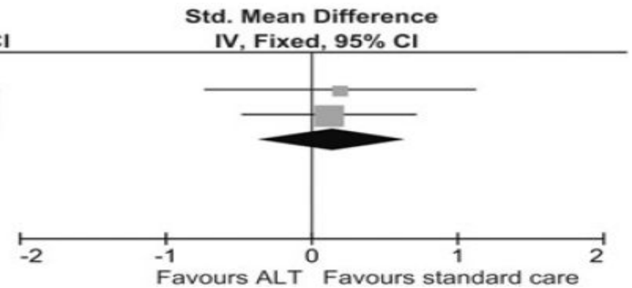


FIG. 2. SMD (95% CI) of effect of aquatic therapy after 3 months of training on lymphedema relative limb volume, pooling data from two studies and presented as an SMD (95% CI). CI, confidence interval; SMD, standardized mean difference.

Other thoughts on edema reduction using water?

What are your “go to” strategies?

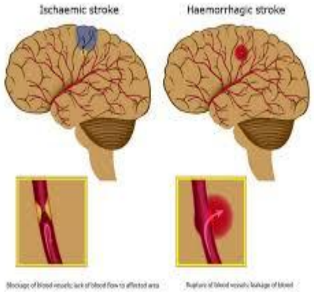
Any new ideas after seeing the research?

THE UNIVERSITY OF
ALABAMA AT BIRMINGHAM

Aquatic Therapy for Stroke

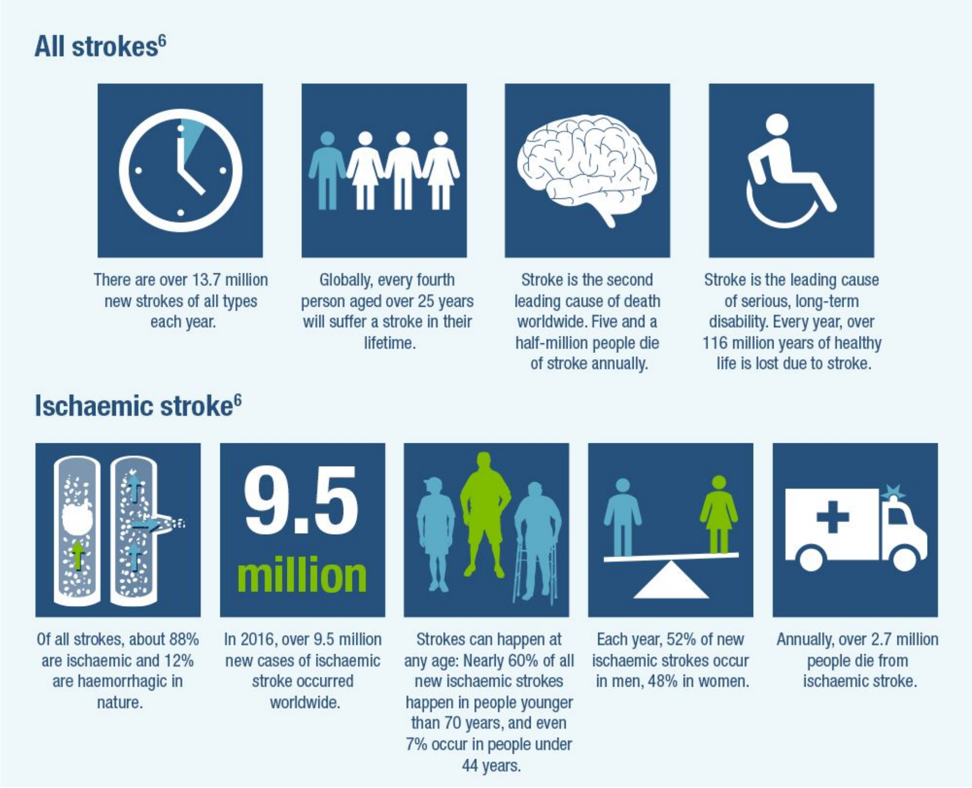
David M. Morris, PT, PhD. FAPTA

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

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

RIGHT CVA

- Right hemiparesis
- Speech-language deficits
- Slow, cautious behavior
- Impaired comprehension
- Aware of deficits, depression, anxiety
- Memory deficits

