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Published in:
PLoS ONE

DOI:
10.1371/journal.pone.0219781

Publication date:
2019

Document Version
Publisher's PDF, also known as Version of record

Link to publication in ResearchOnline

Citation for published version (Harvard):
Arienti, C, Lazzarini, S, Pollock, A & Negrini, S 2019, 'Rehabilitation interventions for improving balance following stroke: an overview of systematic reviews'. PLoS ONE, vol. 14, no. 7, e0219781. https://doi.org/10.1371/journal.pone.0219781

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RESEARCH ARTICLE

Rehabilitation interventions for improving balance following stroke: An overview of systematic reviews

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Abstract

Background
The aim of this study was to synthesize evidence from systematic reviews, to summarise the effects of rehabilitation interventions for improving balance in stroke survivors.

Methods
We conducted an overview of systematic reviews (SRs). We included Cochrane Systematic Reviews and non-Cochrane Systematic Reviews of randomized-controlled clinical trials and not-randomized clinical trials, in all types of stroke, comparing the effects of interventions, control interventions and no interventions on balance-related outcomes. We conducted a comprehensive search of electronic databases, from inception to December 2017. Data extracted included: number and type of participants, type of intervention, control intervention, method of assessing risk of bias of primary studies, balance outcome measures and results of statistical meta-analyses. Methodological quality of included reviews was assessed using AMSTAR 2. A narrative description of the characteristics of the SRs was provided and results of meta-analyses summarised with reference to their methodological quality.

Results
51 SRs (248 primary studies and 10,638 participants) met the inclusion criteria and were included in the overview. All participants were adults with stroke. A wide variety of different balance and postural control outcomes were included. 61% of SRs focussed on the effectiveness of physical therapy, 20% virtual reality, 6% electromechanical devices, 4% Tai-Chi, whole body vibration and circuit training intervention, and 2% cognitive rehabilitation. The methodology of 54% of SRs were judged to be of a “low or critically low” quality, 23% “moderate” quality and 22% “high” quality.
Conclusions
There are 51 SRs of evidence relating to the effectiveness of interventions to improve balance in people with stroke, but the majority of these are of poor methodological quality, limiting our ability to draw clear implications. Only 22% of these SRs were judged to be of high quality, highlighting the need to address important methodological issues within rehabilitation research.

Introduction
Stroke is defined by the World Health Organization (WHO) as “a clinical syndrome consisting of rapidly developing clinical signs of focal (or global in case of coma) disturbance of cerebral function lasting more than 24 hours or leading to death with no apparent cause other than a vascular origin” and it is a leading cause of death and disability in many Western nations [1]. In Australia, the UK and the USA, stroke represents one of the 10 main causes of long-term physical disability [2–5].

The main deficit caused by stroke is motor impairment, which can be described as loss or limitation of muscle control function or movement, or limitation in mobility. It typically affects the control of movement of the face, arm and leg on one side of the body and is present in about 80% of patients [6]. Almost two-thirds of stroke survivors have initial mobility deficits, and six months after stroke, more than 30% of survivors still cannot walk independently [7]. Walking difficulties can have a major impact on stroke survivors, limiting ability to independently perform daily activities and having a negative impact on quality of life. Loss of balance when walking is common after stroke, with 70% of stroke survivors living at home reported to fall within a year of their stroke [8]. Muscle weakness and loss of voluntary movements are common problems immediately following a stroke and these contribute to reduced walking speed, which is a characteristic sign of post-stroke gait [9]. Marked temporal and spatial inter-limb asymmetries are also common, occurring in 48% to 82% and 44% to 62% of post-stroke subjects respectively; these asymmetries are correlated with impaired standing balance control during gait [10].

Generally, a key rehabilitation goal for stroke survivors is to improve walking, in order to enhance opportunities for participation in social activities and return to work [7]. Various rehabilitation approaches, founded on theories and knowledge of motor recovery and brain neuroplasticity[11], have been used to improve balance and, consequently, gait after stroke. However, there continues to be considerable controversy and debate about the relative effectiveness of different approaches to rehabilitation [12]. In order to provide optimal rehabilitation to an individual stroke survivor, a health professional needs to be able to select the most appropriate intervention, based on knowledge of the evidence of effectiveness of different interventions, and taking into account patient preference, resources and clinical setting [13].

Evidence relating to the effectiveness of interventions to improve balance is often synthesised within intervention-specific reviews, where measures of balance are reported as one of many (generally secondary) outcomes. The quantity, focus and structure of these systematic reviews (SRs) arguably create barriers to access and interpretation of evidence relating to the relative effect of different rehabilitation interventions on balance, and consequently these reviews often fail to support efficient healthcare decision making. An overview of reviews has the potential to enhance access to evidence which is dispersed across multiple SRs. This relatively new methodological approach provides a way to systematically synthesise evidence of
the effect of a range of different interventions on one specific outcome, such as balance. Overviews have been developed to address the growing problem of information overload, providing a way to filter large bodies of complex evidence in order to inform healthcare decision-making [14].

Therefore, the aim of this study was to systematically synthesise evidence from systematic reviews in order to summarise the effects of rehabilitation interventions for improving balance in stroke survivors.

Materials and methods

This overview was carried out in accordance with the latest guidance from the Cochrane Handbook for Systematic Reviews of Interventions [15] and reported following the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement [16]. All analyses were based on previous published studies, and thus no ethics approval or patient consent were required. The overview protocol was registered on PROSPERO (no. CRD42018095998).

Search strategy

The search strategy involved searching the following electronic databases: MEDLINE (Pubmed), EMBASE, Cochrane Library, CINAHL, PsycINFO, Campbell Systematic Reviews, Database of Abstracts of Reviews of Effects, Epistemonikos, Joanna Briggs Institute Database of Systematic Reviews and Implementation Reports and International prospective register of systematic reviews, from inception until December 2017. The following keywords were used, customized for each database using the Patient, Intervention, Comparison/control, Outcomes (PICO) approach: "stroke", "balance", "rehabilitation", "postural control", with the filters: "systematic review". There were no date or language restrictions. Further, we hand-searched key Governmental and organisational websites (such as: Evidence for Policy and Practice Information and Co-ordinating Centre, National Institute for Health and Care Excellence, The Community Guide) and the reference lists of included studies. The complete search strategy is reported in the S1 Table.

Following completion of our overview, one reviewer updated the searches from January 2018 to May 2019, identified potentially new SRs, and judged whether review findings were likely to change the conclusions of this overview. As it was judged that there was unlikely to be any impact on our overview conclusions, potentially new SRs have not been integrated into the overview results but, for transparency, have been referenced and discussed in the ‘limitations’ section.

Selection criteria

Two reviewers independently reviewed the citations identified in the search, and full text articles of potentially relevant studies were obtained and assessed for inclusion. In instances of disagreement between the 2 reviewers, eligibility was resolved through discussion with a third reviewer.

The inclusion criteria are described below.

