Overground Robotic Exoskeleton Training for Patients With Stroke on Walking-Related Outcomes: A Systematic Review and Meta-analysis of Randomized Controlled Trials

Leow X., et al. Archives of Physical Medicine and Rehabilitation. 2023 Online

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Outline

1. 簡介機器人類型
2. Background
3. PICO
4. Critical appraisal
5. CASP 系統性文獻回顧檢核表

機器人的應用四個層面

軍事用途

- 主要用以增進表現提升作戰能力

醫療用途

- 可以分為輔助與復健階段

日常用途

- 提供一般人外在支持，強化日常生活功能與能力

工業用途

- 協助工作者的工作能力，如修車或搬運重物

Robotic system types for lower-limb rehabilitation

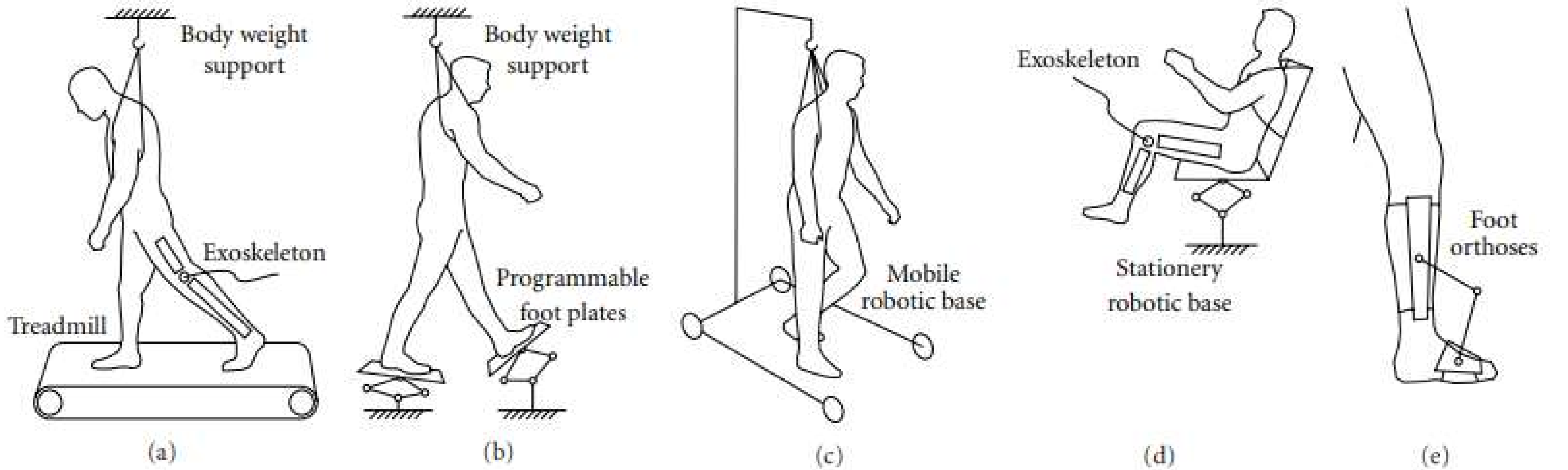


FIGURE 1: Robotic system types for lower-limb rehabilitation: (a) treadmill gait trainers, (b) foot-plate-based gait trainers, (c) overground gait trainers, (d) stationary gait and ankle trainers, and (e) active foot orthoses.

Díaz I. et al. Journal of Robotics, 2011

Treadmill gait trainer

Table 1: Robotic systems for treadmill gait training.

Robotic system	Company	Clinical tests
Lokomat [10]	Hocoma	[11–15]
LokoHelp [16]	LokoHelp Group	[16, 17]
ReoAmbulator [18]	Motorika	—
ARTHuR [19]	—	[21]
POGO and PAM [20]	—	—
ALEX [22]	—	[23]
LOPES [24]	—	[25]
ALTRACO [26]	—	—
RGR [27]	—	—
String-Man [28]	—	—

ALEX

POGO and PAM

Lokomat

LokoHelp

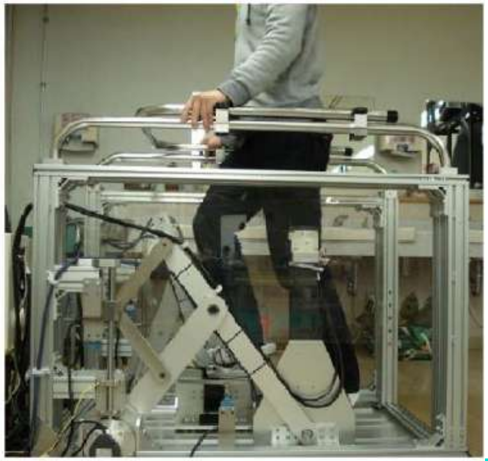
ReoAmbulator

Díaz I. et al. Journal of Robotics, 2011

Foot-Plate-Based Gait Trainers

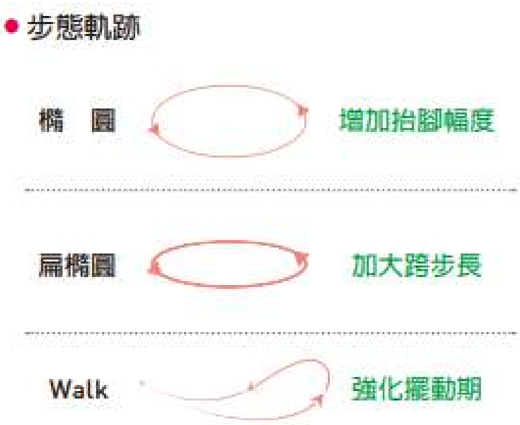
Table 2: Foot-plate-based robotic systems.

Robotic system	Company	Clinical tests
Gangtrainer GT I [29]	Reha-Stim	[29–32]
HapticWalker [33]	—	[34]
GM5 [35]	—	[35]
LLRR [36]	—	—
Univ. Gyeongsang [37]	—	[37]



GaitMaster5

Gangtrainer GT I



上銀互動式下肢復健訓練機

Overground Gait Trainers

TABLE 3: Overground gait trainers.

Robotic System	Company	Clinical Tests
KineAssist [38]	Kinea Design LLC	[39]
WalkTrainer [40]	Swortec SA	[41]
ReWalk [42]	ARGO Medical	—
HAL [43]	CYBERDYNE Inc.	[44, 45]
WHERE I-II [46]	—	[46]

Keeogo 啟而走

KineAssist

ReWalk

Hybrid Assistive Limb

FREE Walk自立行

Stationary Gait Trainers

TABLE 4: Stationary robotic gait trainers.

Robotic system	Company	Clinical tests
MotionMaker [47]	Swortec SA	[40, 47]
Lambda [48]	—	—
AIST Tsukuba [49]	—	—

TABLE 5: Stationery robotic systems for ankle rehabilitation.

Robotic System	Company	Clinical Tests
Rutgers Ankle [51]	—	[52–54]
IIT-HPARR [56]	—	—
AKROD [57]	—	—
Leg-Robot [58]	—	—
GIST [59]	—	—
NUVABAT [60]	—	—
Univ. London [61]	—	—
Univ. Auckland [62]	—	—
Univ. Cheng Kung [63]	—	—
Univ. Fuzhou [50]	—	—
AIST Tsukuba [64]	—	—

MotionMaker

High Performance Ankle Rehabilitation Robot

Background

- Stroke remains the leading cause of long-term disability.

Lancet Neurol, 2019,18, 439-458

- Stroke survivors have a decreased probability of returning to work because of walking dysfunction.

Neurology, 2013,80, S5-12

- The use of robotic exoskeletons (REs) in gait training for patients with stroke is emerging.
    - ✓ locomotion assistance
    - ✓ motion or signals from its sensors and microcomputers

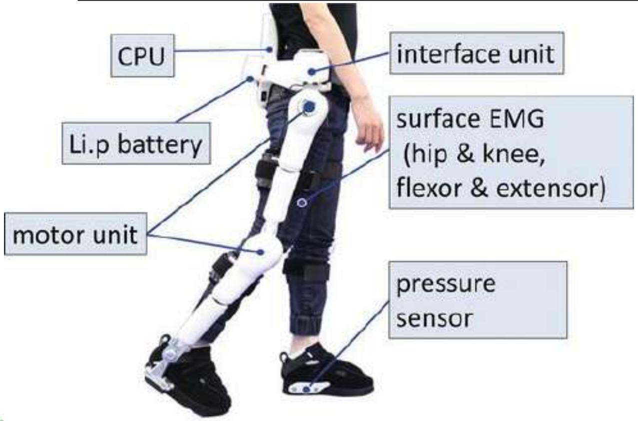
Eur J Phys Rehabil Med, 2019, 55, 710-721

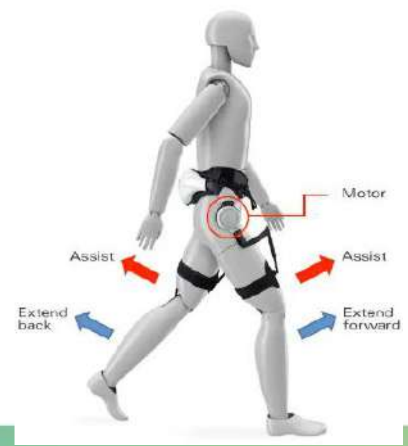
Background

- Overground robotic exoskeleton systems

Hybrid Assistive Limb (HAL), (Cyberdyne Inc, n.d.) | BEAR-H1, (Milebot, n.d.) | Honda Stride Management Assist (SMA), (Honda Motor Co. Ltd., n.d.) | Ekso, (Ekso Bionics, n.d.)

Fig. S1. Examples of commercially available overground robotic exoskeletons.





