Guideline

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European Stroke Organisation (ESO) guideline on motor rehabilitation

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Abstract

Motor rehabilitation aims to help people after stroke to gain optimal motor functioning, independence and quality of life. This European Stroke Organisation (ESO) guideline provides updated, evidence-based support for clinical practice in six agreed critical areas: dose for upper limb and gait therapy, high-intensity gait training, effect of therapy transfer package, group versus individual therapy and sit-to-stand training. The guideline was developed according to ESO standard

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operating procedures and Grading of Recommendations, Assessment, Development and Evaluation (GRADE). Expert consensus statements are provided where a GRADE recommendation cannot be made due to insufficient evidence. For therapy dose, very low quality evidence supports a weak recommendation to provide an additional minimal dose of 20 h of repetitive upper limb practice to improve arm capacity. For gait, expert consensus suggests that an additional minimal dose of 20 h of walking practice could be beneficial for walking capacity. For high-intensity gait training, moderate quality evidence supports a strong recommendation for high-intensity gait training to improve walking endurance in people with chronic stroke and stable cardiovascular status, while low quality evidence supports a weak recommendation for improving walking speed. An expert consensus suggests using a transfer package when providing upper limb task-specific training to enhance transfer to daily life. For group therapy, a weak recommendation based on very low quality evidence suggests that task-specific group-based therapy is non-inferior to individual therapy for improving balance, gait speed and walking endurance. A weak recommendation based on moderate quality evidence suggests additional sit-to-stand training to improve balance.

Keywords
Guideline, stroke, motor rehabilitation, upper limb, lower limb, walking, gait, intensity, dosage

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Plain language summary

Movement deficits are common after stroke, making daily life activities difficult. This guideline is the first to focus specifically on motor rehabilitation after stroke. It provides specific recommendations in areas where clinical guidance is most needed. Its goal is to support healthcare professionals working with people with stroke, in order to improve motor function, activity capacity and performance, independence and participation in daily life.

The **recommendations** are the following:

More arm training

Adding more time spent in repetitive arm training to existing stroke rehabilitation programmes may improve arm function and activity. Although the exact amount of extra practice time in addition to standard programmes is uncertain, it should likely be at least 20 h, commonly delivered 3–5 times per week over 4–6 weeks.

More gait training

Spending more time on gait training can help improve walking capacity (longer distances and faster) in people with stroke. Similar to upper limb therapy, the exact amount of extra practice time in addition to standard programmes is unclear, but it should likely be at least 20 h, commonly delivered 3–5 times per week over 4–6 weeks.

Higher intensity of gait training

For people in the chronic phase after stroke, higher-intensity walking training is strongly recommended over lower-intensity walking training, for improving walking endurance and speed. People should not have heart problems and be medically stable, so that exercising at this intensity can be conducted safely.

Transfer package for real-life improvement

Although there is not enough evidence to make a recommendation, expert consensus suggests using a behavioural transfer package as a tool to ensure that benefits gained from upper limb therapy translate more effectively into real-life arm and hand use.

This package typically includes daily arm-hand use evaluations, a daily diary kept by the patient, problem-solving sessions, a behavioural contract, home practice of specific exercises and weekly follow-up contacts.

Group-based therapy

Task-specific training in a group is suggested to be as effective as individual training for improving balance, gait speed and walking endurance. Supervision is recommended to ensure safety. Expert consensus suggests offering group-based training in addition to individualised therapy to meet patients' goals and preferences.

Additional sit-to-stand training

Adding sit-to-stand training to usual care is recommended to improve balance. The extra sit-to-stand training should include a high number of repetitions and have an appropriate duration and frequency. However, the exact details of these parameters are not yet clear.

Implications for clinical practice and future research

Sufficient dose of therapy

The guideline highlights a lack of studies specifically evaluating the effects of therapy dose for arm and walking rehabilitation after stroke. However, consistent with previous evidence, the findings suggest that a higher therapy dose enhances motor outcomes, as well as training at a higher intensity. Further research is needed to refine what defines a 'sufficient dose' and how this dose could be efficiently provided in a healthcare setting.

Transfer package

The guideline highlights only one low-quality study investigating whether specific strategies to help apply therapy gains to daily life (behavioural transfer package) is effective. More research is needed to evaluate the potential benefits of a transfer package.

Group versus individual therapy

The guideline suggests that group therapy can be an effective and efficient alternative to individual therapy for improving balance, gait speed and walking endurance. This has implications for how rehabilitation services are organised and delivered.

Level of evidence

The overall quality of evidence in the guideline ranges from moderate to very low. This is mainly due to small sample sizes and differences in study protocols, assessments and comparators. Future motor rehabilitation research should focus on global trial collaborations to pool data and use consensus-based, recommended clinical assessments. This will help ensure consistency, improve comparability and enhance the overall quality of evidence.

Key recommendations and suggestions of the Guideline
Consider adding extra time of repetitive upper limb practice to existing stroke rehabilitation programmes. The exact amount of additional practice time is unclear but will likely be at least 20 h, commonly delivered 3–5 times per week over 4–6 weeks.
Consider adding extra time of walking practice to existing stroke rehabilitation programmes. The exact amount of additional practice time is unclear but will likely be at least 20 h, commonly delivered 3–5 times per week over 4–6 weeks.
Provide high-intensity walking training for people in the chronic stage of stroke with stable cardiovascular health, to improve walking endurance and consider this intervention to improve walking speed.
Consider a behavioural transfer package when providing repetitive upper limb task-specific training, to achieve a transfer from treatment to daily life. The transfer package would include daily evaluation, a patient-kept daily diary, problem-solving, behavioural contract, home practice of specified exercises, and weekly follow-up contacts.
Consider task-specific group-based therapy for the lower limb domain, which is at least as effective as individual therapy for improving balance capacity, gait speed, and walking endurance. Provide a reasonable ratio between patients and therapists to ensure safety and supervision. Offer this group-based therapy in addition to individualised therapy to address patients' goals and preferences.
Consider additional sit-to-stand practice on top of usual care to improve postural balance capacity. Include sufficient repetitions, training sessions and adequate duration and content of this additional training. What these parameters are is currently unclear.

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Introduction

Motor impairment that limits functioning in activities of daily living (ADL) and restricts participation in society at large is one of the most common consequences of stroke.[1] The International Classification of Functioning, Disability and Health (ICF)[2] describes motor functions as neuromusculoskeletal and movement-related functions, including muscle force and endurance, control over and coordination of voluntary movements and movement patterns associated with walking, transfers or upper body tasks. Impaired sensation, muscle tone, cognition, mood and fatigue, may co-exist with motor impairments and negatively influence functioning, recovery and rehabilitation.[3] Motor rehabilitation targets all these aspects of functioning with the overall goal of maximising people's independence, participation and well-being.[4]

Current global and regional calls for action emphasise the increased need for rehabilitation. 'Rehabilitation 2030' was launched by the World Health Organization (WHO) and addresses unmet rehabilitation needs across the world.[5,6] The European Stroke Action Plan 2030 describes actions needed to improve management, outcomes and quality of stroke rehabilitation.[3] In this context, the European Stroke Organisation (ESO), in agreement with the Neurorehabilitation committee of ESO, commissioned this guideline, the first with a focus on post-stroke motor

rehabilitation. As an initial step, we developed a consensus-based definition of motor rehabilitation supported by a framework providing a comprehensive and contemporary overview.[4]

Motor rehabilitation is defined as 'a process that engages people with stroke in order to benefit their motor function, activity capacity and performance in daily life. It is necessary for all people with residual motor disability whose goal is to enhance their functioning, independence, and participation'.[4] The core element of motor rehabilitation incorporates principles of motor control in which patients learn to optimise and adapt their motor, sensory and cognitive functioning through appropriately dosed, repetitive, goal-oriented, progressive, task- and context-specific training.[4]

The ESO definition and framework for stroke motor rehabilitation collected and synthesised evidence from five clinical practice national guidelines.[4] These guidelines make strong recommendations for various forms of repetitive task and goal-oriented practice, progressive resistance training, balance training and traditional or modified constraint induced movement therapy (CIMT) for upper limb.[4] A recent Cochrane review further presented that compared to no physical rehabilitation, physical rehabilitation may improve independence in activities of daily living (standardised mean difference (SMD) 1.32, 95% confidence interval (CI) 1.08–1.56; 52 studies, 5403 participants; low-certainty evidence) as well as motor function (SMD 1.01, 95% CI 0.80–1.22; 50 studies, 5669 participants; low-certainty evidence).[7] Current stroke research and guidelines stress the importance of early, intensive and prolonged therapy, but it is unclear how much therapy or what elements of therapy are most appropriate or effective at different stages of stroke. Recently, the UK and Ireland national clinical guideline for stroke specified that people with motor recovery goals undergoing rehabilitation after stroke should receive a minimum of 3 h of multidisciplinary therapy focusing on active exercise, motor training and/or task practice at least 5 days/week.[8] Similar recommendations on time spent in scheduled specific therapies have also been provided in other national guidelines, including from Australia and New Zealand, Sweden and the Netherlands.[9–11]

To develop this guideline, we identified gaps in research evidence to guide the selection of the most critical research questions.[4,12] We anticipated that it would not be possible to cover all potentially relevant questions within the field of motor rehabilitation and therefore focused on areas where specific clinical guidance was unclear, vague or missing. In this first guideline, we did not prioritise newer innovative therapies nor interventions that were currently recommended as adjuvant therapies (e.g. robot-assisted movement training, mental practice, mirror therapy, and electrical stimulation).[4]

The primary aim of this first guideline was to provide specific recommendations for clinicians and healthcare providers working in the field of stroke motor rehabilitation, in areas where the need for clinical guidance was most pressing. The prioritised research questions are specified as PICOs in this guideline. The derived recommendations can be used to guide future research and clinical practice across Europe and around the world, in the context of varied stroke rehabilitation needs, access, delivery and resources.

Methods

Composition and approval of the Module Working Group

These guidelines were initiated by the ESO. Two chairpersons (Geert Verheyden and Margit Alt Murphy) were selected to assemble and coordinate the guideline Module Working Group (MWG). The final group consisted of 17 multidisciplinary experts in the field of motor rehabilitation after stroke (Supplemental Table 1). The ESO Guideline Board and Executive Committee reviewed the intellectual and financial disclosures of all MWG members and approved the composition of the group. The details of all MWG members and their disclosures are included in Supplemental Table 1.

Development and approval of clinical questions

This guideline was prepared according to the ESO standard operating procedures (SOP),[13] which are based on the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) framework.[14] The MWG developed a list of topics and corresponding questions of greatest clinical interest. Questions were formatted using the PICO approach (Population, Intervention, Comparator and Outcome) and reviewed by two external reviewers, as well as members of the ESO Guideline board and Executive Committee. The outcomes were rated by members of the MWG as critical, important, or of limited importance according to GRADE criteria and a Delphi approach was used to reach a final decision. In total, six research questions were selected, which are presented with their respective critical outcomes in Table 1. International Classification of Functioning, Disability and Health (ICF) terminology is used for all outcomes.[2,4] Results of all outcomes ratings and the predefined inclusion and exclusion criteria for each PICO are available in Supplemental Tables 2 and 3.

In short, only (quasi-)randomised-controlled clinical trials (RCTs) in people with stroke and with at least 10 participants in each treatment arm were considered for inclusion. This was agreed to avoid conclusions based on strongly biased or underpowered studies. Publications with

Table 1. Research questions for this first ESO motor rehabilitation guideline and their respective critical outcomes.

PICO	Critical outcomes
1. In people with stroke, does adding at least 20 h or more of the same type of active repetitive upper limb practice produce greater improvements in upper limb motor function, activity capacity and performance?	Upper limb motor function, activity capacity and performance
2. In people with stroke, does adding at least 20 h or more of the same type of gait training produce greater improvements in walking independence, walking speed, walking endurance, and walking capacity?	Walking independence, speed, endurance, capacity
3. In people with stroke, does high-intensity walking training compared to dose-matched (duration) walking training at a lower intensity produce greater improvements in walking independence, walking speed, walking endurance and walking capacity?	Walking independence, speed, endurance, capacity
4. In people with stroke, does repetitive upper limb task-specific training with a behavioural transfer package compared to the same type of duration-matched training without a behavioural transfer package produce greater improvements in upper limb activity capacity, perceived and actual upper limb activity performance?	Upper limb activity capacity and performance
5. In people with stroke, does the provision of task-specific training in groups with at least 1:2 therapist-patient ratio compared to the same type of time-matched 1:1 training have the same effect on motor function, activity capacity and perceived performance?	Motor function, activity capacity and performance
6. In people with stroke, does the provision of usual care plus additional sit-to-stand training compared to usual care alone produce greater improvements in balance capacity, independence and time taken in sit-to-stand?	Activity capacity

International Classification of Functioning, Disability and Health (ICF) terminology is applied for all outcomes.[2,4]

only conference abstracts available were excluded. In studies with several groups of patients, all eligible groups were considered for inclusion.

For PICO 1 and 2, the dose contrast of at least 20 h between the compared groups was selected on the basis of recommendations available in previous research suggesting at least 17–30 h contrast between the groups.[15–22] In PICO 3, 'high-intensity' walking training was defined as 60%–84% Heart Rate Reserve (HRR), 77%–93% Heart Rate Maximum, or 14–16 Rating of Perceived Exertion (RPE) on the 6–20 Borg scale or similar.[23]

Literature search

Search terms were developed by the MWG for each PICO question. When a validated and recent search strategy was available to address one of the questions of interest, this was used or adapted as needed. For PICO 1 and 2, the Cochrane review by Clark et al.[15] was used to cover the search prior to 2021 and for PICO 6, the Cochrane review by Pollock et al.[24] was used to cover the search prior to 2013. For these PICOs, the lists of all included and excluded studies were screened independently by two reviewers against the set inclusion and exclusion criteria for the respective PICO. For PICO 5, a full search was conducted with a search strategy adapted from the Cochrane review by English et al.[25] Search strategies for all PICOs are provided in Supplemental Table 4.