Type of studies. We included all Cochrane Systematic Reviews (CSRs) and non-Cochrane systematic reviews (non-CSRs) of randomized-controlled clinical trials and not-randomized clinical trials, that collated empirical evidence, and met our pre-specified eligibility criteria. These criteria included that the systematic review aimed to answer a specific research question, and used explicit and systematic methods to minimize bias, thus providing reliable findings from which conclusions can be drawn and decisions made [17].

Type of participants. We included systematic reviews regardless of whether they combined data within meta-analyses or not, in which the participants were adults and had any type
of stroke (acute, sub-acute, and chronic), in accordance with the WHO definition. We excluded systematic reviews which included participants who had diseases other than stroke which could impact on balance, such as Parkinson’s disease, cerebral traumas, multiple sclerosis, medications, ear infections and other infections, benign paroxysmal positional vertigo or positional vertigo, labyrinthitis, Ménière’s disease, vestibular neuritis, perilymph fistula, mal de Debarquement syndrome, arthritis, eye muscle imbalance.

**Type of interventions.** We included all rehabilitation interventions that were aimed at promoting balance during maintenance of a posture, restoration of a posture or movement between postures and during gait, including orthosis and excluding prosthetics. Further, we also included interventions which were focused on improving physical functioning and motor impairment in which balance was an outcome. We excluded non-rehabilitation interventions, such as surgery and/or pharmacological treatments. We did not place any restrictions on the setting in which the intervention was delivered, or on the timing of the intervention (i.e. stage of recovery or length of time post stroke).

**Types of outcome measures.** We pre-defined the following as relevant balance outcome measures:

1. General balance outcomes: Berg Balance Scale (BBS), Tinetti balance scale, Brunel balance assessment (BBA).
2. Risk of falls scale: Falls Efficacy Scale (FES).
3. Sitting balance control: Trunk Impairment Scale (TIS) and Motor Assessment Scale (MAS).
4. Standing and static balance: stabilometry platform and postural sway indicated by balance outcome measures.
5. Dynamic balance assessment tests: Timed Up & Go test (TUGT) and Step test (ST).
6. Dynamic balance assessment devices: these include devices which perturb balance, such as balance boards or moving platforms, and involve assessing response to different types of perturbation, such as sudden perturbation or continuous perturbation, using a range of different types of dynamic or static conditions [18].

For inclusion, systematic reviews had to report data relating to at least one of these outcomes of interest. We also evaluated the number of adverse events as an additional outcome, but reporting of adverse events was not an inclusion criteria.

**Data extraction and management**

One reviewer utilized a standardized form to conduct the data extraction. Data extracted was independently checked by a second reviewer, and any disagreements were resolved through discussions with a third reviewer.

Specifically, information collected included:

- Systematic review publication details: title, authors and year of publication.
- Number, type and characteristics of included studies.
- Number and characteristics of participants
- Rehabilitation intervention details: type, dose, intensity and frequency
- Control intervention details: type, dose, intensity and frequency
- Method of assessment of quality of the primary studies included in each SR
• Balance outcome measures
• Results of systematic reviews and any meta-analyses: effect size, standard deviations and measures of heterogeneity, and statistical significance of results.

All extracted data were summarised within tables and/or graphical representations.

Assessment of methodological quality of included reviews
We used the AMSTAR 2 [19] tool to assess the methodological quality of the included SRs. This was a change to our published protocol in which we stated that we intended to use the ROBIS assessment tool [20]. This change was informed by evidence suggesting that AMSTAR 2 may be easier to apply, whilst maintaining similar measurement properties as the ROBIS [21,22]. The AMSTAR 2 [19] is not designed to generate an overall ‘score’ and it is important to note that a high score may disguise critical weaknesses in specific domains. Critical weaknesses could relate to: failure to register a protocol before commencement of the review (item 2); adequacy of the literature search (item 4); justification for excluding individual studies (item 7); risk of bias (RoB) of individual studies included in the review (item 9); appropriateness of meta-analytical methods (item 11); consideration of RoB when interpreting the results of the review (item 13); assessment of presence and likely impact of publication bias (item 15). We used a process of considered judgement to interpret weaknesses detected by these critical items and to reach consensus on the methodological quality of the included reviews. Two independent assessors (CA, SGL) applied this instrument to all included systematic reviews, with any disagreements resolved through discussion with a third assessor (SN).

Data synthesis
We produced a narrative description of the characteristics of the included SRs. We also considered differences between reviews in relation to the: participants, interventions, duration of follow-up, and type of data analysis. We synthesized the main findings relating to the effects of the interventions studied, with reference to the methodological quality of included SRs. We grouped our synthesised evidence within the following categories:
• Systematic Reviews with high methodological quality
• Systematic Reviews with moderate methodological quality
• Systematic Reviews with low and critically low methodological quality

Results
Our search identified 1086 SRs and, after duplicates were removed and eligibility screened against the inclusion and exclusion criteria, 1016 were excluded at the title and abstract stage. Seventy-one full-text articles were obtained and screened, with 51 SRs meeting the inclusion criteria and therefore included in this overview (Fig 1). Of these, 39 were non-CSRs and 12 were CSRs.

Description of included reviews
We included a total of 51 SRs (excluding duplicates, 248 primary studies and 10,638 participants) in which all participants were adults with ischemic and haemorrhagic stroke in all stages (acute, subacute and chronic). 46 of the included SRs only included randomized-controlled trials (RCTs), while 5 included non-randomised evidence (NRCTs) in addition to RCTs. The number of included trials within each SR ranged from 2 to 64 with a mean of 9.96±10.91, and
the number of participants in these trials ranged from 3 to 250 with a mean of $40.09\pm34.20$. 39 of the included SRs conducted a meta-analysis relevant to this overview (i.e. reporting an outcome relevant to balance). The outcomes for which data were combined within meta-analyses included Berg Balance Scale (BBS), TUG test (TUGT), Tinetti score, sitting and standing balance and centre of pressure sway (Table 1). 61% of SRs focused on the effectiveness of physical therapy as defined by World Confederation for Physical Therapy [23], 20% focused on virtual reality, 6% on electromechanical device, 4% on whole body vibration, Tai-Chi interventions and interventions for eye movement and visual field defects, 2% on cognitive rehabilitation.
Table 1. Overview of key characteristics of included reviews.