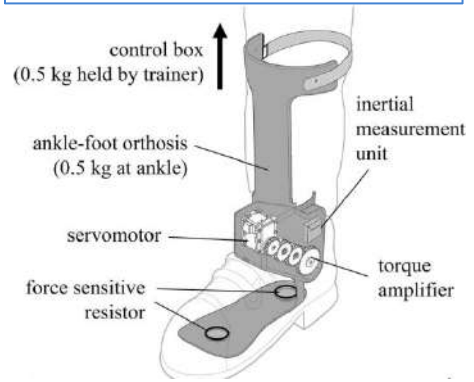
Background

- Overground robotic exoskeleton systems

Gait Enhancing and Motivating System

Alter G-Bionic-Leg

Powered-Assisted Ankle Robot



Background

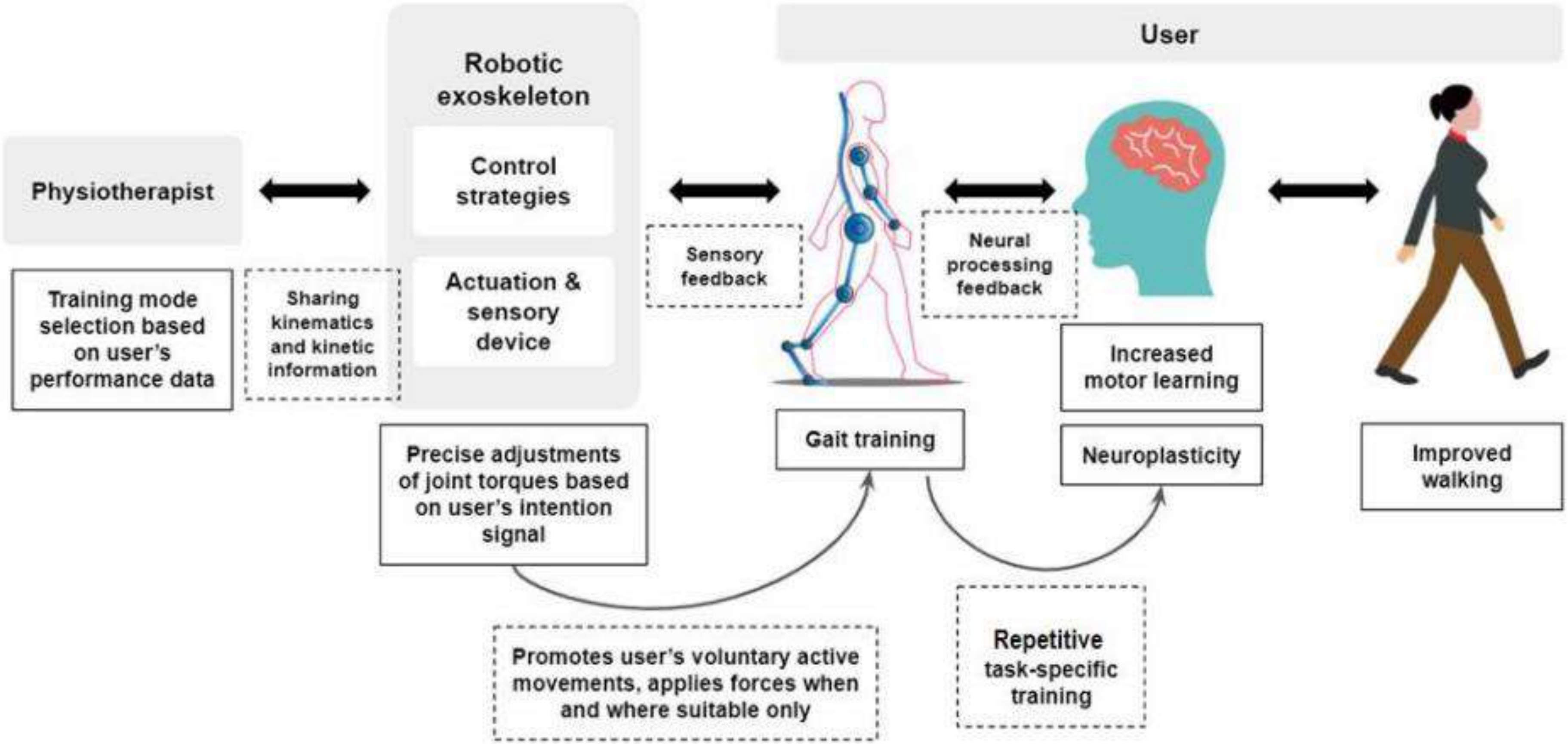


Fig. S2. The mechanism of overground robotic exoskeleton training in improving walking-related outcomes.

臨床問題	下肢外骨骼機器人是否可改善中風病人的功能性行走能力?
問題/研究族群 **P**roblem/Patient	Adults aged 18 years and above with three phases of stroke : acute stroke (< 24 hours), subacute stroke (1 day to 5 days) and chronic (weeks)
給予的措施 **I**ntervention	Overground robotic exoskeleton training
對照組 **C**omparison	placebo, no intervention, or any conventional training
結果 **O**utcome	•Walking speed (metres per second) •Walking endurance (metres walked in 6 minutes) •Walking ability : Functional Ambulation Category (FAC)

CRITICAL APPRAISAL

- **Methods**
- **Results**
- **Discussion**

Methods

- Related terms and synonyms were identified based on the 3 key concepts: “**stroke**,” “**robotic exoskeleton**,” and “**overground gait training**.”
- Publication date: inception to December 27, 2021
- PubMed, EMBASE, CINAHL, CKNI, ProQuest, PEDro, CENTRAL, Scopus and Web of Science
- No restrictions to the publication year were set, and all studies of any language were considered until data extraction to reduce publication bias.

Methods

Inclusion criteria

Adults aged 18 years and above with three phases of stroke according to the computed tomography manifestation of stroke: acute stroke (< 24 hours), subacute stroke (1 day to 5 days) and chronic (weeks)

Exclusion criteria

Participants with comorbidities, such as severe cognitive impairment, heart failure, and exercise contraindications

Results

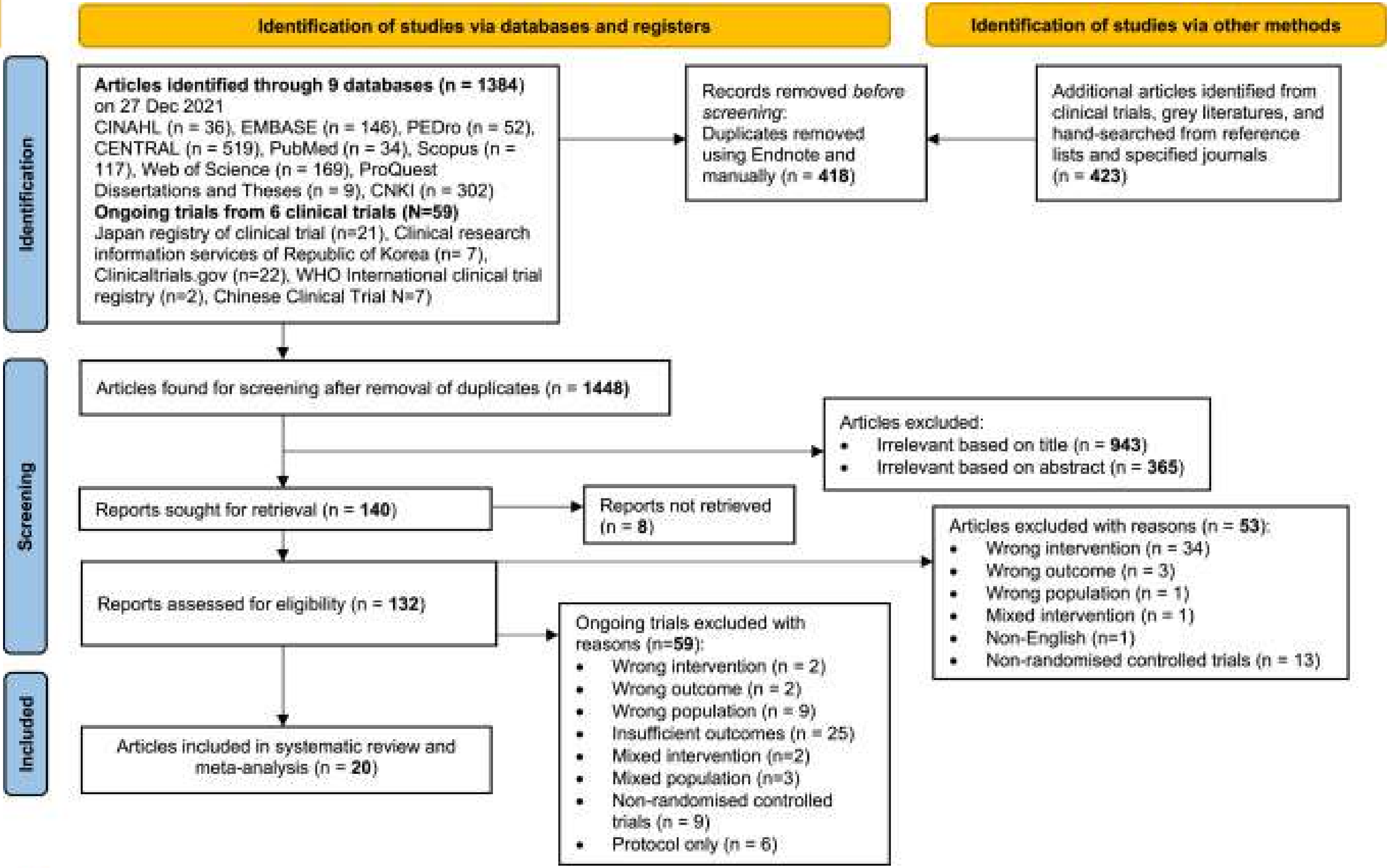

Identification of studies via databases and registers
Identification of studies via other methods
Identification
Articles identified through 9 databases (n = 1384) on 27 Dec 2021
CINAHL (n = 36), EMBASE (n = 146), PEDro (n = 52), CENTRAL (n = 519), PubMed (n = 34), Scopus (n = 117), Web of Science (n = 169), ProQuest Dissertations and Theses (n = 9), CNKI (n = 302)
Ongoing trials from 6 clinical trials (N=59)
Japan registry of clinical trial (n=21), Clinical research information services of Republic of Korea (n= 7), Clinicaltrials.gov (n=22), WHO International clinical trial registry (n=2), Chinese Clinical Trial N=7)
Records removed before screening: Duplicates removed using Endnote and manually (n = 418)
Additional articles identified from clinical trials, grey literatures, and hand-searched from reference lists and specified journals (n = 423)
Screening
Articles found for screening after removal of duplicates (n = 1448)
Articles excluded:
• Irrelevant based on title (n = 943)
• Irrelevant based on abstract (n = 365)
Reports sought for retrieval (n = 140)
Reports not retrieved (n = 8)
Articles excluded with reasons (n = 53):
• Wrong intervention (n = 34)
• Wrong outcome (n = 3)
• Wrong population (n = 1)
• Mixed intervention (n = 1)
• Non-English (n=1)
• Non-randomised controlled trials (n = 13)
Reports assessed for eligibility (n = 132)
Ongoing trials excluded with reasons (n=59):
• Wrong intervention (n = 2)
• Wrong outcome (n = 2)
• Wrong population (n = 9)
• Insufficient outcomes (n = 25)
• Mixed intervention (n=2)
• Mixed population (n=3)
• Non-randomised controlled trials (n = 9)
• Protocol only (n = 6)
Included
Articles included in systematic review and meta-analysis (n = 20)