The searches were performed by a MWG member (AMS) in CINAHL, MEDLINE and Embase databases in August and September 2023. The reference lists of relevant reviews were also considered for inclusion. Search results were loaded into the web-based Covidence platform (Health Innovation, Melbourne, Australia) for assessment by the MWG. Two or more MWG members per PICO were assigned to independently screen the titles and abstracts of publications identified through the search, and to independently assess the full text of studies for consideration of inclusion. All disagreements were resolved by discussion between the two reviewers or by a third MWG member. The search flowcharts for all six PICOs are presented in Supplemental Figures 1 and 2.

Data analysis

Data extraction was independently performed by two or more MWG members assigned to each PICO, and data analysis was performed by the ESO methodologist (AP). When relevant data were not reported in an eligible study, the corresponding author was contacted. When there was no response, the co-authors of the study were also contacted. If no answer was received, or no relevant data could be provided, data were considered missing. If applicable, source data presented as median and interquartile range (IQR) were recalculated to mean and standard deviation (SD).[26–28]

Where appropriate, random-effects meta-analyses were conducted using Review Manager software (RevMan, version 5.4. Copenhagen, Cochrane Collaboration 2020). Results were presented as estimates of effect with associated 95% confidence intervals (95% CIs). Statistical

Table 2. Strength of recommendations and corresponding recommendation formatting following the GRADE approach.

Strength of recommendation	Balance of desirable and undesirable consequences	Recommendation formatting
Strong recommendation for intervention	The desirable consequences clearly outweigh the undesirable consequences in most settings	'We recommend'
Strong recommendation against intervention	The undesirable consequences clearly outweigh the desirable consequences in most settings	'We recommend. . .not'
Weak recommendation for intervention	The desirable consequences probably outweigh the undesirable consequences in most settings	'We suggest'
Weak recommendation against intervention	The undesirable consequences probably outweigh the desirable consequences in most settings or when the balance between desirable and undesirable consequences is closely balanced or uncertain	'We suggest. . .not'
Ungraded consensus-based statement	The desirable consequences probably outweigh the undesirable consequences in most settings, but there is little evidence	'We suggest'

heterogeneity across studies was assessed using the I^2 statistic, and classified as moderate (⩾30%), substantial (⩾50%) or considerable (⩾75%).[29] Publication bias (Funnel plot or Egger's test) was not assessed due to the modest number of studies included in each meta-analysis (less than 10).[30]

For each PICO, the meta-analysis and summary estimates are presented for outcomes where data from at least two studies were available.[30] Pre-defined strategies were used to avoid multiple comparisons in the meta-analysis. In PICO 1, data from higher dose groups were pooled[31] or only the primary outcome assessment time point was used,[32] to avoid inclusion of the same participants in several comparisons. Whenever possible, the original scoring of the mean difference in improvement between groups, for an outcome of interest was prioritised over the standardised mean differences to allow clinical interpretation of the effect's magnitude. Sensitivity analysis excluding studies with high risk of bias was performed, if applicable.

Evaluation of the quality of evidence and formulation of recommendations

The risk of bias of each included RCT was assessed with the Cochrane Rob2 tool and visualised with robvis.[33,34] As recommended, the evidence synthesis did not use a quality 'score' threshold but classified overall risk of bias at outcome level and then in aggregate.[35] Results were imported into the GRADEpro Guideline Development Tool (McMaster University, 2015; developed by Evidence Prime, Inc.). For each outcome, the following were considered: risk of bias based on the type of available evidence (RCTs); considerations on inconsistency of results; indirectness of evidence, imprecision of results, and other possible bias. GRADE evidence profiles tables were generated and used to prepare recommendations. 'Evidence-based Recommendations' were based on the GRADE methodology. The direction, strength and formulation of the recommendations were determined according to the GRADE evidence profiles and the ESO-SOP (Table 2).[13,14]

Finally, expert consensus statements were added whenever the PICO group considered that there was insufficient evidence available to provide evidence-based recommendations. The expert consensus statements were based on voting by all expert MWG members. Importantly, these expert consensus statements should not be regarded as evidence-based recommendations, since they only reflect the informed opinion of experts in the field.

Drafting of the document, revision and approval

Each PICO question was addressed in distinct sections, in line with the updated ESO SOP.[13] First, 'Analysis of current evidence' synthesised current evidence followed by a summary and discussion of the results of the included RCTs. Second, 'Additional information' was added when more details on the studies referred to in the first section were needed, and to provide information on ongoing or future RCTs, systematic reviews or studies that could provide important clinical guidance on the topic. Third, an 'Expert consensus statement' paragraph was added whenever the MWG considered that the evidence available was insufficient to provide evidence-based recommendations for situations in which practical guidance is needed for everyday clinical practice. The Guideline document was reviewed by all MWG members and revised based on comments provided. The final submitted document was peer-reviewed by two external reviewers, two members of the ESO Guideline Board and one member of the Executive Committee of ESO.

Results

PICO 1 **In people with stroke, does adding at least 20 h or more of the same type of active repetitive upper limb practice produce greater improvements in upper limb motor function, activity capacity and performance?**

Analysis of current evidence. The systematic literature search identified three eligible RCTs.[31,32,36] Han et al.[31] ($n = 32$) evaluated the effect of therapy dosage in a 'motor relearning program' that included positioning and caring for the arm; passive, assisted and active movements; strength training and functional activities. Winstein et al.[36] ($n = 41$), evaluated the effect of higher dose in an 'Accelerated Skill Acquisition Program' that involved personalised task-oriented training incorporating skill acquisition, and capacity building with intrinsic motivational enhancements. Dromerick et al.[32] ($n = 72$), evaluated the effect of additional upper limb practice described as constraint-induced movement therapy programme without the constraint component. The programme included individualised shaping protocol based on the principles of motor learning of massed task-specific graded practice, intrinsic motivation and positive reinforcement.

The effect of higher dose was evaluated in the early subacute stage in Han et al.[31] (41 ± 26 days post-stroke) and in chronic stage in Winstein et al.[36] (2.5 ± 2.1 years post-stroke). Dromerick et al.[32] randomised all participants at 15.4 ± 4.5 days post-stroke, while the training in acute, subacute and chronic groups was delivered within the first month, 2–3 months and 6–7 months post-stroke, respectively. Practice in higher dose groups was commonly provided 3–5 times per week over a 4–6-weeks period.[31,32] Upper limb impairment at baseline was severe in Han et al.[31] (mean Fugl-Meyer Motor Assessment for the Upper Extremity, FMA-UE 7.3 ± 2.9), mild/moderate in Winstein et al.[36] (mean FMA-UE 42.8 ± 9.6), and diverse in Dromerick et al.[32] (mean Action Research Arm Test, ARAT 15.8 ± 13.8).

The risk of bias assessment for each included study is further presented in Supplemental Figures 3 and 4. The extracted critical outcomes of interest included upper limb motor function (FMA-UE),[31] activity capacity (ARAT and Wolf Motor Function Test, WMFT)[31,32,36] and upper limb activity performance (Motor Activity Log, MAL).[36] Extracted data of all critical outcomes and subgroups are shown in Supplemental Figure 5.

Critical outcomes. **Upper limb motor function** assessed by FMA-UE showed significantly greater improvement after a higher dosage of upper limb practice (60- or 90-h), delivered in the early subacute stage of stroke, compared to the lower dosage (30-h).[31] There was no significant difference in improvement between the two high-dosage groups. The risk of bias assessment showed some concerns due to potential deviations from intended trial protocol (no trial registration or protocol available), potential risk of drop-out and per-protocol analysis. Meta-analysis was not considered since only one study had evaluated the effect on upper limb function.

Upper limb activity capacity assessed by ARAT showed significantly greater improvement after a higher dosage of upper limb practice compared to the lower dosage in two studies performed in the subacute stage of stroke.[31,32] Han et al.[31] reported a significant effect of 60- and 90-h dosages in the early subacute stage of stroke compared to a 30-h dosage. There was no significant difference in improvement between the two high-dosage groups. Dromerick et al.[32] reported a significant beneficial effect over the course of 12 months post-stroke when an additional 20-h practice was delivered in the acute and subacute stage of stroke compared to the usual care group. The mean dosages in usual care groups were 28, 14, and 6 h in the acute, subacute and chronic stage, respectively. There was no effect of a higher dosage when the additional practice time was delivered in the chronic stage of stroke. In the analysis, the improvements in ARAT were compared between the groups over the course of 12 months after adjusting for baseline and days post-stroke. The overall risk of bias (Figure 1(a)) was low for Dromerick et al.[32] and some concerns were found in the study of Han et al. related to potential deviations from intended trial protocol, potential risk of drop-out and per-protocol analysis.[31]

Winstein et al.[36] investigated the effect of higher dosages and compared them to 0 h of practice in the chronic stage of stroke. Linear mixed effects regression model analyses found no dose-response relationship for activity capacity, assessed by WMFT. Specific analyses between the different dosage groups (15-, 30- and 60-h) were not reported. Mean baseline and post-intervention values were obtained by request from the authors, which allowed comparison between the groups which had at least 20 h difference in practice time (60- vs 15- and 30-h groups). The overall risk of bias was high in this study due to selection of the reported results.

Meta-analysis with summary estimates was only performed for upper limb activity capacity outcome (ARAT), where data were available from two separate studies in the subacute stage of stroke (Figure 1(b)). To avoid multiplicity of data, acute and subacute intervention groups were pooled in the study of Dromerick et al.[32] as both interventions were delivered in the subacute stage, within the first month and during the second and third months post-stroke, respectively. For the same reason, in the study of Han et al.,[31] the high-dose intervention groups (60- and 90-h) were pooled and compared to the low-dose group (30-h). Meta-analysis of these two studies, including 54 participants in the experimental group and 49 participants in the control group, revealed a significantly greater

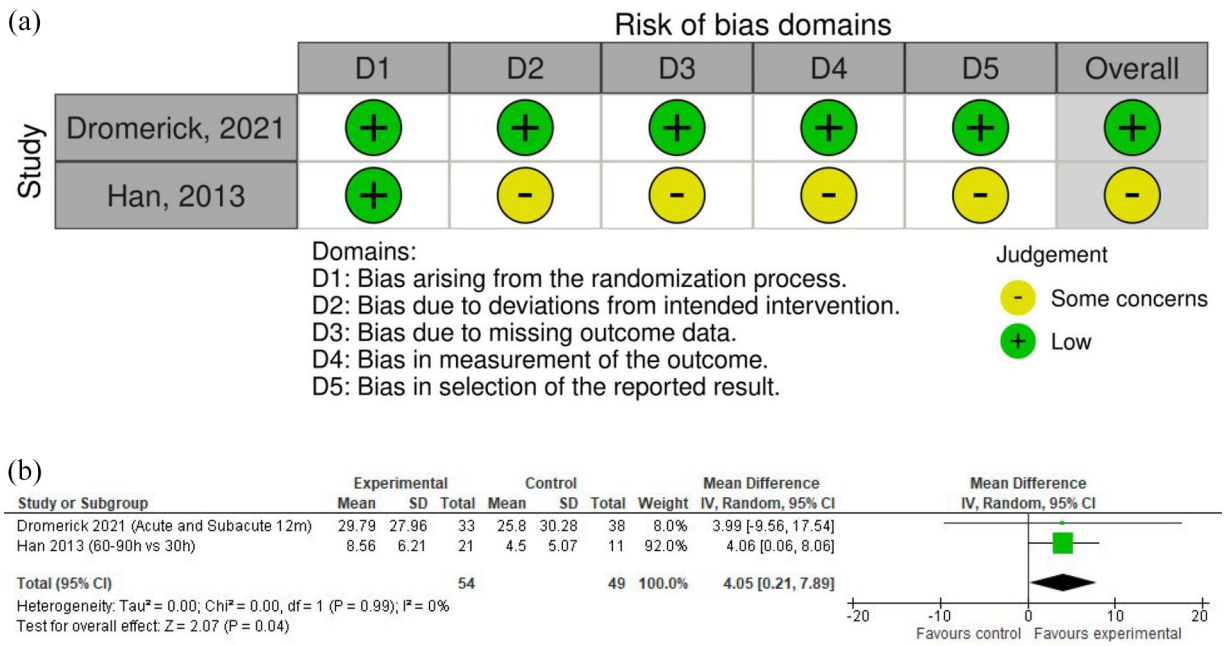

Figure 1. (a; top). Risk of bias for PICO 1 Action Research Arm Test outcome; (b; bottom). Forest plot of meta-analysis for Action Research Arm Test in PICO 1.

improvement for the higher dose groups. The experimental high-dose group improved on average 4.05 (95% CI 0.21–7.89) points more on the ARAT score ($p = 0.04$) compared to the low-dose group. This additional improvement in the high-dose group was less than the reported minimal clinically important difference (MCID) of 6 points (about 10%).[37] There was no evidence of heterogeneity between the studies (Tau2 = 0%, $I^2 = 0\%$, $p = 0.99$). The GRADE assessment is presented in Table 3.

Self-perceived upper limb activity performance (MAL) was evaluated by Winstein et al.,[36] who reported a significant effect in favour of the higher dosage group (60-h upper limb rehabilitation) compared to the zero-dose group in a linear mixed effects regression model analysis. No specific analyses between the different dosage groups were reported. The mean values (baseline and post-intervention) were obtained on request from the authors, which allowed comparison between the high dosage group and the lower dose groups. The overall risk of bias was high due to selection of the reported results in this study. Meta-analysis was not considered since only one study had evaluated self-perceived upper limb activity performance.