| Review               | Trials (n) | Interventions                                      | Methodology quality assessment | Outcomes                                                                 | AMSTAR judgement of review quality |
|----------------------|------------|----------------------------------------------------|--------------------------------|--------------------------------------------------------------------------|------------------------------------|
| **Cochrane Reviews (CSRs)** |            |                                                    |                                |                                                                          |                                    |
| Barclay-Goddard 2004 | 7 (245)    | Visual or auditory force platform feedback         | Jadad (1–3)                    | BBS, TUGT, Centre of Pressure Position (Stance symmetry), Centre of Pressure Behaviour (sway) | Moderate                           |
| Bowen 2013           | 0          | Cognitive rehabilitation                          | RoB Cochrane Tool (NR)         | BBS, FRT, ST, Get up and Go test, Standing Balance test                  | High                               |
| English 2017         | 11 (935)   | Circuit class therapy                             | RoB Cochrane Tool (NR)         | TUG, BBS, ST and ABC Scale                                              | High                               |
| French 2016          | 14 (766)   | Repetitive task training                          | RoB Cochrane Tool (NR)         | Sitting balance/reach: Reaching distance, Sitting Equilibrium Index, MAS—Balance Sitting subscale, Lateral reach—time to return to quiet sitting Standing balance/reach: BBS, Upright Equilibrium Index, FRT, ABC Scale, TBT | High                               |
| Laver 2017           | 13 (320)   | Virtual reality                                   | RoB Cochrane Tool (NR)         | BBS, BBA, FRT, POMA, Forward reach test, FES, PASS, BPM                | High                               |
| Lawrence 2017        | 2 (69)     | Yoga                                               | RoB Cochrane Tool: high risk of bias | BBS, ABC Scale                                                          | High                               |
| Mehrholz 2011         | 2 (38)     | Water-based exercises                              | RoB Cochrane Tool (NR) PEDro Scale (5–6) | BBS                                                                      | High                               |
| Pollock 2011 (a)      | 0          | Interventions for eye movement disorders           | RoB Cochrane Tool (NR)         | BBS, FRT, ST, Get up and Go test, Standing Balance test                  | High                               |
| Pollock 2011 (b)      | 0          | Intervention specifically targeted at improving the visual field defect or improving the ability of the participant to cope with the visual field loss | RoB Cochrane Tool (NR)         | BBS, FRT, ST, Get up and Go test, Standing Balance test                  | High                               |
| Pollock 2014          | 11 (509)   | Physical rehabilitation                           | RoB Cochrane Tool (NR)         | BBS                                                                      | High                               |
| Saunders 2016         | 19 (1128)  | Physical fitness training                         | RoB Cochrane Tool (NR)         | BBS, FRT, TIS, Four Square Step Test, TBT, Postural Sway                | High                               |
| Vloothuis 2016        | 3 (139)    | Caregiver-mediated exercise in addition to usual care or instead of usual care | RoB Cochrane Tool: 1 unclear risk of bias, 2 low risk of bias | BBS, PASS                                                              | High                               |
| **Non-Cochrane Reviews (non-CSRs)** |            |                                                    |                                |                                                                          |                                    |
| An 2011               | 10 (650)   | Exercise-Based Rehabilitation                      | PEDro Scale (4–8): 7 High quality, 3 Lower quality | BBS, Shifting centre of gravity movements, TUGT, SRT, COP variability and total excursion | Critically low                      |
| Bank 2016             | 11 (428)   | Additional physiotherapy to standard physiotherapy | PEDro Scale (4–7)              | TCT, TIS, PASS-TC, Symmetry Index, MAS—Balance Sitting subscale, Sitting Equilibrium Index | Low                                |
| Bonini-Rocha 2018     | 3 (174)    | Circuit-based exercise                             | PEDro Scale (5–8): 2 High quality, 1 low quality RoB Cochrane Tool (NR) | BBS                                                                      | Moderate                           |
| Cabanas-Valdés 2013   | 11 (308)   | Trunk training exercises                           | PEDro Scale (3–8): 6 High quality, 5 low quality RoB Cochrane Tool (NR) | mRT, TIS—Static Sitting Balance subscale, TIS—Dynamic Sitting Balance subscale, TIS—Coordination subscale, BWD, Romberg test, BBS, FTBS, Tinetti score, BBA | Critically low                      |
| Chen BL 2015          | 9 (833)    | Traditional Chinese exercises                      | RoB Cochrane Tool: High risk of bias | BBS, TUGT, FMA—Balance subscale, limit of stability, SOT, SPPB—Balance subscale | Moderate                           |
| Chen J 2015           | 2 (54)     | Tele rehabilitation                                | RoB Cochrane Tool: Low risk of bias | BBS                                                                      | Low                                |
| Chen L 2016           | 5 (204)    | Sling exercise training                            | Modified Jadad Scale           | BBS, SA, SL, Bio Rescue measures, PASS                                   | Critically low                      |

(Continued)
| Review                    | Trials (n) | Interventions                                           | Methodology quality assessment                      | Outcomes                                                                 | AMSTAR judgement of review quality |
|---------------------------|------------|---------------------------------------------------------|------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------|
| Chen Ling 2016            | 9 (265)    | Virtual reality                                        | PEDro Scale (4–9): 2 fair quality, 6 good quality, 1 excellent quality | BBS, TUGT, Static and Dynamic balance assessed by force platform          | Critically low                    |
| Cheok 2015                | 2 (42)     | Additional Wii                                         | PEDro Scale (5–8): 1 good quality, 1 fair quality   | RoB Cochrane Tool (NR)                                                   | Low                               |
| Corbeta 2015              | 9 (216)    | Virtual reality based rehabilitation replacing some or all of standard rehabilitation or virtual reality based rehabilitation used as extra rehabilitation time added to a standard rehabilitation regimen | RoB Cochrane Tool (NR)                               | BBS                                                                         | Low                               |
| de Rooji 2016             | 18 (433)   | Balance training using Virtual reality                 | PEDro Scale (3–8): 11 High quality, 7 Lower quality  | BBS, TUGT                                                                 | Moderate                          |
| Dos Santos 2015           | 3 (54)     | Rehabilitation with Nintendo Wii                       | PEDro Scale (4–7)                                    | BBS, TUGT, Pressure platforms                                             | Critically low                    |
| Ge 2017                   | 21 (1408)  | Traditional Chinese exercises                          | RoB Cochrane Tool (NR)                               | BBS, TUGT, FMA—Balance subscale                                         | Low                               |
| Hammer 2008               | 14 (638)   | Physiotherapy interventions aimed at restoring balance without extensive technical equipment | PEDro Scale (6–8): 6 High quality, 6 Medium quality, 2 Low quality | BBS, FRT, TUGT, MAS, STREAM, RMI, Posturography, ST, SRT                  | Critically low                    |
| Hancock 2012              | 2 (62)     | Lower limb reciprocal pedalling exercise               | RoB Cochrane Tool (NR)                               | PASS, PASS—Static subscale, PASS—Dynamic subscale, BBS, Get Up and Go    | Low                               |
| Iruthayarajah 2017        | 20 (468)   | Virtual reality (isolated or in combination with other therapies) | PEDro Scale (5–8): 17 good quality, 3 fair quality | Dynamic Balance: BBS, TUGT, FRT, 6MWT, 1MWT, 10MWT, 3MWT, ART, TST, 30SST, POMA, BBA Static Balance: COP path lengths and oscillations, Limit of stability, Postural sway path length and velocity, Stability Index, BWD, Symmetry Index | Critically low                    |
| Ko 2014                   | 6 (168)    | Lumbar stabilization exercises (on unstable bases of support) | PEDro Scale (5–8)                                    | TIS, TIS—Static Sitting Balance subscale, TIS—Dynamic Sitting Balance subscale, BBS, BBA, FRT, Tinetti test, Romberg eyes open, Romberg eyes closed, FTBS, SA, SP | Critically low                    |
| Kollen 2009               | 4 (224)    | Bobath Concept                                          | PEDro Scale (4–8): 4 High quality                   | BWD over hemiplegic and non-hemiplegic sides, MAS, BBS                   | Critically low                    |
| Langhorne 2009            | 12 (465)   | Interventions for motor recovery                        | N/R                                                  | BBS, BWD, Postural sway during sitting and standing                      | Moderate                          |
| Li 2016                   | 14 (334)   | Virtual reality                                         | RoB Cochrane Tool (2–4): 3 valued 2 points, 5 valued 3 points, 5 valued 4 points | BBS, TUGT, FRT, ABC Scale, BBA, Tinetti Gait and Balance Test, Sway velocity, BWD | Moderate                          |
| Lin 2018                  | 2 (67)     | Transcutaneous electrical nerve stimulation (TENS)       | Jadad Scale: High quality                            | TUGT, Postural sway velocity                                              | Low                               |
| Lu 2015                   | 3 (133)    | Whole Body Vibration                                    | RoB Cochrane Tool (NR)                               | BBS                                                                         | Critically low                    |
| Lubetzky-Vilnay 2010      | 20 (725)   | Balance training                                        | American Academy of Cerebral Palsy and Developmental Medicine Scale: 5-point scale from Level I to level V; within each level, quality was assessed based on 7 internal and external validity characteristics (Level I-IV, quality rating 4.5–7) | BBS, Postural Control and Balance Test, force platform measures of balance index, dynamic limits of stability, Brunnstrom stage, Number of falls, FMA — Balance subscale, Balance Index on the Kinesthetic Ability Trainer, COP displacement, ABC Scale, FES, DGI | Critically low                    |
| Luque-Moreno 2015         | 4 (99)     | Virtual reality                                         | PEDro Scale (6–7)                                    | BBS, ART, BBA, TUGT, ST, TST, 1MWT, 10MWT, 30SST, BPM, Postural sway, FMA | Critically low                    |