Table 1 Characteristi[…]ized controlled trials

Acute: <24h
Subacute: 1-5days
Chronic: wks

Study/Location	Study Design	Participants: Phase of Stroke	Participants: Sample Size, (n, M/F)	Participants: Age (Mean)	Participants: Duration of Stroke (Months, Mean) [days / years]	Overground Robotic Exoskeletons Training	Comparator	Walking-Related Outcomes (Tools, Unit)	ITT/MDM	Protocol/Registry	Grant	Attrition Rate (%)
Buesing et al[18]/Chicago	2-arm RCT	Chronic stroke	T: 50 I: 25 (17/8) C: 25 (16/9)	I: 60 C: 62	I: 5.4 C: 7.1	Stride management assist (SMA) system training	Conventional physical therapy	Speed (GAITRite system, cm/s)	No/No	Yes (NCT01994395)	No	T: 0% I: 0% C: 0%
Calabrò et al[19]/Italy	2-arm RCT	Chronic stroke	T: 40 I: 20 (12/8) C: 20 (11/9)	I: 69 C: 67	I: 10 C: 11	Wearable exoskeleton Ekso gait training	Conventional gait training	Speed (10MWT, m/s)	No/No	Yes (NCT03162263)	No	T: 0% I: 0% C: 0%
Li et al[20]/Shenzhen, China	2-arm RCT	Subacute stroke	T: 32 I: 17 (15/2) C: 15 (14/1)	I: 50.53 C: 50.13	I: 2.53 C: 3.38	BEAR-H1 assisted gait training (BAGT)	Conventional gait training	Speed (IDEEA3, m/s) Endurance (6MWT, m) Ability (FAC score)	No/No	Yes (ID not reported)	Yes	T: 0% I: 0% C: 0%
Jayaraman et al[61]/United States	2-arm RCT	Chronic stroke	T: 50 I: 25 (17/8) C: 25 (16/9)	I: 59.5 C: 61.6	I: 7.1 C: 5.4	Stride management assist (SMA) system training	Functional task-specific training	Speed (10MWT, m/s) Endurance (6MWT, m)	No/No	Yes (NCT01994395)	Yes	T: 8% I: 7.4% C: 7.4%
Lee et al[21]/Republic of Korea	2-arm RCT	Chronic stroke	T: 26 I: 14 (7/7) C: 12 (7/5)	I: 61.85 C: 62.25	I: 1486 C: 1536	GEMS training	Conventional gait training	Speed (3D motion capture system, m/s)	No/No	Yes (NCT02843828)	Yes	T: 3.6% I: 0% C: 14.3%
Long et al[62]/China	2-arm RCT	Acute stroke	T: 30 I: 15 C: 15	Not reported	Not reported	BEAR-H1 assisted gait training (BAGT)	Conventional gait training	Speed (IDEEA3, m/min)	No/No	No/No	Yes	T: 0% I: 0% C: 0%
Louie et al[67]/Canada	2-arm RCT	Subacute stroke	T: 36 I: 19 (16/3) C: 17 (10/7)	I: 59.6 C: 55.3	I: 36.7 C: 40.9	EksoGT powered exoskeleton training	Conventional physiotherapy	Speed (5MWT, m/s) Endurance (6MWT, m) Ability (FAC score)	Yes/LOCF	Yes (NCT02995265)	Yes	T: 5.6% I: 5.9% C: 5.2%
Molteni et al[66]/Italy	Multi-center 2-arm RCT	Subacute stroke	T: 75 I: 38 (17/21) C: 37 (19/21)	I: 62.13 C: 68.24	I: 35.68 C: 34.14	Ekso robotic-powered exoskeleton training	Conventional gait training	Speed (10MWT, m/s) Endurance (6MWT, m) Ability (FAC score)	No/No	Yes (NCT03395717)	Yes	T: 6.25% I: 5% C: 7.5%
Palmcrantz et al[22]/Sweden	3-arm RCT	Chronic stroke	T: 33 I: 16 (11/5) C: 15 (13/2)	I: 62.25 C: 60	I: 21 C: 28	HAL training	Conventional physiotherapy	Speed (10MWT, m/s) Endurance (6MWT, m) Ability (FAC score)	No/No	No (NCT02545088)	Yes	T: 18.4% I: 20% C: 16.7%
Sczesny-Kaiser et al[57]/Germany	Crossover RCT	Chronic stroke	T: 18 I: 9 (6/3) C: 9 (7/2)	I: 63 C: 66	I: 62 C: 102	HAL training	Conventional physiotherapy	Speed (10MWT, m/s) Endurance (6MWT, m) Ability (FAC score)	No/No	Yes (DRKS00006821)	Yes	T: 5.6% G1: 11% G2: 0%
Stein et al[58]/New York	2-arm RCT	Chronic stroke	T: 24 I: 12 (10/3) C: 12 (7/5)	I: 57.6 C: 56.6	I: 49.1 C: 88.5	Alter G bionic leg training	Conventional physiotherapy	Speed (10MWT, s/m) Endurance (6MWT, m)	Yes/No	No/No	No	T: 16.7% I: 0% C: 16.7%
Tanaka et al[64]/Japan	2-arm RCT	Subacute stroke	T: 41 I: 21 (13/8) C: 20 (14/6)	I: 64.9 C: 62.3	I: 103.9 C: 92.9	Stride management assist (SMA) training	Conventional physiotherapy	Speed (WalkWay MW-1000, cm/s)	Yes/No	No/No	No	T: 24.4% I: 20% C: 28.6%
Wall et al[68]/Sweden	2-arm RCT	Subacute stroke	T:32 I: 16 (13/3) C: 16 (13/3)	I: 55 C: 57.5	I: 32±15 C: 36±16	HAL training	Conventional physiotherapy	Endurance (2MWT, m) Ability (FAC score)	No/No	Yes (NCT02410915)	Yes	T: 3% I: 0% C: 5.9%

Table 1 (*Continued*)

Study/Location	Study Design	Participants: Phase of Stroke	Participants: Sample Size, (n, M/F)	Participants: Age (Mean)	Participants: Duration of Stroke (Months, Mean)	Overground Robotic Exoskeletons Training	Comparator	Walking-Related Outcomes (Tools, Unit)	ITT/MDM	Protocol/Registry	Grant	Attrition Rate (%)
Watanabe et al[59]/Japan	2-arm RCT	Subacute stroke	T:22 I: 11 (7/4) C: 11 (4/7)	I: 67.0 C: 75.6	I: 58.9 C: 50.6	HAL training	Conventional gait rehabilitation	Speed (10MWT, m/s) Endurance (6MWT, m) Ability (FAC score)	No/No	No/No	Yes	T: 31.3% I: 35.3% C: 26.7%
Watanabe et al[63]/Japan	2-arm RCT	Subacute stroke	T:24 I: 12 (8/4) C: 12 (8/4)	I: 66.9 C: 76.8	I: 57.0 C: 48.1	HAL training	Conventional gait rehabilitation	Speed (10MWT, m/s) Endurance (6MWT, m) Ability (FAC score)	No/No	Yes (UMIN000022335)	No	T: 27.3% I: 29.4% C: 25%
Watanabe et al[60]/Japan	2-arm RCT	Subacute stroke	T: 31 I: 20 (10/10) C: 11 (4/7)	I: 66.6 C: 77.4	I: 52.9 C: 46.5	HAL training	Conventional gait rehabilitation	Speed (10MWT, m/s) Endurance (6MWT, m) Ability (FAC score)	No/No		No	T: 39.4% I: 43.8% C: 35.3%
Wright et al[65]/ Winchester, UK	2-arm RCT	Chronic stroke	T: 34 I: 16 (14/2) C: 18 (14/4)	I: 59.6±10.1 C: 65.1±10.1	I: 31±19 C: 32±21	Alter G bionic leg training	Conventional physiotherapy	Endurance (6MWT, m) Ability (FAC score)	Yes/LOCF	Yes (NCT03104127)	Yes	T: 5.9% I: 0% C: 16.7%
Y. Li et al[83]/China	Multicenter 2-arm RCT	Subacute stroke	T: 130 I: 65 C: 65	Not reported	Not reported	BEAR-H1 assisted gait training (BAGT)	Conventional gait training	Endurance (6MWT, m) Ability (FAC score)	Yes/LOCF	Yes (ChiCTR2100044475)	Yes	T: 12.3% I: 12.3% C: 12.3%
Yeung et al[56]/Hong Kong	3-arm RCT	Subacute stroke	T: 31 I: 14 (8/6) C: 17 (8/9)	I: 64.6 C: 63.6	I: 23 C: 28	Powered-assisted ankle robot (PAAR) training	Conventional rehabilitation	Speed (10MWT, m/s) Ability (FAC score)	Yes/LOCF	Yes (NCT03184259)	Yes	T: 3.2% I: 7.1% C: 0%
Yokota et al[61]/Osaka, Japan	2-arm RCT	Acute atroke	T: 37 I: 18 (16/2) C: 19 (12/7)	I: 69±17.8C: 69±10.37	I: 3±12.6 C: 3±11.9	HAL training	Conventional gait rehabilitation	Ability (FAC score)	No/No	No (UMIN000024655)	No	T: 21.3% I: 21.7% C: 20.8%

Abbreviations: 2MWT, two-minute walk test; 6MWT, six-minute walk test; 10MWT, 10-meter walk test; BAGT, BEAR-H1 assisted gait training; C, control group; F, female; GEMS, Gait Enhancing and Motivating System; HAL, Hybrid Assistive Limb; I, intervention group; ITT, intention-to-treat; LOCF, last observation carried forward; m/s, M, male; MDM, missing data management; PAAR, powered-assisted ankle robot training; RCT, randomized controlled trial; RMI, Rivermead Mobility Index; SMA, Stride Management Assist System training; step/min, steps per minutes; T, total.

- 20 RCTs / 9 countries/ 785 patients with stroke
- 2-arm : 17/ 3-arm : 2 /crossover study : 1
- sample size : 18~130
- mean age : 50.13~ 76.8 years old

Table S6. Description of overground robotic exoskeleton training.

Author (year) [(Ref)]	Baseline of walking ability	Device: type/ weight	Training setting	Combined with conventional rehabilitation	Comparator group setting	Training intensity, sessions & duration	Follow up	Assessment	
								Used of walking aid	Used of device
Buesing et al. (2015)[18]	LCA, walked 10m with maximum 1 person[b]	Single-joint exoskeleton/ 2.8 Kg	Overground gait training + functional training with SMA	No	FTST: overground walking/ treadmill training + functional training	45 minutes/session 3 times/week Maximum 18 sessions, 6-8 weeks	3 months	Yes	Yes
Calabrò et al. (2018)[19]	FAC of ≤ 4[c]	Multiple-joints exoskeleton	Overground gait training + functional training with Ekso	Yes	Overground gait training + functional training	45 minutes/session 3 times/week, 6-8 weeks	No	Not reported	Not reported
D.-X. Li et al. (2021)[20]	FAC of < 4[a]	Multiple-joints exoskeleton	Overground gait training + functional training with BEAR-H1	Yes	Overground gait training + functional training	30 minutes/session Twice a day, 5 times/week, 4 weeks	No	Yes	No
Jayaraman et al. (2019)[81]	LCA, walked 10m with maximum 1 person[b]	Single-joint exoskeleton/ 2.8 Kg	Overground gait training + functional gait training with SMA	No	FTST: overground walking/ treadmill training + functional training	45 minutes/session 3 times/week 18 sessions, 6-8 weeks	3 months	Yes	No
Lee et al. (2019)[21]	FAC of 3-4[c]	Single-joint exoskeleton/ 2.8 Kg	Overground or treadmill gait training with GEMS	No	Overground/ treadmill gait training	45 minutes/session 3 times/week 10 sessions, 4 weeks	No	No	No
Long et al. (2021)[82]	Walk independently without physical help and assistive devices[b]	Multiple-joints exoskeleton	Overground gait training with the BEAR-H1	No	Overground gait training	30 minutes/session twice a day, daily 3 weeks	No	Not reported	Not reported
Louie et al. (2021)[67]	FAC of 0-1[a]	Multiple-joints exoskeleton	Overground gait training with EksoGT	No	Mobility and gait training	60 minutes/session 3 times/week Maximum 8 weeks	6 months	Not reported	Not reported
Molteni et al. (2021)[66]	No limit; FAC range of 0-5[c]	Multiple-joints exoskeleton	Overground gait training + functional training with Ekso	Yes	Overground gait training + functional training	60 minutes/session 5 times/week 15 sessions, 3 weeks	No	Not reported	Not reported
Palmcrantz et al. (2021)[22]	FAC of 2-3 or 4 (with reduced gait speed)[c]	Multiple-joints exoskeleton	Gait training with HAL	Yes	Gait training + functional training + strength & balance	90 minutes/session 3 times/week, 6 weeks	6 months and 12 months	Not reported	Not reported

Table S6. Description of overground robotic exoskeleton training.

