UNIVERSIDADE FEDERAL DE PERNAMBUCO
CENTRO DE CIÊNCIAS DA SAÚDE
PROGRAMA DE PÓS-GRADUAÇÃO EM FISIOTERAPIA

Beatriz Rithiely Henrique Ramos da Silva

NEUROMODULAÇÃO NÃO INVASIVA PARA O TRATAMENTO DA FUNÇÃO MOTORA DE PESSOAS PÓS ACIDENTE VASCULAR CEREBRAL: UMA *UMBRELLA REVIEW*

Recife
2025

Beatriz Rithiely Henrique Ramos da Silva

NEUROMODULAÇÃO NÃO INVASIVA PARA O TRATAMENTO DA FUNÇÃO MOTORA DE PESSOAS PÓS ACIDENTE VASCULAR CEREBRAL: UMA *UMBRELLA REVIEW*

Dissertação apresentada ao Programa de Pós-Graduação em Fisioterapia da Universidade Federal de Pernambuco, como requisito parcial para obtenção do título de mestre em Fisioterapia.
Área de concentração: Fisioterapia na Atenção à Saúde.

Orientadora: Profª. Drª. Kátia Monte-Silva

Co-orientadora: Profª. Drª. Lívia Shirahige

Recife

2025

.Catalogação de Publicação na Fonte. UFPE - Biblioteca Central

Rithiely, Beatriz.
Neuromodulação não invasiva para o tratamento da função motora de pessoas pós Acidente Vascular Cerebral: uma umbrella review / Beatriz Rithiely Henrique Ramos da Silva. - Recife, 2025.
128f.: il.

Dissertação (Mestrado)- Universidade Federal de Pernambuco, Centro de Ciências da Saúde, Programa de Pós-Graduação em Fisioterapia, 2025.
Orientação: Kátia Monte-Silva.
Coorientação: Lívia Shirahige.

1. Meta-análise; 2. AVC; 3. Revisão sistemática. I. Monte-Silva, Kátia. II. Shirahige, Lívia. III. Título.

UFPE-Biblioteca Central

Beatriz Rithiely Henrique Ramos da Silva

NEUROMODULAÇÃO NÃO INVASIVA PARA O TRATAMENTO DA FUNÇÃO MOTORA DE PESSOAS PÓS ACIDENTE VASCULAR CEREBRAL: UMA *UMBRELLA REVIEW*

Dissertação apresentada ao Programa de Pós-Graduação em Fisioterapia da Universidade Federal de Pernambuco, como requisito parcial para obtenção do título de mestre em Fisioterapia.
Área de concentração: Fisioterapia na Atenção à Saúde.

Aprovada em: 29/08/2025

BANCA EXAMINADORA

_____

Profª. Dra. Gisela Rocha de Siqueira (Presidente)

Universidade Federal de Pernambuco

_____

Profª. Dra. Vivian Farahte Giangiardi (Examinadora Interna)

Universidade Federal de Pernambuco

_____

Profª. Dra. Déborah Marques de Oliveira (Examinadora Externa)

Instituto de Neurociências Aplicada

APRESENTAÇÃO

Este trabalho de dissertação está vinculada a linha de pesquisa do Programa de Pós-Graduação em Fisioterapia da Universidade Federal de Pernambuco intitulada como “Avaliação e intervenção nas condições neuromusculoesqueléticas”, vinculada ao projeto de pesquisa “Estudo da aplicação de estimulações cerebrais não-invasivas no desempenho motor de indivíduos saudáveis e na reabilitação motora de pacientes neurológicos” do Laboratório de Neurociência Aplicada (LANA) do Departamento de Fisioterapia da UFPE.

A dissertação integra uma série de revisões gerais (PROSPERO (CRD42021239577; fevereiro/2020 - ANEXO A) produzidas pelo *Working Group* sobre evidências científicas para o uso de estimulação cerebral não invasiva (NIBS), vinculado ao grupo de Desenvolvimento de Diretrizes Brasileiras da Rede NAPeN (Núcleo de Assistência e Pesquisa em Neuromodulação Não Invasiva). O projeto ao qual esta dissertação se vincula tem como objetivo “Sintetizar, com base nos principais domínios da estrutura da Classificação Internacional de Funcionalidade, Incapacidade e Saúde (CIF), as melhores evidências disponíveis sobre a eficácia e a segurança da estimulação cerebral não invasiva (NIBS, do inglês, non invasive brain stimulation) para melhorar o comprometimento motor e a incapacidade após Acidente Vascular Cerebral (AVC)”.

A linha de investigação adotada tem buscado aprofundar-se nos seguintes aspectos:

1. Eficácia e segurança das técnicas de NIBS, como a rTMS e a tDCS, nos pacientes pós-AVC, com ênfase na melhoria dos déficits neurológicos, considerando os impactos nas funções motoras, cognitiva e na qualidade de vida do paciente;
2. Padronização dos protocolos terapêuticos de NIBS, abordando aspectos fundamentais como frequência, intensidade, localização dos eletrodos, número de sessões e duração do tratamento, com o objetivo de identificar parâmetros otimizados para maximizar os resultados clínicos em pacientes pós-AVC;
3. Análise dos desfechos clínicos relevantes, abrangendo a função motora, o equilíbrio, a mobilidade funcional e a capacidade de realizar atividades da vida diária. Este aspecto busca estabelecer uma compreensão detalhada dos

efeitos das intervenções de NIBS na recuperação de capacidades essenciais para a reabilitação pós-AVC;

4. Identificação de lacunas na literatura científica existente, além do desenvolvimento de revisões sistemáticas e estudos clínicos robustos, com o intuito de fornecer uma base sólida e confiável de evidências que fundamentem a prática clínica da NIBS em contextos de reabilitação pós-AVC;

A dissertação foi organizada no formato de artigo científico, conforme previsto nas diretrizes Programa de Pós-graduação Stricto Sensu em Fisioterapia da UFPE. A escolha desse formato visou otimizar a disseminação dos resultados da pesquisa, permitindo sua submissão para publicação em periódico científico de relevância na área.

Durante o período do mestrado, a aluna também realizou as seguintes atividades técnicas e contribuições científicas:

1. Submissão do artigo: Non-invasive brain stimulation for stroke-related motor impairment and disability: an umbrella review of systematic review and meta-analysis. Aceito em 30 de julho de 2025 na revista: Frontiers in Neuroscience, qualis A3 para a área 21 da CAPES, fator de impacto: 3.2 (ANEXO B)
2. Submissão do artigo: Transcranial direct current stimulation associated with aerobic exercise as a strategy for managing fatigue and pain in long covid: a feasibility study, submetido em 21 de Agosto de 2025 na revista: The Journal of Pain, qualis A1 para a área 21 da CAPES, fator de impacto: 4 (ANEXO C)
3. Elaboração do pôster premiado no VII Simpósio Internacional De Neuromodulação Não Invasiva, intitulado “Estimulação Magnética Transcraniana Repetitiva Na Função Motora Pós-Avc: Uma Revisão Guarda-Chuva” (São Paulo/Agosto 2025 - ANEXO D)
4. Participou do projeto de extensão Departamento de Fisioterapia, do Centro de Ciências da Saúde da UFPE, intitulado “Núcleo de Estudos para Desenvolvimento Tecnológico e Inovação em Terapia Intensiva” (Recife/Fevereiro 2024 - ANEXO E)
5. Coorientação do aluno do curso de graduação em Fisioterapia da UFPE, Pedro Vanderley (Recife/Março 2025 - ANEXO F)

6. Coorientação da aluna do curso de graduação em Fisioterapia da UNIFACOL, Maria Clara (Vitória/Maio 2024 - ANEXO G)
7. Coorientação da aluno do curso de graduação em Fisioterapia da UNICAP, Thalyta Marques (Recife/Junho 2024 - ANEXO H)
8. Participou do do XXI Simpósio Internacional de Fisioterapia Respiratória, Cardiovascular e Terapia Intensiva (Brasília/Junho 2024 - ANEXO I)
9. Elaboração do pôster no Congresso Brasileiro de Fisioterapia intitulado “Comparação do impacto da rtms de baixa frequência sobre os sintomas motores e não motores na DP” (Salvador/Agosto 2024 - ANEXO J)
10. Participou da banca de graduação em Fisioterapia da UNIFACOL, das alunas Apoliana Mikaelly e Júlia Gabrielly (Vitória de Santo Antão/Dezembro 2024 - ANEXO K)
11. Participou da banca de graduação em Fisioterapia da UNIFACOL, da aluna Érika Maria (Vitória de Santo Antão/Dezembro 2024- ANEXO L)
12. Participação no IV Simpósio do Programa de Pós-Graduação em Fisioterapia da UFPE, intitulado “Uso da estimulação transcraniana por corrente contínua (tDCS) para o tratamento do acidente vascular cerebral (AVC): uma umbrella review de meta-análises” (Recife/Dezembro 2024 - ANEXO M).
13. Elaboração do pôster no 13º Congresso Internacional de Fisioterapia, intitulado “Avaliação do nível de conhecimento e aplicabilidade do perme escore de mobilidade em unidade de terapia intensiva entre fisioterapeutas atuantes na área no estado de Pernambuco” (Florianópolis/Setembro 2023 - ANEXO N)
14. Apresentação do pôster no VIII Congresso Pernambucano de Fisioterapia Respiratória, Cardiovascular e em Terapia Intensiva da Assobrafir, intitulado “Relação entre sarcopenia, força muscular respiratória e função pulmonar em idosos com DPOC” (Recife/Novembro 2023 - ANEXO O)
15. Participou do curso teórico prático intitulado “Utilização da estimulação elétrica neuromuscular: da UTI ao ambulatório” no VIII Congresso Pernambucano de Fisioterapia Respiratória, Cardiovascular e em Terapia Intensiva da Assobrafir (Recife/Novembro 2023 - ANEXO P)

16. Participou do curso teórico prático intitulado “Curso teórico prático: Cateter Nasal de alto fluxo aplicado à pediatria” no VIII Congresso Pernambucano de Fisioterapia Respiratória, Cardiovascular e em Terapia Intensiva da Assobrafir (Recife/Novembro 2023 - ANEXO Q)
17. Participou do curso teórico prático intitulado “Estratégias de utilização da ultrassonografia cinesiológica para fisioterapeutas” no VIII Congresso Pernambucano de Fisioterapia Respiratória, Cardiovascular e em Terapia Intensiva da Assobrafir (Recife/Novembro 2023 - ANEXO R)

Dedico esse trabalho aos meus pais e aos meus avós. Obrigada por sempre acreditarem em mim. E para meu avô, que faleceu no final de 2024, José Ivanildo Ramos, o senhor sempre estará vivo em minhas memórias.

AGRADECIMENTOS

Primeiramente, agradeço a Deus, por ter me concedido forças e sabedoria ao longo de todo o processo do mestrado. Foram muitos momentos de incertezas, cansaço e renúncias, e sei que sem a presença d'Ele ao meu lado, eu não teria conseguido chegar até aqui. Agradeço também à Nossa Senhora Aparecida, que intercedeu por mim em todas as minhas preces, e me manteve firme nos dias mais difíceis.

Agradeço aos meus pais, Lisandra e Emerson, minha eterna gratidão. Vocês sempre foram minha base, meu porto seguro, e o exemplo mais puro de amor, dedicação e sacrifício. Sei que muitas vezes abriram mão dos próprios sonhos para que eu pudesse seguir os meus. Estiveram ao meu lado em cada vitória e, principalmente, em cada desafio, segurando minha mão e me incentivando a continuar. Obrigada por acreditarem em mim até quando eu mesma duvidei. Tudo o que sou e tudo o que conquistei tem a marca do amor de vocês.

Aos meus avós, que sempre demonstraram tanto carinho, cuidado e apoio, o meu sincero agradecimento. Vocês também fizeram parte dessa conquista, torcendo por mim e se disponibilizando sempre que precisei. Obrigada por me ensinarem tanto com seus gestos, conselhos e exemplos de vida. O apoio de vocês foi essencial ao longo dessa jornada.

Aos demais familiares — tias, tios, primas e primos —, muito obrigada por estarem presentes, por escutarem minhas angústias, comemorarem minhas pequenas conquistas e sempre me ofereceram palavras de apoio e incentivo. Ter uma família presente, fez toda a diferença para que eu nunca me sentisse sozinha nesse percurso.

Ao meu namorado, Fabrício, que viveu intensamente comigo cada fase deste processo, e escutou meus anseios, medos, angústias, agonias e esperanças. Obrigada por ter sido meu alicerce quando eu me sentia perdida e por, em nenhum momento, duvidar da minha capacidade. Sua presença constante, seu amor, sua paciência e suas palavras de conforto foram fundamentais para que eu seguisse em frente.

Aos meus amigos, que são a família que a vida me permitiu escolher, deixo aqui meu carinho e gratidão. Obrigada por cada palavra de incentivo, por cada escuta atenta e por me oferecerem abrigo emocional quando tudo parecia difícil demais. Em especial, obrigada aos que permaneceram mesmo nos meus momentos mais silenciosos. Vocês sabem quem são, e o quanto foram essenciais para mim.

À Patrícia, minha amiga desde a graduação e, por obra divina, minha parceira também no mestrado — você foi uma luz nessa jornada. Obrigada por estar comigo nos momentos mais desafiadores, por passar horas, dias e madrugadas ao meu lado, me ajudando com dedicação, paciência e companheirismo. Sua generosidade e apoio foram fundamentais, e serei sempre grata por ter caminhado ao seu lado nessa fase tão importante da minha vida.