(Continued)
| Review          | Trials (n) | Interventions                        | Methodology quality assessment                                                                 | Outcomes                                                                 | AMSTAR judgement of review quality |
|-----------------|------------|--------------------------------------|-------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|-------------------------------------|
| Sorinola 2014   | 2 (53)     | Additional trunk exercises           | RoB Cochrane Tool: one moderate and one low risk of bias                                         | Upright equilibrium index, Tinetti Scale                                | Low                                 |
| Stoller 2012    | 3 (163)    | Early cardiovascular exercise        | PEDro Scale (6–8): good quality                                                                | BBS, FRT                                                               | Moderate                            |
| Swinnen 2014    | 9 (359)    | Robot-assisted gait training        | Evaluation of Quality of an Intervention Study checklist (56–81%) 7 true experimental, 3 pre-experimental studies | BBS, TUGT, Tinetti test, Postural sway tests, Romberg test            | Critically low                      |
| Tally 2017      | 8 (275)    | Treadmill training, isolated or with | PEDro Scale (5–9): 7 High quality, 1 Lower quality                                              | BBS, combination of directional postural sway and limits of stability assessment | Critically low                      |
| Tang 2015       | 19 (729)   | Interventions on improving balance self-efficacy | PEDro Scale (3–8): 1 poor, 4 fair, 14 good quality                                              | Balance self-efficacy: ABC Scale, FES-International and FES-Swedish version | Low                                 |
| Tyson 2013      | 5 (183)    | Walking with Ankle-Foot Orthosis     | RoB Cochrane Tool: low risk of bias                                                              | BBS, Postural sway, BWD while standing                                  | Moderate                            |
| Van Criekinge 2018 | 7 (184) | Trunk rehabilitation using unstable surfaces | PEDro Scale (4–8): 6 high risk of bias and 1 low risk of bias                                      | Sitting balance: TIS, TIS—Static Sitting Balance subscale, TIS—Dynamic Sitting Balance subscale, TIS—Coordination subscale, MAS—Balance Sitting subscale Standing balance: BBS, centre of gravity displacements, BBA—Standing subscale, MAS—Sitting to standing subscale, FICSIT-4 | Moderate                          |
| van Duijnoven 2016 | 43 (1522) | Exercise therapy                    | PEDro Scale (4–9): 34 High quality, 9 Moderate quality                                           | BBS, FRT, SOT, Mean postural sway velocity                              | Moderate                            |
| Van Peppen 2004 | 20 (658)   | Physical therapy                    | PEDro Scale (4–7)                                                                               | Postural symmetry sit-to-stand (BWD, vertical force difference between left and right, peak vertical ground reaction force through affected foot), Postural symmetry stand-to-sit (BWD, vertical force difference between left and right), Time needed to stand-up, Time needed to sit-down, Postural sway/symmetry, BBS, TUGT | Critically low                      |
| Van Peppen 2006 | 7 (177)    | Bilateral standing with visual feedback therapy | PEDro Scale (3–6)                                                                               | BWD while bilateral standing, postural sway in bilateral standing, BBS, TUGT | Critically low                      |
| Veerbeek 2014   | 64 (2469)  | Physical therapy                    | PEDro Scale (2–8)                                                                               | BBS, BBA, PASS, ST, FRT, LRT, TIS, SRT, FMA, BWD, STS, SST, ABC Scale, Sitting and standing symmetry, Sitting equilibrium test, Reach distance, Posturography, Static balance, Dynamic balance, Tinetti, Postural sway | Moderate                          |
| Wang 2015       | 9 (276)    | Cognitive motor interference        | RoB Cochrane Tool: High Risk of bias                                                            | SA, SD, BBS, TUGT, ABC Scale                                           | Low                                 |
| Wevers 2009     | 5 (241)    | Circuit class training              | PEDro Scale (4–8): high quality                                                                | BBS, ST                                                                | Critically low                      |
| Wist 2016       | 7 (291)    | Strengthening of the lower limbs    | RoB Cochrane Tool (NR)                                                                           | BBS, TUGT                                                             | Low                                 |
Methodological quality of included reviews

The results of AMSTAR 2 assessment are reported in Table 2. Our findings show that the main weakness was lack of protocol registration and there was generally very poor reporting, with only 16% of SRs adequately adhering to PRISMA reporting guidelines. 61% did not justify reasons for excluding individual studies and did not consider the RoB assessment when interpreting the results of the review. 63% did not evaluate the risks of publication bias but, despite that, 75% conducted meta-analysis using an appropriate meta-analytical method.