Author (year) [(Ref)]	Baseline of walking ability	Device: type/ weight	Training setting	Combined with conventional rehabilitation	Comparator group setting	Training intensity, sessions & duration	Follow up	Assessment	
								Used of walking aid	Used of device
Sczesny-Kaiser at al. (2019)[57]	No limit; FAC range of 0-5[c]	Multiple-joints exoskeleton	Gait training with HAL	No	Gait training + strength & balance	30 minutes/session 5 times/week 30 sessions, 6 weeks	No	No	No
Stein et al. (2014)[58]	Independent household ambulation with/ without assistive aid[b]	Multiple-joints exoskeleton	Overground gait training + functional training with Alter G Bionic Leg	No	Gait training + (relaxation/ meditation, self-stretching, gentle ROM exercises)	1 hr/session 3 times/week 18 sessions, 6 weeks	1 month and 3 months	Not reported	Not reported
Tanaka et al. (2019)[64]	Walk independently or with minimal assistance[b]	Single-joint exoskeleton/ 2.4 Kg	Gait training with SMA	No	Gait training	1-2 hrs/session 10 consecutive days	No	Yes	Not reported
Wall et al., (2020)[68]	FAC of 0-1[a]	Multiple-joints exoskeleton	Gait training with Single-leg version of HAL	No	Standing, weight shifting, stepping, overground walking, use of treadmill	60-90 minutes/session 4 times/week 16 sessions, 4 weeks	6 months	Yes	Not reported
Watanabe et al. (2014)[59]	FAC of 4 or 5[b]	Multiple-joints exoskeleton	Gait training with Single-leg version of HAL	No	Gait rehabilitation	20 minutes/session 3 times/week 12 sessions, 4 weeks	No	Yes	No
Watanabe et al. (2017)[63]	FAC of 4 or 5[b]	Multiple-joints exoskeleton	Gait training with Single-leg version HAL	No	Gait rehabilitation	20 minutes/session 3 times/week 12 sessions, 4 weeks	No	Yes	No
Watanabe et al. (2021)[60]	FAC of 4 or 5[b]	Multiple-joints exoskeleton	Gait training with Single-leg version HAL	No	Gait rehabilitation	20 minutes/sessi[illegible] 3 times/week 12 sessions, 4 w[illegible]	[illegible]	[illegible]	[illegible]
Wright et al. (2021)[65]	FAC of 2-5[c]	Multiple-joints exoskeleton	Self-administered overground gait training with Alter G Bionic Leg	Yes	Stretching, muscle strengthening exercises, functional gait training	Min. 30 minutes[illegible] 10 weeks	[illegible]	[illegible]	[illegible]
Y. Li et al., (2021)[83]	No limitation[c]	Multiple-joints exoskeleton	Overground gait training with the BEAR-H1	No	Overground gait training	30 minutes/session Twice a day, 5 times/week 4 weeks	No	No	Yes
Yeung et al. (2021)[56]	FAC of ≥ 1[a]	Single-joint exoskeleton/ 0.5 Kg	Overground gait training + stair training with PAAR	Yes	Standard lower-limb functional gait training	30 minutes/session Min. 2 times/week 20 sessions	No	Yes	No
Yokota et al. (2019)[61]	FAC of 4 or 5[b]	Multiple-joints exoskeleton	Gait training with HAL	Yes	Overground gait training	20 minutes/session 1-3 times per day 5-6 times/week, up to 6 weeks	3 months	Yes	No

Ref = Reference, *= self-administered intervention at home, participants may use walking aid; [a]= ambulatory status at the start of the study: dependent walkers; [b]= ambulatory status at the start of the study: independent walkers; [c]= ambulatory status at the start of the study: mixture of dependent and independent walkers; CP/CR= conventional physiotherapy/ rehabilitation; CR= conventional rehabilitation; FAC= Functional Ambulatory Categories; FTST= functional task-specific training; LCA= Limited community ambulators; ROM= range of motion

Intervention: 10 days~ 10 weeks

Frequency : 2~5 times/week

Time: 20~120min./session

Results_ Walking ability

Study or Subgroup	Overground RE Mean	Overground RE SD	Overground RE Total	Conventional Mean	Conventional SD	Conventional Total	Weight	Std. Mean Difference IV, Random, 95% CI
D.-X. Li et al. (2021)	3.76	0.9	17	3.67	0.72	15	8.8%	0.11 [-0.59, 0.80]
Louie et al. (2021)	3	2.22	19	3	0.74	17	9.9%	0.00 [-0.65, 0.65]
Molteni et al. (2021)	2.71	1.12	38	2.69	1.49	37	20.6%	0.02 [-0.44, 0.47]
Palmcrantz et al. (2021)	3.5	1.48	16	3	1.48	15	8.4%	0.33 [-0.38, 1.04]
Wall et al. (2020)	2	1.3	16	2.5	1.3	16	8.6%	-0.37 [-1.07, 0.32]
Watanabe et al. (2014)	3.1	1.4	11	2.6	1.4	11	5.9%	0.34 [-0.50, 1.19]
Watanabe et al. (2017)	3	1.3	12	2.5	1.3	12	6.5%	0.37 [-0.44, 1.18]
Watanabe et al. (2021)	3.6	0.8	9	3	1	11	5.1%	0.63 [-0.28, 1.53]
Wright et al. (2021)	3.8	0.9	16	3.3	1.1	15	8.2%	0.49 [-0.23, 1.20]
Yeung et al. (2021)	3.3	1	14	3	1	17	8.3%	0.29 [-0.42, 1.00]
Yokota et al. (2019)	2.44	0.67	18	2	0.65	19	9.6%	0.65 [-0.01, 1.32]
Total (95% CI)			**186**			**185**	**100.0%**	**0.21 [0.01, 0.42]**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 7.38$, df = 10 (P = 0.69); $I^2 = 0\%$

Test for overall effect: Z = 2.02 (P = 0.04)

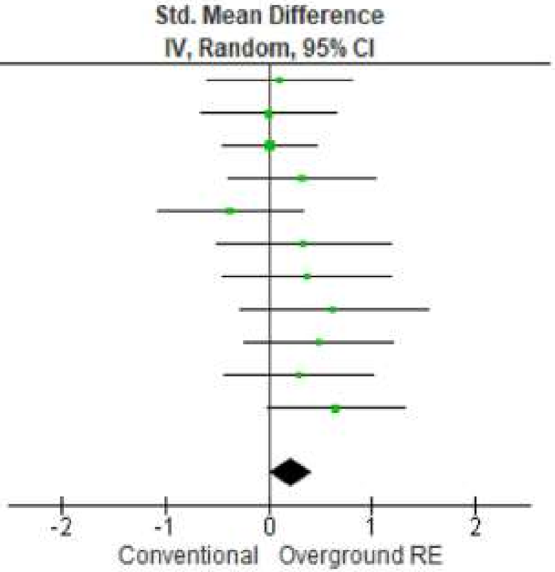


Fig 2 Forest plot of standardised mean differences in walking ability (functional ambulation category scores) at post-intervention for overground robotic exoskeleton training and control group.

- 11 trials
- 371 participants
- favoring the overground RE training
  - ✓ postintervention (Z=2.02, P=0.04)
  - ✓ small effect size (d=0.21)

Results_ Walking ability

Table 2 Subgroup analyses of overground robotic exoskeleton training on walking ability in 11 trials

Category	Subgroups	No. of Trials (Reference)	Sample Size	SMD (*d*)	95% CI	Heterogeneity *P* Value of Chi-Square Test (I^2)	Overall Effect *Z* Value (*P* Value)	Test for Subgroup Difference *P* Value
Region	Asian	6[20,56,59–61,63]	166	0.39	0.08, 0.70	0.90 (0%)	2.48 (.01*)	.18
	Non-Asian	5[22,65–68]	205	0.08	−0.20, 0.35	0.55 (0%)	2.55 (.58)	
Phase of stroke	Acute stroke	2[20,61]	69	0.39	−0.14, 0.92	0.27 (19%)	1.43 (.15)	.53
	Subacute stroke	7[56,59,60,63,66–68]	240	0.14	−0.11, 0.40	0.83 (0%)	1.10 (.27)	
	Chronic stroke	2[22,65]	62	0.41	−0.10, 0.91	0.76 (0%)	1.58 (.11)	
Combined with conventional rehabilitation	Yes	6[20,22,56,61,65,66]	237	0.26	0.00, 0.52	0.69 (0%)	1.99 (.05)	.71
	No	5[59,60,63,67,68]	134	0.18	−0.16, 0.52	0.67 (0%)	1.04 (.30)	
Ambulatory status before training	Dependent walker	4[20,56,67,68]	131	0.06	−0.28, 0.41	0.86 (0%)	0.36 (.72)	.23
	Independent walker	4[59–61,63]	103	0.51	0.12, 0.91	0.92 (0%)	2.55 (.01*)	
	Mixture*	3[22,65,66]	137	0.19	−0.15, 0.53	0.50 (0%)	1.11 (.27)	
Length of training session	≤30 min/session	5[20,59–61,63]	134	0.46	0.12, 0.81	0.94 (0%)	2.62 (.009**)	.11
	>30 min/session	6[20,22,65–68]	237	0.11	−0.15, 0.36	0.83 (0%)	0.82 (.41)	
Frequency of training	<4 times/week	6[22,56,59,60,63,67]	164	0.29	−0.02, 0.60	0.93 (0%)	1.85 (.06)	.62
	≥4 times/week	5[20,61,65,66,68]	207	0.19	−0.09, 0.46	0.41 (0%)	1.32 (.19)	
Duration of training	<6 weeks	7[20,60,61,63,65,66,68]	242	0.22	−0.04, 0.47	0.61 (3%)	1.66 (.10)	.82
	≥6 weeks	4[22,56,65,67]	129	0.26	−0.08, 0.61	0.79 (0%)	1.49 (.14)	

Abbreviations: CI, confidence interval; FAC, Functional Ambulation Category.

* $P<.05$.