À minha orientadora, Katia Monte-Silva, minha mais profunda e eterna gratidão. Desde o primeiro momento, fui acolhida com generosidade, respeito e confiança. Você me abriu as portas do seu laboratório e do seu projeto com uma disposição admirável, fazendo com que eu me sentisse parte de algo muito maior do que imaginava. Ao longo desse percurso, sua orientação foi muito mais do que acadêmica — foi humana e inspiradora. Se eu agradecesse milhões de vezes, ainda assim seria insuficiente para expressar o quanto sou grata por tudo que você fez por mim. Obrigada por acreditar, apoiar e, sobretudo, por me impulsionar a crescer.

À Lívia Shirahige, obrigada por me acolher com tanto carinho e por aceitar o convite para ser minha co-orientadora. Você fez toda a diferença na minha trajetória, e sua presença nesse processo me trouxe motivação. Você é uma inspiração profissional, e levo comigo o privilégio de ter sido co-orientada por alguém tão comprometida com a ciência, com o ensino e com as pessoas. Serei eternamente grata por ter feito parte da minha jornada.

Ao LANA — Laboratório de Neurociência Aplicada — meu sincero agradecimento. Encontrar esse espaço foi como encontrar um novo lar dentro da universidade. A forma como fui recebida, a troca com os colegas, o ambiente de colaboração e respeito me fizeram sentir acolhida e fortalecida. Estar nesse laboratório não apenas contribuiu para minha formação científica, como também me proporcionou momentos de pertencimento, aprendizado e amadurecimento pessoal.

À Niége Melo, funcionária do Programa de Pós-graduação em Fisioterapia/CCS/UFPE, pela constante disponibilidade, atenção e prontidão em me auxiliar sempre que necessário. Sou profundamente grata por todo o apoio prestado.

À todas as pessoas da UFPE que se tornaram parte da minha vida, deixo aqui todo o meu carinho. Foram anos de convivência, trocas e apoio mútuo que me ensinaram sobre companheirismo, empatia e resistência. Em cada corredor, sala ou laboratório, encontrei afeto, força e amizade. Não tenho dúvidas de que essas relações foram fundamentais para que eu pudesse superar os desafios do caminho e seguir adiante.

Encerro uma etapa importante da minha vida com o coração cheio de gratidão. Essa trajetória não foi fácil — houve dúvidas, medos, noites sem dormir, desafios que pareciam insuperáveis. Mas, olhando para trás, vejo que cada obstáculo superado teve um propósito. Tudo o que vivi me moldou, me fortaleceu e me trouxe até aqui.

E, apesar de todas as tempestades, sigo acreditando: o sol sempre volta amanhã.

RESUMO

Introdução: a recuperação de indivíduos pós-AVC ainda é um desafio, mesmo para aqueles que estão em processo de reabilitação, e continuam enfrentando limitações motoras significativas. Por causa disso, as técnicas de estimulação cerebral não invasiva (NIBS, do inglês, non invasive brain stimulation), particularmente a estimulação magnética transcraniana repetitiva (rTMS, do inglês, repetitive transcranial magnetic stimulation) e a estimulação transcraniana por corrente contínua (tDCS, do inglês, transcranial direct current stimulation), têm sido estudadas e demonstram benefícios na recuperação e incapacidades sensório-motoras nessa população. No entanto, revisões sistemáticas frequentemente chegam a conclusões conflitantes, mesmo abordando desfechos semelhantes, ressaltando a necessidade de uma *umbrella review*. **Objetivo:** sintetizar, com base nos principais domínios da estrutura da Classificação Internacional de Funcionalidade, Incapacidade e Saúde (CIF), as melhores evidências disponíveis sobre a eficácia e a segurança da NIBS para melhorar o comprometimento motor e a incapacidade após AVC. **Métodos:** foi realizada uma *umbrella review* (PROSPERO: CRD42021239577) que incluiu meta-análises de ensaios controlados que investigaram os efeitos da NIBS em pacientes pós-AVC, retirados do PubMed/MEDLINE no período de fevereiro de 2020 a julho de 2025. A qualidade metodológica foi avaliada usando o AMSTAR-2 e na avaliação da qualidade da evidência foi utilizado o GRADE-pro. Os resultados foram mapeados para os domínios de estrutura/função corporal e atividade da CIF. **Resultados:** Foram incluídos 56 estudos, que avaliaram exclusivamente rTMS e tDCS. A qualidade metodológica foi considerada alta ou moderada em 85,7% das meta-análises, enquanto em 14,3% dos estudos a qualidade da evidência foi classificada como baixa ou muito baixa. A aplicação da rTMS demonstrou benefícios nas atividades de vida diária (AVD) (Standardized Mean Difference - SMD = –0,82; IC 95% –1,05 a –0,59), no comprometimento motor dos membros superiores (SMD = –0,32; IC 95% –0,55 a –0,09) e na mobilidade (SMD = –0,97; IC 95% –1,28 a –0,66). No entanto, apenas uma revisão envolvendo rTMS apresentou evidência de qualidade moderada para AVD. Já para a tDCS, no desfecho de comprometimento motor, foram observados tamanhos de efeito variando de pequeno (SMD = –0,22; IC 95% –0,32 a –0,12) a grande (SMD = –1,54; IC 95% –2,78 a –0,29) e na atividade de membros superiores (SMD = –0,31; IC 95% –0,55 a –0,01), mas com evidências de qualidade muito baixa. Os resultados para AVD e mobilidade com tDCS, porém, mostraram-se inconsistentes e na maioria das vezes não significativos. **Conclusão:** a rTMS esteve mais frequentemente relacionada a tamanhos de efeito moderados a altos nos desfechos de estrutura e função corporal, em especial na função neurológica geral. Em contrapartida, a tDCS apresentou apenas pequenos efeitos na recuperação motora, com evidência de muito baixa qualidade em razão da heterogeneidade, da imprecisão e da variabilidade dos protocolos utilizados. No domínio da atividade, os efeitos da NIBS foram menores, sendo a rTMS a técnica que demonstrou resultados mais consistentes para as AVD. Já os efeitos da tDCS mostraram-se em geral limitados e sustentados por evidências de baixa a muito baixa certeza.

Palavras-chave: meta-análise; AVC; revisão sistemática.

ABSTRACT

Introduction: the recovery of post-stroke individuals remains a challenge, even for those undergoing rehabilitation and still facing significant motor limitations. Therefore, non-invasive brain stimulation (NIBS) techniques, particularly repetitive transcranial magnetic stimulation (rTMS) and transcranial direct current stimulation (tDCS), have been studied and demonstrated benefits in recovery and sensorimotor impairments in this population. However, systematic reviews often reach conflicting conclusions, even when addressing similar outcomes, highlighting the need for an umbrella review. **Objective:** To synthesize, based on the main domains of the International Classification of Functioning, Disability and Health (ICF) framework, the best available evidence on the efficacy and safety of NIBS for improving motor impairment and disability after stroke. **Methods:** an umbrella review (PROSPERO: CRD42021239577) was conducted, including meta-analyses of controlled trials investigating the effects of NIBS in post-stroke patients, retrieved from PubMed/MEDLINE from February 2020 to July 2025. Methodological quality was assessed using AMSTAR-2, and GRADE-pro was used to assess the quality of evidence. The results were mapped to the ICF body structure/function and activity domains. **Results:** fifty-six studies were included, which exclusively evaluated rTMS and tDCS. The methodological quality was considered high or moderate in 85.7% of the meta-analyses, while in 14.3% of the studies the quality of the evidence was classified as low or very low. The application of rTMS demonstrated benefits in activities of daily living (ADL) (Standardized Mean Difference - SMD = –0.82; 95% CI –1.05 to –0.59), in upper limb motor impairment (SMD = –0.32; 95% CI –0.55 to –0.09) and in mobility (SMD = –0.97; 95% CI –1.28 to –0.66). However, only one review involving rTMS presented moderate-quality evidence for ADL. For tDCS, in the outcome of motor impairment, effect sizes ranging from small (SMD = –0.22; 95% CI –0.32 to –0.12) to large (SMD = –1.54; 95% CI –2.78 to –0.29) were observed, and in upper limb activity (SMD = –0.31; 95% CI –0.55 to –0.01), but with very low quality evidence. The results for ADL and mobility with tDCS, however, were inconsistent and mostly non-significant. **Conclusion:** rTMS was most frequently associated with moderate to large effect sizes on body structure and function outcomes, especially general neurological function. In contrast, tDCS showed only small effects on motor recovery, with very low-quality evidence due to the heterogeneity, imprecision, and variability of the protocols used. In the activity domain, the effects of NIBS were smaller, with rTMS demonstrating the most consistent results for ADL. The effects of tDCS were generally limited and supported by low- to very low-certainty evidence.

KEYWORDS

meta-analysis; stroke; umbrella review.

LISTA DE QUADROS

Dissertação:

Artigo:

LISTA DE TABELAS

Artigo:

LISTA DE FIGURAS

Dissertação:

Artigo:

LISTA DE ABREVIATURAS E SIGLAS

10MWT	*10-metre walking test*
6MWT	*6-minute Walk Test*
AVD	Atividade de vida diária
AMSTAR	*A Measurement Tool to Assess Systematic Reviews*
AVC	Acidente vascular cerebral
ARAT	*Action Research Arm Test*
BBS	*Berg Balance Scale*
BI	*Barthel Index*
CIF	Classificação internacional de funcionalidade, incapacidade e saúde (do inglês, *International Classification of Functioning, Disability and Health*)
CHIEF	*Craig Hospital Inventory of Environmental Factors*
CTs	Ensaios clínicos (do inglês, *controlled trials*)
DTI	Imagem de tensor de difusão
DP	Desvio padrão
FAC	*Functional ambulation category*
FDC	Função de distribuição cumulativa
FIM	*Functional independence measure*

FMA *Fugl-Meyer Assessment Scale*

FMA-LL *Fugl-Meyer Assessment Scale Lower Limb*

FMA-LE *Fugl-Meyer Assessment for Lower Extremity*

FMA-UE *Fugl-Meyer Assessment*

GRADE *Grading of Recommendations Assessment, Development and Evaluation Guideline Development Tool*

Hz *Hertz*

HD-tDCS *High-definition transcranial direct current stimulation*

I^2 *Heterogeneity index*

JTT *Jebsen Taylor Test*

mA *Miliampere*

MAS *Modified Ashworth Scale*

MeSH *Medical Subject Headings*

NNT Número necessário para tratar

NIBS Estimulação cerebral não invasiva (do inglês, *non invasive brain stimulation*)

NHPT *Nine Hole Peg Test*

NIHSS *National Institutes of Health Stroke Scale*

OMS Organização Mundial da Saúde

PRIOR Relatórios para visões gerais de revisões (do inglês, *recommendations of the preferred reporting items for overviews of reviews*)

RCT *Randomized clinical trials*

rTMS Estimulação Magnética Transcraniana Repetitiva (do inglês, *repetitive transcranial magnetic stimulation*)

SD *Standard deviation*

SIS *Stroke Impact Scale*

SMD *Standardized mean difference*

SNC Sistema nervoso central (do inglês, *central nervous system*)

tACS *Transcranial alternating current stimulation*

taVNS *transcutaneous auricular vagus nerve stimulation*

tDCS Estimulação transcraniana por corrente contínua (do inglês, *transcranial direct current stimulation*)

tRNS *Transcranial random noise stimulation*

tsDCS *Transcutaneous spinal direct current stimulation*

tsMS *Transcranial static magnetic stimulation*

TUG *Timed Up-and-Go test*

tVNS *Transcutaneous vagus nerve stimulation*

URs Revisões Guarda chuva *(*do inglês*, umbrella reviews)*

WMFT *Wolf Motor Function Test*

SUMÁRIO

1 INTRODUÇÃO

O Acidente Vascular Cerebral (AVC) é a principal causa de incapacidade em todo o mundo, exercendo consistentemente um impacto significativo na saúde pública em vários países (Campbell et al., 2019). Estima-se que, mais de 101 milhões de pessoas vivem com sequelas de AVC em todo o mundo (Feigin et al., 2022), representando, portanto, um grande impacto na qualidade de vida dos afetados. Apesar dos avanços nas terapias convencionais de reabilitação, muitos indivíduos no pós-AVC continuam a enfrentar limitações motoras significativas, o que torna urgente explorar estratégias complementares que possam potencializar os resultados.

Nas últimas décadas, a estimulação cerebral não invasiva (NIBS, do inglês, non invasive brain stimulation) tem emergido como uma abordagem promissora, com potencial para modular a plasticidade do sistema nervoso central e melhorar a recuperação funcional pós-AVC (Marín-Medina et al., 2024; Dionísio; Carvalho; Castelham 2023). Neste contexto, várias modalidades de NIBS têm sido investigadas (Kim; Park, 2024; Shen et al., 2022). Dentre estas, a estimulação magnética transcraniana repetitiva (rTMS, do inglês, *repetitive transcranial magnetic stimulation*) e a estimulação transcraniana por corrente contínua (tDCS, do inglês, *transcranial direct current stimulation*) são as mais amplamente investigadas (Klomjai et al., 2015).