In summary, 55% of SRs were judged to provide “low/critically low” quality evidence, 23% to provide “moderate” quality evidence and only 22% to provide “high” quality evidence.

Interventions studied

We synthesized the main results of the included SRs by categorising their findings according to methodological quality of included SRs, organised by groups of interventions. For further details, see S5 Table. We based our grouping of SRs according to types of intervention, using the terminologies and descriptions provided within each SR.

Systematic reviews with high methodological quality: Physical therapy. Seven SRs focussed on physical therapy interventions and were judged to be of high methodological quality. All of these were CSRs and investigated the effectiveness of different physical approaches [24,25], repetitive task training [26], caregiver-mediated exercise [27], yoga [28], water-based exercises [29], circuit class therapy [30] on balance and postural control. All of these SRs used the GRADE approach to evaluate the quality of evidence [31].

Pollock 2014 [24] CSR reported, from 11 trials (509 participants), a significant beneficial effect of physical approaches with very low quality of evidence for the comparison of intervention versus no treatment and moderate quality evidence for the comparison of intervention versus usual care. No significant differences were found between subgroups in which the intervention included different treatment components. French 2016 [26] CSR, based on 14 trials

| Review   | Trials (n) | Interventions | Methodology quality assessment | Outcomes | AMSTAR judgement of review quality |
|----------|------------|---------------|--------------------------------|----------|-----------------------------------|
| Yang 2015 | 4 (186)    | Whole Body Vibration | RoB Cochrane Tool (NR)       | BBS      | Moderate                          |

(S2 Table). See S3 Table for the complete list of all included SRs, and trials included in these SRs, which have contributed to this overview. See S4 Table for the characteristics of the included SRs, including full details of the participants, interventions, comparisons and outcomes. No study reported any adverse events of rehabilitation interventions.
| Reference            | AMSTAR-2 Domains | Overall quality |
|----------------------|------------------|-----------------|
| **Cochrane Systematic Reviews** |                  |                 |
| Barclay-Goddard 2004 | Y N Y Y Y Y Y Y N Y N Y N Y              moderate |
| Bowen 2013           | Y Y Y Y Y Y Y Y N Y Y Y Y              high |
| English 2017         | Y Y Y Y Y Y Y Y N Y Y Y Y              high |
| French 2016          | Y Y Y Y Y Y Y Y N Y Y Y Y              high |
| Laver 2017           | Y Y Y Y Y Y Y Y N Y Y Y Y              high |
| Lawrence 2017        | Y Y Y Y Y Y Y Y N Y Y Y Y              high |
| Mehrholz 2011        | Y Y Y Y Y Y Y Y N Y Y Y Y              high |
| Pollock 2011a        | Y Y Y Y Y Y Y Y N Y Y Y Y              high |
| Pollock 2011b        | Y Y Y Y Y Y Y Y N Y Y Y Y              high |
| Pollock 2014         | Y Y Y Y Y Y Y Y N Y Y Y Y              high |
| Saunders 2016        | Y Y Y Y Y Y Y Y N Y Y Y Y              high |
| Vloothuis 2016       | Y Y Y Y Y Y Y Y N Y Y Y Y              high |
| **non-Cochrane Systematic Reviews** |                  |                 |
| An 2011              | Y N Y PY N N PY PY Y N NMA NMA N N NMA Y          critically low |
| Bank 2016            | Y Y Y PY Y PY PY PY Y N N N N N Y           low |
| Bonini-Rocha 2018    | Y N Y Y Y N Y Y Y N Y N N N Y           moderate |
| Cabanas-Valdés 2013  | Y N Y Y Y Y PY PY Y N NMA NMA N Y NMA Y     critically low |
| Chen BL 2015         | Y PY Y PY Y PY PY PY Y N Y Y Y Y          moderate |
| Chen J 2015          | N N Y PY Y PY PY PY Y N Y Y Y Y          low |
| Chen L 2016          | Y N Y PY Y PY PY PY Y N N N N N Y        critically low |
| Chen Ling 2016       | Y N N PY Y N N PY Y N NMA NMA Y N NMA Y      critically low |
| Cheok 2015           | N N Y PY Y Y Y PY PY Y N N N N N Y        low |
| Corbetta 2015        | Y N N Y Y Y N Y Y N Y N N N Y           low |
| de Rooij 2016        | Y N Y Y Y Y Y Y Y N Y N N N Y           moderate |
| Dos Santos 2015      | Y Y Y PY Y PY PY PY Y N NMA NMA N N NMA Y     critically low |
| Ge 2017              | Y N N PY Y Y PY PY Y N Y N Y Y Y          low |
| Hammer 2008          | N PY Y PY Y PY PY PY Y N NMA NMA N N NMA Y     critically low |
| Hancock 2012         | Y PY Y Y Y Y PY Y Y N NMA NMA Y Y NMA Y      low |
| Iruthayarajah 2017   | Y PY N PY N Y PY Y Y Y N Y N N N Y       critically low |
| Ko 2014              | N N N N Y Y N N Y N NMA NMA N N NMA Y     critically low |
| Kollen 2009          | Y N N PY Y PY PY PY Y N NMA NMA N N NMA Y     critically low |
| Langhorne 2009       | Y N Y Y Y Y Y Y Y Y N Y Y Y Y           moderate |
| Li 2016              | Y Y Y Y Y Y Y Y Y Y Y Y Y N Y N N Y N Y     moderate |
| Lin 2018             | Y Y N PY N N N PY Y N Y N N N N Y        low |
| Lu 2015              | N N N PY N N PY PY Y N N N N Y           critically low |
| Lubetzyk-Vilnay 2010 | Y N N PY N N N PY PY Y NMA NMA N N NMA Y    critically low |
| Luque-Moreno 2015    | N N Y PY Y N PY PY Y N NMA NMA N N NMA Y     critically low |
| Sorinola 2014        | Y Y Y PY Y PY PY PY Y N N Y N Y N         low |
| Stoller 2012         | Y PY Y Y Y Y Y Y Y Y Y Y N Y N N Y N Y     moderate |
| Swinnen 2014         | N N N PY Y N PY N PY N NMA NMA N N NMA Y     critically low |
| Tally 2017           | Y PY N PY Y PY PY Y PY Y N NMA NMA N N NMA Y     critically low |
| Tang 2015            | N Y Y PY Y N PY PY Y N Y N N N N Y        low |
| Tyson 2013           | N N Y PY Y N N PY Y N Y N Y Y Y           moderate |
| Van Crieginge 2018   | Y PY N Y Y Y Y PY Y N N Y N N Y           moderate |
| van Duijnshoven 2016 | Y PY Y PY N N PY PY Y N Y Y Y Y Y           moderate |