Additional information. The effect of additional time spent in the same type of upper limb practice was investigated in the Cochrane review by Clark et al.[15] and in the systematic review and meta-analysis by Schneider et al.[18] Both reviews showed statistically significant effects in favour of more time in practice for selected outcomes at post-intervention assessment. Clark et al.[15] (9 RCTs, $n = 287$) reported favourable effects for upper limb motor impairment measures (FMA-UE, Motricity Index) immediately after intervention, but not at 3- and 6-months follow-up times. Schneider et al.[18] (14 RCTs, $n = 954$) found a favourable effect for activity capacity measures pooled across upper and lower limb outcomes directly after intervention compared to control groups. Clark et al. found no significant effect on ADL outcomes, (Functional Independence Measure, Barthel Index), activity capacity (WMFT, ARAT) or self-perceived activity performance (MAL).[15] The subgroup analysis showed no evidence of differences depending on the stage after stroke (subacute vs chronic).[15]

The contrast between groups in practice time was not defined to any specific amount in these reviews. Clark et al.[15] included studies with any contrast greater than zero and reported that contrast in total time spent in therapy between control and intervention groups was available from 19 studies (both upper and lower limb studies) and ranged from 186 to 6160 min (median 840 min). Therapy was delivered between 3 and 7 days per week, and 5 days per week was most common. The total duration varied from 2 weeks to 6 months. Both reviews performed also subgroup analyses between studies with larger versus smaller contrast for time in practice. The analysis of Clark et al.[15] showed significant favourable effect for larger contrast ($\geqslant$852 min) between groups in ADL ($p = 0.02$) and upper limb activity capacity ($p = 0.04$), but not for upper limb motor impairment ($p = 0.06$). Schneider et al.[18] included studies where experimental group received extra rehabilitation on top of usual rehabilitation and showed

Table 3. GRADE evidence profile for PICOs including meta-analyses.

Certainty assessment							No. of patients		Effect		Certainty	Importance
No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Intervention	Comparator	Relative (95% CI)	Absolute (95% CI)		
PICO 1: Higher dosage (total time in practice) - upper limb activity capacity (ARAT)												
2	RCT	Serious[a]	Not serious	Very serious[d]	Not serious	Publication bias strongly suspected[f]	54/103 (52.4%)	49/103 (47.6%)	-	MD **4.06 pts higher** (0.21 higher to 7.9 higher)	⊕◯◯◯ Very low	CRITICAL
PICO 3: Higher intensity – Comfortable walking speed (m/s)												
3	RCT	Not serious	Serious[c]	Not serious	Not serious	Publication bias strongly suspected[f]	86/177 (48.6%)	91/177 (51.4%)	-	MD **0.1 m/s higher** (0.01 higher to 0.19 higher)	⊕⊕◯◯ Low	CRITICAL
PICO 3: Higher intensity – Maximum walking speed (m/s)												
3	RCT	Not serious	Serious[c]	Not serious	Not serious	Publication bias strongly suspected[f]	66/137 (48.2%)	71/137 (51.8%)	-	MD **0.09 m/s higher** (−0.03 lower to 0.22 higher)	⊕⊕◯◯ Low	CRITICAL
PICO 3: Higher intensity – Walking endurance (6MWT, m)												
3	RCT	Not serious	Not serious	Not serious	Not serious	Publication bias strongly suspected[f]	66/137 (48.2%)	71/137 (51.8%)	-	MD **39.23 m longer** (20.25 longer to 58.21 longer)	⊕⊕⊕◯ Moderate	CRITICAL
PICO 5: Group therapy – Postural balance capacity (BBS, 0–56)												
2	RCT	Serious[a]	Serious[c]	Not serious	Serious[e]	Publication bias strongly suspected[f]	30/60 (50%)	30/60 (50%)	-	MD **7.88 pts higher** (−1.43 lower to 17.18 higher)	⊕◯◯◯ Very low	CRITICAL
PICO 5: Group therapy – Mobility (TUG, s)												
2	RCT	Serious[a]	Serious[c]	Not serious	Serious[e]	Publication bias strongly suspected[f]	44/94 (46.8%)	50/94 (53.2%)	-	MD **1.6 s longer** (−2.75 shorter to 5.95 longer)	⊕◯◯◯ Very low	CRITICAL
PICO 5: Group therapy – Gait Speed (m/s)												
2	RCT	Very serious[b]	Not serious	Not serious	Serious[e]	Publication bias strongly suspected[f]	39/84 (46.4%)	45/84 (53.6%)	-	MD **0.1 m/s higher** (−0.03 lower to 0.23 higher)	⊕◯◯◯ Very low	CRITICAL
PICO 5: Group therapy – Walking endurance (6MWT, m)												
2	RCT	Serious[a]	Not serious	Not serious	Serious[e]	Publication bias strongly suspected[f]	44/94 (46.8%)	50/94 (53.2%)	-	MD **18.76 m longer** (−18.62 shorter to 56.14 longer)	⊕◯◯◯ Very Low	CRITICAL
PICO 6: Additional sit-to-stand training – Postural balance capacity (BBS, 0–56)												
2	RCT	Not serious	Not serious	Not serious	Not serious	Publication bias strongly suspected[f]	39/78 (50%)	39/78 (50%)	-	MD **1.05 pts higher** (−0.72 lower to 2.82 higher)	⊕⊕⊕◯ Moderate	CRITICAL

RCT: randomised controlled trials: CI: confidence interval; MD: mean difference.
[a]Some concerns in risk of bias assessment.
[b]High risk of bias study included.
[c]High heterogeneity.
[d]Different outcome time points (weeks), different doses of intervention (hours).
[e]Large confidence interval with modest sample size.
[f]Less than 10 studies, therefore impossible to assess statistically the publication bias.

that a >100% increase in therapy time resulted in a larger effect (SMD 0.59, 95% CI 0.23–0.94, $I^2 = 44\%$) than a <100% increase. When the beneficial effect of added practice time in percentage reached an SMD of 0.5 in favour of the added time, the ROC curve analysis indicated that at least 240% of additional rehabilitation time was needed to achieve significant likelihood of improving activity. Clark et al.[15] suggested that total amount of practice time needed to reach a threshold of approximately 1000 min (16 h and 40 min) to show beneficial effects on upper limb activity outcomes. It was also acknowledged that there was a lack of studies with large enough contrast between the intervention and control groups.[15]

Other previous reviews evaluating the effect of additional therapy, by Veerbeek et al.[20] and French et al.,[22] accepted several types of therapies (usual care, attention control, no therapy) as comparator rather than comparing the effect dose alone. Veerbeek et al.[20] (80 RCTs, $n = 5776$) showed a significant effect of higher dosage (mean contrast between groups was 17 h), with pooled effect sizes of 0.21 (95% CI 0.02–0.39; $I^2 = 6\%$) for upper limb motor function. French et al.,[22] (33 RCTs, $n = 1853$) included predefined subgroup analysis of upper limb function evaluating the effect of dosage dichotomised as less or more than 20 h therapy. Low- to moderate-quality evidence was found that repetitive task training (RTT) improves upper limb activity capacity outcomes, but this effect was not modified by the dosage, intervention type or time since stroke.

Another meta-analysis by Lohse et al.[38] (30 RCTs, $n = 1750$) exploring the dose-response effect in diverse types of upper and lower limb interventions used meta-regression to predict improvement during therapy as function of time spent in therapy. The results showed that groups with more therapy time (33 ± 36 h more on average) improved significantly more compared to groups with less therapy time (standardised effect size 0.35, 95% CI 0.26–0.45, $I^2 = 16\%$). This overall benefit for longer time spent in therapy was independent of the stage of recovery.

In contrast to PICO 1, Clark et al.[15] and Schneider et al.[18] accepted any difference greater than zero in time spent in the same kind of therapy. Schneider et al.[18] and Lohse et al.[38] evaluated the dose effect in diverse types of interventions rather than upper limb interventions alone, and Veerbeek et al.[20] and French et al.[22] accepted several types of therapies (usual care, attention control, no therapy) as comparator rather than the same type of therapy. In our PICO 1, the therapy content and dosage needed to be quantifiable for both comparison groups, to ensure that the contrast between groups was at least 20 h and that the therapy delivered was active repetitive upper limb practice in both compared groups, to isolate the effect of dose rather than a mixed effect of dose and content.

To summarise, the evidence from previous research indicates that a larger dose in terms of more time spent in practice is beneficial for people with stroke at any stage of recovery. However, from these previous meta-analyses it is not possible to conclude whether the effect can be attributed to the higher dose, to potential differences in therapy content, or to an interaction between dose and content. Despite these potential mixed effects of content and dose, the research evidence from previous reviews indicates that the minimum amount of additional time spent in any active repetitive practice to gain positive effects for function or activity needs probably to be at least 20 h.

The results from our meta-analysis of two studies performed in PICO 1, along with the information from previous reviews, suggests that at least 20 h additional active repetitive upper limb practice, compared to a lower dose of the same type of practice, can improve upper limb activity capacity assessed by ARAT in people with subacute stroke. The higher dose was commonly provided 3–5 times per week over a 4–6-week period, typically in a 2-h long session or in a 1-h long session twice a day.[31,32,39] The lower dose of the same type of practice was also delivered 3–5 times per week over 4–6 weeks, but typically in a session lasting for 45 min to 1-h.[31,32,40] The effect of dose in the chronic stage of stroke could not be evaluated by the meta-analysis as data was only available from single studies. The available data from the included RCTs suggest that the beneficial effect of a higher dose was less clear for the chronic stage of stroke (Supplement Figure 5).

Evidence-based Recommendation
For clinical practice, we suggest considering adding extra time of repetitive upper limb practice to existing stroke rehabilitation programmes. The exact amount of additional practice time is unclear but will likely be at least 20 h, commonly delivered 3–5 times per week over 4–6 weeks.
Quality of evidence: Very low ⊕
Strength of recommendation: Weak for intervention ↑?

PICO 2 **In people with stroke, does adding at least 20 h or more of same type of gait training produce greater improvements in walking independence, walking speed, walking endurance and walking capacity?**

Analysis of current evidence. The literature search identified one RCT by Klassen et al.[41] investigating the effect of higher dosages of task-specific, progressive walking exercise, including weight-bearing walking related activities, compared to a lower dosage. The study included 75 participants (mean age 57 ± 11 years) who were randomly assigned to one of three groups (Usual Care, DOSE1, or DOSE2) and received about 4 weeks of therapy provided 5 times per week during inpatient rehabilitation in the early subacute phase (mean 27 ± 10 days post stroke onset). The usual care (UC) group received standard inpatient physical therapy including walking exercise (mean total

duration of practice 414 min), while the DOSE1 (mean total duration 1028 min) and DOSE2 (mean total duration 3921 min) groups received a higher dose of walking practice. According to our inclusion criteria, the contrast in hours spent in practice exceeded 20-h for comparison between the UC and DOSE2 groups, but not for any comparisons with DOSE1 group. In addition to differences in time spent in practice, the groups also differed on the time spent in ⩾40% HRR walking practice. The mean total time spent in ⩾40% HRR was approximately 104 min in UC (25% of total time), 534 min in DOSE1 and 1960 min in DOSE2 group (50% of total time). Similarly to the total time in practice, time in ⩾40% HRR reached the 20 h contrast criterion between UC and DOSE2 group.

The primary outcome measure was walking endurance evaluated by the 6-min walking test (6MWT), and walking speed measured by 5-m walk test was one of the secondary outcomes. Between-group differences for the primary and secondary measures at the post-evaluation were compared by multiple linear regression, while controlling for the baseline score centred on the mean. The overall risk of bias was considered low for outcomes reported in Klassen et al.[41] (Supplemental Figures 3 and 4). Since data were only available from a single study, meta-analysis was not performed. Extracted data of all subgroups on critical outcomes are shown in Supplemental Figure 5.

Critical outcomes. **Walking capacity (6MWT)** was significantly greater in the higher dosage walking group (DOSE2 mean change 58 m, 95% CI 6–110; $p = 0.03$) at post-evaluation compared to the lower dosage UC group. This effect was sustained at 6- and 12-months post intervention. The overall risk of bias was considered low for 6MWT.

Walking speed (comfortable self-paced) was significantly greater in the higher dosage walking group (DOSE2 mean change 0.19 m/s, 95% CI 0.04–0.34, $p = 0.02$) at post-evaluation compared to the lower dosage UC group. This effect was not retained at 6- and 12-months follow-up assessments. The overall risk of bias was considered low for walking speed.

Additional information. The effect of additional time spent in the same type of practice was investigated in the Cochrane review by Clark et al.[15] and in the systematic review and meta-analysis by Schneider et al.[18] Clark et al.[15] (5 RCTs, $n = 425$) reported no significant effect of additional time spent in lower limb mobility and walking practice for walking capacity outcomes (6MWT, Rivermead Mobility Index). However, a significant effect was observed (SMD 0.36, 95% CI 0.02–0.70; $I^2 = 0\%$) when studies with high risk of overall bias and adherence bias were excluded.[15] Predefined subgroup analyses comparing studies with a larger versus smaller difference in total hours per week showed no significant effect on lower limb outcomes. Schneider et al.[18] (14 RCTs, $n = 954$) showed significant improvement in activity capacity measures (pooled data of upper and lower limb outcomes) directly after intervention compared to control groups (SMD 0.39, 95% CI 0.07–0.71, $I^2 = 66\%$). In studies with a higher dose, that is, >100 % increase in therapy time, a larger effect was observed (SMD 0.59, 95% CI 0.23–0.94, $I^2 = 44\%$). The ROC curve analysis indicated that an increase of 240% in therapy time of the same type of practice was necessary to have a significant improvement in activity outcomes.[18]

Other previous reviews evaluating the effect of additional therapy, by Veerbeek et al.[20] and French et al.,[22] accepted several types of therapies (usual care, attention control, no therapy) as comparator rather than comparing the effect dose alone. Veerbeek et al.[20] (80 RCTs, $n = 5776$) showed a significant effect of higher dosage (mean contrast between groups was 17 h), with pooled effect sizes of 0.61 (95% CI 0.41–0.82, $I^2 = 41\%$) for leg muscle strength outcomes. French et al.,[22] (33 RCTs, $n = 1853$) included predefined subgroup analysis of upper limb function evaluating the effect of dosage dichotomised as less or more than 20 h therapy. Low- to moderate-quality evidence was found that repetitive task training (RTT) improves lower limb activity capacity outcomes, but this effect was not modified by the dosage, intervention type or time since stroke.