Inúmeras revisões sistemáticas demonstram o benefício do uso da NIBS para recuperar deficiências e incapacidades sensório-motoras do AVC, incluindo: espasticidade (McIntyre et al. 2018; Graef et al. 2016), disfunção motora de membro superior ou inferior (Vaz et al. 2019; Kang et al., 2018; Zhang et al. 2017a), déficit no equilíbrio (Tien et al. 2020; Kang et al. 2020; Ghayour-Najafabadi et al. 2019a; Li et al. 2018), e mobilidade funcional (Tien et al. 2020; Ghayour-Najafabadi et al. 2019; Li et al. 2018) e desempenho durante as atividades da vida diária (AVD) (Ahmed et al., 2022; Xiang et al. 2019; Subramanian; Prasanna 2018).

No entanto, o grande número de revisões disponíveis pode resultar em conclusões conflitantes, e dificultar o consenso sobre a efetividade da NIBS. Além disso, muitas dessas revisões apresentam um tamanho da amostra menor que o necessário, tanto em estudos sobre rTMS (Liu et al., 2019; Graef et al., 2016; McIntyre et al., 2018) quanto para tDCS (Ren et al., 2024; Lima et al., 2023; Comino-Suàrez et al 2021; Sun et al 2021), o que pode comprometer a qualidade da evidência.

Para enfrentar esse desafio, as revisões guardas-chuvas (URs, do inglês umbrella reviews) têm ganhado relevância. As URs constituem um tipo avançado de revisão sistemática cujo objetivo é sintetizar e integrar de forma qualitativa os resultados de outras revisões sistemáticas e meta-análises previamente publicados, sendo, portanto, consideradas uma das formas mais elevadas de síntese de evidências disponíveis na atualidade (Aromataris et al., 2015; Liu, Hu; Yin, 2020). Assim, as URs são necessárias para o contexto da NIBS pós-AVC, pois em relação à neuroreabilitação, o AVC é uma das doenças mais estudadas para a utilização da NIBS (Juhi et al., 2024; Li et al., 2024).

Outra limitação recorrente nas revisões sobre o uso da NIBS para recuperação motora pós-AVC é o foco restrito em desfechos clínicos isolados (como comprometimento motor ou espasticidade), sem considerar o impacto em contextos amplos da funcionalidade, como as limitações na atividade, levando em consideração os fatores ambientais e pessoais. Diante disso, a Classificação Internacional de Funcionalidade, Incapacidade e Saúde (CIF) surge como um referencial adequado para preencher essa lacuna, ao organizar as consequências do dano neurológico em três domínios centrais: deficiências em funções e estruturas corporais, limitações nas atividades e restrições na participação (Leonardi e Fheodoroff, 2021). Nesse sentido, a CIF consolidou-se como padrão internacional para compreender e classificar o impacto multidimensional de condições de saúde, incluindo o AVC (Virani et al., 2021).

O presente estudo visa sintetizar, com base nos principais domínios da CIF, as melhores evidências disponíveis sobre a eficácia e a segurança da NIBS para melhorar o comprometimento motor e a incapacidade após AVC. Espera-se que esta revisão amplie a relevância clínica dos achados sintetizados e apoie interpretações

mais holísticas dos efeitos da NIBS, trazendo um panorama dos principais desafios e possíveis direções futuras.

2 REVISÃO DA LITERATURA

2.1 Acidente Vascular Cerebral

O AVC é causado pela interrupção do fluxo sanguíneo para uma parte do cérebro, o que pode ocorrer devido a um bloqueio (AVC isquêmico) ou ao rompimento de um vaso sanguíneo (AVC hemorrágico) (Diener; Hankey, 2020). Essa interrupção do fluxo sanguíneo cerebral tem consequências devastadoras, fazendo do AVC uma das principais causas de mortalidade e incapacidade em todo o mundo, afetando milhões de pessoas anualmente. Estima-se que, globalmente, que mais de 12,2 milhões de pessoas sofram um primeiro AVC a cada ano, resultando em aproximadamente 6,5 milhões de mortes. Adicionalmente, mais de 101 milhões de indivíduos vivem com sequelas decorrentes da doença (Feigin et al., 2022).

As sequelas do AVC podem incluir perda de função motora, comprometimentos de linguagem, dificuldades cognitivas e psicológicas, além de problemas emocionais e comportamentais (Kernan et al., 2021). Entre 30% e 50% dos sobreviventes ao AVC apresentam alguma forma de incapacidade permanente (Markus et al., 2023), o que representa um grande impacto na qualidade de vida dos afetados.

Apesar da incidência de AVC ter diminuído em muitos países de alta renda, devido às estratégias de prevenção e controle dos fatores de risco (Feigin et al., 2024), os casos são ainda significativos em países de baixa e média renda. Esses países detêm uma boa parte dos casos de mortes e incapacidades, revelando disparidades no acesso a cuidados médicos e prevenção entre os países (Markus et al., 2023). Previsões futuras indicam que a carga global de AVC continuará a crescer devido ao aumento da expectativa de vida e à persistência dos fatores de risco, particularmente em regiões de baixa renda (Feigin et al., 2024). Além dessas disparidades globais, o AVC impõe consequências socioeconômicas relevantes, especialmente pela sua repercussão sobre a força de trabalho e pelos elevados custos associados ao cuidado.

O impacto do AVC na força de trabalho ocorre devido às incapacidades de

longo prazo que a doença pode ocasionar (Gerstl et al., 2023). Os custos diretos relacionados à AVC incluem despesas com hospitalização, exames de imagem, tratamentos farmacológicos, reabilitação e cuidados médicos de longo prazo e os indiretos incluem a perda de produtividade e necessidade de cuidadores (Gerstl et al., 2023). Em países de alta renda, como o Canadá, os custos indiretos associados ao AVC, superam os custos diretos de tratamento, refletindo a carga substancial que a condição impõe sobre a economia (Gerstl et al., 2023). Esse cenário se agrava em regiões de baixa e média renda, onde o acesso à reabilitação é limitado, aumentando as chances de incapacidade permanente e perda de renda.

Além disso, as sequelas de AVC representam um grande impacto na qualidade de vida dos pacientes. Entre 30% e 50% dos indivíduos que sobreviveram a um AVC sofrem alguma forma de incapacidade permanente, como deficiência motora, afasia, ou comprometimentos cognitivos e emocionais (Benjamin et al., 2021). Para reduzir esse impacto, é crucial fortalecer as políticas de prevenção, melhorar o acesso a tratamentos agudos e promover a reabilitação precoce e contínua. Abordagens integradas, que combinam esforços de prevenção primária e secundária com tratamentos baseados em evidências, são essenciais para enfrentar os desafios epidemiológicos do AVC no futuro (Campbell et al., 2019).

Os programas de reabilitação precoce e intensivos têm mostrado reduzir os custos a longo prazo para melhorar os resultados funcionais e reduzir a necessidade de cuidados de longo prazo (Ye et al., 2025). No entanto, a reabilitação pós-AVC representa uma parcela substancial dos custos contínuos, uma vez que muitos sobreviventes precisam de fisioterapia, terapia ocupacional e acompanhamento médico prolongado. Esse cenário pode limitar o acesso a um tratamento adequado, principalmente em países de baixa e média renda, onde limitações financeiras, de estrutura e de suporte especializado são mais pronunciadas (Kayola et al., 2023).

2.2 Reabilitação após o AVC

A recuperação motora após o AVC é um processo complexo que envolve mecanismos de neuroplasticidade e reorganização cortical. Um fator essencial para a recuperação motora é a ativação de áreas corticais intactas que podem compensar as funções perdidas. Um estudo recente de neuroimagem demonstra

que essa recuperação está associada a uma reorganização funcional no córtex motor contralateral à lesão e em áreas motoras secundárias, como o córtex pré-motor e regiões associativas (Katai et al., 2023). Essa reorganização é acompanhada por mudanças na conectividade funcional e estrutural, que facilitam a formação de novas redes neurais para sustentar a função motora. Esses achados sugerem que a reorganização cortical em áreas preservadas pode promover a restauração de padrões de ativação mais fisiológicos, contribuindo significativamente para a recuperação de habilidades motoras em pacientes pós-AVC (Katai et al., 2023).

A extensão e a qualidade dessa reorganização estão intimamente relacionadas ao período em que as intervenções de reabilitação são iniciadas, reforçando a importância do tempo como um fator determinante para o prognóstico funcional. Nesse sentido, os primeiros meses após o AVC podem ser críticos para a recuperação motora, devido à maior plasticidade neural durante essa fase, o que facilita uma reorganização sináptica e cortical. Intervenções terapêuticas que aproveitam essa "janela de tempo" têm mostrado potencial para melhorar os resultados motores dos pacientes (Salvalaggio et al., 2023).

O tratamento do AVC envolve múltiplas abordagens, com foco na reabilitação para recuperação motora, cognitiva e funcional, além de melhorar a qualidade de vida dos pacientes. Esse processo pode ser iniciado logo após a estabilização do quadro clínico do paciente e visa maximizar a plasticidade cerebral pós-lesão. No entanto, muitos pacientes apresentam uma recuperação lenta e, em grande parte dos casos, incompleta, sobretudo quando há lesões extensas ou fatores clínicos desfavoráveis (Salvalaggio et al., 2023).

Esse processo lento de recuperação pode comprometer a autonomia funcional e a qualidade de vida dos indivíduos, exigindo intervenções adicionais que favoreçam a neuroplasticidade adaptativa. Apesar dos avanços nas terapias convencionais de reabilitação, muitos indivíduos no pós-AVC continuam a enfrentar limitações motoras significativas, o que torna urgente explorar estratégias complementares que possam potencializar os resultados. Por esse motivo, cresce o interesse por abordagens terapêuticas adjuvantes que potencializam os efeitos da reabilitação convencional, como por exemplo, a NIBS (Liu et al., 2022).

2.3 Uso da NIBS para o tratamento pós-AVC

A NIBS tem emergido como uma abordagem promissora, com potencial para modular a plasticidade do sistema nervoso central e melhorar a recuperação motora pós-AVC (Marín-Medina et al., 2024). A NIBS consiste em um conjunto de técnicas que aplicam estímulos elétricos ou magnéticos de forma não invasiva, ou seja, sem necessidade de intervenção cirúrgica, para modular a excitabilidade cortical e a reorganização neural (Polanía; Nitsche; Ruff, 2018).

Podem-se citar como NIBS técnicas como: a rTMS, a tDCS, a estimulação transcraniana por corrente alternada (tACS, do inglês: *transcranial alternating current stimulation*), a estimulação transcraniana por ruído randômico (tRNS, do inglês: *transcranial random noise stimulation*), a estimulação transespinal por corrente contínua (tsDCS, do inglês: *transcutaneous spinal direct current stimulation*), a estimulação transespinal magnética repetitiva (do inglês: *repetitive trans-spinal magnetic stimulation*) a estimulação transcutânea auricular do nervo vago (taVNS, do inglês: *transcutaneous auricular vagus nerve stimulation*) e estimulação transcraniana de alta definição por corrente contínua (HD-tDCS, do inglês: *high-definition transcranial direct current stimulation*). Essas modalidades visam modular a atividade neuronal de maneira específica, com crescente evidência científica sobre sua eficácia. A segurança e a tolerabilidade da NIBS têm sido avaliada através de estudos recentes. Os efeitos adversos, quando presentes, variam entre leves e graves, incluindo sensação de desconforto no local de aplicação e fadiga (Yu et al., 2025; Zhang et al., 2024b). Esses dados suportam o uso seguro da NIBS em diferentes populações de pacientes, permitindo que seja considerada uma opção viável mesmo para aqueles com comprometimento neurológico (Chen, Sun & Huang, 2024).

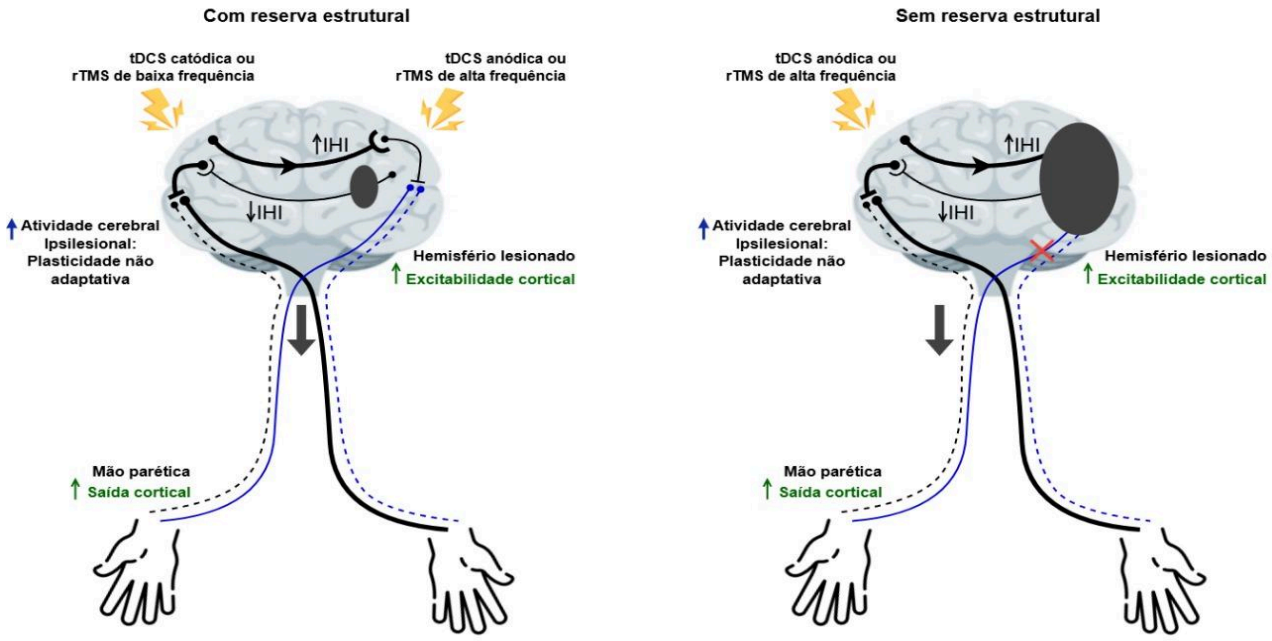
Duas dessas técnicas têm se estabelecido como referências centrais da NIBS, tanto em contextos de pesquisa quanto na prática clínica: a rTMS, fundamentada nos princípios do eletromagnetismo, e a tDCS, que emprega correntes elétricas contínuas de baixa intensidade, indolores, aplicadas ao couro cabeludo (aproximadamente 1–2 mA) (Polanía; Nitsche; Ruff, 2018). A aplicação de ambas as técnicas no pós-AVC baseia-se principalmente na premissa de que há um desequilíbrio da atividade neural entre os hemisférios cerebrais, caracterizado por

hiperatividade do hemisfério não lesionado e hipoatividade do hemisfério lesionado. Este desequilíbrio poderia comprometer a neuroplasticidade adaptativa (Lefaucheur et al., 2020).