(Continued)
Stroke rehabilitation for improving balance

Table 2. (Continued)

| Reference           | AMSTAR-2 Domains |
|---------------------|------------------|
|                     | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Overall quality |
| Van Peppen 2004     | N  | N  | N  | PY | Y  | N  | PY | Y  | N  | NMA| N  | NMA| N  | N  | NMA| Y  | critically low |
| Van Peppen 2006     | N  | N  | Y  | PY | Y  | N  | PY | Y  | N  | NMA| N  | NMA| N  | N  | N  | Y  | critically low |
| Veerbeek 2014       | Y  | N  | Y  | Y  | Y  | Y  | Y  | Y  | Y  | N  | Y  | Y  | N  | Y  | N  | moderate      |
| Wang 2015           | Y  | N  | Y  | PY | Y  | Y  | PY | Y  | N  | N  | N  | Y  | Y  | Y  | low           |
| Wevers 2009         | Y  | N  | Y  | PY | Y  | N  | PY | Y  | N  | Y  | N  | N  | N  | N  | Y  | critically low |
| Wist 2016           | Y  | N  | Y  | Y  | Y  | PY | Y  | N  | Y  | N  | N  | N  | Y  | N  | Y  | low           |
| Yang 2015           | Y  | N  | N  | Y  | Y  | N  | PY | Y  | N  | Y  | Y  | Y  | Y  | Y  | Y  | moderate      |
| Total Yes           | 78%| 33%| 73%| 47%| 88%| 71%| 39%| 41%| 96%| 0% | 75%| 31%| 39%| 53%| 37%| 100%|

**Domains:**
1. Did the research questions and inclusion criteria for the review include the components of PICO?
2. Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol?
3. Did the review authors justify any significant deviations from the protocol?
4. Did the review authors explain their selection of the study designs for inclusion in the review?
5. Did the review authors perform study selection in duplicate?
6. Did the review authors provide a list of excluded studies and justify the exclusions?
7. Did the review authors provide a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review?
8. Did the review authors report the sources of funding for the studies included in the review?
9. Did the review authors report on the sources of funding for the studies included in the review?
10. Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?
11. If meta-analysis was performed did the review authors use appropriate methods for statistical combination of results?
12. If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?
13. Did the review authors account for RoB in individual studies when interpreting/discussing the results of the review?
14. Did the review authors account for RoB in individual studies when interpreting/discussing the results of the review?
15. If the review authors performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?
16. Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?

**Answers:**
Y = Yes; PY = Partial Yes; N = No; NMA = No meta-analysis conducted

https://doi.org/10.1371/journal.pone.0219781.t002

(766 participants), reported a statistically significant improvement of repetitive task training, with low quality of evidence. Saunders 2016 [23] CSR, based on 19 trials (1128 participants), reported significant beneficial effects of resistance training and mixed training and no effect of cardiorespiratory training, with high quality of evidence for all comparison with balance outcomes.

Vloothuis 2016 [27] CSR, based on 3 trials (139 participants), reported significant improvement of care-mediated exercise in addition to usual care, with low quality of evidence for balance in caregiver-mediated exercises compared with control intervention. Lawrence 2017 [28] CSR, with 2 trials (69 participants), and Mehrholz 2011 [29] CSR, with 2 trials (38 participants), reported no significant effect of yoga and water-based exercises, respectively, with very low quality of evidence.

English 2017 [30] CSR, based on 11 trials (935 participants), reported significant beneficial effects of circuit class therapy with low quality of evidence.

**Systematic reviews with high methodological quality: Other interventions.** Four CSRs evaluated the effectiveness of interventions for eye movement disorders and visual field defects [32,33], virtual reality [34] and cognitive rehabilitation [35] on outcome measures of balance. Pollock 2011a, b [32,33] CSR were not able to draw conclusions from their studies on balance outcomes because they found no studies. Laver 2017 [34] CSR, based on 13 trials (320 participants), reported significant improvement of virtual reality combined with usual care, but no improvement when comparing virtual reality to conventional therapy. GRADE judgement quality was not reported for the balance outcomes. Bowen 2013 [35] CSR found no relevant outcome data for evaluating cognitive rehabilitation effects on balance.

**Systematic reviews with moderate methodological quality: Physical therapy.** Eight moderate-quality reviews, 1 CSRs and 7 non-CSRs, evaluated the effect of exercise therapy
[36], moving platform and biofeedback using a force plate [37], ankle-foot orthosis [38], cardiovascular exercise [39], balance training, electromechanical-assisted gait training, circuit class training, mixed strength, cardiorespiratory exercise and high-intensity practice [40], trunk rehabilitation using unstable support surfaces [41], visual force platform feedback [42] and circuit-based exercise [43] on balance outcomes. van Duijnhoven 2016 [36] non-CSR, included 43 trials (1,522 participants), evaluating the effectiveness of exercise therapy compared with usual care on BBS. They reported a significative effect of exercise therapy. Langhorne 2009 [37] non-CSR, based on 12 trials (465 participants), reported a positive improvement of moving platform and an improvement of biofeedback using a force plate. Other interventions did not report any effect on balance outcomes. Tyson 2013 [38] non-CSR, based on 5 trials (183 participants), reported a significant effect of walking with an ankle-foot orthosis and weight distribution while standing. No significant effects were found on measures of postural sway. Stoller 2012 [39] non-CSR, based on 3 trials (163 participants), reported an improvement in balance after early cardiovascular exercise. Veerbeek 2014 [40] non-CSR, based on 64 trials (2,469 participants), reported significant improvements in sitting and standing balance as a result of sitting balance training, balance training during various activities, electromechanical-assisted gait training with ES, circuit class training, mixed strength and cardiorespiratory exercise and high-intensity practice. Van Criekinge 2018 [41] non-CSR, including 7 trials (184 participants), found that trunk rehabilitation using unstable support surfaces, except for the sling, showed larger improvements compared to stable support surfaces on balance sitting, but no consensus has been reached regarding the superiority of unstable support surfaces on standing balance. Barclay-Goddard 2004 [42] CSR, based on 7 trials (245 participants), reported no significant improvement as a result of visual force platform feedback and Bonini-Rocha 2018 [43] non-CSR, based on 3 trials (174 participants), found no significant improvement in response to circuit-based exercise.

Systematic reviews with moderate methodological quality: Other interventions. Four moderate-quality reviews investigated the effectiveness of virtual reality [44,45], traditional Chinese exercise [46] and whole-body vibration training [47] on outcome measures of balance. de Rooij 2016 [44] non-CSR, including 18 trials (433 participants) and Li 2016 [45] non-CSR, with 14 trials (334 participants), both found a significant improvement when a virtual reality intervention was compared with a similar time-dose of conventional intervention. They did not find significant results when virtual reality treatment was combined with conventional therapy.

Chen 2015 [46] non-CSR, based on 9 trials (833 participants), found that traditional Chinese exercise significantly improved all balance outcomes. Yang 2015 [47] non-CSR, with 4 trials (186 participants), showed no significant benefit of whole-body vibration training.