Another meta-analysis using meta-regression by Lohse et al.[38] (30 RCTs, $n = 1750$) explored the dose-response effect in diverse types of interventions and dosages. They showed that groups with more therapy time (on average 33 ± 36 h more time) improved significantly more compared to groups with less therapy time. This was also seen after controlling for the effect of time after stroke (SES 0.35, 95% CI 0.26–0.45, $I^2 = 16\%$), which confirmed an overall benefit for more time spent in therapy when compared to less time, independent of the stage of recovery.

In contrast to PICO 2, Clark et al.[15] and Schneider et al.[18] accepted any difference greater than zero in time spent in the same kind of therapy. Schneider et al.[18] and Lohse et al.[38] evaluated the dose effect in diverse types of interventions rather than gait training alone, and Veerbeek et al.[20] and French et al.[22] accepted several types of therapies (usual care, attention control, no therapy) as the comparator rather than the same type of therapy. In PICO 2, the dose contrast of 20 h in same type of therapy was required to isolate the effect of dose from a mixed effect of time and content. The study of Klassen et al.[41] met these criteria but reported also that the compared groups differed in the proportion of time spent at a higher intensity (⩾40% HRR). In general, the intensity of practice in each session is not addressed or reported at all in previous studies focusing on therapy dosage, which makes differentiation between time and intensity impossible. This pinpoints a clear need for future studies on therapy dosage to consider and report not only time spent in therapy but also the intensity of practice in each session.

To summarise, the evidence from previous research suggests that more time spent in walking practice is beneficial for people with stroke at any stage of recovery. However, previous meta-analyses cannot discern whether the effect is due to the higher dose, to potential differences in content or intensity, or to interactions between dose, content and intensity. Despite these potential mixed effects, the research evidence suggests that at least 20 h of additional time spent in any active repetitive practice is needed for a positive effect on function or activity, as seen for PICO 1. Results from previous meta-analyses agree with the results reported in the study of Klassen et al.,[41] included in PICO 2, in which a higher dose of walking practice delivered 5 times per week over a 4-week period in the sub-acute phase of stroke was associated with greater walking endurance capacity (6MWT) and comfortable walking speed directly after the intervention when compared to a lower dose of walking practice. In Klassen et al.[41] the higher dose of walking practice was delivered as 45-–60-min session twice a day, while the lower dose groups practiced about the same session time but only once a day. Both dosage groups trained 5 days per week over a 4-week period.

Due to the limited evidence of only a single RCT in PICO 2, evidence-based recommendation was not considered. Instead, an expert consensus statement was developed and voted on by the MVG members. Voting results are reported in detail in Supplemental Table 5.

Evidence-based Recommendation
Due to the limited evidence of only a single RCT, we cannot make an overall recommendation that a certain amount of additional time spent in walking practice will have an additional effect on walking capacity in people with stroke.
Quality of evidence: -
Strength of recommendation: -

Expert consensus statement
Based on the overall available evidence, 13 out of 17 MWG members (76%) suggest that additional time spent in walking practice can improve walking capacity in people with stroke. The exact amount of the additional practice time is unclear but will likely be at least 20 h, commonly delivered 3–5 times per week over 4–6 weeks.
Thus, for clinical practice, we suggest considering adding extra time of walking practice to existing stroke rehabilitation programmes, preferably at least 20 h.

PICO 3 **In people with stroke, does high-intensity walking training compared to dose-matched (in duration) walking training at a lower intensity produce greater improvement in walking independence, walking speed, walking endurance and walking capacity?**

Analysis of current evidence. The systematic literature search identified four eligible RCTs.[42–45] Three of the studies were conducted in the chronic phase of stroke (>6 months),[42–44] whereas Pohl et al.[45] included participants in the subacute phase (mean 16 weeks post-stroke). All participants in the four studies were able to walk without physical assistance, three studies included participants with slower than normal walking speeds, and one included only inactive individuals (unable to spend at least 10 min in light physical activity). All studies excluded participants based on unstable cardiovascular status, and three conducted cardiorespiratory exercise testing prior to intervention.[42,43,45] In Aguiar et al.,[42] 6 out of 39 participants were excluded due to an inability to perform the cardiorespiratory exercise test, 6 due to other precluding disorders and five participants in the high-intensity group reported lower-limb pain and one had incidences of balance loss, but no fall during training. In all four studies, no serious adverse events related to study procedures were reported, and no between-groups differences were reported in terms of adverse events.

Walking training was delivered as a combination of treadmill and overground training in all studies. The dosage of intervention varied from 8 weeks delivered 3–5 times per week[44] to 12 weeks delivered 3 times per week[42,43] for 30[45] to 45 min[43] per session. The total time spent in high-intensity walking practice was reported as 6,[45] 15,[44] 24,[42] and 27 h.[43]

In Aguiar et al.[42] and Hornby et al.,[44] the high-intensity training was defined as 60%–80% HRR and the low-intensity training as below 40% HRR. Boyne et al.[43] used 30-s bursts of walking at maximum safe speed, alternating with 30- to 60-s rest periods, targeting a mean aerobic intensity above 60% of the HRR. This was compared to moderate intensity continuous aerobic training with an initial target of 40% HRR progressing to 60% HRR as tolerated. Pohl et al.[45] evaluated structured speed dependent treadmill training (STT) delivered by progressive 10% increases in speed as tolerated during each session. This was compared to a limited progressive treadmill training (LTT) where the increase in speed was restricted to a maximum of 5% each week. Hornby et al.[44] investigated both the effects of exercise type and intensity in three groups, and therefore only the two groups with the same type of variable stepping and walking practice were considered for this PICO. Boyne et al.[43] and Hornby et al.[44] had low risk of bias, Aguiar et al.[42] had some concerns related to missing outcome data, and Pohl.[45] had a high risk of bias related to the randomisation process and deviation from the intended intervention (Supplemental Figures 3 and 4). The extracted critical outcomes of interest included walking independence (Functional Ambulation Category),[45] walking speed[42–45] and walking endurance (6MWT).[42–44]

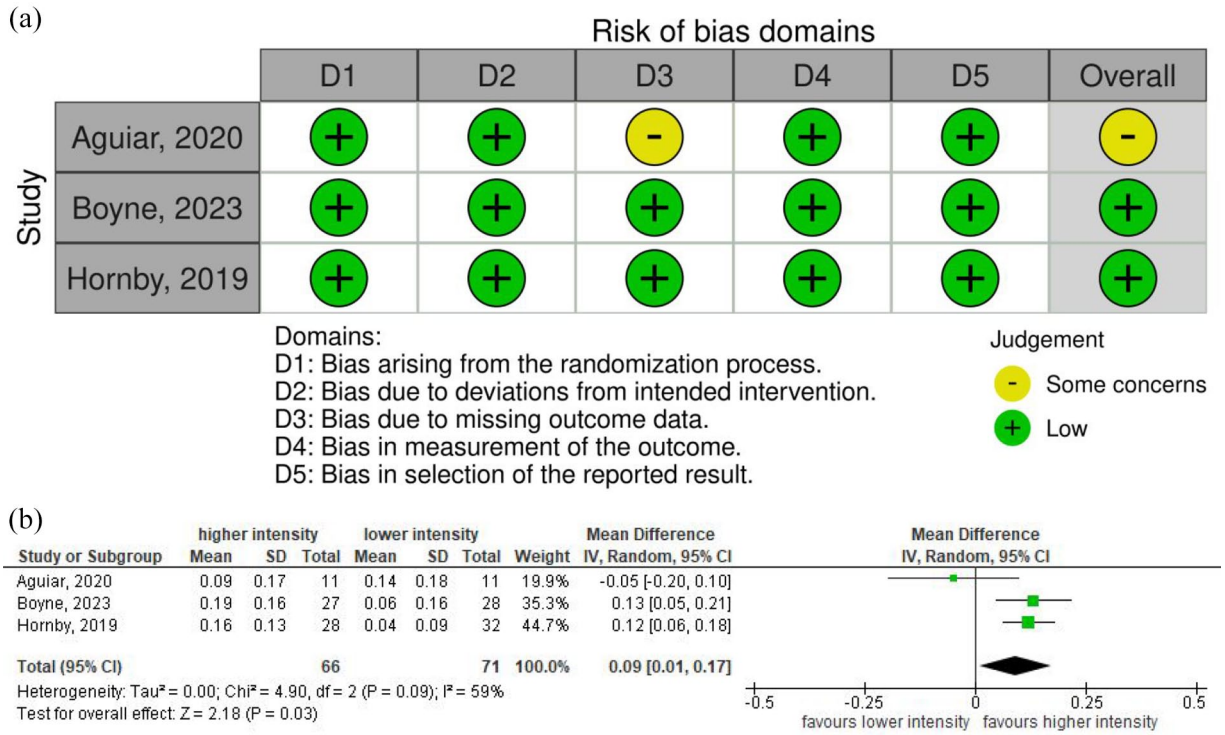

Figure 2. (a; top). Risk of bias for PICO 3 comfortable walking speed outcome; (b; bottom). Forest plot of meta-analysis for comfortable walking speed in PICO 3.

Critical outcomes. **Walking independence (Functional Ambulation Category, FAC)** showed significantly greater improvement ($p = 0.007$) after higher intensity variable walking practice (mean FAC 5.0 ± 0.0) compared to lower intensity variable walking practice (mean FAC 4.6 ± 0.6) in the subacute stage of stroke.[45] Meta-analysis was not conducted for this outcome, since only one study was available.

Comfortable (self-selected) walking speed was measured in all four trials.[37–40] Meta-analysis of the 4 trials included 86 participants in the higher intensity group and 91 in the lower intensity group. The analysis revealed a significantly greater improvement for the higher intensity groups ($p = 0.03$). The higher intensity group achieved 0.1 (95% CI of 0.01–0.19) m/s faster comfortable speed than the lower intensity group.

Additional sensitivity analysis, excluding one study with a high risk of bias,[45] was conducted to ensure the robustness of the results. Risk of bias for this outcome is presented in Figure 2(a). Meta-analysis of the remaining three trials, all in the chronic phase of stroke, included 66 participants in the higher intensity group and 71 in the lower intensity group (Figure 2(b)). The analysis showed a significantly greater improvement for the higher intensity groups ($p = 0.03$). The higher intensity group achieved 0.09 (95% CI of 0.01–0.17) m/s faster comfortable speed than the lower intensity group. A MCID above 0.14–0.18 m/s[46] and above 0.06 m/s[47] are reported to indicate a substantial or a small difference in comfortable walking speed after stroke. Thus, the results of our meta-analysis show a small clinically important difference according to the MCID reports for stroke survivors.[47] There was a substantial heterogeneity between the studies ($Tau^2 = 0.00$, $I^2 = 59\%$, $p = 0.09$). The GRADE assessment is presented in Table 3.

Maximum walking speed was measured in three trials with risk of bias for this outcome presented in Figure 3(a).[42–44] Meta-analysis of 3 studies included 66 participants in the higher intensity group and 71 in the lower intensity group (Figure 3(b)). The analysis showed no statistically greater improvement for the higher intensity groups ($p = 0.14$). The higher intensity group achieved 0.09 (95% CI of −0.03 to 0.22) m/s faster maximum walking speed than the lower intensity group. There was substantial heterogeneity between the studies ($Tau^2 = 0.01$, $I^2 = 69\%$, $p = 0.04$). The GRADE assessment is presented in Table 3.

Walking endurance was measured in three trials using the 6MWT and risk of bias for this outcome is presented in Figure 4(a).[42–44] Meta-analysis of three studies included 66 participants in the higher intensity group and 71 in the lower intensity group (Figure 4(b)). The analysis revealed a significantly greater improvement for the higher intensity groups ($p < 0.0001$). The higher intensity group achieved 39.23 (95% CI of 20.25–58.21) metres further distance in 6MWT than the lower intensity group. In the

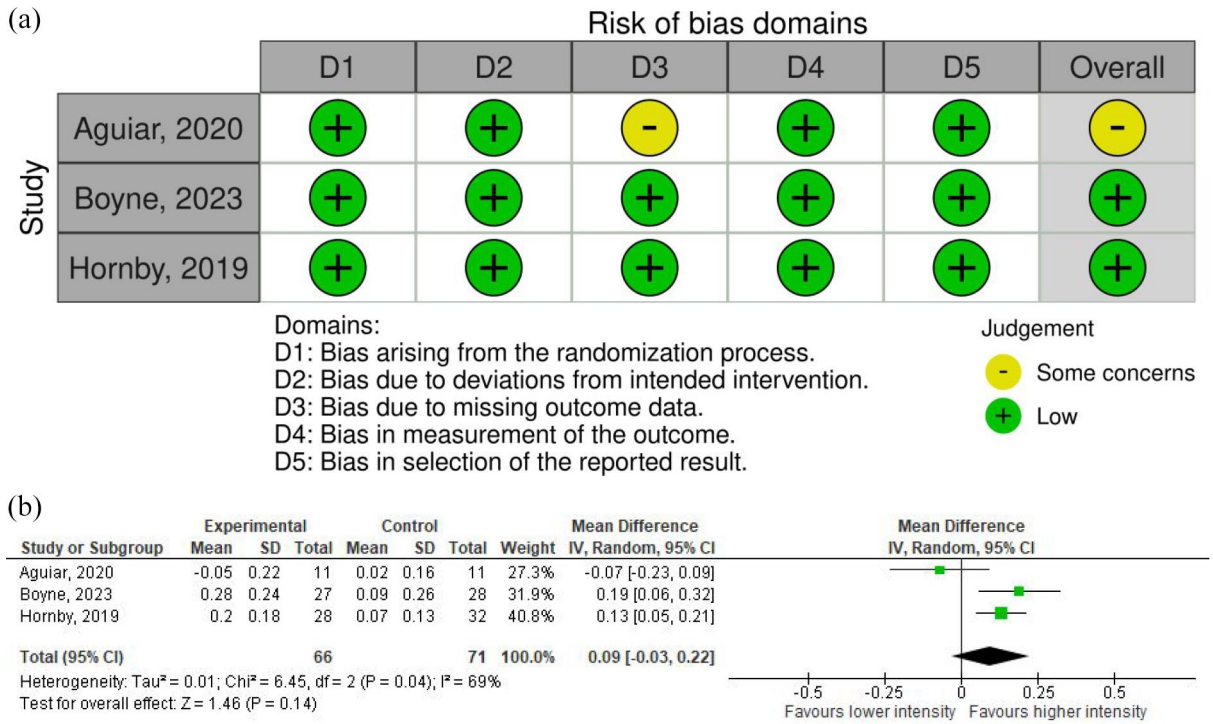

Figure 3. (a; top). Risk of bias for PICO 3 maximum walking speed outcome; (b; bottom). Forest plot of meta-analysis for maximum walking speed in PICO 3.

chronic phase of stroke, the minimal clinically important difference for the 6MWT is reported as 34.4 m.[48] There was no evidence of heterogeneity between the studies ($Tau^2 = 0.00$, $I^2 = 0\%$, $p = 0.91$). The GRADE assessment is presented in Table 3.