Assim, a rTMS poderia ser aplicada com protocolos de alta frequência (>5 Hz) no hemisfério lesionado, a fim de aumentar a atividade cortical, ou com protocolos de baixa frequência (≤1 Hz) no hemisfério não lesionado, para inibir sua atividade e promover um efeito de reequilíbrio inter-hemisférico (Lefaucheur et al., 2014). Similarmente, na aplicação da tDCS, o polo positivo (ânodo), responsável por aumentar a excitabilidade neural, seria posicionado sobre o hemisfério lesionado, enquanto o polo negativo (cátodo), associado à redução da excitabilidade, seria colocado sobre o hemisfério não lesionado, favorecendo também o reequilíbrio inter-hemisférico (Chow et al., 2022). Essa modulação contribui para reduzir a inibição transcalosa, considerada um dos principais fatores que limitam a recuperação motora após o AVC (Schjetnan et al., 2013) (Figura 1).

Outro modelo relevante para fundamentar intervenções de NIBS no pós-AVC é o modelo *bimodal-balance recovery,* que utiliza o conceito de *reserva estrutural* como critério para escolher a abordagem mais adequada (Figura 1). A reserva estrutural refere-se à integridade dos tratos de substância branca motora preservados após o AVC e pode ser estimada por técnicas como imagem de tensor de difusão (DTI). De acordo com esse modelo, em pacientes com alta reserva estrutural, deve-se favorecer protocolos que inibem a hiperatividade do hemisfério não lesionado, já que essa hiperativação é mal-adaptativa. Em contraste, em pacientes com baixa reserva estrutural, a ativação do hemisfério não lesionado pode servir como mecanismo compensatório, tendo benefício para a recuperação motora. Tal abordagem permite personalizar o protocolo de NIBS individualmente, otimizando seus efeitos (Di Pino et al., 2014).

Figura 1. Modelo *bimodal-balance recovery* para fundamentação do uso da NIBS pós-AVC



Legenda: IHI - Inibição interhemisférica; tDCS: estimulação transcraniana por corrente contínua.

Seja à luz da teoria do desequilíbrio inter-hemisférico ou do modelo da reserva estrutural, vários estudos sugerem que as técnicas de NIBS podem oferecer benefícios adicionais à reabilitação pós-AVC. Meta-análises com rTMS e tDCS demonstram o benefício do uso da NIBS para recuperar deficiências e incapacidades sensório-motoras do AVC, incluindo: função neurológica geral (Liu et al., 2019), disfunção motora superior ou inferior (Lima et al., 2023; Zhang et al. 2017), déficit no equilíbrio/mobilidade funcional (Hofmeijer et al., 2023; Ghayour-Najafabadi et al., 2019;) e desempenho durante as atividades da vida diária (AVD) (Ahmed et al., 2023; Allida et al., 2020). O quadro 1 sumariza alguns dos achados, e demonstra os resultados conflitantes dos estudos, refletindo diferenças nos protocolos de estimulação.

Quadro 1. Resultados conflitantes sobre o uso da rTMS e da tDCS na reabilitação pós-AVC.

Nome do autor/ano	Desfechos/técnica	Medida de desfecho	Tamanho de efeito	Interpretação do resultado	I^2 / P valor da heterogeneidade
Ahmed et al., 2023	Atividade de vida	BI, FIM,	SMD: -0,87 (-1,66 a	Melhora o	73%; 0,02

	diária - tDCS	MAL	-0,08)	desempenho das AVDs após a intervenção.	
Hofmeijer et al., 2023	Mobilidade - rTMS	FAC; BBS	SMD: -0,68 (-1,38 a 0,02)	Não houve diferença significativa para mobilidade após a intervenção.	69%; 0,02
Lima et al., 2023	Função motora - tDCS	FMA-LL	SMD: -0,41 (-0,75 a -0,08)	Melhora da função motora após a intervenção.	0%; 0,79
Krogh et al., 2022	Função motora - rTMS	FMA-LL	SMD: -0,19 (-0,51 a 0,13)	Não houve diferença significativa para a função motora após a intervenção.	9%; 0,24
Comino-Suárez et al., 2021	Atividade de membro superior - tDCS	FMA-UL	SMD: -0,06 (-0,34 a 0,46)	Não houve diferença significativa para a função motora após a intervenção.	0%; 0,80
Allida et al., 2020	Atividade de vida diária - rTMS	BI	SMD: -2,21 (-3,32 a -1,09)	Melhora do desempenho das AVDs aps a intervenção.	93%; <0,01
Liu et al., 2019	Função neurológica geral - rTMS	NIHSS	SMD: -0,91 (-1,19 a -0,63)	Melhora da função neurológica geral após a intervenção.	0%; 0,94
Vaz et al. 2019	Mobilidade - tDCS	10m-WT; 3-D gait analysis; 6MWT; FAC	SMD: -0,10 (-0,31 a 0,11)	Não houve diferença significativa para a mobilidade após a intervenção.	25%;0,16
Ghayour-Najafabadi et al., 2018	Mobilidade - tDCS	BBS; TUG	SMD: -0,55 (-0,93 a -0,16)	Melhora na mobilidade após a intervenção.	0%; 0,62
Li et al., 2018	Mobilidade - tDCS	TUG; 6MWT; 10MWT	SMD: -0,35 (-0,70 a 0,01)	Não houve diferença na mobilidade após a intervenção.	0%; 0,71
Zhang et al. 2017	Atividade de membro superior -	JTT; NHPT;	SMD: -0,32 (-0,55 a -0,09)	Melhora para a atividade de	0%; 0,46

	rTMS	WMFT		membro superior após a intervenção.	
Triccas et al., 2016	Atividade de vida diária - tDCS	BI	SMD: -0,19 (-0,50 a 0,12)	Não houve diferença significativa para desempenho das AVDs após a intervenção.	33%; 0,20

Legenda: Os números sublinhados são os estudos estaticamente significantes, com tamanho de efeito moderado (SMD=0,40–0,70) a alto (SMD >0,70). Os valores de SMD negativos indicam resultados favoráveis às NIBS. *10MWT, 10-metre walking test; FMA-LL, 6MWT, 6-minute Walk Test; BI, Barthel Index; BBS, Berg Balance Scale; FAC, functional ambulation category; FIM, functional independence measure; FMA-LL, Fugl-Meyer Assessment Scale Lower Limb; FMA, Fugl-Meyer Assessment Scale; JTT, Jebsen Taylor Test; MAL, motor activity log; NHPT, Nine Hole Peg Test; NIHSS, National Institutes of Health Stroke Scale; TUG, Timed Up-and-Go test; WMFT, Wolf Motor Function Test.*

Apesar da existência de um corpo de evidências amplo e consistente sobre a aplicação da rTMS e da tDCS na reabilitação pós-AVC, as meta-análises disponíveis ainda apresentam resultados divergentes, ora indicando benefícios significativos, ora não confirmando tal eficácia. Essa inconsistência dificulta a consolidação do conhecimento e a translação dos achados para a prática clínica. Nesse contexto, a realização de revisões mais abrangentes, como as *umbrella reviews,* pode oferecer uma síntese crítica e de maior alcance do conjunto de evidências, fornecendo subsídios mais claros para a ciência e para a prática clínica, além de apoiar de forma mais sólida o processo de tomada de decisão em saúde.

2.4 Umbrella reviews (URs)

Também conhecidas como revisões panorâmicas ou revisões de revisões, as URs constituem um tipo avançado de revisão sistemática cujo objetivo é sintetizar e integrar os resultados de estudos de investigação secundária previamente publicados. Essas revisões avaliam revisões sistemáticas com ou sem meta-análises, e portanto, ocupam um papel de destaque na hierarquia da síntese do conhecimento, constituindo-se como o nível mais abrangente de evidência disponível (Aromataris; Pearson, 2015).

As URs oferecem uma visão mais ampla e estruturada para a tomada de

decisão clínica, ao reunir múltiplas fontes de evidência, seja sobre um único tema ou sobre diferentes tópicos inter-relacionados (Choi; Kang, 2022). Essa abordagem metodológica apresenta múltiplas vantagens. Primeiramente, permite uma análise crítica das convergências e divergências entre revisões sistemáticas já existentes, identificando inconsistências nos achados e fontes potenciais de heterogeneidade (Fusar-Poli; Radua, 2018). Além disso, possibilita avaliar a qualidade metodológica das revisões incluídas e a confiabilidade das evidências disponíveis, trazendo uma visão mais ampla e consistente da literatura (Pollock et al., 2023). Outro aspecto relevante é a sua utilidade para destacar lacunas na produção científica, direcionando futuros estudos primários e revisões sistemáticas (Ioannidis, 2017).

Para que a UR seja conduzida, é necessário o cumprimento de alguns passos. Entre os principais aspectos está o registro prévio do protocolo em plataformas como o PROSPERO, o que assegura transparência e evita vieses relacionadas à seleção de resultados (Pacheco et al., 2018). Assim como, a recomendação PRISMA, que tem por objetivo ajudar os autores a melhorarem o relato de revisões sistemáticas e meta-análises (Galvão et al., 2015). Além disso, o GRADE é considerado um sistema que fornece uma classificação para determinar se a evidência é considerada de alta, moderada ou baixa de qualidade (Schünemann et al., 2008).

. A abordagem GRADE fornece uma classificação de qualidade para cada meta-análise, podendo variar entre alta, moderada, baixa ou muito baixa. De acordo com o GRADE, alguns pontos são essenciais para classificar uma evidência de alta qualidade, são eles: risco de viés, inconsistência, imprecisão, evidência indireta e viés de publicação. Quando não há limitações nesses domínios, a evidência pode ser mantida como alta qualidade, o que significa que há alta confiança de que o efeito estimado está próximo do verdadeiro efeito. Evidências de alta qualidade são fundamentais para embasar diretrizes clínicas, decisões terapêuticas e políticas de saúde (Guyatt et al., 2008), evidências de qualidade moderada sugerem que futuros ensaios clínicos randomizados podem ter um impacto na estimativa do tamanho do efeito; evidências de baixa qualidade indicam que há uma alta probabilidade de que estudos futuros alterem a estimativa do tamanho do efeito; e evidências de qualidade muito baixa indicam que há muito pouca certeza sobre a estimativa do tamanho do efeito (Schünemann et al., 2008).

Mais especificamente, para o tópico análise do risco de viés da GRADE, ainda não há uma abordagem própria já consolidada para avaliação deste tópico em relação à análise de meta-análises. Neste contexto, o AMSTAR (do inglês: *A Measurement Tool to Assess Systematic Reviews*) é uma ferramenta validada amplamente utilizada, podendo ser aplicada para julgar o rigor metodológico das revisões sistemáticas que compõem a síntese. Com base nas classificações de itens críticos e não críticos, a revisão sistemática pode ser enquadrada em quatro níveis de qualidade: o “alta” (nenhuma ou uma fraqueza não crítica); “moderada” (mais de uma fraqueza crítica); “baixa” (uma falha crítica com ou sem fraquezas críticas); e “criticamente baixa” (mais de uma falha crítica com ou sem fraquezas não críticas). Os itens considerados críticos no checklist correspondem aos números 2, 4, 7, 9, 11, 13 e 15 (Shea et al., 2017).

Nos últimos anos, as umbrella reviews têm sido cada vez mais aplicadas no campo da saúde, especialmente em áreas caracterizadas por grande volume de publicações e achados conflitantes (Fusar-Poli; Radua, 2018). Nesse cenário, mostram-se particularmente úteis em contextos complexos, como a neuromodulação não invasiva na reabilitação pós-AVC, em que a existência de múltiplas revisões sistemáticas com resultados divergentes torna desafiadora a tomada de decisão baseada em evidências.

Assim, ao oferecer uma síntese de mais alto nível, as *umbrella reviews* contribuem para fortalecer a prática clínica e apoiar a formulação de políticas de saúde fundamentadas em evidência científica de maior qualidade. Além disso, a integração de seus resultados a referenciais conceituais amplamente reconhecidos, como a CIF, permite uma análise mais abrangente dos desfechos, contemplando não apenas aspectos relacionados à função e à estrutura corporal, mas também dimensões de atividade, participação, fatores ambientais e pessoais (Peres et al., 2018).