Systematic reviews with low and critically low methodological quality: Physical therapy. There were sixteen low or critically low non-CSRs which explored the effect of physical therapy interventions on balance outcomes. These provide evidence that the following interventions may have some beneficial impact on a measure of balance: trunk exercises (Sorinola 2014 [48], 2 trials, 53 participants) and more intense physical exercise-based interventions (Tang 2015 [49], 19 trials, 729 participants). These reviews reported no evidence of beneficial effects on balance outcomes for the following interventions: reciprocal pedaling exercise (Hancock 2012 [50], 2 trials, 62 participants); aerobic exercise (An 2011 [51], 10 trials, 650 participants); muscle strengthening of lower limb, progressive resistance training, aerobic exercise, task-specific training and functional electrical stimulation (FES) (Wist 2016 [52], 7 trials, 291 participants); training sit-to-stand transfers and vice versa, training standing balance and treadmill training (Van Peppen 2004 [53], 20 trials, 658 participants); lumbar stabilization exercises on stable and unstable surfaces (Ko 2014 [54], 6 trials, 168 participants); trunk
training exercise (Cabanas-Valdés 2013 [55], 11 trials, 308 participants); sling exercise training (Chen L 2016 [56], 5 trials, 204 participants); balance training and motor relearning program (Lubetzky-Vilnai 2010 [57], 20 trials, 725 participants); additional physiotherapy to standard therapy (Bank 2016 [58], 11 trials, 428 participants); Bobath technique (Hammer 2008 [59], 14 trials, 638 participants, and Kollen 2009 [60], 4 trials, 224 participants); cognitive motor interference (Wang 2015 [61], 9 trials, 276 participants); visual feedback therapy (Van Peppen 2006 [62], 7 trials, 177 participants); circuit class training (Wevers 2009 [63], 5 trials, 241 participants).

**Systematic reviews with low and critically low methodological quality: Virtual reality.** There were seven low or critically low quality non-CSRs which evaluated the effectiveness of virtual reality therapy on balance outcomes. These highlighted evidence that virtual reality may have some beneficial effects on balance (Corbetta 2015 [7], 9 trials, 216 participants, Chen Ling [64] 2016, 9 trials, 265 participants and Luque-Moreno 2015 [65], 4 trials, 99 participants). However use of the Nintendo Wii (Cheok 2015 [66], 2 trials, 42 participants, Dos Santos 2015 [67], 3 trials, 54 participants and Iruthayarajah 2017 [68], 20 trials, 468 participants) and tele-rehabilitation (Chen 2015 [69], 2 trials, 54 participants) were not found to result in any improvement to balance.

**Systematic reviews with low and critically low methodological quality: Other interventions.** There were five low or critically low quality non-CSRs which evaluated the effectiveness of treadmill training (Tally 2017 [70], 8 trials, 275 participants), robot-assisted gait training (Swinnen 2014 [71], 9 trials, 359 participants), transcutaneous electrical nerve stimulation (TENS) (Lin 2018 [72], 2 trials, 67 participants), whole-body vibration (Lu 2015 [73], 3 trials, 133 participants), traditional Chinese exercise (Ge 2017 [74], 21 trials, 1408 participants); none of these reported any evidence of beneficial effects on balance outcomes.

The rehabilitation interventions that may be considered effective on balance are reported in Table 3 and the methodological quality of each rehabilitation approach is showed in Fig 2.

**Discussion**

The aim of this overview of systematic reviews was to summarise evidence about the effectiveness of rehabilitation interventions for improving balance in stroke survivors.

This overview identified 248 primary studies, including more than 10,000 participants, combined within 51 SRs which contain evidence relevant to interventions to improve balance following stroke. However, there are very few SRs which are of high methodological quality (22%) and consequently this limits our ability to draw clear implications relating to the effectiveness of stroke rehabilitation interventions on balance. Those interventions for which there is evidence of a significant beneficial effect on balance include: exercise therapy, physical fitness training, care-mediated exercise in addition to usual care, repetitive task training, virtual reality and unstable support surface. Interventions for which there is no evidence of any significant benefit on balance include: yoga, water-based exercise, visual force platform feedback, lower limb reciprocal pedalling exercise, aerobic exercise, muscle strengthening, sitting and standing balance training, treadmill training, lumbar stabilization exercises, trunk training exercise, sling exercise training, exercise balance training, motor re-learning program therapy, cognitive motor therapy, Bobath technique, virtual therapy with Nintendo Wii and robot-assisted gait training have any effects. The evidence of traditional Chinese exercise, whole-body vibration training and circuit training effects is inconclusive.

This overview demonstrates that, while there is limited evidence showing benefit of some interventions, the quality of the evidence is insufficient to support firm conclusions relating to
Table 3. Effectiveness of rehabilitation interventions on balance.

| Systematic Reviews | Interventions Classification | Outcome | Intervention and comparison | Relative effect | Quality of evidence (GRADE) |
|--------------------|----------------------------|---------|----------------------------|----------------|-----------------------------|
| Saunders 2016      | Physical therapy           | BBS     | Mixed training vs Control intervention | Statistically significant benefit of intervention | High            |
| Saunders 2016      | Physical therapy           | Balance (BBS, FRT, Four Square Step Test, TBT) | Mixed training vs Control intervention | Statistically significant benefit of intervention | High            |
| Pollock 2014       | Physical therapy           | BBS     | Intervention vs attention control or usual care | Statistically significant benefit of intervention | Moderate        |
| Vloothuis 2016     | Physical therapy           | BBS     | Caregiver-mediated exercise as only intervention (CME-core vs Usual care) | Statistically significant benefit of intervention | Moderate        |
| English 2017       | Physical therapy           | TUGT    | Circuit class therapy vs Other interventions | Statistically significant benefit of intervention | Low             |
| French 2016        | Physical therapy           | Sitting balance/reach | Repetitive task training vs Attention control, usual care | Statistically significant benefit of intervention | Low             |
| Vloothuis 2016     | Physical therapy           | BBS     | Caregiver-mediated exercise in addition to usual care or instead of usual care vs Usual care | Statistically significant benefit of intervention | Low             |
| Vloothuis 2016     | Physical therapy           | PASS    | Caregiver-mediated exercise in addition to usual care or instead of usual care vs Usual care | NO statistically significant differences between groups | Low             |
| Vloothuis 2016     | Physical therapy           | Balance (BBS, PASS) | Caregiver-mediated exercise in addition to usual care or instead of usual care vs Usual care | Statistically significant benefit of intervention | Low             |
| Pollock 2014       | Physical therapy           | BBS     | Intervention vs no treatment | NO statistically significant differences between groups | Very low        |
| Pollock 2014       | Physical therapy           | BBS     | Intervention vs no treatment | NO statistically significant differences between groups | Very low        |
| Vloothuis 2016     | Physical therapy           | BBS     | Caregiver-mediated exercise in addition to usual care or instead of usual care vs Usual care | NO statistically significant differences between groups | Very low        |
| Vloothuis 2016     | Physical therapy           | BBS     | Caregiver-mediated exercise in addition to usual care or instead of usual care vs Usual care | NO statistically significant differences between groups | Very low        |
| Lawrence 2017      | Physical therapy           | BBS     | Yoga vs Waiting-list control | NO statistically significant differences between groups | Very low        |
| Chen BL 2015       | Tai Chi                    | BBS     | Traditional Chinese exercises vs No intervention or other treatment | Statistically significant benefit of intervention | Very low        |