Walking capacity (Functional Gait Assessment) was only measured in one trial,[44] which showed non-significant between-group interactions in analysis of this secondary outcome. No meta-analysis was conducted.

Additional information. The systematic review of Mah et al.[49] including seven studies ($n = 944$) investigated the effects of high-intensity exercise (HIE) on lower limb function in early subacute (0–3 months) and late subacute (3–6 months) stage of stroke. The HIE, provided as high-intensity treadmill walking, stepping, cycling or overground walking exercises, was compared to either a low-intensity exercise ($n = 4$) or passive control condition ($n = 3$). Three out of the four studies that reported results on 6MWT reported significantly greater improvements in walking distance in favour of the HIE group compared to the control. Three studies found significantly greater improvements in gait speed in the group performing HIE compared to the control groups. Improvements in the HIE group were retained at 3–6 months post-stroke compared to the controls as reported in two studies. No major adverse events were reported. The authors concluded that HIE should be considered for implementation in the subacute stage of stroke, considering the possible benefits in functional outcomes, relative to lower intensity interventions.

Another systematic review and network meta-analysis by Moncion et al.[50] of 47 RCTs explored the effectiveness of various high-intensity aerobic exercise interventions on $\dot{V}O_2$ peak (28 studies, $n = 1298$), 6 min walking distance (28 studies, $n = 1494$) and 10 m comfortable walking speed (18 studies, $n = 775$) post-stroke compared to lower-intensity and usual care exercise programmes. Improvements larger that the established minimal clinically important difference (MCID) were observed for $\dot{V}O_2$ peak, and the 10 m comfortable walking in favour of high-intensity interval training (HIIT).

In contrast to these reviews, PICO 2 only included studies where the time spent in practice was matched between the high- and low-intensity groups, to allow evaluation of the effect of intensity rather than a mix of effects of time and intensity. The findings of previous systematic reviews align well with the results of our meta-analysis. Our meta-analyses showed significantly greater improvements in comfortable walking speeds and walking endurance (6MWT) for people with chronic stroke in favour of high-intensity walking exercise compared to the same amount of exercise at a lower intensity. The improvements in comfortable walking speed and walking endurance were larger than the established minimal clinically important

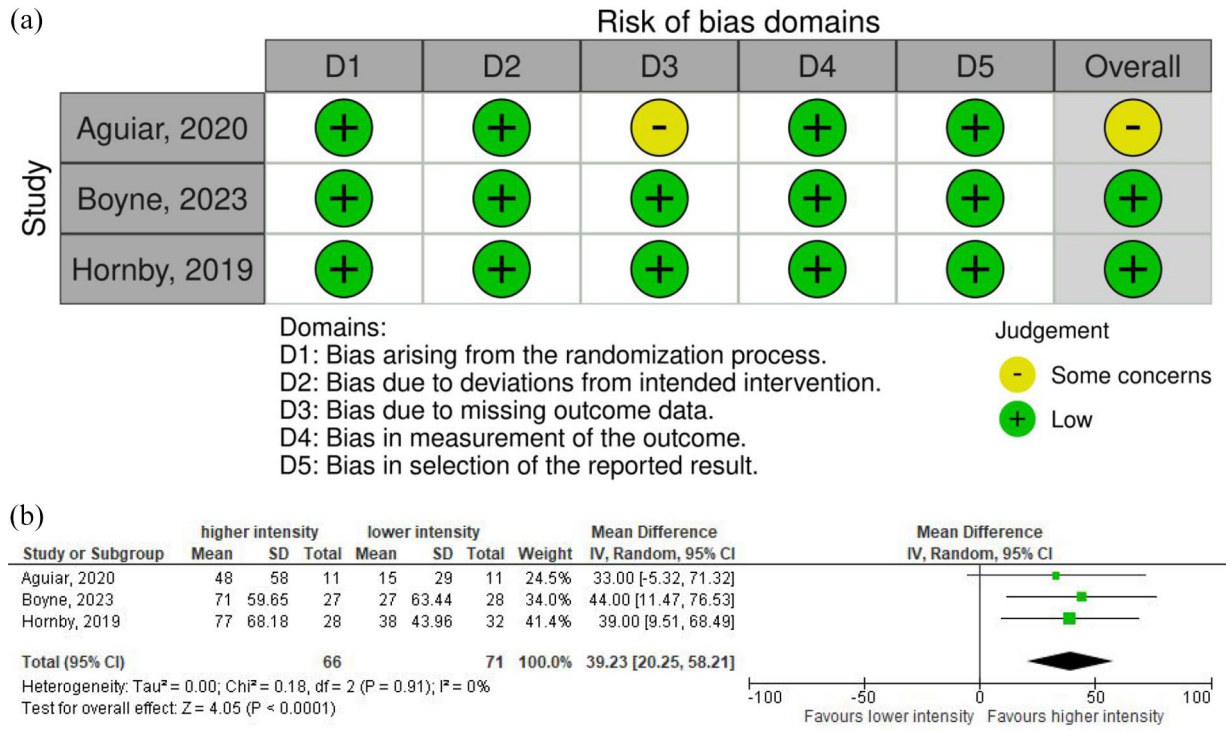

Figure 4. (a; top) Risk of bias for PICO 3 6-Minute Walk Test outcome; (b; bottom) Forest plot of meta-analysis for 6-Minute Walk Test in PICO 3.

difference. However, due to high heterogeneity among included studies, the quality of evidence was assessed as low for the comfortable and maximum walking speed.

Evidence-based Recommendation
In people in the chronic stage of stroke with stable cardiovascular status, we recommend high-intensity walking training rather than duration-matched walking training at a lower intensity to improve walking endurance.
Quality of evidence: Moderate ⊕⊕⊕
Strength of recommendation: Strong for intervention ↑↑
In people in the chronic stage of stroke with stable cardiovascular status, we suggest high-intensity walking training rather than duration-matched walking training at a lower intensity to improve comfortable and maximum walking speed.
Quality of evidence: Low ⊕⊕
Strength of recommendation: Weak for intervention ↑?

PICO 4 **In people with stroke, does repetitive upper limb task-specific training with a behavioural transfer package compared to the same type of duration-matched training without a behavioural transfer package produce greater improvements in upper limb activity capacity, perceived (patient-reported) and actual (wearable sensors) upper limb activity performance?**

Analysis of current evidence. Taub et al.[51] described the transfer package as a set of behavioural techniques to facilitate transfer of therapeutic gains from the treatment setting to daily life. The literature search identified one RCT by Takebayashi et al.[52] This was a pilot quasi-randomised assessor-blind controlled trial to compare the effects of a 2-week programme of CIMT with and without a transfer package for patients with upper limb hemiparesis after stroke. The transfer package aimed to facilitate the actual use of the affected arm in daily life. A total of 23 patients at the chronic stage were allocated to the intervention (with transfer package) or control group (without transfer package) depending on the location of their home. All 23 patients completed the assigned 2-week programme, although two were lost at follow-up. Consequently, there were 11 patients analysed in the intervention group and 10 patients analysed in the control group. Effects were assessed post treatment and at 6-months follow up using the patient-reported MAL - Amount of Use scale (MAL-AoU, upper limb perceived activity performance). Statistical analyses of transfer package effects included two-way analysis of variance (ANOVA) with factors group (intervention, control) and time (pre, post, follow-up), post-hoc t-tests with Bonferroni correction, and the calculation of effect sizes (eta squared, Glass's Δ and Cohen's *d*).

Critical outcomes. The effect of the transfer package on **upper limb activity performance (MAL-AoU)**

is unclear as there was no interaction reported between group (intervention, control) and time (pre, post, follow-up). Post-hoc multiple comparisons for each group identified that post-treatment and follow-up MAL-AoU scores were higher than pre-treatment scores for the intervention group but not the control group. There was no effect of time on the MAL-AoU for the control group. This latter finding indicates that the 2-week CIMT without transfer package had no detected benefit for the control group. The overall risk of bias was high because participants were pseudo-randomised based on where they lived, there was no information about deviations from the intended intervention, and one of the two main outcome measures was patient-reported and open to bias as participants were not blinded. The authors noted the need for future research to objectively assess the accuracy of patient reports and to investigate the effects of the transfer package through a more properly designed RCT. The MWG notes the need for an adequately powered RCT to investigate the effects of a transfer package provided in addition to evidence-based motor rehabilitation. The risk of bias assessment is presented in Supplemental Figures 3 and 4.

Additional information. This PICO searched specifically for studies comparing active interventions with and without a transfer package. The inclusion criteria of this ESO guideline defined this transfer package although we recognise that there is no international consensus about the exact content and delivery of this component. The transfer package is mostly related to interventions like CIMT. CIMT as a complete package has been studied widely and produced high-quality evidence for clinical effectiveness.[4,53]

A detailed description of the transfer package used in the CIMT intervention can be found elsewhere,[54] but in brief, these techniques included:

- Monitoring by asking participants to observe and document performance of target behaviour. This can be done by daily evaluation of the amount of use of the more affected arm in ADL with an instrument such as the MAL. It can also be done through a patient-kept daily diary providing an overview of what the patient did with the more affected arm outside of ADL. The monitoring records could be submitted, for instance, to the therapist to support active involvement of the participant, and also serve as input for the next therapeutic strategy.
- Problem-solving by teaching patients to identify obstacles, to generate potential solutions, to select and use a solution, to evaluate the outcome and to select another solution if needed.
- Behavioural contracting by asking participants to write specific behaviours that are normally carried out during the day and then record in an agreement with the therapist which behaviours will be carried out and how the affected upper limb will be used during the tasks. Whether the contract is adhered to is part of the monitoring;
- Home practice of specified exercises with the most affected upper limb during and after the intervention. The patient should not be overloaded but provided with a set of tasks from which up to two tasks per day are selected and practiced for 15–30 min. The therapist should ascertain that the participant understands and is able to independently practice all tasks.
- Weekly follow-up contacts by the therapist in, for instance, the first month post treatment to discuss the monitoring records, problem-solving approach used, behavioural contract expectations and home practice tasks.

The relevance of a transfer package is identified in guidelines such as the National Clinical Guideline for Stroke 2023 (UK and Ireland).[8] In the CIMT recommendation the authors state that 'evidence suggests the transfer package is of particular importance, ensuring that motor gains translate into functional tasks and improve outcomes'. However, no evidence was provided to support this statement, and there are no separate recommendations for a transfer package without CIMT. The Clinical Pathways in Stroke Rehabilitation evidence-based clinical practice recommendations[55] also emphasise the importance of the transfer package when combined with restraint outside therapeutic sessions to promote actual daily life use of the more affected upper limb. For patients with mild-to-moderate paresis, the transfer package is considered an optional component (with level of evidence 1b, quality of evidence moderate, GRADE B+: weak recommendation). According to our reading, this recommendation was made based on only one study.[56] This study included 40 chronic stroke participants and examined the effectiveness of different combinations of CIMT components. The groups receiving therapy with a transfer package demonstrated significantly better outcomes compared to those without the transfer package in perceived upper limb use (mean difference between groups on MAL = 1.2 points, $p < 0.01$) and upper limb activity capacity (mean difference between groups on WMFT = 6.4 repetitions/min, $p < 0.05$). This study was not included in our PICO analysis as the duration of mitt wearing on the less affected arm was also different between the groups (90% of waking hours for 10 training days and 4 weekend days vs mitt-wearing for in-laboratory treatment only). Hence it did not fulfil our intervention inclusion criteria. Thus, for this PICO an expert consensus statement was voted on by the MVG members (Supplemental Table 5).

Evidence-based Recommendation
Due to the limited evidence, based on a single RCT, we cannot make an overall recommendation that including a transfer package in upper limb therapy compared to not including a transfer package has an additional effect on upper limb activity capacity or performance.
Quality of evidence: -
Strength of recommendation: -

Expert consensus statement
Acknowledging the current lack of evidence for this PICO, 13 out of 17 MWG members (76%) suggest considering a transfer package when providing repetitive upper limb task-specific training, when aiming to achieve a transfer from treatment to daily life.
The transfer package would include daily evaluation, a patient-kept daily diary, problem-solving, behavioural contract, home practice of specified exercises, and weekly follow-up contacts.