Asian>non-Asian

chronic>acute>subacute

combined>only

ID>D

≦30min > >30min

<4/wk > ≧4/wk

≧6wks > <6wks

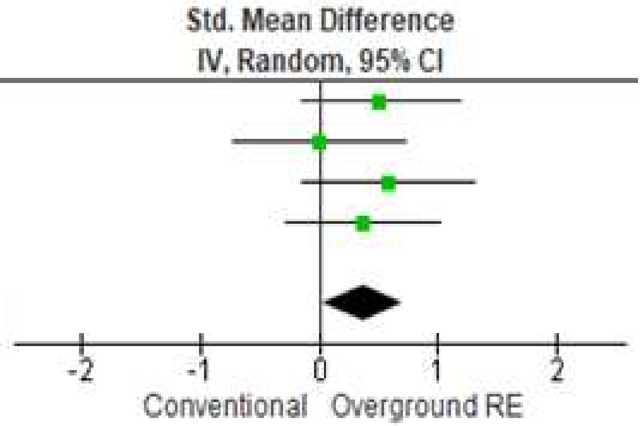
No significant

Results_ Walking ability_Follow-up

4a Walking ability (functional ambulation category scores) at follow-up between 3-6 months

	Overground RE			Conventional				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Louie et al. (2021)	4	2.22	19	3	1.48	17	26.6%	0.51 [-0.15, 1.18]
Wall et al. (2020)	4	1.48	16	4	1.67	14	22.9%	0.00 [-0.72, 0.72]
Wright et al. (2021)	3.8	0.9	16	3.2	1.1	15	22.7%	0.58 [-0.14, 1.30]
Yokota et al. (2019)	3.78	0.67	18	3.53	0.66	19	27.8%	0.37 [-0.28, 1.02]
Total (95% CI)			**69**			**65**	**100.0%**	**0.37 [0.03, 0.71]**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 1.53$, df = 3 (P = 0.67); $I^2 = 0\%$
Test for overall effect: Z = 2.12 (P = 0.03)



- 4 trials
- 134 participants
- favoring the overground RE training
  - ✓ Follow-up (Z=2.12, P=.03)
  - ✓ Small~medium effect size (d=0.37)

Results_ Walking speed

Study or Subgroup	Overground RE Mean	Overground RE SD	Overground RE Total	Conventional Mean	Conventional SD	Conventional Total	Weight	Std. Mean Difference IV, Random, 95% CI
Buesing et al. (2015)	0.87	0.3	25	0.89	0.3	25	9.3%	-0.07 [-0.62, 0.49]
Calabrò et al. (2018)	1.15	0.3	20	0.85	0.2	20	7.4%	1.15 [0.48, 1.83]
D.-X. Li et al. (2021)	0.59	0.35	17	0.52	0.22	15	7.1%	0.23 [-0.47, 0.93]
Jayaraman et al. (2019)	0.93	0.47	25	0.85	0.47	25	9.3%	0.17 [-0.39, 0.72]
Lee et al. (2019)	0.91	0.15	14	0.78	0.11	12	5.6%	0.95 [0.13, 1.77]
Long et al. (2021)	0.57	0.26	15	0.45	0.23	15	6.7%	0.48 [-0.25, 1.20]
Louie et al. (2021)	0.38	0.3	19	0.35	0.3	17	7.7%	0.10 [-0.56, 0.75]
Palmcrantz et al. (2021)	0.29	0.14	16	0.35	0.24	15	6.9%	-0.30 [-1.01, 0.41]
Sczesny-Kaiser et al. (2019)	0.56	0.23	8	0.8	0.26	9	4.1%	-0.92 [-1.94, 0.09]
Stein et al. (2014)	0.49	0.36	12	0.52	0.25	12	5.8%	-0.09 [-0.89, 0.71]
Tanaka et al. (2019)	1.08	0.44	21	1.07	0.61	20	8.3%	0.02 [-0.59, 0.63]
Watanabe et al. (2014)	0.85	0.43	11	0.63	0.51	11	5.4%	0.45 [-0.40, 1.30]
Watanabe et al. (2017)	0.85	0.43	8	0.61	0.47	11	4.7%	0.51 [-0.42, 1.43]
Watanabe et al. (2021)	0.75	0.49	9	0.58	0.49	11	5.0%	0.33 [-0.56, 1.22]
Yeung et al. (2021)	0.45	0.29	14	0.32	0.31	17	6.8%	0.42 [-0.30, 1.14]
Total (95% CI)			**234**			**235**	**100.0%**	**0.23 [0.01, 0.46]**

Heterogeneity: $Tau^2 = 0.07; Chi^2 = 20.96, df = 14 (P = 0.10); I^2 = 33\%$

Test for overall effect: Z = 2.01 (P = 0.04)

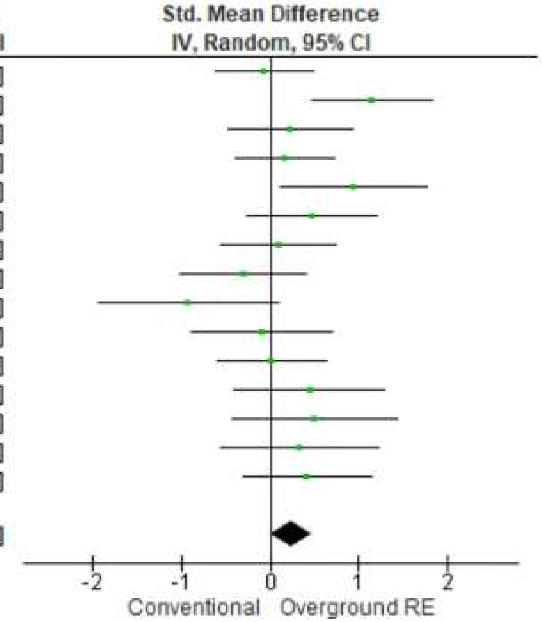


Fig 3 Forest plot of standardised mean differences in walking speed (meters per second) at post-intervention for overground robotic exoskeleton training and control group.

- 15 trials
- 469 participants
- favoring the overground RE training
  - ✓ postintervention (Z=2.01, P=.04)
  - ✓ small effect size (d=0.23)

Results_ Walking endurance

Study or Subgroup	Overground RE Mean	Overground RE SD	Overground RE Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
D.-X. Li et al. (2021)	197.24	86.78	17	179.8	80.86	15	6.3%	0.20 [-0.49, 0.90]
Jayaraman et al. (2019)	380	195	25	330	130	25	9.9%	0.30 [-0.26, 0.85]
Louie et al. (2021)	117	112.7	19	93	84	17	7.1%	0.23 [-0.42, 0.89]
Molteni et al. (2021)	139.24	104.7	38	149.43	130.15	37	15.0%	-0.09 [-0.54, 0.37]
Palmcrantz et al. (2021)	87.64	51.73	16	110.19	79.37	15	6.1%	-0.33 [-1.04, 0.38]
Sczesny-Kaiser et al. (2019)	190.38	87.98	8	243.06	102.62	9	3.2%	-0.52 [-1.49, 0.45]
Stein et al. (2014)	213.4	108.2	12	194.8	83.2	12	4.8%	0.19 [-0.62, 0.99]
Wall et al. (2020)	24.67	26.85	16	29.42	39.26	16	6.4%	-0.14 [-0.83, 0.56]
Watanabe et al. (2014)	156.7	137.9	8	134.5	132.1	10	3.5%	0.16 [-0.77, 1.09]
Watanabe et al. (2017)	156.7	137.3	11	140.8	127.8	12	4.6%	0.12 [-0.70, 0.93]
Watanabe et al. (2021)	192.8	125.3	9	146.6	130.2	11	3.9%	0.35 [-0.54, 1.23]
Wright et al. (2021)	158	93	16	119	84	18	6.6%	0.43 [-0.25, 1.11]
Y. Li et al. (2021)	150.43	100.77	57	160.37	101.17	57	22.7%	-0.10 [-0.47, 0.27]
Total (95% CI)			**252**			**254**	**100.0%**	**0.04 [-0.14, 0.21]**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 6.70$, df = 12 (P = 0.88); $I^2 = 0\%$

Test for overall effect: Z = 0.44 (P = 0.66)

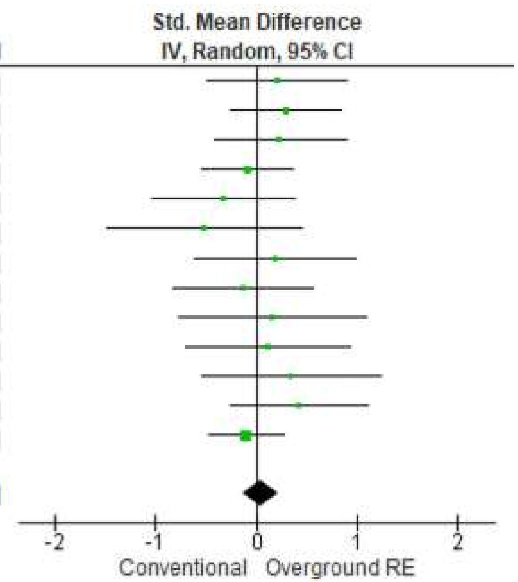


Fig 4 Forest plot of standardised mean differences in walking endurance (meters walked within 6 minutes, meter) at post-intervention for overground robotic exoskeleton training and control group.

- 13 trials
- 506 participants
- No significant difference
  - ✓ postintervention (Z=0.44, P=.66)
  - ✓ effect size (d=0.04)

Discussion_ Walking ability

- This work is the first study to review and ascertain the level of evidence in determining the effectiveness of **solely overground RE training** or **overground RE training with conventional rehabilitation** in improving walking-related outcomes.
- Minimal clinically important difference of FAC: **0.5**

Spine J 2007;7:541–6.

- Mehrholz et al., 2000
  - ✓ no significant effect of overground RE training
  - ✓ included more RCTs → positive effect

Cochrane Database Syst Rev 2020;2020(10)

Discussion_ Walking ability

- Nolan et al., 2021
  - ✓ results similar to our study
  - ✓ FAC scale : closer to 4

Front Neurorobot 2021;15:689363.

- An FAC score of ≥4 after a gait rehabilitation program predicts community ambulation at the 6th month.

Arch Phys Med Rehabil 2007; 88:1314–9.

Discussion_ Walking speed

- Similarly, previous studies reported improvements in walking speed after overground RE training.

Front Neurol 2020;10:1344 ; Zh Nevrol Psikhiatr Im Korsakova 2020;120:73–80

- That promotes human–robot interactions with kinematic and kinetic feedback to induce correct relearning motor processes. *Front Neurorobot 2018;12:10.*

Discussion_ Walking endurance

- Similarly, the insignificant effect of overground RE training on walking endurance.

Cochrane Database Syst Rev 2020;2020(10):CD006185.

- The participants included patients in different phases of stroke.
- Different phases of stroke may relate to different conditions of sensorimotor, visual, balance, pain, mood, and cognitive impairments.
- Personal factors such as age and prestroke activity may affect walking endurance among patients with stroke.

Stroke 2022;53:3494–505; Disabil Rehabil 2020;42:763–9.