LEFT CVA

- Left hemiparesis
- Spatial-perceptual deficits
- Quick impulsive behavior
- Impaired judgement
- Tends to minimize problems
- Memory deficits

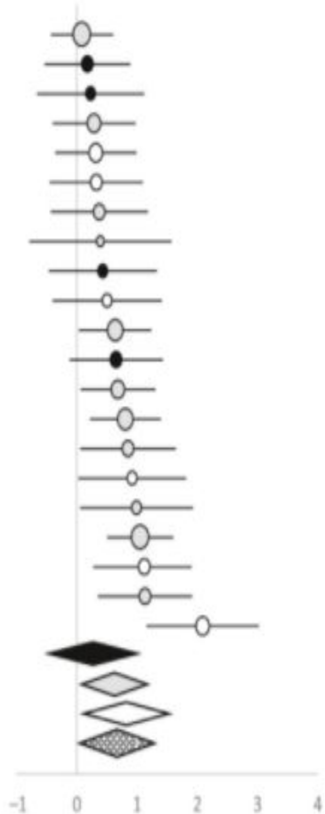
Movement Control Issues

- 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!

(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%



Previous Metanalyses/Reviews (at least 4)

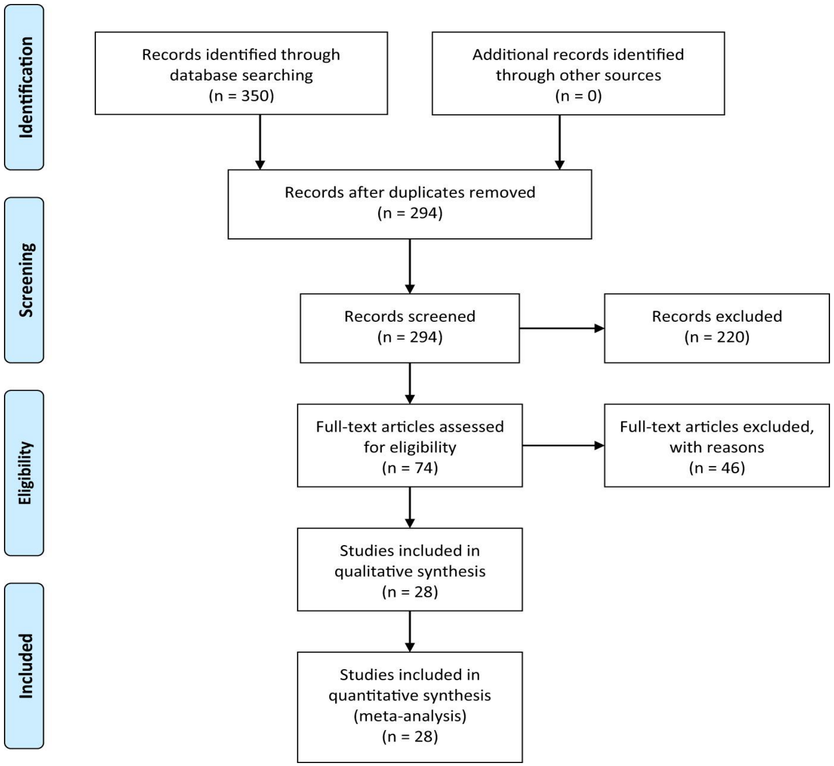
- Results indicated aquatic therapy is superior to land-based therapy in:
  - ✔ Gait
  - ✔ Balance
  - ✔ Independence with ADLs
  - ✔ Mobility
  - ✔ Muscular Strength
  - ✔ Aerobic Capacity
  - ✔ Body Structure and Function