PICO 5 **In people with stroke, does the provision of task-specific training in a group with at least 2:1 patient-therapist ratio compared to the same type of time-matched one-to-one training have the same effect on motor function, activity capacity and perceived performance?**

Analysis of current evidence. The systematic literature search identified five eligible RCTs.[57–61] Two trials[57,58] were identified from the English et al. Cochrane review[25] and three[59–61] from the updated literature search. Doussoulin et al.[59] ($n = 36$) evaluated the effects of modified CIMT on upper extremity activity capacity and arm use in daily activities. Kim et al.[57] ($n = 30$) evaluated the effects of lower extremity task-oriented circuit training on balance ability and gait endurance. Qurat-ul-Ain et al.[60] ($n = 32$) compared the effects of circuit gait training versus traditional gait training on mobility performance and quality of life. Renner et al.[61] ($n = 73$) investigated the effect of task-specific training on walking ability. Song et al.[58] ($n = 30$) evaluated the effectiveness of task-oriented circuit training on gait outcomes. The group-based therapy versus individual therapy was evaluated in the subacute,[61] chronic[57–59] or both subacute and chronic phase[60] after stroke. All included studies compared individual therapy to group therapy.

With respect to our critical outcomes, lower limb activity capacity was evaluated in four studies[57,58,60,61] by BBS, Timed Up & Go test (TUG), 6MWT, 10mWT at comfortable speed and 2-Minute Walk Test (2MWT) and upper limb activity performance in one study[59] using MAL. The risk of bias assessment is presented in Supplemental Figures 3 and 4.

Critical outcomes. **Upper limb self-perceived activity performance (MAL)** was investigated by Doussoulin et al.,[59] and showed improvement in both modified CIMT group training (mean increase 1.30) and individual training (mean increase 1.18 points). After controlling for baseline scores, a significant difference at post-intervention was found between the groups favouring the group therapy (effect size = 0.57).[59] This significant difference in outcome between groups at post intervention remained at 6 months follow-up. The study of Doussoulin et al.[59] had a high risk of bias due to the randomisation process, measurement of the outcome and selection of the reported results. Meta-analysis was not performed, since data from only one study was available.

Lower limb activity capacity included assessment of postural control and mobility (BBS, TUG), walking endurance (6MWT, 2MWT) and walking speed. BBS was investigated by Kim et al.[57] and Qurat-ul-Ain et al.,[60] TUG and 6MWT by Kim et al.[57] and Renner et al.,[61] 2MWT by Song et al.,[58] and walking speed by Song et al.[58] and Renner et al.[61] Significant post-intervention differences were found between the group-based and individual training interventions for BBS favouring the group therapy,[57,60] while no significant improvements were observed for TUG[57,61] (post-intervention and change scores), 6MWT[57,61] (post-intervention and change scores), 2MWT[58] (post-intervention) and 10mWT[58,61] (post-intervention and change scores). The study of Song et al.[58,59] had a high risk of bias due to measurement of the outcome and selection of the reported results. The remaining studies showed some concerns in several domains (Supplemental Figure 3).

Meta-analyses with summary estimates indicating change from pre- to post-intervention were performed for lower limb activity capacity outcomes (BBS, TUG, walking speed, 6MWT), where data were available from two studies. The GRADE assessment is presented in Table 3. For our meta-analyses we applied non-inferiority margins. Since the trials included were not non-inferiority trials, we used minimal clinically important difference (MCID) or minimal detectable change (MDC) reported for the chronic stroke population, where available.

Berg Balance Scale (BBS). Meta-analysis of two studies included 60 participants with risk of bias for this outcome presented in Figure 5(a). The analysis revealed no statistically significant difference in BBS improvement between group and individual therapy (mean difference 7.88, 95% CI −1.43 to 17.18 points, $p = 0.10$). There was substantial heterogeneity between the two included studies ($Tau^2 = 34.97$, $I^2 = 76\%$, $p = 0.04$; Figure 5(b)). The non-inferiority margin of 4.66 points was considered for the BBS (MDC reported for chronic stroke in Hiengkaew et al.[62]), represented as the blue line in Figure 5. For this outcome, group training is considered non-inferior to individual training.

Timed Up and Go (TUG). Meta-analysis of two studies included 94 participants with risk of bias for this outcome

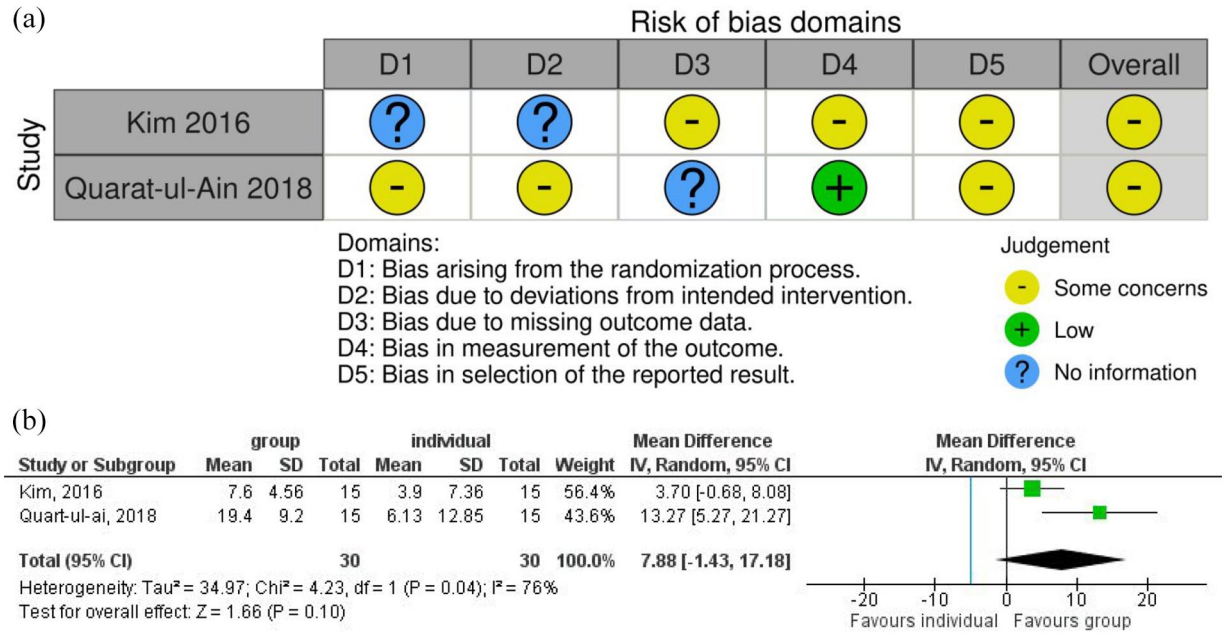

Figure 5. (a; top). Risk of bias for PICO 5 Berg Balance Scale outcome; (b; bottom). Forest plot of meta-analysis for Berg Balance Scale in PICO 5. The blue line represents the non-inferiority margin.

presented in Figure 6(a). The analysis revealed no statistically significant difference in TUG improvement between group and individual therapy (mean difference 1.60, 95% CI −2.75 to 5.95 s, $p = 0.47$). There was moderate heterogeneity between the studies ($Tau^2 = 3.76$, $I^2 = 36\%$, $p = 0.21$; Figure 6(b)). The non-inferiority margin of 2.9 s was considered for the TUG (MDC reported for chronic stroke in Flansbjer et al.[63]), represented as the blue line in Figure 6. For this outcome, non-inferiority is not shown.

Gait speed. Meta-analysis of two studies included 84 participants with risk of bias for this outcome presented in Figure 7(a). The analysis revealed no statistically significant difference in gait speed improvement between the group and individual therapy groups (mean difference 0.10, 95% CI −0.03 to 0.22 m/s, $p = 0.14$). There was no evidence of heterogeneity between the studies ($Tau^2 = 0.0$, $I^2 = 0\%$, $p = 0.48$; Figure 7). This result needs to be interpreted with caution due to high risk of bias of an included study.[58] Removing this study leaves only one study with a similar conclusion. The non-inferiority margin of 0.14 m/s was considered for gait speed (MCID reported in Perera et al.[47]), represented as the blue line in Figure 7(b). For this outcome, group training is considered non-inferior to individual training.

6-Minute Walk Test (6MWT). Meta-analysis of two studies included 94 participants with risk of bias for this outcome presented in Figure 8(a). The analysis revealed no statistically significant difference in 6MWT improvement between group and individual therapy (mean difference 18.76, 95% CI −18.6 to 56.1 m, $p = 0.33$). There was no evidence of heterogeneity between the studies ($Tau^2 = 0.0$, $I^2 = 0\%$, $p = 0.5$; Figure 8). The non-inferiority margin of 50 m was considered for gait endurance (MCID reported in Perera et al.[47]), represented as the blue line in Figure 8(b). For this outcome, group training is considered non-inferior to individual training.

Additional information. The Cochrane review by English et al.[25] found that group-based circuit class training (CCT) was more effective than other interventions for improving walking distance, speed, endurance and independence. These positive effects were observed both early and late after stroke. CCT may also improve cardiorespiratory fitness in people recovering from stroke. However, its effectiveness in enhancing postural control remains uncertain. This review also reported that some evidence suggests CCT can reduce hospital stays. The review noted a higher incidence of falls in the CCT group, although this difference was not statistically significant.

Bonini-Rocha et al.[64] conducted a systematic review and meta-analysis with eight RCTs, and reported that circuit-based exercises performed in a group significantly improve gait compared to conventional interventions. However, the study found no significant effects on balance or functional mobility. Similarly, Wevers et al.[65] conducted a systematic review and meta-analysis that supports the use of

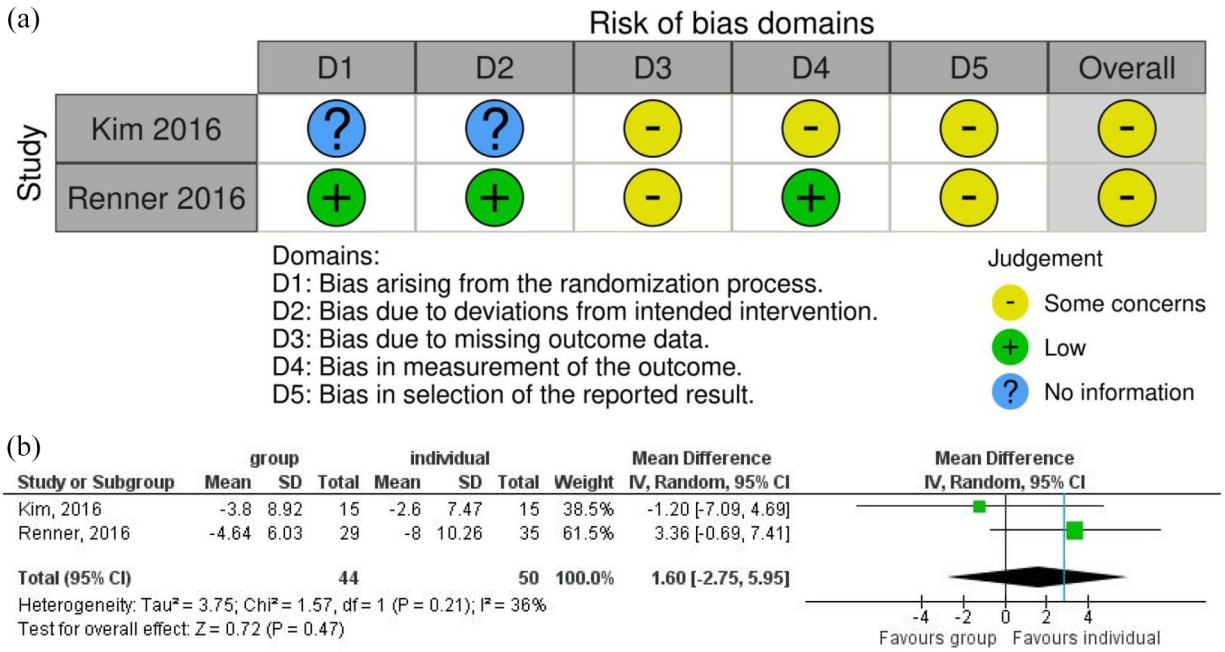

Figure 6. (a; top). Risk of bias for PICO 5 Timed Up and Go outcome; (b; bottom). Forest plot of meta-analysis for Timed Up and Go in PICO 5. The blue line represents the non-inferiority margin.

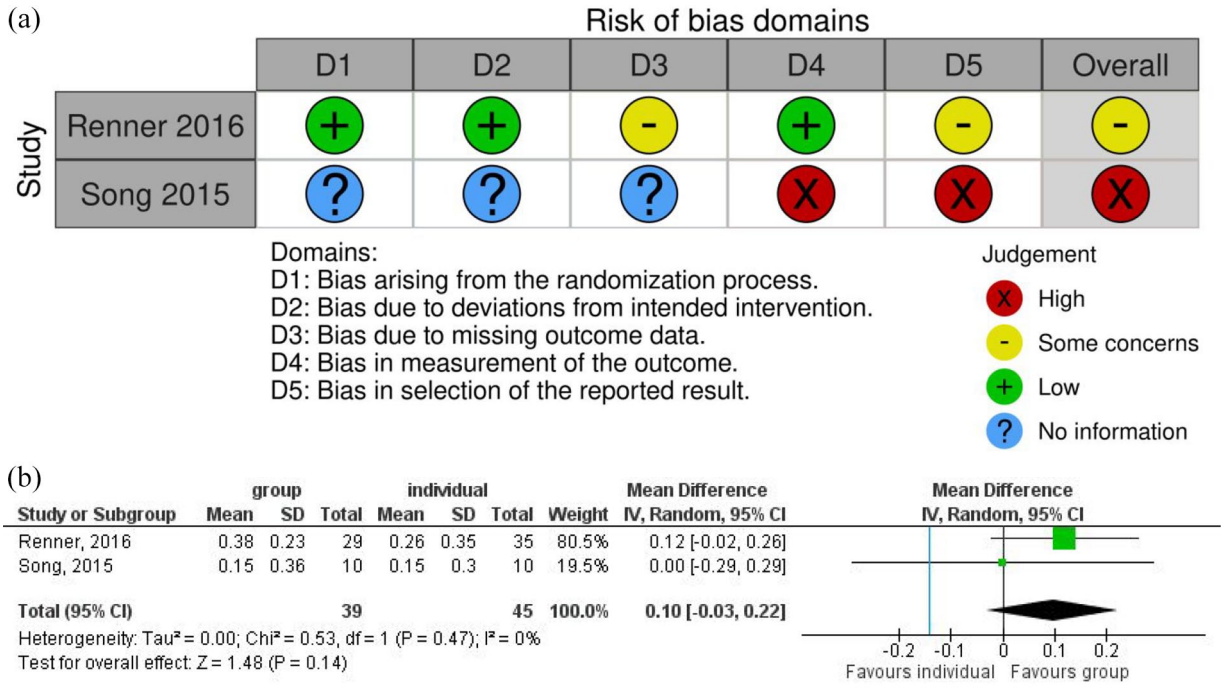

Figure 7. (a; top) Risk of bias for PICO 5 Gait Speed outcome; (b; bottom) Forest plot of meta-analysis for Gait Speed in PICO 5. The blue line represents the non-inferiority margin.