Discussion

- **Limitation**

1. Small sample sizes were detected in more than half of the RCTs
2. The number of sessions, length of training sessions, frequency and duration of training, and follow-up assessment periods varied across RCTs.
3. Five trials had a high attrition rate (>20%).
4. Various overground RE systems based around exogenous sensing may not provide the same motor learning stimulation.
5. The overall evidence was very low.
6. None of studies reported users' perceptions of the devices.

- **Strengths**

1. This review followed the PRISMA checklist strictly.
2. A comprehensive 3-step search strategy, with no language restriction, was performed on 9 databases, 5 trial registries, gray literature, and reference lists to reduce publication bias.
3. This review included RCTs from Asian (n=11) and non-Asian countries (n=9).
4. Publication bias was not detected among our included trials.
5. No statistical heterogeneity was attained.
6. Subgroup analyses were performed to identify the preferred design of overground RE .
7. Both immediate and long-term effects were investigated to increase the overall effectiveness of the research effort.

CASP系統性文獻回顧檢核表

(A)研究結果可信嗎?

(B)研究結果為何?

(C)研究結果對於當地病人有幫助嗎?

CASP
Critical Appraisal
Skills Programme

(A)研究結果可信嗎?

1. 此篇系統性文獻回顧是否問了一個清楚、明確的問題?

問題/研究族群 **P**roblem/Patient	Adults aged 18 years and above with three phases of stroke : acute stroke (< 24 hours), subacute stroke (1 day to 5 days) and chronic (weeks)
給予的措施 **I**ntervention	Overground robotic exoskeleton training
對照組 **C**omparison	placebo, no intervention, or any conventional training
結果 **O**utcome	•Walking speed (metres per second) •Walking endurance (metres walked in 6 minutes) •Walking ability : Functional Ambulation Category (FAC)

✓	**P**opulation studied
✓	**I**ntervention given
✓	**C**omparator chosen
✓	**O**utcomes measured

是	V
不明確	
否	

(A)研究結果可信嗎?

2. 作者是否尋找適當研究型態的文獻?

archives-pmr.org/). Selected RCTs included the following criteria: adults aged 18 years and above, of any gender, clinically diagnosed with a stroke, regardless of stroke type and severity and baseline ambulatory status. Three main stages of stroke were

review. RCTs were included if the intervention group used overground RE for gait training. Overground RE training was either performed solely or combined with conventional rehabilitation that was wearable and designed to assist individuals with lower limb paralysis and weakness in walking overground in real-world settings. All RCTs that evaluated any electromechanical devices other than overground RE training were excluded.

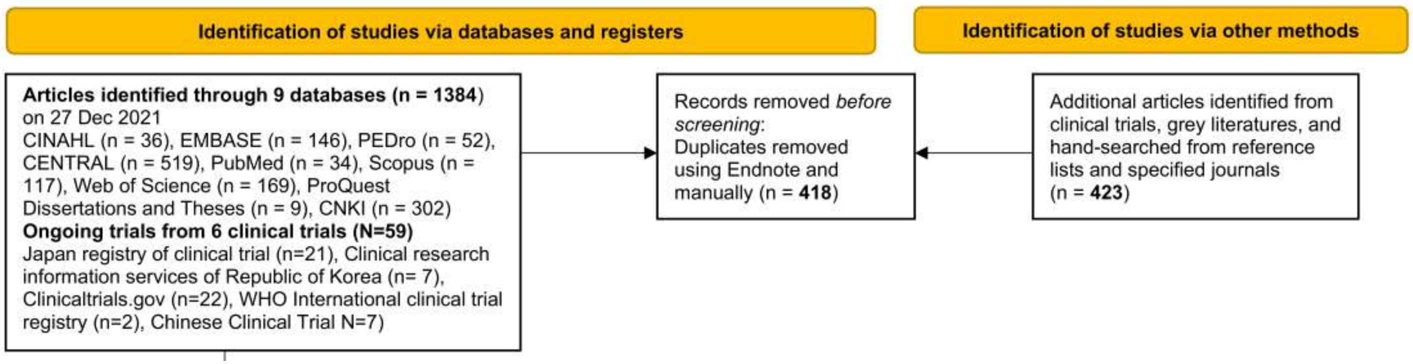
評讀的面向	
✔	有提及系統性文獻回顧的問題
✔	有適當的研究設計 (RCT)

是	V
不明確	
否	

(A)研究結果可信嗎?

3. 你認為所有重要且相關的研究都被納入?

Studies were identified through systematic searches from inception to December 27, 2021, in the following databases: PubMed,



評讀的面向	
✓	使用資料庫 (PubMed, EMBASE, CINAHL, CKNI, ProQuest, PEDro, CENTRAL, Scopus and Web of Science
✓	是否從參考資料清單中再進行搜尋
✓	與專家進行個別聯繫
✓	除了已發表的研究文獻，也搜尋未發表的研究文獻
✓	搜尋非英文的研究文獻
✓	出版日期無受限(inception to 12, 27, 2021)

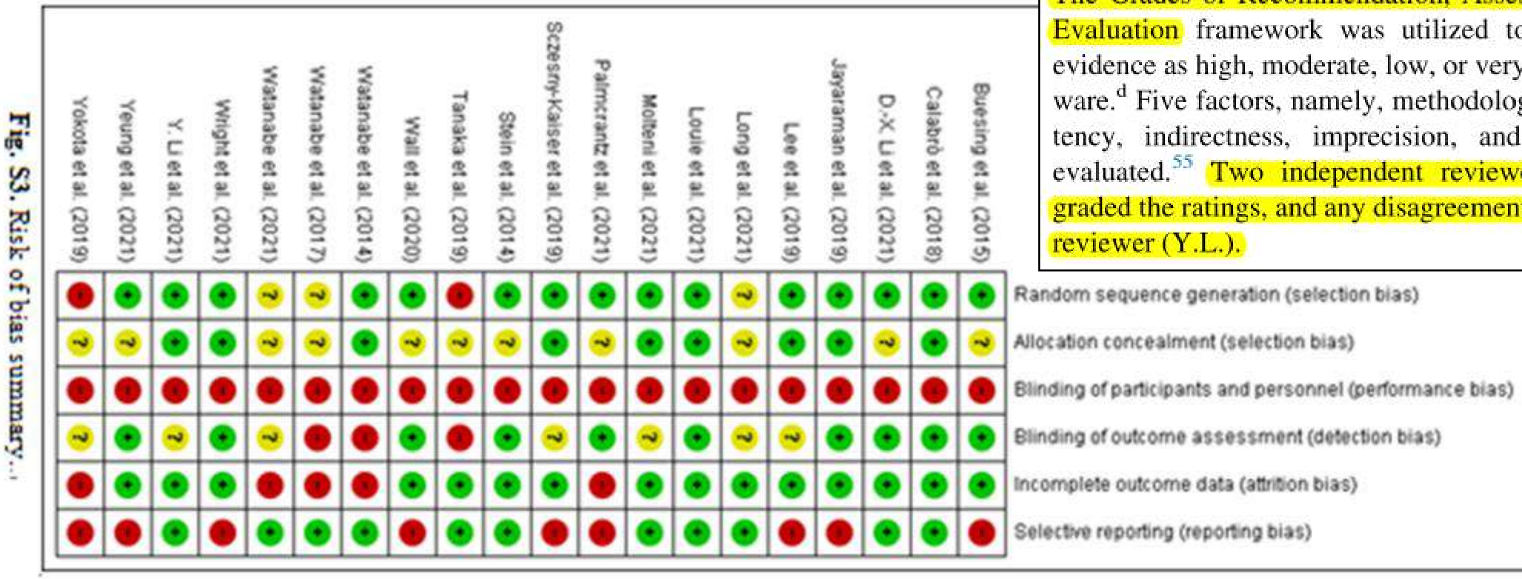
是	V
不明確	
否	

(A)研究結果可信嗎?

4.系統性文獻回顧的作者**是否評估所納入研究文獻的品質?**

Certainty of evidence

The Grades of Recommendation, Assessment, Development and Evaluation framework was utilized to assess the certainty of evidence as high, moderate, low, or very low via GRADEpro software.[d] Five factors, namely, methodological limitations, inconsistency, indirectness, imprecision, and publication bias, were evaluated.[55] Two independent reviewers (X.R.G.L., S.L.A.N.) graded the ratings, and any disagreements were settled by the third reviewer (Y.L.).



評讀的面向	
✔	使用GRADE評讀systematic reviews
✔	當2位獨立評讀人員文獻出現分歧，會再由第3人評估

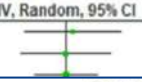
是	V
不明確	
否	

(A)研究結果可信嗎?

5.如果作者將研究結果進行合併，這樣的合併是否合理?

Study or Subgroup	Overground RE Mean	SD	Total	Conventional Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
D.-X. Li et al. (2021)	3.76	0.9	17	3.67	0.72	15	8.8%	0.11 [-0.59, 0.80]
Louie et al. (2021)	3	2.22	19	3	0.74	17	9.9%	0.00 [-0.65, 0.65]
Molteni et al. (2021)	2.71	1.12	38	2.69	1.49	37	20.6%	
Palmcrantz et al. (2021)	3.5	1.48	16	3	1.48	15	8.4%	
Wall et al. (2020)	2	1.3	16	2.5	1.3	16	8.6%	
Watanabe et al. (2014)	3.1	1.4	11	2.6	1.4	11	5.9%	
Watanabe et al. (2017)	3	1.3	12	2.5	1.3	12	6.5%	
Watanabe et al. (2021)	3.6	0.8	9	3	1	11	5.1%	
Wright et al. (2021)	3.8	0.9	16	3.3	1.1	15	8.2%	
Yeung et al. (2021)	3.3	1	14	3	1	17	8.3%	
Yokota et al. (2019)	2.44	0.67	18	2	0.65	19	9.6%	
Total (95% CI)			186			85	100.0%	

Heterogeneity: Tau² = 0.00; Chi² = 7.38, df = 10 (P = 0.69); I² = 0%
Test for overall effect: Z = 2.02 (P = 0.04)

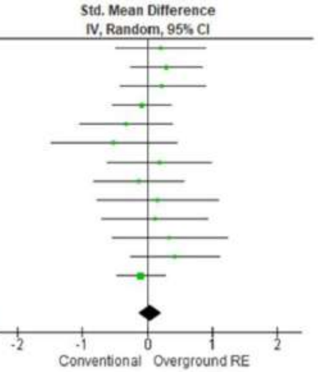


Walking ability

Fig 2 … mean differences in walking ability (fun… ground r… and control group.