- 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



Acta Neuro Scandinavica, Volume: 143, Issue: 3, Pages: 221-241, First published: 03 November 2020, DOI: (10.1111/ane.13371)

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

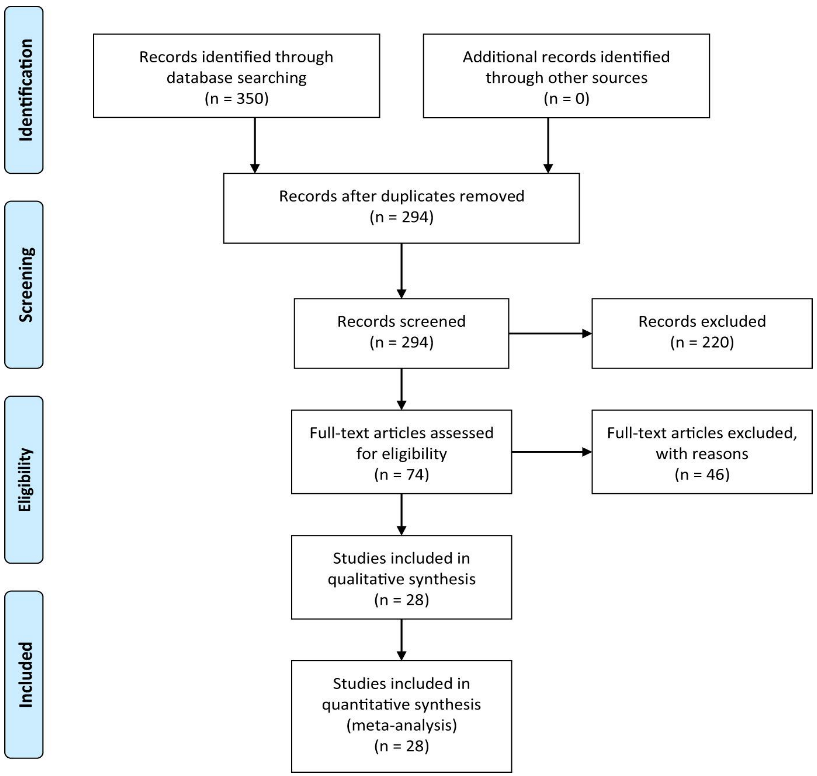
Large = .8

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



Acta Neuro Scandinavica, Volume: 143, Issue: 3, Pages: 221-241, First published: 03 November 2020, DOI: (10.1111/ane.13371)

Comparison to Land-Based Interventions

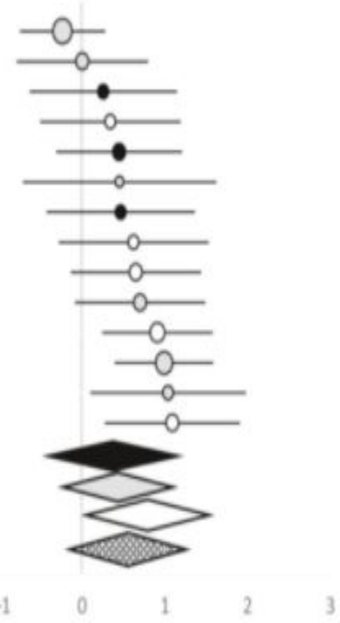
- 21 Trials
- 691 participants
- 24 weeks - > 12 months
- Aquatic Therapy superior to Land-based
- Similar effects on Independence in ADLS
  - Balance
  - Walking
  - Muscular Strength
  - Proprioception
  - HRQL
  - Physiological Indicators
  - Cardiorespiratory fitness
- Water-based therapy concepts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