2.5 Classificação Internacional da Funcionalidade, Incapacidade e saúde

A CIF foi desenvolvida pela Organização Mundial da Saúde (OMS) em 2001 (WHO, 2001), com o objetivo de fornecer um modelo unificado e padronizado para descrever a saúde e os estados relacionados à saúde (WHO, 2001).

Com isso, a CIF organiza as informações em duas partes principais. A primeira parte, denominada Funcionalidade e Incapacidade, é composta pelos componentes Funções e Estruturas do Corpo e Atividades e Participação. A segunda parte, denominada Fatores Contextuais, inclui dois componentes: Fatores Ambientais e Fatores Pessoais. Os fatores ambientais abrangem o ambiente físico, social e atitudinal em que os indivíduos vivem e conduzem suas vidas, podendo funcionar como barreiras ou facilitadores da funcionalidade. Por sua vez, os fatores pessoais englobam características individuais, como idade, gênero, estilo de vida, experiências e comportamentos, que, embora não sejam codificados pela CIF, exercem influência direta sobre a saúde, a funcionalidade e a incapacidade (Peres et al., 2018; Athayde et al., 2017).

Após um tempo da criação da CIF, houve uma mudança significativa no raciocínio clínico e científico da fisioterapia. A CIF possibilita uma análise mais ampla e integrada, em que o paciente deixa de ser visto apenas como portador de uma doença ou deficiência e passa a ser compreendido como um indivíduo inserido em um contexto biopsicossocial. É essencial a utilização da CIF na prática, pois ela permite maior conhecimento acerca das condições de saúde do paciente, possibilita o acompanhamento longitudinal da sua recuperação, acolher as necessidades de forma mais abrangente e, consequentemente, contribui para a melhora da qualidade do cuidado ofertado (Stucki et al., 2017; Tempest et al., 2012).

Diante disso, a perda da funcionalidade e incapacidade resultante do pós-AVC decorre, em grande parte, de déficits motores classificados, em sua maioria, como graves ou moderados. Dessa forma, atividades de vida diária, como alimentar-se, vestir-se ou segurar objetos, tornam-se limitadas em razão da hemiparesia, que também compromete a capacidade de deambulação e, consequentemente, a interação social. Ressalta-se ainda que fatores como nível educacional, condição socioeconômica e prática de atividade física exercem influência direta tanto no acesso quanto no sucesso da reabilitação (Carvalho-Pinto; Faria, 2016).

Nesse contexto, diversas escalas de avaliação são utilizadas na prática na reabilitação pós-AVC, e podem ser classificadas de acordo com os domínios propostos pela CIF. Essa organização permite compreender de maneira mais ampla

quais aspectos da funcionalidade estão sendo mensurados por cada instrumento, indo além da avaliação isolada e favorecendo uma abordagem centrada no paciente (Pohl et al., 2020). O quadro 1, apresenta alguns exemplos de escalas utilizadas na reabilitação pós-AVC, categorizadas segundo os componentes da CIF.

Quadro 2. Escalas utilizadas na reabilitação pós-AVC através dos domínios da CIF.

Domínio da CIF	Escalas
Função e estrutura do corpo	ARAT, COMPLEX HAND MOVEMENT, FMA, FMA-LL, FMA-UL, HAND GRIP, MAS, MRC, NIHSS, PINCH FORCE,
Atividade e Participação	10MWT, 6MWT, 3-D GAIT ANALYSIS, ABMS II, ACTIVITY INDEX, BBS, BI, FAC, FIM, GAIT ANALYSIS, JTT, MBI, MOTRICITY INDEX, NHPT, PPT, TINET TEST, TUG, TRUNK CONTROL, SIS, WALKING SPEED, WMFT,
Fatores ambientais	CHIEF, MQE
Fatores pessoais	-

Legenda: -, não há escalas padronizadas; 6MWT, 6-minute Walk Tes, 10MWT, 10-metre walking test; ABMS II, Ability for Basic Movement Scale II; ARAT, Action Research Arm Test; BBS, Berg Balance Scale; BI, Barthel Index; CHIEF, Craig Hospital Inventory of Environmental Factors; FMA, Fugl-Meyer Assessment Scale; FIM, functional independence measure; FMA-LL, Fugl-Meyer Assessment Scale Lower Limb; FMA-UL, Fugl-Meyer Assessment Scale Upper Limb; JTT, Jebsen Taylor Test; MAS, modified ashworth scale; MQE, Measure of the Quality of the Environment; MRC, Medical Research Council Motor Power Score; NHPT, Nine Hole Peg Test; NIHSS, National Institutes of Health Stroke Scale; PPT, Purdue Pegboard Test; SIS, Stroke Impact Scale; TUG, Timed Up-and-Go test; WMFT, Wolf Motor Function Test.

3 HIPÓTESES

Presume-se que a literatura científica, composta por revisões sistemáticas e metanálises, demonstre evidências de qualidade moderada a alta quanto à eficácia da NIBS na reabilitação de pacientes pós-AVC, em relação aos domínios da CIF de estrutura e função (função neurológica geral, função motora) e atividade (mobilidade, AVD e atividade de membro superior). Espera-se ainda que a NIBS possa promover melhora nos domínios da CIF.

Além disso, supõe-se que a NIBS apresente um perfil de segurança aceitável, ainda que a sua tolerabilidade possa variar entre os indivíduos e deva ser monitorada em aplicações clínicas.

4 OBJETIVOS

4.1 Geral

Sintetizar, com base nos principais domínios da Classificação Internacional de Funcionalidade, Incapacidade e Saúde (CIF), as melhores evidências disponíveis sobre a eficácia e a segurança da NIBS para melhorar o comprometimento motor e a incapacidade após AVC.

4.2 Específicos:

- Analisar a qualidade da evidência atual em relação ao uso da NIBS para o tratamento da função motora pós-AVC;
- Sintetizar as principais conclusões das revisões sistemáticas com metanálises sobre a eficácia da NIBS nos domínios de estrutura e função (função neurológica geral, função motora) e atividade da CIF (mobilidade, AVD e atividade de membro superior);
- Avaliar a consistência e heterogeneidade dos resultados das revisões sistemáticas com metanálises sobre o uso da NIBS para o tratamento de pacientes pós-AVC nos domínios de estrutura e função (função neurológica geral, função motora) e atividade da CIF (mobilidade, AVD e atividade de membro superior);
- Avaliar a segurança e a tolerabilidade da NIBS em pacientes pós-AVC, considerando a descrição dos eventos adversos, sua frequência e gravidade relatadas nas revisões sistemáticas.

5 METODOLOGIA

5.1 Desenho do estudo

*E*sta revisão é uma de uma série de revisões gerais produzidas pelo Working-Group sobre evidências científicas para o uso de estimulação cerebral não invasiva dentro do grupo de Desenvolvimento de Diretrizes Brasileiras NIBS da Rede NAPeN (Núcleo de Assistência e Pesquisa em Neuromodulação - www.neuromodulation-net.com). A Rede NAPeN é uma organização intelectual sem fins lucrativos composta por grupos do setor público ou privado, pessoas físicas ou jurídicas, dedicados à assistência, ensino, pesquisa, desenvolvimento científico e/ou inovação tecnológica, no âmbito da neuromodulação não invasiva.

O protocolo foi registrado no PROSPERO (CRD42021239577; fevereiro/2020), posteriormente publicado por Shirahige et al., (2022), seguindo as recomendações da declaração PRIOR (Gates et al., 2022). No estudo, constam as seguintes perguntas condutoras: 1): “Qual a evidência atual em relação ao uso da NIBS em pacientes pós-AVC em comparação ao grupo sham?; 2) Qual a qualidade da evidência atual em relação ao uso da NIBS em pacientes pós-AVC?”

5.2 Fonte dos dados e pesquisa

A pesquisa foi realizada na base de dados MEDLINE pela PubMed de Fevereiro de 2020 a Julho de 2025 por dois autores independentes (BR e PL), e revisada por um terceiro autor (LS), a pesquisa foi realizada apenas na PubMed por ser a base de dados mais utilizada na área da saúde.

A estratégia de busca foi desenvolvida utilizando termos do *Medical Subject Heading (MeSH),* e validada em consulta com especialistas em metodologia científica e especialistas em NIBS. Esses especialistas revisaram a seleção de palavras-chave, termos de vocabulário e operadores booleanos para garantir a adequação, a sensibilidade e a especificidade do processo de busca, em consonância com os objetivos desta revisão abrangente. O objetivo da busca foi guiado pela lista de modalidades de NIBS elétricas e magnéticas mais frequentemente relatadas na literatura científica, conforme descrito por especialistas do NAPeN Network Group. Para aumentar a abrangência da meta-análise, o método bola de neve (Vinuto, 2014)

também foi empregado. Isso envolveu a identificação de estudos relevantes adicionais a partir das listas de referências dos artigos selecionados e por meio do rastreamento de citações, garantindo assim a inclusão robusta da literatura pertinente. A estratégia está descrita com detalhes no Quadro 2.

Quadro 3. Estratégias de busca.

Descritores
"Transcranial Magnetic Stimulation"[Mesh) AND "Stroke"[Mesh]
"TMS" AND "Stroke"[Mesh]
"repetitive Transcranial Magnetic Stimulation" AND "Stroke"[Mesh]
"rTMS" AND "Stroke"[Mesh]
"Noninvasive Brain Stimulation" AND "Stroke"[Mesh]
"transcranial direct current stimulation"[Mesh) AND "Stroke"[Mesh]
"tDCS" AND "Stroke"[Mesh]
"brain polarization" AND "Stroke"[Mesh]
"transcranial alternating current stimulation" AND "Stroke"[Mesh]
"tACS" AND "Stroke"[Mesh]
"transcranial electrical stimulation" AND "Stroke"[Mesh]
"tES" AND "Stroke"[Mesh]
"transcranial random noise stimulation" AND "Stroke"[Mesh]
"tRNS" AND "Stroke"[Mesh]
"transcranial cerebellar direct current stimulation" AND "Stroke"[Mesh]
"cerebellar direct current stimulation" AND "Stroke"[Mesh]
"tcDCS" AND "Stroke"[Mesh]
"transcranial spinal direct current stimulation" AND "Stroke"[Mesh]
"transspinal direct current stimulation" AND "Stroke"[Mesh]
"trans-spinal direct current stimulation" AND "Stroke"[Mesh]
"tsDCS" AND "Stroke"[Mesh]
"transcutaneous vagus nerve stimulation" AND "Stroke"[Mesh]
"tVNS" AND "Stroke"[Mesh]
"transcutaneous auricular vagus nerve stimulation" AND "Stroke"[Mesh]
"high-definition transcranial direct current stimulation" AND "Stroke"[Mesh]

"HD-tDCS" AND "Stroke"[Mesh]
"Theta Burst Stimulation" AND "Stroke"[Mesh]
"TBS" AND "Stroke"[Mesh]
"cerebellar repetitive transcranial magnetic stimulation" AND "Stroke"[Mesh]
"crTMS" AND "Stroke"[Mesh]
"Transcranial Magnetic Stimulation"[Mesh) AND "Brain ischemia"[Mesh]
"TMS" AND "Brain ischemia"[Mesh]
"repetitive Transcranial Magnetic Stimulation" AND "Brain ischemia"[Mesh]
"rTMS" AND "Brain ischemia"[Mesh]
"Noninvasive Brain Stimulation" AND "Brain ischemia"[Mesh]
"transcranial Direct Current Stimulation"[Mesh) AND "Brain ischemia"[Mesh]
"tDCS" AND "Brain ischemia"[Mesh]
"brain polarization" AND "Brain ischemia"[Mesh]
"transcranial alternating current stimulation" AND "Brain ischemia"[Mesh]
"tACS" AND "Brain ischemia"[Mesh]
"transcranial electrical stimulation" AND "Brain ischemia"[Mesh]
"tES" AND "Brain ischemia"[Mesh]
"transcranial random noise stimulation" AND "Brain ischemia"[Mesh]
"tRNS" AND "Brain ischemia"[Mesh]
"transcranial cerebellar direct current stimulation" AND "Brain ischemia"[Mesh]
"cerebellar direct current stimulation" AND "Brain ischemia"[Mesh]
"tcDCS" AND "Brain ischemia"[Mesh]
"transcranial spinal direct current stimulation" AND "Brain ischemia"[Mesh]
"transspinal direct current stimulation" AND "Brain ischemia"[Mesh]
"trans-spinal direct current stimulation" AND "Brain ischemia"[Mesh]
"tsDCS" AND "Brain ischemia"[Mesh]
"transcutaneous vagus nerve stimulation" AND "Brain ischemia"[Mesh]
"tVNS" AND "Brain ischemia"[Mesh]
"transcutaneous auricular vagus nerve stimulation" AND "Brain ischemia"[Mesh]
"High-definition transcranial direct current stimulation" AND "Brain ischemia"[Mesh]