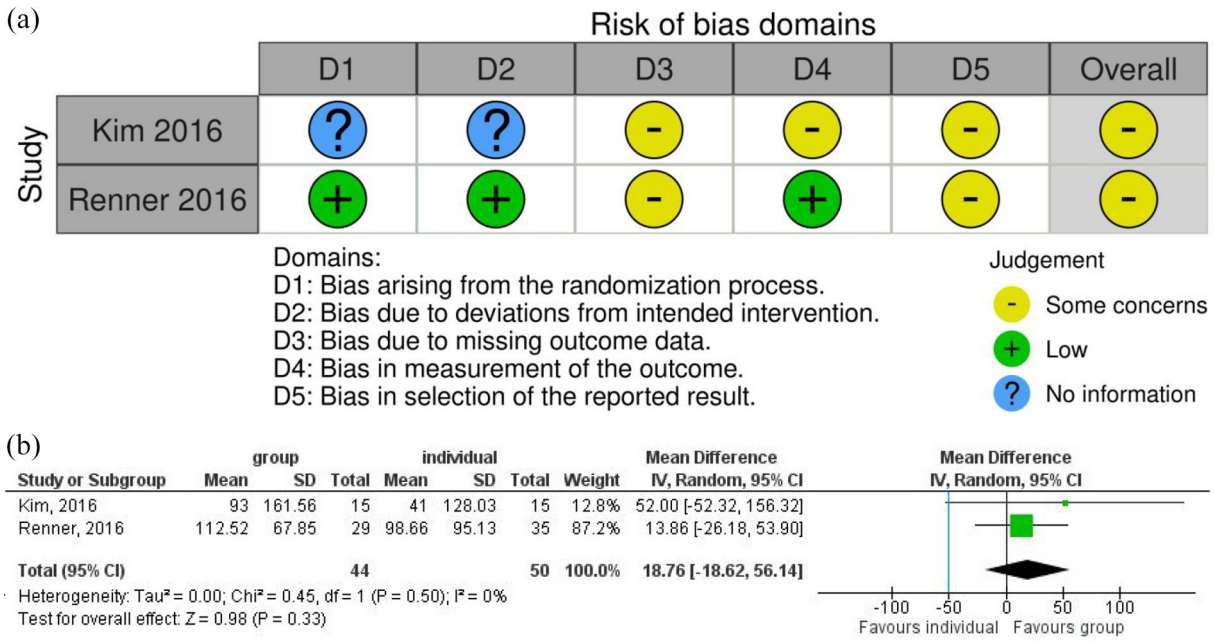

Figure 8. (a; top) Risk of bias for PICO 5 6-Minute Walk Test outcome; (b; bottom) Forest plot of meta-analysis for 6-Minute Walk Test in PICO 5. The blue line represents the non-inferiority margin.

task-oriented, group-based CCT to improve gait and gait-related activities in people with chronic stroke. This conclusion was drawn from six RCTs.

The research questions and inclusion criteria in these previous systematic reviews differed from our more specific PICO question. We only included studies where both the dose and type of training were comparable between the group training and one-on-one training, while the previous reviews included studies with varying doses, types of therapy or even usual care as the control group intervention. Additionally, the review by Wevers et al.[65] focused exclusively on the chronic phase after stroke while our PICO included studies in any stage.

Guidelines often recommend group training. For instance, the American Stroke Association[66] suggests that group therapy with circuit training is a reasonable approach to improving walking. They also indicate that balance training can be effectively implemented in group, circuit or one-on-one settings. The Royal Dutch Society of Physiotherapy (KNGF) guideline[11] aligns with this by stating that CCT delivered in groups for walking and other mobility-related activities enhances walking distance and speed, as well as sitting and standing balance, in both the subacute and chronic phases after stroke.

The Evidence-based Clinical Practice Recommendations from the Clinical Pathways in Stroke Rehabilitation[55] highlight that CCT allows therapists to combine the benefits of group and individual treatments, making it more economically efficient. However, two key points were emphasised: (1) a reasonable ratio between patients and therapists should be maintained to ensure safety and supervision, and (2) individual therapy should also be available, suggesting that CCT should supplement individual therapy. With regard to patient-therapist ratio, the studies in our analysis varied. Song et al.[58] and Qurat-ul-Ain et al.[60] were included in the analysis of one critical outcome and reported 4–6 patients per 2 therapists or did not specify a ratio, respectively. Kim et al.[57] and Renner et al.[61] were included in the analysis of three outcomes and reported 2–3 patients per therapist and 2–8 patients (without the exact number of therapists), respectively. Hence, an overall recommendation seems difficult to make. The patient-therapist ratio will also be affected by the patients' impairment severity and whether therapy can be set up as a whole-group class, a circuit class or with patients working in pairs.

The 2023 National Clinical Guideline for Stroke in the United Kingdom and Ireland[8] recommends that circuit training classes be available at least 3 days per week for 20 weeks. However, they also emphasise that the choice of programme should be guided by the patient's goals and preferences, with the programme tailored to their level of impairment. The 2023 NICE (National Institute for Health and Care Excellence) guideline[67] advises that group circuit training should be considered in addition to one-on-one walking therapy for stroke survivors who can walk with or without assistance. They recommend incorporating an educational component, such as fall prevention advice, and fostering peer support through interaction with other

patients. However, they note that the evidence supporting these recommendations is of low quality.

In summary, previous systematic reviews and guidelines recommend group or circuit training as a supplementary therapy to individual sessions. It is important to note that current guidelines and research evidence from this PICO primarily focus on lower limb training, with limited information on upper limb training.

Evidence-based Recommendation
For clinical practice, we suggest task-specific group-based therapy being at least as effective as individual therapy for improving balance capacity, gait speed and walking endurance. A reasonable ratio between patients and therapists is required to ensure safety and supervision as well as offering additional individualised therapy to address patients' goals and preferences.
Quality of evidence: Very low ⊕
Strength of recommendation: Weak for intervention ↑?

PICO 6 In people with stroke, does the provision of usual care plus additional sit-to-stand training compared to usual care alone produce greater improvements in balance capacity, independence and time taken in sit-to-stand?

Analysis of current evidence. The systematic literature search identified 4 eligible RCTs[68–71] according to our inclusion criteria, in which usual care plus additional sit-to-stand training was compared to usual care alone. Two studies were identified from the Pollock et al. Cochrane review[24] and the other two[70,71] from the additional literature search. We included studies where sit-to-stand training incorporated mainly practicing sit-to-stand repetitions but allowed the inclusion of other exercises that aimed to improve sit-to-stand performance.

Barreca et al.[68] ($n = 48$) evaluated the effects of extra sit-to-stand (STS) practice in people with stroke. The usual care group received regular stroke rehabilitation, while the extra practice group received the same rehabilitation programme along with three 45-min STS practice sessions per week during inpatient rehabilitation. Tung et al.[69] ($n = 32$), delivered 30 min of general physical therapy three times a week for 4 weeks to both groups, and the experimental group received an extra 15 min of STS training during each session. Six different STS activities were designed to challenge the participants' abilities, varying in degrees of knee flexion and standing surface conditions. Gbiri and Shittu[70] ($n = 46$) investigated the effectiveness of adding a 6-week balance training programme to conventional treatment relative to conventional treatment only. The balance training included an STS protocol with the number of repetitions progressing from 10 to 20. De Sousa et al.[71] ($n = 30$) investigated whether two sessions of physiotherapy per day for 2 weeks with a focus on intensive sit-to-stand training, in addition to usual care, was of greater benefit than only usual care consisting of two 1-h sessions of physiotherapy on each weekday.

Two studies investigated the effect of additional STS training in the subacute phase[68,71] and two in the chronic phase[69,70] of stroke. Regarding the critical outcomes, the ability to perform sit-to-stand independently was evaluated in two studies,[68,71] and postural balance capacity in two studies.[69,70] The aggregated risk of bias assessment of each study is presented in Supplemental Figures 3 and 4.

Critical outcomes. **Postural balance capacity** assessed by BBS was significantly improved at post-intervention in the intervention group (mean score 51.22 ± 5.47) compared to the control group (45.26 ± 3.03) after 6-weeks training.[70] Tung et al.[69] found no significant differences between the groups in BBS after 4 weeks training with additional 15 min STS practice delivered 3 times per week. Both studies included patients in the chronic stage of stroke.

Meta-analysis of two studies[69,70] included 78 participants with risk of bias for this outcome presented inFigure 9(a). The analysis showed no statistically significantly greater improvement for the experimental groups (mean difference = 1.05 (95% CI −0.72 to 2.82), $p = 0.25$). The heterogeneity was low between the studies ($Tau^2 = 0.29$, $I^2 = 8\%$, $p = 0.3$; Figure 9(b)). The GRADE assessment is presented in Table 3.

The ability to perform STS independently, defined as the ability to stand up two times from a 16″ (40.6 cm) surface without arm support for two consecutive days,[68] was significantly improved post-intervention in the group with additional STS practice (17 participants achieved STS independence vs 7 in the conventional group). De Sousa et al.[71] defined STS ability as clinician's impressions of STS change (using 15-point Global Impressions of Change Scale), the STS item of the Mobility Scale for Acute Stroke Patients, the ranking of change in ability to move from sitting to standing, and the Goal Attainment Scale. The mean between-group differences in the clinicians' impressions on STS change was 1.57 out of 15 points (95% CI 0.02–3.11) in favour of the experimental group, the STS item of the Mobility Scale was 0.6 out of 6 points (95% CI −1.4 to 1.5), the ranking of change in ability to move from sitting to standing was −7 (95% CI −1 to −13) in favour of the experimental group, and the Goal Attainment Scale was 0.7 out of 5 points (95% CI −0.2 to 1.7). Meta-analysis was not considered due to differences in outcome measures.

Additional information. Repetitive task-specific training, such as sit-to-stand practice, falls under the current therapy approaches with a strong evidence base in stroke rehabilitation.[22] The Cochrane review by Pollock et al.[24] investigated the effect of interventions targeting

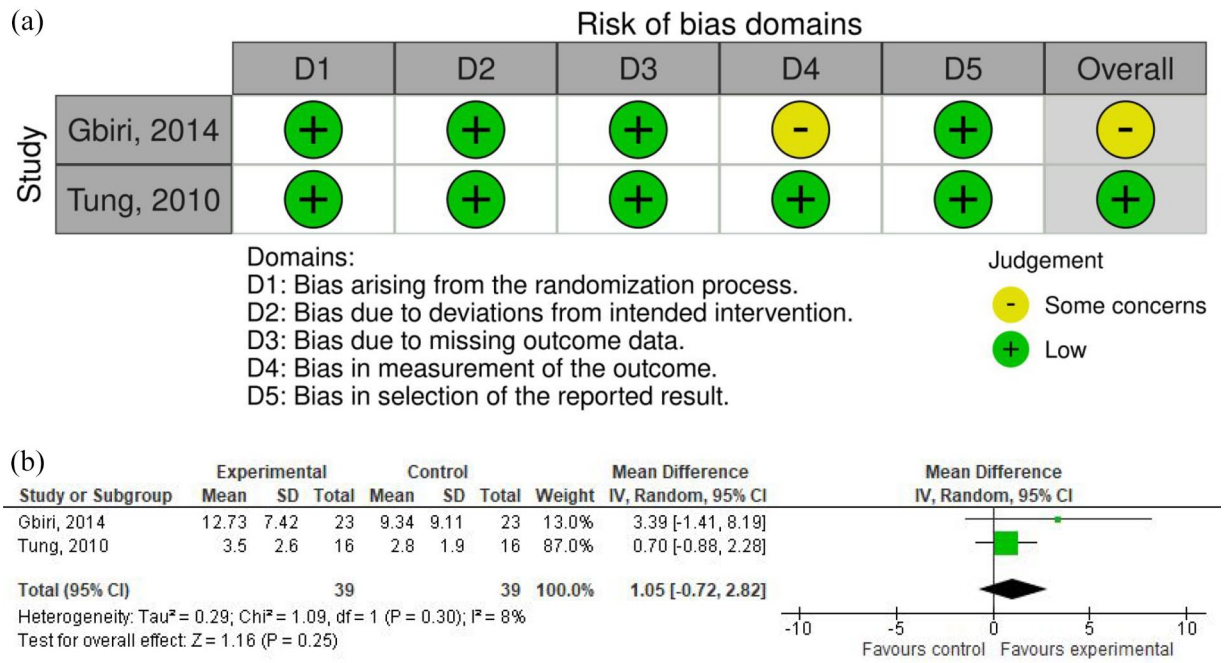

Figure 9. (a; top) Risk of bias for PICO 6 Berg Balance Scale outcome; (b; bottom) Forest plot of meta-analysis for Berg Balance Scale in PICO 6.

sit-to-stand performance, alone or integrated with other tasks such as sit-to-stand transitions, in people with stroke who could perform the STS task independently. The review found insufficient evidence of effectiveness to improve the ability to sit-to-stand independently. However, significant improvements were found in the time taken to complete the STS task and in lateral weight distribution symmetry during STS, both at post-intervention and at follow-up, compared to conventional therapy. The quality of evidence was moderate and suggests a beneficial effect of STS practice on time taken to sit-to-stand and lateral symmetry during sit-to-stand, in people with stroke who were already able to sit-to-stand independently.[24] The effect of sit-to-stand training on the number of falls was unclear, demonstrating no benefit or harm.[24]

Various clinical guidelines emphasise the importance of sit-to-stand practice in stroke rehabilitation. For instance, the living guidelines of Australia and New Zealand,[9] the national clinical guidelines of Canada,[72] and the 2023 NICE (National Institute for Health and Care Excellence) guideline[67] recommend repetitive task training, including sit-to-stand tasks, for enhancing lower limb strength, sit-to-stand and walking ability. Furthermore, the National Clinical Guideline for Stroke of the United Kingdom and Ireland of 2023 states that transfer training, including sit-to-stand, is a key part of stroke rehabilitation.[8] The Cochrane review by Legg et al.[73] demonstrated that occupational therapy with particular focus on activities of daily living, including transfers, produced significantly more improvements in personal activities of daily living than usual care.