Overall

(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**

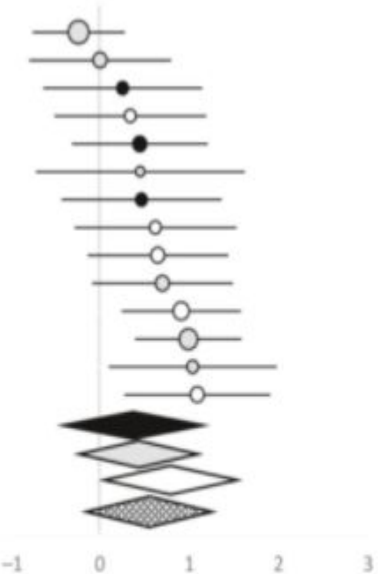
Subgroup heterogeneity: I^2 = 32.1%



Balance

(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%

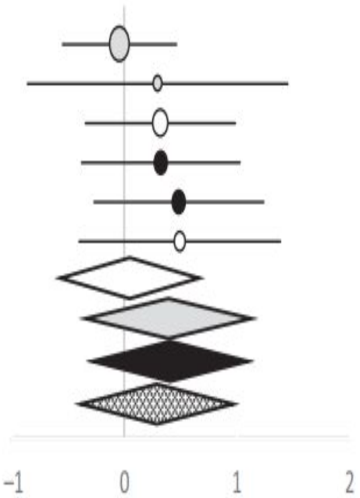


Gait

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**

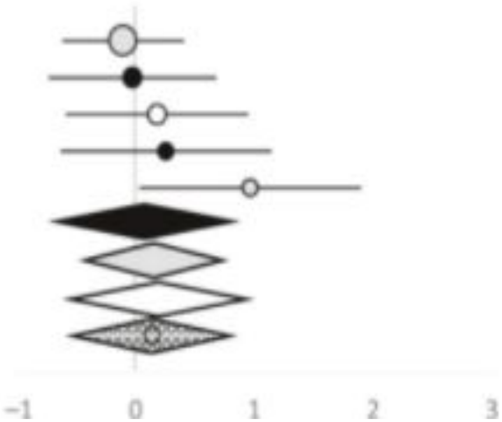
Subgroup heterogeneity: $I^2 = 0.0\%$



Muscular Function/Strength

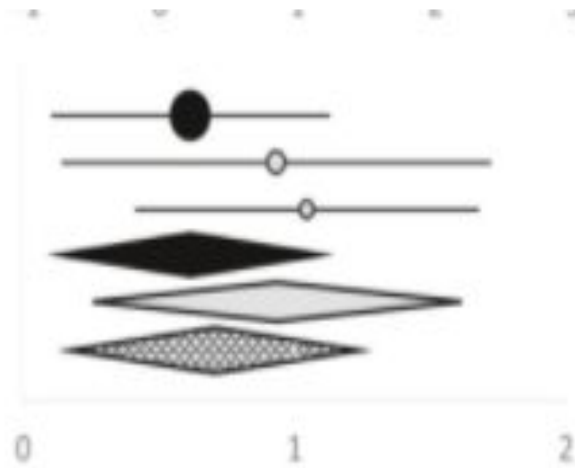
ADL independence (n = 159)					
Eyvaz et al., 2018	walking	−0,10	−0,61	0,40	37,74
Lee et al., 2018	treadmill	−0,02	−0,72	0,68	20,13
Tripp et al., 2014	concept	0,18	−0,58	0,94	16,98
Han et al., 2018	treadmill	0,26	−0,62	1,14	12,58
Kim et al., 2015b	walking	0,97	0,04	1,89	12,58
Subtotal	**treadmill**	**0,09**	**−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%