Study or Subgroup	Overground RE Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
D.-X. Li et al. (2021)	197.24	86.78	17	179.8	80.86	15	6.3%	0.20 [-0.49, 0.90]
Jayaraman et al. (2019)	380	195	25	330	130	25	9.9%	0.30 [-0.26, 0.85]
Louie et al. (2021)	117	112.7	19	93	84	17	7.1%	0.23 [-0.42, 0.89]
Molteni et al. (2021)	139.24	104.7	38	149.43	130.15	37	15.0%	-0.09 [-0.54, 0.37]
Palmcrantz et al. (2021)	87.64	51.73	16	110.19	79.37	15	6.1%	-0.33 [-1.04, 0.38]
Sczesny-Kaiser et al. (2019)	190.38	87.98	8	243.06	102.62	9	3.2%	-0.52 [-1.49, 0.45]
Stein et al. (2014)	213.4	108.2	12	194.8	83.2	12	4.8%	0.19 [-0.62, 0.99]
Wall et al. (2020)	24.67	26.85	16	29.42	39.26	16	6.4%	-0.14 [-0.83, 0.56]
Watanabe et al. (2014)	156.7	137.9	8	134.5	132.1	10	3.5%	0.16 [-0.77, 1.09]
Watanabe et al. (2017)	156.7	137.3	11	140.8	127.8	12	4.6%	0.12 [-0.70, 0.93]
Watanabe et al. (2021)	192.8	125.3	9	146.6	130.2	11	3.9%	0.35 [-0.54, 1.23]
Wright et al. (2021)	158	93	16	119	84	18	6.6%	0.43 [-0.25, 1.11]
Y. Li et al. (2021)	150.43	100.77	57	160.37	101.17	57	22.7%	-0.10 [-0.47, 0.27]
Total (95% CI)			252			254	100.0%	0.04 [-0.14, 0.21]

Heterogeneity: Tau² = 0.00; Chi² = 6.70, df = 12 (P = 0.88); I² = 0%
Test for overall effect: Z = 0.44 (P = 0.66)

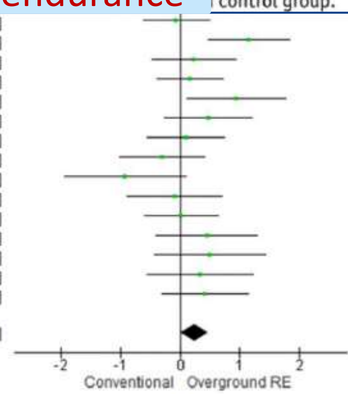


Walking endurance

Fig 4 Fo… n differences in walking endurance (meters walked within 6 minutes, meter) at post-intervention for over-ground rob… control group.

Study or Subgroup	Overground RE Mean	SD	Total	Conventional Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Buesing et al. (2015)	0.87	0.3	25	0.89	0.3	25	9.3%	-0.07 [-0.62, 0.49]
Calabrò et al. (2018)	1.15	0.3	20	0.85	0.2	20	7.4%	1.15 [0.48, 1.83]
D.-X. Li et al. (2021)	0.59	0.35	17	0.52	0.22	15	7.1%	0.23 [-0.47, 0.93]
Jayaraman et al. (2019)	0.93	0.47	25	0.85	0.47	25	9.3%	0.17 [-0.39, 0.72]
Lee et al. (2019)	0.91	0.15	14	0.78	0.11	12	5.6%	0.95 [0.13, 1.77]
Long et al. (2021)	0.57	0.26	15	0.45	0.23	15	6.7%	0.48 [-0.25, 1.20]
Louie et al. (2021)	0.38	0.3	19	0.35	0.3	17	7.7%	0.10 [-0.56, 0.75]
Palmcrantz et al. (2021)	0.29	0.14	16	0.35	0.24	15	6.9%	-0.30 [-1.01, 0.41]
Sczesny-Kaiser et al. (2019)	0.56	0.23	8	0.8	0.26	9	4.1%	-0.92 [-1.94, 0.09]
Stein et al. (2014)	0.49	0.36	12	0.52	0.25	12	5.8%	-0.09 [-0.89, 0.71]
Tanaka et al. (2019)	1.08	0.44	21	1.07	0.61	20	8.3%	0.02 [-0.59, 0.63]
Watanabe et al. (2014)	0.85	0.43	11	0.63	0.51	11	5.4%	0.45 [-0.40, 1.30]
Watanabe et al. (2017)	0.85	0.43	8	0.61	0.47	11	4.7%	0.51 [-0.42, 1.43]
Watanabe et al. (2021)	0.75	0.49	9	0.58	0.49	11	5.0%	0.33 [-0.56, 1.22]
Yeung et al. (2021)	0.45	0.29	14	0.32	0.31	17	6.8%	0.42 [-0.30, 1.14]
Total (95% CI)			234			235	100.0%	0.23 [0.01, 0.46]

Heterogeneity: Tau² = 0.07; Chi² = 20.96, df = 14 (P = 0.10); I² = 33%
Test for overall effect: Z = 2.01 (P = 0.04)



Walking speed

Fig 3 … ed mean differences in walking speed (meters per second) at post-intervention for overground robotic exoskele-ton tra…

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(B)研究結果為何?

6. 這篇系統性文獻回顧的整體結果為何？

(1) Walking ability : functional ambulation category

Study or Subgroup	Overground RE Mean	Overground RE SD	Overground RE Total	Conventional Mean	Conventional SD	Conventional Total	Weight	Std. Mean Difference IV, Random, 95% CI
D.-X. Li et al. (2021)	3.76	0.9	17	3.67	0.72	15	8.8%	0.11 [-0.59, 0.80]
Louie et al. (2021)	3	2.22	19	3	0.74	17	9.9%	0.00 [-0.65, 0.65]
Molteni et al. (2021)	2.71	1.12	38	2.69	1.49	37	20.6%	0.02 [-0.44, 0.47]
Palmcrantz et al. (2021)	3.5	1.48	16	3	1.48	15	8.4%	0.33 [-0.38, 1.04]
Wall et al. (2020)	2	1.3	16	2.5	1.3	16	8.6%	-0.37 [-1.07, 0.32]
Watanabe et al. (2014)	3.1	1.4	11	2.6	1.4	11	5.9%	0.34 [-0.50, 1.19]
Watanabe et al. (2017)	3	1.3	12	2.5	1.3	12	6.5%	0.37 [-0.44, 1.18]
Watanabe et al. (2021)	3.6	0.8	9	3	1	11	5.1%	0.63 [-0.28, 1.53]
Wright et al. (2021)	3.8	0.9	16	3.3	1.1	15	8.2%	0.49 [-0.23, 1.20]
Yeung et al. (2021)	3.3	1	14	3	1	17	8.3%	0.29 [-0.42, 1.00]
Yokota et al. (2019)	2.44	0.67	18	2	0.65	19	9.6%	0.65 [-0.01, 1.32]
Total (95% CI)			186			185	100.0%	0.21 [0.01, 0.42]

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 7.38$, $df = 10$ ($P = 0.69$); $I^2 = 0\%$

Test for overall effect: $Z = 2.02$ ($P = 0.04$)

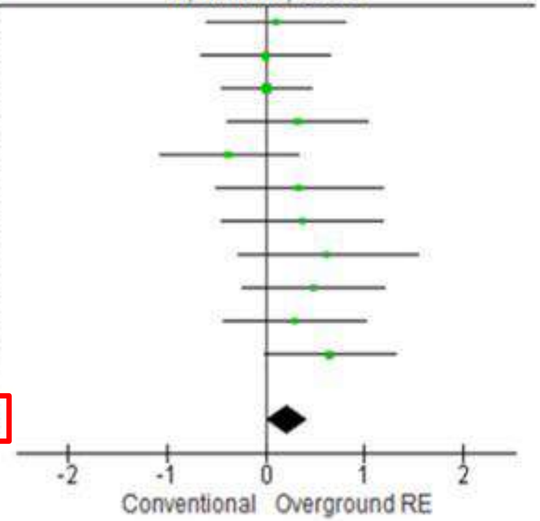

Fig 2 Forest plot of standardised mean differences in walking ability (functional ambulation category scores) at post-intervention for overground robotic exoskeleton training and control group.

其結果顯示: 在地面外骨骼機器人訓練後介入組相較於控制組的功能性行走能力有顯著提升

(B)研究結果為何?

6. 這篇系統性文獻回顧的**整體結果**為何？

(2)Walking speed : meters/second

Study or Subgroup	Overground RE Mean	Overground RE SD	Overground RE Total	Conventional Mean	Conventional SD	Conventional Total	Weight	Std. Mean Difference IV, Random, 95% CI
Buesing et al. (2015)	0.87	0.3	25	0.89	0.3	25	9.3%	-0.07 [-0.62, 0.49]
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Sczesny-Kaiser et al. (2019)	0.56	0.23	8	0.8	0.26	9	4.1%	-0.92 [-1.94, 0.09]
Stein et al. (2014)	0.49	0.36	12	0.52	0.25	12	5.8%	-0.09 [-0.89, 0.71]
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Watanabe et al. (2021)	0.75	0.49	9	0.58	0.49	11	5.0%	0.33 [-0.56, 1.22]
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Total (95% CI)			**234**			**235**	**100.0%**	**0.23 [0.01, 0.46]**

Heterogeneity: Tau² = 0.07; Chi² = 20.96, df = 14 (P = 0.10); I² = 33%
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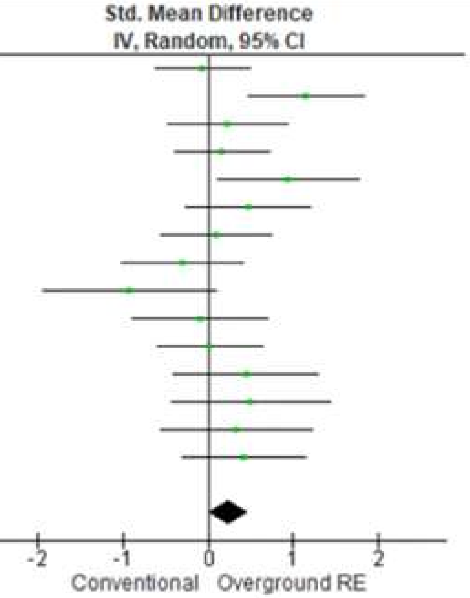

Fig 3 Forest plot of standardised mean differences in walking speed (meters per second) at post-intervention for overground robotic exoskeleton training and control group.

其結果顯示: 在地面外骨骼機器人訓練後介入組相較於控制組的行走速度有顯著提升

(B)研究結果為何?