Our findings as well as the Royal Dutch Society of Physiotherapy (KNGF) guidelines[11] indicate that it currently remains unclear whether sit-to-stand practice is more effective than control interventions due to limitations of the studies that examined this question. It seems plausible that repeatedly practicing standing up will improve sit-to-stand, however the effects may further depend on the number of repetitions, the amount and content of training sessions and the duration of the additional sit-to-stand training. Furthermore, it remains unclear to what extent exercising standing up and sitting down improves mobility.

Evidence-based Recommendation
For clinical practice, we suggest additional sit-to-stand practice on top of usual care to improve postural balance capacity. Additional training should include sufficient repetitions, training sessions and adequate duration and content of training. What these parameters are is currently unclear.
Quality of evidence: Moderate ⊕⊕⊕
Strength of recommendation: Weak for intervention ↑?

Discussion

This first ESO guideline on motor rehabilitation for people with stroke was developed to answer the most critical and clinically relevant questions faced by rehabilitation teams and therapists in clinical decision-making. The selection of PICOs was informed by the existing evidence base across multiple stroke guidelines[4] and prioritised by the expert

module working group. To target the current clinical need, the comprehensive SOP of ESO were followed including the GRADE assessment of the evidence. All evidence-based recommendations and expert consensus statements are summarised in Table 4.

The guideline provides evidence-based recommendations for nine rehabilitation outcomes derived from four PICO questions. Overall, the evidence base is limited. The GRADE evaluations were based on only two to three RCTs and the overall quality of evidence was moderate for two, low for three and very low for four critical outcomes. For two PICOs, only one relevant study could be included, and therefore no evidence-based recommendation could be provided. Thus, for PICO 2 and PICO 4, expert consensus statements were developed and voted on by the module working group.

Table 4. Synoptic table of all recommendations and expert consensus statements.

Recommendation	Expert consensus statement
PICO 1 In people with stroke, does adding at least 20 h or more of the same type of active repetitive upper limb practice produce greater improvements in upper limb motor function, activity capacity and performance?	
For clinical practice, we suggest considering adding additional time of repetitive upper limb practice to existing stroke rehabilitation programmes. The exact amount of additional practice time is unclear but will likely be at least 20 h, commonly delivered 3–5 times per week over 4–6 weeks. Quality of evidence: **Very low** ⊕ Strength of recommendation: **Weak for intervention** ↑?	
PICO 2 In people with stroke, does adding at least 20 h or more of the same type of gait training produce greater improvements in walking independence, walking speed, walking endurance, and walking capacity?	
Due to the limited evidence of only a single RCT, we cannot make an overall recommendation that a certain amount of additional time spent in walking practice will have an additional effect on walking capacity in people with stroke. Quality of evidence: - Strength of recommendation: -	Based on the overall available evidence, 13 out of 17 MWG members (76%) suggest that additional time spent in walking practice can improve walking capacity in people with stroke. The exact amount of the additional practice time is unclear but will likely be at least 20 h, commonly delivered 3–5 times per week over 4–6 weeks. Thus, for clinical practice, we suggest considering adding extra time of walking practice to existing stroke rehabilitation programmes, preferably at least 20 h.
PICO 3 In people with stroke, does high-intensity walking training compared to dose-matched (in duration) walking training at a lower intensity produce greater improvements in walking independence, walking speed, walking endurance and walking capacity?	
In people in the chronic stage of stroke with stable cardiovascular status, we recommend high-intensity walking training rather than duration-matched walking training at a lower intensity to improve walking endurance. Quality of evidence: **Moderate** ⊕⊕⊕ Strength of recommendation: **Strong for intervention** ↑↑ In people in the chronic stage of stroke with stable cardiovascular status, we suggest high-intensity walking training rather than duration-matched walking training at a lower intensity to improve comfortable and maximum walking speed. Quality of evidence: **Low** ⊕⊕ Strength of recommendation: **Weak for intervention** ↑?	

(Continued)

Table 4. (Continued)

Recommendation	Expert consensus statement
PICO 4 In people with stroke, does repetitive upper limb task-specific training with a behavioural transfer package compared to the same type of duration-matched training without a behavioural transfer package produce greater improvements in upper limb activity capacity, perceived and actual upper limb activity performance?	
Due to the limited evidence, based only on a single RCT, we cannot make an overall recommendation that including a transfer package in upper limb therapy compared to not including a transfer package has an additional effect on upper limb activity capacity or performance. Quality of evidence: - Strength of recommendation: -	Acknowledging the current lack of evidence for this PICO, 13 out of 17 MWG members (76%) suggest considering a transfer package when providing repetitive upper limb task-specific training, when aiming to achieve a transfer from treatment to daily life. The transfer package would include daily evaluation, a patient-kept daily diary, problem-solving, behavioural contract, home practice of specified exercises, and weekly follow-up contacts.
PICO 5 In people with stroke, does the provision of task-specific training in groups with at least 1:2 therapist-patient ratio compared to the same type of time-matched 1: 1 training have the same effect on motor function, activity capacity and perceived performance?	
For clinical practice, group-based lower limb training could be offered to improve lower limb activity capacity, but a reasonable ratio between patients and therapists is required to ensure safety and supervision as well as offering additional individualised therapy to address patients' goals and preferences. Quality of evidence: **Very low** ⊕ Strength of recommendation: **Weak for intervention** ↑?	
PICO 6 In people with stroke, does the provision of usual care plus additional sit-to-stand training compared to usual care alone produce greater improvements in balance capacity, independence and time taken in sit-to-stand?	
For clinical practice, additional sit-to-stand training on top of usual care could be provided but the additional training should include sufficient repetitions, training sessions and adequate duration and content of training. What these parameters are is currently unclear. Quality of evidence: **Moderate** ⊕⊕⊕ Strength of recommendation: **Weak for intervention** ↑?	

This guideline targeted the effect of dose on rehabilitation outcomes with PICO 1 and 2. This is a timely and highly discussed topic, and there is a commonly held understanding in the motor rehabilitation domain that 'more therapy is better'. However, we found that the number of studies specifically investigating the effect of dose when applying the same type of therapy, was surprisingly small. The limited number of studies is reflected in the modest recommendations we can provide. For PICO 1, very low-quality evidence supports a weak recommendation for an additional 20 h upper limb practice to improve arm activity capacity. For PICO 2, the majority of expert group members (13 out of 17) agreed on and suggested that at least 20 h of additional walking practice would be beneficial for people in any stage of stroke.

A somewhat stronger evidence-based recommendation could be presented in PICO 3 for the benefits of high-intensity walking practice compared to low-intensity practice for walking endurance (moderate quality of evidence) and walking speed (low quality of evidence). However, this recommendation is valid only for people with stable cardiovascular status in the chronic stage of stroke. In clinical practice, exercise testing of cardiovascular status prior to high-intensity training can become a barrier to implementation. As a result, clinicians may instead choose to only implement moderate intensity protocols for all and not use the full potential of intensive practice. Although we did not find RCT evidence supporting the use of high intensity training in the early subacute setting, there are several quasi-experimental studies indicating

high-intensity training is safe and implementable in clinical practice leading to improvements in walking and balance outcomes.[74,75] Further research is required in this field to guide the safe and effective implementation of this intervention.

PICO 4 investigated whether the inclusion of a transfer package in an upper limb therapy programme provided better outcomes compared to therapy without a transfer package. Since only one quasi-RCT was identified, no evidence-based recommendation could be made. The majority of expert group members (13 out of 17) agreed on suggesting that a transfer package should be considered when providing repetitive upper limb task-specific training in order to enhance transfer of the training effects to daily life. The optimal content of this transfer package is unclear, but in the meantime, possible content is extensively described in clinical studies.[54]

A non-inferiority analysis for whether group-based therapy was as effective as one-to-one therapy was examined in PICO 5. Regarding the lower limb domain, we made a weak recommendation that group-based therapy is equally (not less) effective as one-to-one therapy for improving balance capacity, walking speed, and walking endurance. However, the quality of evidence was graded as very low. For clinical practice, when applying group-based therapy we suggest that a reasonable ratio between patients and therapists should be considered to ensure optimal safety and supervision. In addition to group therapy, clinicians ought to offer individual therapy to specifically address patients' goals and preferences.

Finally, the beneficial effect of additional sit-to-stand (STS) training on top of usual care, in comparison to usual care, was evaluated in PICO 6. We made a weak recommendation for additional STS practice in addition to usual care in order to improve postural balance capacity. This recommendation had moderate quality of evidence. In clinical practice, we suggest that additional STS training on top of usual care should be considered, provided that the additional training has sufficient dose in terms of number of repetitions, number of training sessions and duration of the intervention. Given the current evidence, the exact dosage and delivery modes of additional STS practice still need to be defined.

Strengths and limitations

For this first ESO motor rehabilitation guideline we selected very specific PICO comparisons, addressing both current challenges in the stroke rehabilitation domain, as well as core focus areas for rehabilitation. We limited the number of PICOs, recognising that the motor rehabilitation domain is broad, with many different approaches investigated. The inclusion of newer technologies was considered but with the first ESO guidelines, we aimed to develop guidelines that are relevant for stroke motor rehabilitation in widespread clinical practice across the world. Therefore, advanced neuromodulation therapies were also not prioritised in this first ESO guideline.

The outcomes were rated by members of the MWG as critical, important, or of limited importance according to GRADE criteria and a Delphi approach was used to reach a final decision. Only critical outcomes according to GRADE criteria were selected and rated by the members of the MWG. Safety outcomes were identified for some PICOs, but these were not graded as critical. The adverse effects of high-intensity walking practice were extracted from the literature in PICO 3, but no adverse effects were reported in the included studies. None of the studies included participants with unstable cardiovascular status and this is stated in our evidence-based recommendation.

In several international guidelines, recommendations are already provided but generally, they offer little specific guidance for the clinical field. That is why, for instance, for PICO 1 and 2 we focused on a specific difference in therapy dose (hours spent in therapy), while the content of therapy provided in both groups needed to be the same. This ensured that we could draw conclusions based on only one element, the number of hours spent in therapy. We applied a similar strategy for our other PICO questions, focusing on a specific comparison, with the aim of providing more specific guidance for clinical practice. Based on a systematic screening of the literature, a very limited number of studies met our inclusion and exclusion criteria, thus providing only a small evidence-base for selected PICOs. Here we see a clear need for the stroke rehabilitation research field to concentrate future investigations on specific comparisons of one element of an intervention, as this could allow future updates of our PICO analyses with more and potentially stronger evidence-based recommendations.

Overall, the quality of evidence for this ESO guideline was moderate to very low, and for two PICOs no recommendations could be provided. Despite this, there is no lack of evidence for stroke rehabilitation.[4,7] This guideline provides additional and more detailed information summarising the evidence base with respect to each focus area, and we have previously provided an overview of strongly recommended interventions across international guidelines.[4] Information that is presented in guidelines is commonly derived through various independent, yet frequently national, collaborations. For more optimal use of resources we call for global initiatives where trial collaborations are set up including all stakeholders for the stroke rehabilitation domain to allow development of methodological approaches for 'pooling' of data and knowledge bases.

The expertise of our international module working group is a strength of this work and future updates should strive for balanced expertise of recognised specialists, both in the research and clinical practice domain. Our MWG identified the PICOs to investigate based on their

expertise and knowledge needs for rehabilitation. Future involvement of people with lived experience could further ensure that guidelines address the needs of the people affected by stroke as well.

Conclusions

The first ESO guideline on motor rehabilitation for patients with stroke addresses critical clinical questions to support clinicians and healthcare providers. Despite the limited evidence base, the guideline provides evidence-based recommendations for nine rehabilitation outcomes derived from four PICO questions. The recommendations suggest additional upper limb practice, high-intensity walking practice for chronic stroke patients with stable cardiovascular status, group-based therapy being non-inferior to one-to-one therapy for balance and walking outcomes and additional sit-to-stand training to improve postural balance. The expert consensus statements suggest additional walking practice, and the inclusion of a transfer package for upper limb training. The guideline emphasises the need for future trial designs to focus on specific comparisons of therapy elements to strengthen evidence-based recommendations and calls for global collaborations to optimise resources and enhance stroke rehabilitation research and practice.

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Contributorship

Margit Alt Murphy and Geert Verheyden supported by Maria Munoz-Novoa and Charlotte Heremans wrote the first draft of the manuscript. Anna Podlasek conducted the statistical analyses. All authors contributed to the data analyses and drafting of results sections of their assigned PICO group. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

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Supplemental material

Supplemental material for this article is available online.

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