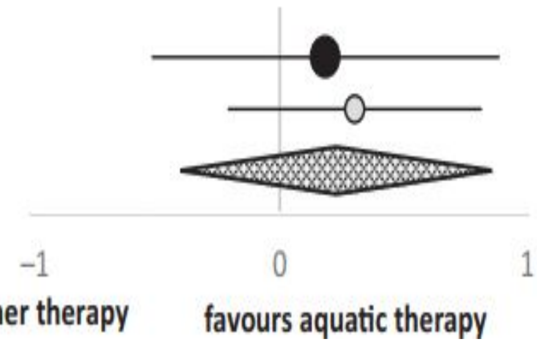


ADL Independence

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%					



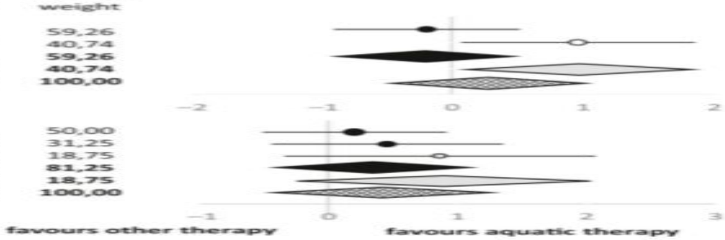
Health related quality of life (n = 92)					
Lee et al., 2018	treadmill	0,19	−0,51	0,89	65,22
Eyvaz et al., 2018	walking	0,30	−0,21	0,81	34,78
Total		**0,23**	**−0,41**	**0,86**	**100,00**
Subgroup heterogeneity: I^2 = 0.0%					



HRQOL

(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%					



Physiological Factors/Cardiorespiratory Fitness

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http://dx.doi.org/10.1080/10749357.2016.1251742

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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

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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