"HD-tDCS" AND "Brain ischemia"[Mesh]
"Theta Burst Stimulation" AND "Brain ischemia"[Mesh]
"TBS" AND "Brain ischemia"[Mesh]
"cerebellar repetitive transcranial magnetic stimulation" AND "Brain ischemia"[Mesh]
"crTMS" AND "Brain ischemia"[Mesh]
"Transcranial Magnetic Stimulation"[Mesh] AND "Intracranial hemorrhages"[Mesh]
"TMS" AND "Intracranial hemorrhages"[Mesh]
"repetitive Transcranial Magnetic Stimulation" AND "Intracranial hemorrhages"[Mesh]
"rTMS" AND "Intracranial hemorrhages"[Mesh]
"Noninvasive Brain Stimulation" AND "Intracranial hemorrhages"[Mesh]
"transcranial direct current stimluation" AND "Intracranial hemorrhages"[Mesh]
"tDCS" AND "Intracranial hemorrhages"[Mesh]
"brain polarization" AND "Intracranial hemorrhages"[Mesh]
"transcranial alternating current stimulation" AND "Intracranial hemorrhages"[Mesh]
"tACS" AND "Intracranial hemorrhages"[Mesh]
"transcranial electrical stimulation" AND "Intracranial hemorrhages"[Mesh]
"tES" AND "Intracranial hemorrhages"[Mesh]
"transcranial random noise stimulation" AND "Intracranial hemorrhages"[Mesh]
"tRNS" AND "Intracranial hemorrhages"[Mesh]
"transcranial cerebellar direct current stimulation" AND "Intracranial hemorrhages"[Mesh]
"ctDCS" AND "Intracranial hemorrhages"[Mesh]
"transcranial spinal direct current stimulation" AND "Intracranial hemorrhages"[Mesh]
"transspinal direct current stimulation" AND "Intracranial hemorrhages"[Mesh]
"trans-spinal direct current stimulation" AND "Intracranial hemorrhages"[Mesh]
"tsDCS" AND "Intracranial hemorrhages"[Mesh]

"transcutaneous auricular vagus nerve stimulation" AND "Intracranial hemorrhages"[Mesh]
"taVNS" AND "Intracranial hemorrhages"[Mesh]
"transcutaneous auricular vagus nerve stimulation" AND "Intracranial hemorrhages"[Mesh]
"High-definition transcranial Direct Current Stimulation" AND "Intracranial hemorrhages"[Mesh]
"HD-tDCS" AND "Intracranial hemorrhages"[Mesh]
"Theta Burst Stimulation" AND "Intracranial hemorrhages"[Mesh]
"TBS" AND "Intracranial hemorrhages"[Mesh]
"cerebellar repetitive Transcranial Magnetic Stimulation" AND "Intracranial hemorrhages"[Mesh]
"crTMS" AND "Intracranial hemorrhages"[Mesh]
"Non-invasive Brain Stimulation" AND "Stroke"[Mesh]
"NIBS" AND "Stroke"[Mesh]
"Non-invasive Brain Stimulation" AND "Brain ischemia"[Mesh]
"NIBS" AND "Brain ischemia"[Mesh]
"Non-invasive Brain Stimulation" AND "Intracranial hemorrhages"[Mesh]
"NIBS" AND "Intracranial hemorrhages"[Mesh]

5.3 Critérios de elegibilidade

Foram incluídas metanálises de ensaios clínicos controlados envolvendo qualquer técnica de NIBS usada como tratamento para deficiências motoras e incapacidade em pacientes pós-AVC.

Os critérios de elegibilidade estão resumidos no Quadro 3.

Quadro 4: critérios de elegibilidade para os artigos da umbrella review.

Critérios	Inclusão	Exclusão
População (P)	Meta-análises que incluam indivíduos adultos com AVC que foram tratados com uma das técnicas NIBS	Estudos em animais

Intervenção (I)	tDCS, rTMS, tACS, tRNS, tsDCS, taVNS, and tsMS	Associações de duas ou mais técnicas da NIBS na mesma intervenção
Comparação (C)	NIBS *sham* ou nenhuma intervenção associada ou não a outra abordagem de tratamento (por exemplo, medicamentos, fisioterapia, terapia ocupacional, treinamento cognitivo, etc.)	Comparação entre duas ou mais técnicas (ex. rTMS vs. tDCS)
Desfechos (O)	Disfunções motoras relacionados ao AVC	Resultados eletrofisiológicos
Desenho do estudo (S)	Revisões sistemáticas com metanálise randomizadas ou não, publicadas em inglês	Metanálise sem análise qualitativa e publicada antes de 2015; Meta-análises de rede; Estudos dos quais não foi possível extrair ou converter os dados para SMD.

Legenda: *AVC- Acidente vascular cerebral; NIBS - non-invasive brain stimulation; rTMS - repetitive transcranial magnetic stimulation; tACS - transcranial alternating current stimulation; tDCS - transcranial direct current stimulation; tRNS - transcranial random noise stimulation; tsDCS - transcutaneous spinal direct current stimulation; taVNS - transcutaneous auricular vagus nerve stimulation; tsMS, transcranial static magnetic stimulation.*

5.4 Seleção de estudos e extração de dados

Os títulos, resumos e textos foram selecionados por dois autores (BR e PL), de maneira independente, para determinar se os estudos eram elegíveis. Se houvesse discordâncias durante o processo, elas eram resolvidas por meio de reuniões para chegar a um consenso e, se não houvesse consenso, a opinião de um terceiro avaliador (LS) era consultada.

Os dois autores mencionados anteriormente extraíram dos estudos os seguintes dados dos estudos: (1) autor/ano de publicação; (2) características dos pacientes dos artigos selecionados (tempo de lesão pós-AVC) ; (3) protocolos de intervenção utilizados nos artigos (tipo de estimulação, protocolos utilizados, intervenções adjuvantes); (4) número de pacientes, número de pacientes incluídos na meta-análise, índice de heterogeneidade e valor de p; (5) efeitos adversos graves; (6) desfechos e medidas de desfecho utilizadas em cada meta-análise. Foram considerados como efeitos adversos graves: cefaleias incapacitantes, convulsões, síncope vasovagal, alterações comportamentais, psiquiátricas e cognitivas/neuropsicológicas e lesão tecidual.

As medidas de desfecho foram classificadas de acordo com a estrutura conceitual da Classificação Internacional de Funcionalidade, Incapacidade e Saúde (CIF) (Salter et al., 2019), nas categorias de estrutura/função corporal e atividade, de acordo com Salter et al. 2019. Além disso, especificamos todas as medidas de desfecho utilizadas nos estudos incluídos dentro dos subdomínios correspondentes da CIF. As tabelas de resultados para cada técnica NIBS abordando resultados de estrutura/função corporal e atividade da CIF.

5.5 Avaliação de qualidade metodológica das meta-análises

A qualidade das revisões sistemáticas incluídas foi avaliada utilizando *A Measurement Tool to Asses Systematic Reviews (AMSTAR)-2* (Shea et al., 2017), realizada por dois autores independentes (BR e PL), e se caso não houvesse consenso a opinião de um terceiro avaliador (LS) era consultada.

A pontuação segundo a AMSTAR varia de 0 a 16, de acordo com a quantidade de itens que foram contemplados no estudo avaliado. Cada item foi classificado como "sim", "sim parcial" ou "não", com ênfase em sete itens críticos que impactam significativamente a pontuação geral.

Especificamente, os seguintes aspectos foram considerados:

- Inclusão de componentes PICO na questão de pesquisa e critérios de elegibilidade (Item 1);
- Registro prospectivo do protocolo de revisão e justificativa para desvios (Item 2);
- Justificativa para a seleção dos desenhos de estudo (Item 3);
- Uso de uma estratégia abrangente de busca bibliográfica (Item 4);
- Seleção de estudos realizada em duplicata (Item 5);
- Extração de dados realizada em duplicata (Item 6);
- Listagem e justificativa dos estudos excluídos (Item 7);
- Descrição adequada dos estudos incluídos (Item 8);
- Avaliação apropriada do risco de viés em estudos individuais (Item 9);
- Relato das fontes de financiamento dos estudos incluídos (Item 10);
- Uso de métodos apropriados para combinação estatística de resultados (Item 11);

- Consideração do risco de viés ao interpretar os resultados da metanálise (Item 12);
- Consideração do risco de viés na discussão ou interpretação dos achados da revisão (Item 13);
- Explicação da heterogeneidade nos resultados da revisão (Item 14);
- Avaliação do viés de publicação e seu potencial impacto nos achados (Item 15);
- Divulgação de conflitos de interesse e financiamento para a revisão em si (Item 16).

Com base nas classificações de itens críticos e não críticos, a revisão sistemática é então categorizada em uma das quatro classificações de qualidade: o "alta" (nenhuma ou uma fraqueza não crítica); "moderada" (mais de uma fraqueza crítica); "baixa" (uma falha crítica com ou sem fraquezas críticas); e "criticamente baixa" (mais de uma falha crítica com ou sem fraquezas não críticas). São consideradas fraquezas críticas os itens 2,4,7,9,11,13 e 15 do checklist (Shea et al., 2017).

5.6 Avaliação da qualidade da evidência

Para avaliação da qualidade da evidência foi utilizado o *Grading of Recommendations, Assessment, Development and Evaluation Guideline Development Tool* (GRAD-pro; www.gradepro.org). Esta etapa também foi realizada por dois autores independentes (BR e PL), e se caso não houvesse consenso a opinião de um terceiro avaliador (LS) era consultada. A abordagem GRADE fornece uma classificação de qualidade para cada resultado como alta, moderada, baixa ou muito baixa. Evidências de alta qualidade indicam que é improvável que estudos futuros alterem a estimativa do tamanho do efeito; evidências de qualidade moderada sugerem que futuros ensaios clínicos randomizados podem ter um impacto na estimativa do tamanho do efeito; evidências de baixa qualidade indicam que há uma alta probabilidade de que estudos futuros alterem a estimativa do tamanho do efeito; e evidências de qualidade muito baixa indicam que há muito pouca certeza sobre a estimativa do tamanho do efeito (Schünemann et al., 2008).

Além disso, a qualidade da evidência pode ser afetada por cinco fatores, o que pode resultar em uma redução de sua classificação inicial. Esses fatores são: limitações metodológicas (risco de viés), inconsistência, imprecisão, evidência indireta e viés de publicação (Guyatt et al., 2008).

Para a avaliação das limitações metodológicas, no GRADE, as meta-análises iniciam com um nível de evidência alto, no entanto, podem ter sua qualidade reduzida devido a limitações metodológicas, que podem surgir tanto no delineamento, na condução quanto na validade externa dos estudos. Para aumentar a robustez metodológica da presente revisão, foi utilizada a ferramenta *AMSTAR-2* como critério para avaliar a qualidade metodológica das revisões sistemáticas incluídas, sendo considerada como parte do julgamento sobre a confiabilidade dos achados, contribuindo para a tomada de decisões quanto ao rebaixamento ou não da evidência no item “limitações metodológicas”.

Já a inconsistência, é outro critério para reduzir o nível de evidência. Os itens que foram considerados para avaliação foram: a variação metodológica (diferenças no delineamento dos estudos, nas intervenções aplicadas, nos instrumentos de avaliação e na qualidade dos estudos) e populacional (diferenças nas características dos participantes, idade ou presença de comorbidades) entre os estudos analisados. Essa heterogeneidade é considerada importante quando persiste mesmo após análises de sensibilidade baseadas em hipóteses pré-estabelecidas. O julgamento da inconsistência também leva em conta a semelhança entre as estimativas de efeito, a sobreposição dos intervalos de confiança, bem como indicadores estatísticos, como o valor de I^2 (Guyatt et al., 2011a).

No que se refere à imprecisão, o principal critério adotado pelo GRADE é a amplitude do intervalo de confiança de 95%. Idealmente, a avaliação deve se basear nos efeitos absolutos e não nos relativos. Quando há pequeno número de eventos, mesmo que o intervalo de confiança pareça reduzido, pode-se considerar a redução da evidência por conta da incerteza envolvida nas estimativas. Além da análise do intervalo de confiança, outros fatores foram considerados na presente revisão para o julgamento da imprecisão, como a adequação do tamanho amostral dos estudos incluídos para estimar o efeito com precisão e a magnitude do tamanho do efeito na avaliação da imprecisão (Guyatt et al., 2011b). Para essa avaliação, realizamos o cálculo da adequação amostral a partir dos valores de média e desvio padrão reportados nas meta-análises.

A evidência indireta compromete a confiança nas estimativas quando os participantes, intervenções ou desfechos dos estudos analisados são substancialmente diferentes daqueles definidos pela questão PICO da revisão ou da diretriz. Isso também ocorre quando não existem comparações diretas entre as intervenções avaliadas.

Nesses casos, é necessário recorrer a comparações indiretas, como, por exemplo, quando se estima o efeito relativo entre duas intervenções com base em sua comparação com um terceiro grupo controle (Guyatt et al., 2011a).

Por fim, o viés de publicação representa um fator crítico que pode reduzir a qualidade da evidência. Estudos com tamanho amostral pequeno e resultados positivos, especialmente quando há conflitos de interesse relevantes (como patrocínio da indústria), devem ser interpretados com cautela. A análise gráfica, como o *funnel plot*, pode ajudar a detectar esse viés (Guyatt et al., 2011b). Na presente revisão, o viés de publicação foi avaliado a partir de duas abordagens principais: Análise gráfica através do *funnel plot* e do teste de Egger, além da avaliação da presença de conflitos de interesse de cada meta-análise.