BBS = Berg Performance Scale; FRT = Functional Reach Test; PASS = Postural Assessment Scale for Stroke patients; TBT = Timed Balance Test; TUGT = Timed Up and Go Test

the effectiveness of most balance rehabilitation interventions. The inability to draw conclusions relating to the effectiveness of balance rehabilitation is largely dependent on the methodological quality of the available evidence. This overview has highlighted several important methodological considerations which have impacted on the ability to draw conclusions from the current evidence base. There is an urgent need for improved methodological quality in order to generate evidence which can support clinical decisions relating to balance rehabilitation for stroke survivors.

Evidence from this overview demonstrates that some of the main methodological issues which need addressed in order to improve the evidence base for rehabilitation include: 1. the heterogeneity of primary studies; 2. assessment and interpretation of risk of bias (RoB) of primary studies; 3. absence of systematic assessment and interpretation of the overall quality of the evidence combined within a SR.
First, there was generally clinical heterogeneity across studies included within SRs, in terms of participants (type and phase of stroke), interventions (dose, intensity and frequency) and balance outcomes. Results from heterogeneous studies were often pooled within meta-analyses, impacting on the results and conclusions of SRs. It is important that meta-analyses only combine the results of studies which have sufficient homogeneity [75]. Second, in rehabilitation research, the optimal approach to evaluation of RoB is still debated and which tool to use remains unclear. Often several criteria related to the design, conduct and analysis of trials are aggregated into a unique scale and an overall score, despite the fact that there is widespread consensus that use of an overall score is not recommended [76–78]. Our overview found that most SRs (53%) used the Physiotherapy Evidence Database (PEDro) scale for the risk of bias assessment. While the PEDro scale is widely used [79,80], it does not contain items that are specific to the rehabilitation field, it has been suggested that the optimal approach to assessing RoB in trials of physical therapy is the Cochrane RoB tool, rather than using the summary score from the PEDro scale [76]. The use of the PEDro scale therefore created difficulty in our evaluation of the methodological quality of included SRs and our interpretation of their results [19]. The importance of incorporating RoB assessments in evidence synthesis is widely recognized and the quality of evidence involves consideration of within-study RoB (methodological quality), directness of evidence, heterogeneity, precision of effect estimates and risk of publication bias [77]. It would be good practice to evaluate the influence of RoB on treatment effect and to interpret the results on this [81], but in our overview, only 25% interpreted the results taking into account the RoB assessment and mainly they described the results as ‘not statistically significant’ or ‘statistically significant’ without evaluating the quality of evidence.

Other methodological issues which may influence the quality of evidence of SRs include [82]: the number of participants, which are often not enough to evaluate the impact of treatment; the description of interventions, which is often not sufficiently detailed to allow replication; and heterogeneity of outcome measures which do not enable statistical pooling of data using meta-analysis.

The management of these issues is a challenge and how best to address these within an overview of SRs method is still not well defined in literature [14]. The lack of alignment between PICO elements of overview questions and the aim of systematic reviews, and the overlap between primary studies, which may contribute data to more than one SR, can lead to challenges in the overview process. Furthermore, discordant RoB assessments of primary studies included in SRs can lead to difficulties in interpretation of results [13,83]. Therefore,
systematic evaluation of certainty of evidence arising from the overview is difficult to achieve for several different methodological reasons, including the lack of standard methods for overviews, the use of overall scores to summarise RoB assessment and the assessment of certainty of evidence. While the GRADE approach provides a systematic method for assessing the certainty of evidence, there remains uncertainty about the best way to implement this within overviews [84].

In conclusion, the evaluation of quality of evidence is central to our ability to use rehabilitation research to inform clinical practice. We found 51 SRs (248 primary studies, including more than 10,000 participants) which contain evidence relating to balance rehabilitation for stroke, but most of them were of low methodological quality, which limits the ability for this evidence to inform clinical decision making. There is a need for carefully planned SRs addressing research questions which are priorities of key stakeholders, and which are conducted according to the highest possible methodological standards, in order to inform clinical practice and support optimal patient outcomes.

Study limitations

The overview has some limitations. While it could be expected that there would be some overlap of primary articles within included SRs, we have not systematically explored these overlaps. Consequently, this may lead to inaccuracies in the reporting of data such as the numbers of participants and primary studies and may contribute to “double counting” of data within reported meta-analyses. Our findings—including assessments of certainty of evidence—are based on the information provided by the authors of the reviews, and we have not retrieved or evaluated data from any primary studies. Furthermore, we have grouped evidence according to different types of interventions, based on the terminology and descriptions provided within the SR; there may be considerable variations in the definitions used within individual SRs (for example, ‘physical therapy’), and this may have led to some inaccuracies in our categorisation of SRs. However, we used this approach to avoid introducing biases through our own interpretation of intervention descriptions. Our search is now out of date, as we conducted searches of databases up to December 2017. Running our searches from January 2018 to May 2019 identifies at least a further 7 other new SRs [85–91]. Exploration of these, by one reviewer, indicates that these would not change the conclusions within this overview. The issue of rapidly growing numbers of SRs highlights the challenges that healthcare decision makers and researchers face in relation to keeping up to date with evidence. Our overview finds that often there are large numbers of low quality reviews; to aid the evidence-based practice there is an urgent need for fewer high quality reviews, which do not overlap and which are maintained up to date.

Conclusion

There are 51 SRs of evidence relating to the effectiveness of interventions to improve balance in people with stroke, but the majority of these are of poor methodological quality, limiting our ability to draw clear implications. Only 22% of these SRs were judged to be of high quality, highlighting the need to address important methodological issues within rehabilitation research. SRs summarised within this overview do provide some limited evidence that rehabilitation interventions, including exercise therapy, repetitive task training, physical fitness training, care-mediated exercise, virtual therapy and use of unstable support surfaces, may be beneficial for people with balance impairment after stroke, but further research is necessary to be confident in this finding.
Supporting information

S1 Table. Search strategy.
(DOCX)

S2 Table. Type of intervention.
(DOCX)

S3 Table. List of reviews, interventions and trials that contributed to the overview.
(DOCX)

S4 Table. Characteristics of included reviews.
(DOCX)

S5 Table. Overview of reviews.
(DOCX)

S6 Table. Prisma 2009 checklist.
(DOC)

Acknowledgments

The overview has been registered on PROSPERO (n. CRD42018095998). The authors sincerely thank Dr. Elia Furlani for his technical support.

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