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

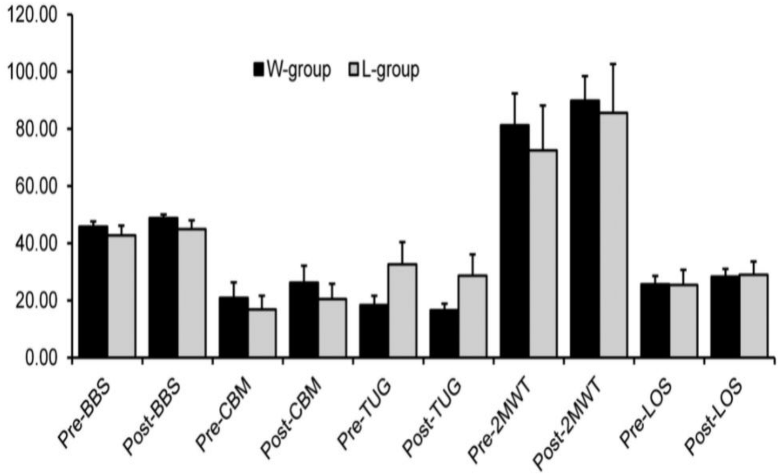
Land Based Activities

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

Water-Based Activities

Figure 2 of 3

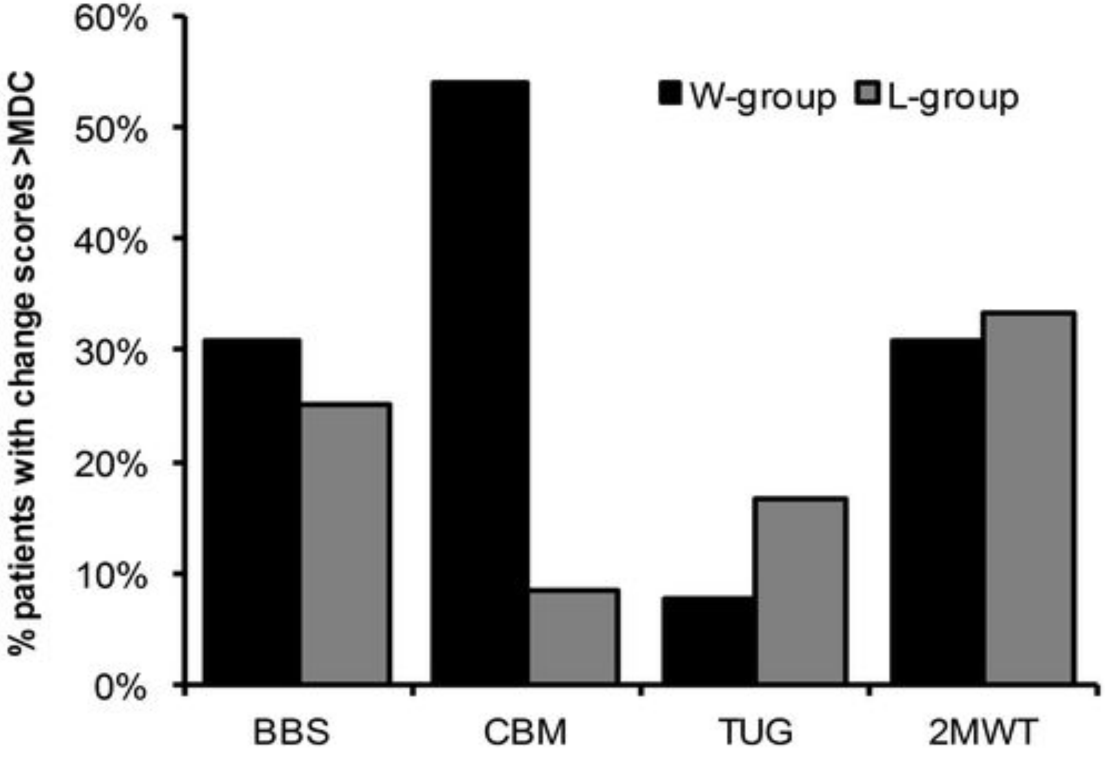
Figure 2. Average change in clinical scores post-both types of training.



Outcome Measures

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

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



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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Disclosures:

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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.

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Results

- Water + Land Group –
  - ✔ significantly better outcomes compared to land only - with more exceeding the published minimal detectable change scores

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

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

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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.

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**

Variable		Conventional Group			Aquatic Group			Pretreatment Comparison Between-Groups	Posttreatment Comparison Between-Groups
		Pretreatment	Posttreatment	P	Pretreatment	Posttreatment	P	P Value	P Value
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]
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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

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

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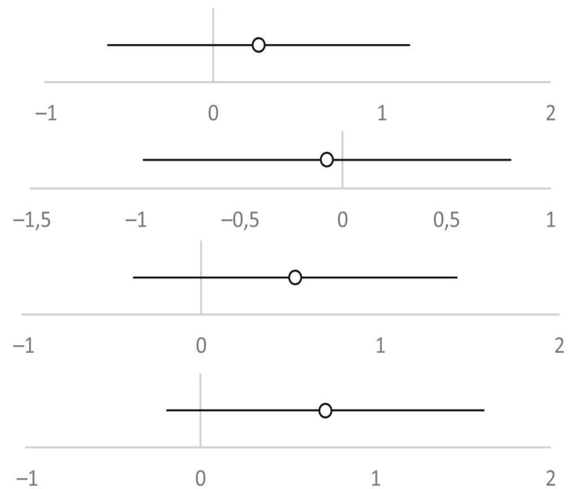
Results

- 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

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

	Effect size	Lower limit	Upper limit	Relative weight
Overall (n = 20)				
Ku et al., 2020	0,27	−0,62	1,16	100,00
Gait (n = 20)				
Ku et al., 2020	−0,07	−0,96	0,81	100,00
Balance (n = 20)				
Ku et al., 2020	0,53	−0,38	1,43	100,00
Motor function/strength of lower limbs (n = 20)				
Ku et al., 2020	0,71	−0,19	1,62	100,00



favours sthength and stretching based aquatic therapy **favours Ai Chi method**

Acta Neuro Scandinavica, Volume: 143, Issue: 3, Pages: 221-241, First published: 03 November 2020, DOI: (10.1111/ane.13371)

Other thoughts on balance recovery using water?

What are your “go to” strategies?

Any new ideas after seeing the research?