O *funnel plot* avalia a distribuição dos estudos em relação ao tamanho do efeito e ao erro padrão. Em condições ideais, espera-se uma distribuição simétrica dos pontos ao redor da média do efeito. No entanto, uma assimetria no gráfico pode ajudar a distinguir se é decorrente do viés de publicação (Sterne et al., 2011; Peters et al., 2008). Já o teste de Egger é utilizado para detectar assimetria estatisticamente significativa no gráfico de funil. Esse teste examina a relação entre o tamanho do efeito e a precisão do estudo, sendo um p-valor inferior a 0,05 indicativo de possível viés de publicação (Egger et al., 1997).

5.7 Análise estatística

Devido à variabilidade dos protocolos de NIBS e dos instrumentos utilizados para avaliar estrutura/função corporal, optou-se pelo uso da diferença média padronizada (SMD, do inglês *standard mean deviation*) para padronizar os desfechos contínuos entre os estudos. As SMDs combinadas foram interpretadas segundo o Manual Cochrane (<0,40 = pequeno; 0,40–0,70 = moderado; >0,70 = grande efeito) de acordo com o Manual Cochrane para Revisões Sistemáticas de Intervenções (Higgins et al., 2024). A fins de padronização, resultados favoráveis às NIBS foram considerados com o sinal negativo, à esquerda da linha de nulidade.

Quando as metanálises originais relataram resultados apenas como diferenças médias, os dados foram re-analisados pós-intervenção extraindo a média e o desvio padrão (DP) de cada estudo incluído e geramos novos *forest plots* usando SMDs.

Se médias e DPs não foram fornecidas pelos ensaios clínicos incluídos nas meta-análises, os valores da mediana foram assumidos como iguais aos valores

médios se os dados fossem distribuídos normalmente, e os intervalos interquartis foram divididos por 1,35 para obter o DP (Higgins et al., 2024). Caso necessário, valores de DP também poderiam ser extraídos a partir de intervalos de confiança, seguindo o Cochrane Handbook (Higgins et al., 2024). Caso o estudo apresentasse apenas resultados gráficos, os dados foram extraídos usando o WebPlotDigitizer (disponível em https://apps.automeris.io/wpd/). Todas as metanálises ajustadas foram realizadas usando o software RevMan 5 (Cochrane Information Management System).

Para aprimorar a interpretação clínica dos tamanhos de efeito relatados na revisão sistemática, convertemos as SMDs em estimativas aproximadas do Número Necessário para Tratar (NNT), seguindo a abordagem proposta por Furukawa e Leucht (2011). A conversão foi realizada usando a seguinte fórmula:

$$\mathrm{NNT} = \frac{1}{\Phi\left(\frac{\mathrm{SMD}}{\sqrt{2}}\right) - 0.5}$$

Na qual Φ é a função de distribuição cumulativa (FDC) da distribuição normal padrão, e SMD é a diferença média padronizada para o desfecho de interesse. Essa abordagem permite uma aproximação informativa do NNT a partir de desfechos contínuos. As SMDs negativas, quando aplicáveis, foram interpretadas no contexto da direção do benefício, e o sinal foi ajustado de acordo no cálculo do NNT.

Todos os testes estatísticos foram com hipóteses bicaudais, com significância estabelecida em $p \leq 0,05$ e a homogeneidade foi avaliada pelo teste de heterogeneidade. Uma metanálise foi considerada homogênea quando o valor de p foi maior que 0,05 e o índice de heterogeneidade (I^2) foi de até 30%. Caso a heterogeneidade fosse maior que 30%, um modelo de efeitos randômicos foi utilizado, enquanto um modelo de efeito fixo foi utilizado quando I^2 foi ≤ 30%.

6 RESULTADOS

Os resultados deste estudo são apresentados em um artigo original.

6.1 Artigo original - “Non-invasive brain stimulation for stroke-related motor impairment and disability: an umbrella review of systematic review and meta-analysis”.

Este artigo (APÊNDICE A) foi elaborado segundo os objetivos, metodologias e resultados do estudo 1 desta dissertação e foi publicado na *Frontiers in Neuroscience* (Qualis A3, para a área 21 da CAPES, Fator de impacto: 3.2).

7 CONSIDERAÇÕES FINAIS

De acordo com os resultados apresentados pelo estudo 1 desta dissertação, está *umbrella review* representa um marco importante por ser a primeira a sintetizar e avaliar a qualidade das evidências de metanálises sobre NIBS na reabilitação pós-AVC estruturada a partir dos domínios da CIF. Nossos achados indicam que, embora tanto a rTMS quanto a tDCS apresentem potencial terapêutico, a magnitude, consistência e qualidade dos efeitos variam substancialmente entre as técnicas, domínios avaliados e parâmetros utilizados.

No conjunto das evidências, a rTMS apresentou os tamanhos de efeitos variando de médio a grande em relação ao domínio da CIF de estrutura e função corporal. No domínio de atividade, observou-se efeito de pequeno à grande, com resultados mais favoráveis para AVD do que para mobilidade e atividade de membro superior.

Por sua vez, a tDCS apresentou tamanho de efeito variando de pequeno a grande nos desfechos relacionados à estrutura e função corporal e atividade. Em contraste, os desfechos relacionados à atividade, especialmente AVD, mostraram relatos de benefício mais frequentes, ainda que com tamanhos de efeito menores.

Embora algumas revisões, tanto de rTMS quando de tDCS, tenham apontado tamanhos de efeito moderados a altos, alguns fatores como a alta variabilidade de protocolos incluídos nos estudos, ausência de consistência entre as meta-análises e a predominância de evidências de baixa e muito baixa qualidade dificultam o estabelecimento de recomendações clínicas sólidas.

Quanto aos eventos adversos, uma parte dos estudos relataram efeitos leves a moderado, como cefaleia, fadiga, tontura e formigamento, contudo houveram estudos que relataram efeitos adversos graves, como cefaleias incapacitantes, convulsões, síncope, alterações psiquiátricas e cognitivas/neuropsicológicas e lesão tecidual, e por fim, mais da metade dos estudos não relataram eventos adversos.Esses achados indicam que, embora a NIBS pareça ter um perfil de segurança aceitável, sua tolerabilidade pode variar entre os indivíduos e deve ser cuidadosamente monitorada em aplicações clínicas.

Apesar dos avanços metodológicos observados, como maior adesão a critérios rigorosos de revisão sistemática, ainda persistem fragilidades (como:ausência de registro prévio e alta variabilidade dos protocolos, estratégias de busca incompletas, tamanho de amostras menores que o necessário, e a heterogeneidade nos desfechos) que podem dificultar análises mais precisas, e limitar a aplicabilidade clínica direta dos achados.

Apesar disso, a NIBS tem avançado significativamente como ferramenta na reabilitação neurológica, com a personalização dos protocolos despontando como tendência promissora para otimizar resultados. No entanto, essa individualização também impõe desafios à síntese de evidências, exigindo novas estratégias capazes de lidar com a heterogeneidade sem comprometer o poder estatístico.

Portanto, embora a NIBS, apresente evidências encorajadoras para determinados desfechos na reabilitação pós-AVC, sua incorporação ampla à prática clínica requer cautela e deve considerar não apenas a significância estatística, mas também a relevância clínica, segurança, viabilidade e adequação ao perfil do paciente. O fortalecimento dessa base de evidências dependerá de ensaios clínicos randomizados com amostras maiores, protocolos mais padronizados, análises de subgrupos que explorem preditores de resposta e acompanhamento de longo prazo para avaliar a durabilidade dos efeitos. Com essa evolução metodológica poderá ser possível consolidar a NIBS como tratamento de primeira escolha na reabilitação de pacientes pós-AVC.

REFERÊNCIAS

ADERINTO, N. et al. Clinical Applications of Non-Invasive Brain Stimulation in Stroke Recovery: A Review of Current Evidence and Therapeutic Strategies. Current Treatment Options in Neurology, v. 27, n. 1, p. 8, 2025.

AHMED, I.; YELDAN, I.; MUSTAFAOGLU, R. The adjunct of electric neurostimulation to rehabilitation approaches in upper limb stroke rehabilitation: a systematic review with network meta-analysis of randomized controlled trials. *Neuromodulation*, v. 25, p. 1197–1214, 2022.

AHMED, I. et al. Does noninvasive brain stimulation combined with other therapies improve upper extremity motor impairment, functional performance, and participation in activities of daily living after stroke? A systematic review and meta-analysis of randomized controlled trial. Topics in Stroke Rehabilitation, v. 30, n. 3, p. 213-234, 2023.

ALLIDA, S. et al. Pharmacological, psychological, and non‐invasive brain stimulation interventions for treating depression after stroke. Cochrane Database of Systematic Reviews, n. 1, 2020.

AROMATARIS, E. et al. Summarizing systematic reviews: methodological development, conduct and reporting of an umbrella review approach. *International Journal of Evidence-Based Healthcare*, v. 13, p. 132–140, 2015.

AROMATARIS, E.; MUNN, Z. (Ed.). *JBI manual for evidence synthesis*. JBI, 2020.

ATHAYDE, F. et al. Influência ambiental sobre a incapacidade física: uma revisão sistemática da literatura. Ciência & Saúde Coletiva, v. 22, n. 11, p. 3645-3652, 2017.

BRUNONI, A. R. et al. Repetitive transcranial magnetic stimulation for the acute treatment of major depressive episodes: a systematic review with network meta-analysis. *JAMA Psychiatry*, v. 74, n. 2, p. 143-152, 2017.

BRUNONI, A. R.; SAMPAIO-JUNIOR, B.; MOFFA, A. H. et al. Noninvasive brain stimulation in psychiatric disorders: a primer. *Brazilian Journal of Psychiatry*, v. 41, p. 70–81, 2019.

CAMPBELL, B. C. V. et al. Ischaemic stroke. *Nature Reviews Disease Primers*, v. 5, n. 1, p. 70, 2019.

CARVALHO-PINTO, B. P.B; FARIA, C. D. C. M. Health, function and disability in stroke patients in the community. Brazilian journal of physical therapy, v. 20, n. 4, p. 355-366, 2016.

CHEN, K.; SUN, M.; ZHUANG, H. Effect of theta burst stimulation on lower extremity motor function improvement and balance recovery in patients with stroke: A systematic review and meta-analysis of randomized controlled trials. Medicine, v. 103, n. 44, p. e40098, 2024.

CHOI, G. J.; KANG, H. The umbrella review: a useful strategy in the rain of evidence. The Korean journal of pain, v. 35, n. 2, p. 127, 2022.

CHOW, A. M. D. et al. Influence of transcranial direct current stimulation dosage and associated therapy on motor recovery post-stroke: a systematic review and meta-analysis. *Frontiers in Aging Neuroscience*, v. 14, p. 821915, 2022.

COMINO-SUÁREZ, N. et al. Transcranial direct current stimulation combined with robotic therapy for upper and lower limb function after stroke: a systematic review and meta-analysis of randomized control trials. Journal of NeuroEngineering and Rehabilitation, v. 18, n. 1, p. 148, 2021.

DIONÍSIO, A.; CARVALHO, S.; CASTELHANO, J. TMS application in both health and disease. *Frontiers in Human Neuroscience*, v. 16, 1110274, 2023.

DI PINO, G. et al. Modulation of brain plasticity in stroke: a novel model for neurorehabilitation. *Nature Reviews Neurology*, v. 10, n. 10, p. 597-608, 2014.

EGGER, Matthias et al. Bias in meta-analysis detected by a simple, graphical test. *British Medical Journal*, v. 315, n. 7109, p. 629-634, 1997.

ELSNER, B.; KUGLER, J.; MEHRHOLZ, J. Transcranial direct current stimulation (tDCS) for improving arm function after stroke. *Cochrane Database of Systematic Reviews*, n. 11, CD009645, 2020.

FEIGIN, V. L. et al. Global, regional, and national burden of stroke and its risk factors, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *The Lancet Neurology*, v. 23, n. 10, p. 973-1003, 2024.

FEIGIN, V. L. et al. Pragmatic solutions to reduce the global burden of stroke: a World Stroke Organization–Lancet Neurology Commission. *The Lancet Neurology*, v. 22, n. 12, p. 1160-1206, 2023.

FEIGIN, V. L. et al. World Stroke Organization (WSO): global stroke fact sheet 2022. *International Journal of Stroke*, v. 17, n. 1, p. 18-29, 2022.

FERREIRA, R. C. et al. A influência da plasticidade neural na recuperação de acidentes vasculares cerebrais. *Arche Scientific and Editorial Consultancy*, v. 10, n. 5, 2024.

FREGNI, F. et al. Evidence-based guidelines and secondary meta-analysis for the use of transcranial direct current stimulation in neurological and psychiatric disorders. *The International Journal of Neuropsychopharmacology*, v. 24, n. 4, p. 256-313, 2021.

FUSAR-POLI, P.; RADUA, J. Ten simple rules for conducting umbrella reviews. BMJ Ment Health, v. 21, n. 3, p. 95-100, 2018.

GATES, M. et al. Reporting guideline for overviews of reviews of healthcare interventions: development of the PRIOR statement. *BMJ*, v. 378, e070849, 2022.

GALVÃO, T. F. et al. Principais itens para relatar Revisões sistemáticas e Meta-análises: A recomendação PRISMA. Epidemiologia e serviços de saúde, v. 24, p. 335-342, 2015.

GERSTL, J. V. E. et al. Global, regional, and national economic consequences of stroke. *Stroke*, v. 54, n. 9, p. 2380-2389, 2023.

GHAYOUR-NAJAFABADI, M. et al. Repetitive transcranial magnetic stimulation for the treatment of lower limb dysfunction in patients poststroke: a systematic review with meta-analysis. *Journal of Stroke and Cerebrovascular Diseases*, v. 28, 104412, 2019.