6. 這篇系統性文獻回顧的整體結果為何？

(3)Walking endurance : meters walked with 6 min

Study or Subgroup	Overground RE Mean	Overground RE SD	Overground RE Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
D.-X. Li et al. (2021)	197.24	86.78	17	179.8	80.86	15	6.3%	0.20 [-0.49, 0.90]
Jayaraman et al. (2019)	380	195	25	330	130	25	9.9%	0.30 [-0.26, 0.85]
Louie et al. (2021)	117	112.7	19	93	84	17	7.1%	0.23 [-0.42, 0.89]
Molteni et al. (2021)	139.24	104.7	38	149.43	130.15	37	15.0%	-0.09 [-0.54, 0.37]
Palmcrantz et al. (2021)	87.64	51.73	16	110.19	79.37	15	6.1%	-0.33 [-1.04, 0.38]
Sczesny-Kaiser et al. (2019)	190.38	87.98	8	243.06	102.62	9	3.2%	-0.52 [-1.49, 0.45]
Stein et al. (2014)	213.4	108.2	12	194.8	83.2	12	4.8%	0.19 [-0.62, 0.99]
Wall et al. (2020)	24.67	26.85	16	29.42	39.26	16	6.4%	-0.14 [-0.83, 0.56]
Watanabe et al. (2014)	156.7	137.9	8	134.5	132.1	10	3.5%	0.16 [-0.77, 1.09]
Watanabe et al. (2017)	156.7	137.3	11	140.8	127.8	12	4.6%	0.12 [-0.70, 0.93]
Watanabe et al. (2021)	192.8	125.3	9	146.6	130.2	11	3.9%	0.35 [-0.54, 1.23]
Wright et al. (2021)	158	93	16	119	84	18	6.6%	0.43 [-0.25, 1.11]
Y. Li et al. (2021)	150.43	100.77	57	160.37	101.17	57	22.7%	-0.10 [-0.47, 0.27]
Total (95% CI)			**252**			**254**	**100.0%**	**0.04 [-0.14, 0.21]**

Heterogeneity: Tau² = 0.00; Chi² = 6.70, df = 12 (P = 0.88); I² = 0%

Test for overall effect: Z = 0.44 (P = 0.66)

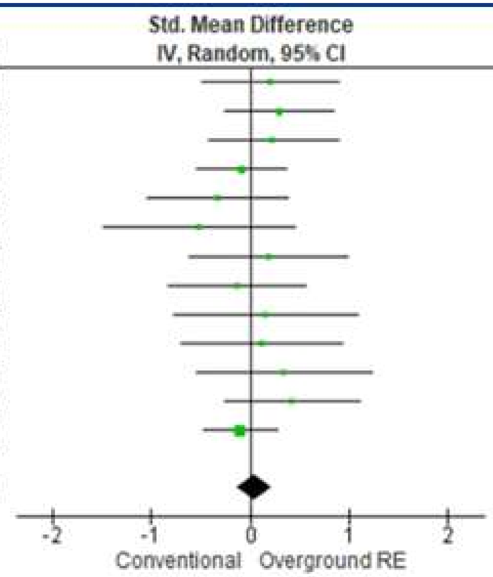

Fig 4 Forest plot of standardised mean differences in walking endurance (meters walked within 6 minutes, meter) at post-intervention for over-ground robotic exoskeleton training and control group.

其結果顯示: 在地面外骨骼機器人訓練後介入組相較於控制組的行走耐力速度**無**顯著提升

(B)研究結果為何?

7. 結果精準嗎？

(1) Walking ability : functional ambulation category

Study or Subgroup	Overground RE Mean	SD	Total	Conventional Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
D.-X. Li et al. (2021)	3.76	0.9	17	3.67	0.72	15	8.8%	0.11 [-0.59, 0.80]
Louie et al. (2021)	3	2.22	19	3	0.74	17	9.9%	0.00 [-0.65, 0.65]
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Yokota et al. (2019)	2.44	0.67	18	2	0.65	19	9.6%	0.65 [-0.01, 1.32]
Total (95% CI)			**186**			**185**	**100.0%**	**0.21 [0.01, 0.42]**

Heterogeneity: Tau² = 0.00; Chi² = 7.38, df = 10 (P = 0.69); I² = 0%
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Std. Mean Difference IV, Random, 95% CI

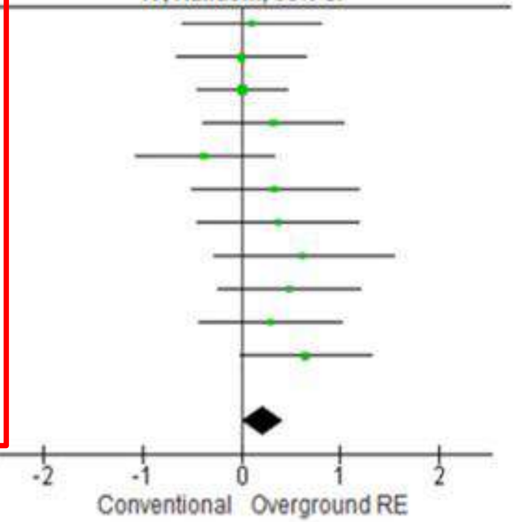

Fig 2 Forest plot of standardised mean differences in walking ability (functional ambulation category scores) at post-intervention for overground robotic exoskeleton training and control group.

(B)研究結果為何?

7. 結果精準嗎？

(2)Walking speed : meters/second

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Watanabe et al. (2017)	0.85	0.43	8	0.61	0.47	11	4.7%	0.51 [-0.42, 1.43]
Watanabe et al. (2021)	0.75	0.49	9	0.58	0.49	11	5.0%	0.33 [-0.56, 1.22]
Yeung et al. (2021)	0.45	0.29	14	0.32	0.31	17	6.8%	0.42 [-0.30, 1.14]
Total (95% CI)			234			235	100.0%	0.23 [0.01, 0.46]

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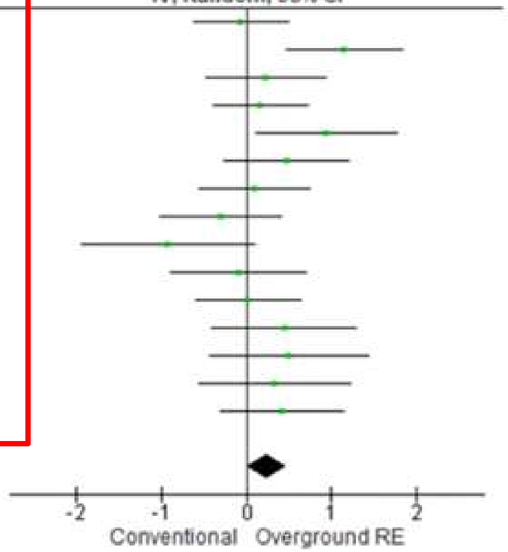

Fig 3 Forest plot of standardised mean differences in walking speed (meters per second) at post-intervention for overground robotic exoskeleton training and control group.

(B)研究結果為何?

7. 結果精準嗎？

(3)Walking endurance : meters walked with 6 min

Study or Subgroup	Overground RE Mean	Overground RE SD	Overground RE Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
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Total (95% CI)			**252**			**254**	**100.0%**	**0.04 [-0.14, 0.21]**

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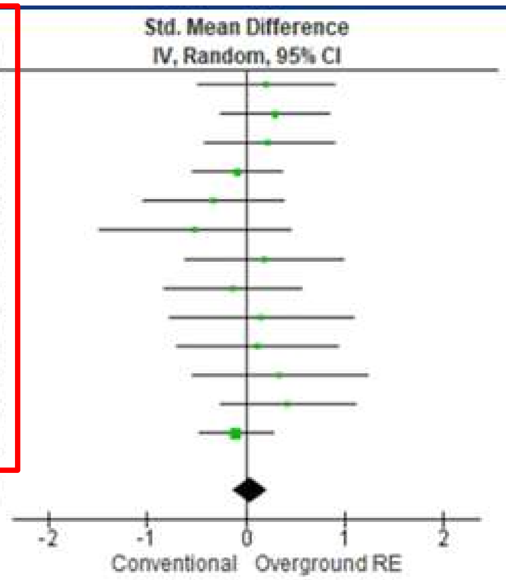

Fig 4 Forest plot of standardised mean differences in walking endurance (meters walked within 6 minutes, meter) at post-intervention for overground robotic exoskeleton training and control group.

(C)研究結果對於當地病人有幫助嗎?

8. 此研究結果是否可應用到當地的族群？

Table 2 Subgroup analyses of overground robotic exoskeleton training on walking ability in 11 trials

Category	Subgroups	No. of Trials (Reference)	Sample Size	SMD (*d*)	95% CI	Heterogeneity *P* Value of Chi-Square Test (I^2)	Overall Effect *Z* Value (*P* Value)	Test for Subgroup Difference *P* Value
Region	Asian	6[20,56,59–61,63]	166	0.39	0.08, 0.70	0.90 (0%)	2.48 (.01*)	.18
	Non-Asian	5[22,65–68]	205	0.08	−0.20, 0.35	0.55 (0%)	2.55 (.58)	
Phase of stroke	Acute stroke	2[20,61]	69	0.39	−0.14, 0.92	0.27 (19%)	1.43 (.15)	.53
	Subacute stroke	7[56,59,60,63,66–68]	240	0.14	−0.11, 0.40	0.83 (0%)	1.10 (.27)	
	Chronic stroke	2[22,65]	62	0.41	−0.10, 0.91	0.76 (0%)	1.58 (.11)	
Combined with conventional rehabilitation	Yes	6[20,22,56,61,65,66]	237	0.26	0.00, 0.52	0.69 (0%)	1.99 (.05)	.71
	No	5[59,60,63,67,68]	134	0.18	−0.16, 0.52	0.67 (0%)	1.04 (.30)	
Ambulatory status before training	Dependent walker	4[20,56,67,68]	131	0.06	−0.28, 0.41	0.86 (0%)	0.36 (.72)	.23
	Independent walker	4[59–61,63]	103	0.51	0.12, 0.91	0.92 (0%)	2.55 (.01*)	
	Mixture*	3[22,65,66]	137	0.19	−0.15, 0.53	0.50 (0%)	1.11 (.27)	
Length of training session	≤30 min/session	5[56,59–61,63]	134	0.46	0.12, 0.81	0.94 (0%)	2.62 (.009**)	.11
	>30 min/session	6[20,22,65–68]	237	0.11	−0.15, 0.36	0.83 (0%)	0.82 (.41)	
Frequency of training	<4 times/week	6[22,56,59,60,63,67]	164	0.29	−0.02, 0.60	0.93 (0%)	1.85 (.06)	.62
	≥4 times/week	5[20,61,65,66,68]	207	0.19	−0.09, 0.46	0.41 (0%)	1.32 (.19)	
Duration of training	<6 weeks	7[20,60,61,63,65,66,68]	242	0.22	−0.04, 0.47	0.61 (3%)	1.66 (.10)	.82
	≥6 weeks	4[22,56,65,67]	129	0.26	−0.08, 0.61	0.79 (0%)	1.49 (.14)	

Abbreviations: CI, confidence interval; FAC, Functional Ambulation Category.
* $P < .05$.

評讀的面向	
✔	病人與本地族群亞洲與非亞洲文獻與人次無統計學上差異
	使用器材部分是相同
	訓練模式, 時間, 頻率不一定

是	
不明確	V
否	

(C)研究結果對於當地病人有幫助嗎?

9. 是否所有**重要的臨床結果**都有被考量到？

評讀的面向	
✓	Walking ability
✓	Walking speed
✓	Walking endurance
	balance
	Quality of live
	ADL function

是	
不明確	V
否	

(C)研究結果對於當地病人有幫助嗎?

10.付出的傷害和花費換得介入措施所產生的益處是否值得？

評讀的面向	
✔	高費用
	傷害
✔	時間成本、便利性

是	
不明確	V
否	

下肢外骨骼機器人是否可改善中風病人的功能性行走能力?

同意: 13位

不同意: 0位

需要更多文獻支持: 16位

感謝聆聽，請多指教!