GRAEF, P. et al. Transcranial magnetic stimulation combined with upper-limb training for improving function after stroke: a systematic review and meta-analysis. *Journal of Neurological Sciences*, v. 369, p. 149–158, 2016.

GUYATT, G. H. et al. GRADE guidelines: 4 rating the quality of evidence-study limitations (risk of bias). *Journal of Clinical Epidemiology*, v. 64, n. 4, p. 407-415, 2011a.

GUYATT, G. H. et al. GRADE guidelines: 5 rating the quality of evidence-publication bias. *Journal of Clinical Epidemiology*, v. 64, n. 12, p. 1277-1282, 2011b.

GUYATT, G. H. et al. GRADE guidelines: 7 rating the quality of evidence-inconsistency. *Journal of Clinical Epidemiology*, v. 64, n. 12, p. 1294-1302, 2011.

GUYATT, G. H. et al. Rating quality of evidence and strength of recommendations: what is “quality of evidence” and why is it important to clinicians? *British Medical Journal*, v. 336, n. 7651, p. 995-998, 2008.

HE, Y. et al. Repetitive transcranial magnetic stimulation on motor recovery for patients with stroke: a PRISMA compliant systematic review and meta-analysis. *American Journal of Physical Medicine & Rehabilitation*, v. 99, n. 2, p. 99-108, 2020.

HIGGINS, J. P. T. et al. *Cochrane Handbook for Systematic Reviews of Interventions* version 6.5 (updated August 2024). Cochrane, 2024.

HSU, S.-P. et al. Effects of bihemispheric transcranial direct current stimulation on motor recovery in subacute stroke patients: a double-blind, randomized sham-controlled trial. *Journal of NeuroEngineering and Rehabilitation*, v. 20, n. 1, p. 27, 2023.

IOANNIDIS, J. Next-generation systematic reviews: prospective meta-analysis, individual-level data, networks and umbrella reviews. British journal of sports medicine, v. 51, n. 20, p. 1456-1458, 2017.

JUHI, Ayesha et al. Exploring the research landscape of transcranial direct current stimulation in stroke: a bibliometric review. Cureus, v. 16, n. 12, 2024.

JÚNIOR, G. L. V. Saúde baseada em evidência e a prática da farmácia. Revista Científica Eletrônica do Conselho Regional de Farmácia da Bahia, p. e03012401-e03012401, 2024.

KANG, N. et al. Functional balance and postural control improvements in patients with stroke after noninvasive brain stimulation: a meta-analysis. *Archives of Physical Medicine and Rehabilitation*, v. 101, p. 141–153, 2020.

KANG, N.; WEINGART, A.; CAURAUGH, J. H. Transcranial direct current stimulation and suppression of contralesional primary motor cortex post-stroke: a systematic review and meta-analysis. *Brain Injury*, v. 32, p. 1063–1070, 2018.

KATAI, S. et al. Cortical reorganization correlates with motor recovery after low-frequency repetitive transcranial magnetic stimulation combined with occupational therapy in chronic subcortical stroke patients. *NeuroImage: Reports*, v. 3, n. 1, p. 100156, 2023.

KAYOLA, G. et al. Stroke rehabilitation in low-and middle-income countries: challenges and opportunities. *American Journal of Physical Medicine & Rehabilitation*, v. 102, n. 2S, p. S24-S32, 2023.

KERNAN, W. N. et al. Primary care of adult patients after stroke: a scientific statement from the American Heart Association/American Stroke Association. *Stroke*, v. 52, p. e558–e571, 2021.

KIM, S.; PARK, H. Update on Non-invasive Brain Stimulation on Stroke Motor Impairment: A Narrative Review. Brain & Neurorehabilitation, v. 17, n. 1, p. e5, 2024.

KLOMJAI, W. et al. Repetitive transcranial magnetic stimulation and transcranial direct current stimulation in motor rehabilitation after stroke: an update. *Annals of physical and rehabilitation medicine,* v. 58, n. 4, p. 220-224. 2015.

KROGH, S. et al. Efficacy of repetitive transcranial magnetic stimulation for improving lower limb function in individuals with neurological disorders: a systematic review and meta-analysis of randomized sham-controlled trials. Journal of Rehabilitation Medicine, v. 54, p. 1097, 2022.

LEFAUCHEUR, J. P. et al. Evidence-based guidelines on the therapeutic use of repetitive transcranial magnetic stimulation (rTMS). *Clinical Neurophysiology*, v. 125, n. 11, p. 2150-2206, 2014.

LEFAUCHEUR, J. et al. Evidence-based guidelines on the therapeutic use of repetitive transcranial magnetic stimulation (rTMS): an update (2014-2018). *Clinical Neurophysiology*, v. 131, n. 2, p. 474-528, 2020.

LEONARDI, M.; FHEODOROFF, K. Goal setting with ICF (international classification of functioning, disability and health) and multidisciplinary team approach in stroke rehabilitation. Clinical pathways in stroke rehabilitation: Evidence-based clinical practice recommendations, p. 35-56, 2021.

LI, Xin-Yu et al. Global research trends in transcranial magnetic stimulation for stroke (1994–2023): promising, yet requiring further practice. Frontiers in Neurology, v. 15, p. 1424545, 2024.

LI, Y. et al. Effects of transcranial direct current stimulation on walking ability after stroke: a systematic review and meta-analysis. *Restorative Neurology and Neuroscience*, v. 36, p. 59–71, 2018.

LIMA, E. et al. Effects of transcranial direct current stimulation on lower limb function, balance and quality of life after stroke: a systematic review and meta-analysis. Neurological Research, v. 45, n. 9, p. 843-853, 2023.

LIU, C. et al. Efficacy and safety of high-frequency repetitive transcranial magnetic stimulation for poststroke depression: a systematic review and meta-analysis. Archives of Physical Medicine and Rehabilitation, v. 100, n. 10, p. 1964-1975, 2019.

LIU, H. X.; HU, D. H.; YIN, H. Q. [Umbrella review - a new method related to evidence-based medical analysis]. *Zhonghua Liu Xing Bing Xue Za Zhi*, v. 41, 2020.

LIU, Y. et al. Early rehabilitation after acute stroke: the golden recovery period. *Acta Neurol Taiwan*, v. 32, p. 1-8, 2022.

MARÍN-MEDINA, D. S. et al. New approaches to recovery after stroke. Neurological Sciences, v. 45, p. 55–63, 2024.

MARKUS, H.S. The global burden of stroke. *International Journal of Stroke*, v. 18, n. 6, p.632-633, 2023.

MCINTYRE, A. et al. systematic review and meta-analysis on the use of repetitive transcranial magnetic stimulation for spasticity poststroke. PM&R, v. 10, p. 293–302, 2018.

MELNIC, A. et al. Chronic pain and multimorbidity in stroke rehabilitation. Archives of the Balkan Medical Union, p. 368-375, 2023.

MORONE, G. et al. Long-term spasticity management in post-stroke patients: issues and possible actions—a systematic review with an Italian expert opinion. In: Healthcare. MDPI, 2023. p. 783.

PAPATHEODOROU, S. I.; EVANGELOU, E. Umbrella reviews: what they are and why we need them. Meta-research: Methods and protocols, p. 135-146, 2022.

PETERS, J. L. et al. Contour-enhanced meta-analysis funnel plots help distinguish publication bias from other causes of asymmetry. Journal of clinical epidemiology, v. 61, n. 10, p. 991-996, 2008.

PERES, P. A. T. et al. Aspectos da sobrecarga e qualidade de vida de cuidadores de pacientes hospitalizados: uma análise baseada na Classificação Internacional de Funcionalidade, Incapacidade e Saúde (CIF). Revista Brasileira de Saúde Ocupacional, v. 43, n. 12, 2018.

POHL, J. et al. Consensus-based core set of outcome measures for clinical motor rehabilitation after stroke—a Delphi study. Frontiers in neurology, v. 11, p. 875, 2020.POLANÍA, R., NITSCHE, M.A., & RUFF, C.C. Studying and modifying brain function with non-invasive brain stimulation. *Natute Neuroscience*, v. 21, p. 174–187, 2018.

POLLOCK M. et al. Capítulo V: Visões Gerais das Revisões [última atualização em agosto de 2023].

ROSS, R. E. et al. Feasibility of performing a multi-arm clinical trial examining the novel combination of repetitive transcranial magnetic stimulation and aerobic exercise for post-stroke depression. Topics in stroke rehabilitation, v. 30, n. 7, p. 649-662, 2023.

SALTER K. et al. Evidence-Based Review of Stroke Rehabilitation. 16th ed. London, England: Evidence-Based Review of Stroke Rehabilitation. 2019.

SALVALAGGIO, S. et al. Prediction of rehabilitation induced motor recovery after stroke using a multi-dimensional and multi-modal approach. Frontiers in Aging Neuroscience, v. 15, p. 1205063, 2023.

SCHJETNAN, A. G. et al. Transcranial Direct Current Stimulation in Stroke Rehabilitation: A Review of Recent Advancements. Stroke Research and Treatment, 2013, Article ID: 170256 [em linha]. 2013.

SCHÜNEMANN, H. J. et al. Grading quality of evidence and strength of recommendations for diagnostic tests and strategies. British Medical Journal, London, v. 336, n. 7653, p. 1106-1110, 2008.

SHEA, B. J. et al. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. BMJ, V. 21, p. 358:j4008. 2017.

STERNE, J. A. C et al. Recommendations for examining and interpreting funnel plot asymmetry in meta-analyses of randomised controlled trials. Bmj, v. 343, 2011.

STUCKI, Gerold et al. Practice, science and governance in interaction: European effort for the system-wide implementation of the International Classification of Functioning, Disability and Health (ICF) in Physical and Rehabilitation Medicine. European journal of physical and rehabilitation medicine, v. 53, n. 2, p. 299-307, 2017.

STRAUS, S. E. et al. Evidence-based medicine E-book: How to practice and teach EBM. Elsevier Health Sciences, 2018.

SUBRAMANIAN, S.K., PRASANNA, S.S. Virtual Reality and Noninvasive Brain Stimulation in Stroke: How Effective Is Their Combination for Upper Limb Motor Improvement?-A Meta-Analysis. PM R, v. 10, n.11, p.1261-1270, 2018.

TANG, Z. et al. Estimulação magnética transcraniana repetitiva excitatória sobre o hemisfério ipsilateral para a função motora dos membros superiores após acidente vascular cerebral: uma revisão sistemática e meta-análise. Frontiers in Neurology, 13:918597, 2022.

TEMPEST, Stephanie et al. To adopt is to adapt: the process of implementing the ICF with an acute stroke multidisciplinary team in England. Disability and rehabilitation, v. 34, n. 20, p. 1686-1694, 2012.

TIEN, H.-H. et al. Transcranial direct current stimulation for improving ambulation after stroke: a systematic review and meta-analysis. International Journal of Rehabilitation Research, v.43, p. 299–309. 2020.

TRICCAS, L. Tedesco et al. Multiple sessions of transcranial direct current stimulation and upper extremity rehabilitation in stroke: a review and meta-analysis. Clinical Neurophysiology, v. 127, n. 1, p. 946-955, 2016.

TUNG, Y-C. et al. Repetitive transcranial magnetic stimulation of lower limb motor function in patients with stroke: a systematic review and meta-analysis of randomized controlled trials. Clinical rehabilitation, v. 33, n. 7, p. 1102-1112, 2019.

UNNITHAN, A. K. A. et al., Hemorrhagic Stroke. 2023 May 8. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan–. PMID: 32644599.

VAZ, P. G. et al. Noninvasive brain stimulation combined with other therapies improves gait speed after stroke: a systematic review and meta-analysis. Top Stroke Rehabil, v. 26, n. 3, p. 201-213, 2019.

VINUTO, J.. Amostragem em bola de neve na pesquisa qualitativa: um debate em aberto. Revista Temáticas, Campinas, v. 22, n. 44, p. 203-220, ago./dez. 2014

XIANG, H. et al. The effect and optimal parameters of repetitive transcranial magnetic stimulation on motor recovery in stroke patients: a systematic review and meta-analysis of randomized controlled trials. Clin Rehabil, v. 33, n. 5, p. 847-864, 2019.

WHO. International classification of functioning, disabilities and health. Geneva, Switzerland: WHO, 2001.

YAGI, M. et al. Impact of rehabilitation on outcomes in patients with ischemic stroke: a nationwide retrospective cohort study in Japan. Stroke, v. 48, n. 3, p. 740-746, 2017.

YE, Q. et al. Clinical efficacy of NIBS in enhancing neuroplasticity for stroke recovery. Journal of Neuroscience Methods, v. 417, p. 110399, 2025.

YU, L.. Efficacy of anodal transcranial direct current stimulation for upper extremity function after ischemic stroke: a systematic review of parallel randomized clinical trials. Journal of Stroke and Cerebrovascular Diseases, v. 34, n. 1, p. 108112, 2025.

ZHANG, L., et al. Low-Frequency Repetitive Transcranial Magnetic Stimulation for Stroke-Induced Upper Limb Motor Deficit: A Meta-Analysis. Neural Plasticity. 2017, 2758097.

ZHANG, N. et al. Impact of the combination of virtual reality and noninvasive brain stimulation on the upper limb motor function of stroke patients: a systematic review and meta-analysis. Journal of NeuroEngineering and Rehabilitation, v. 21, n. 1, p. 179, 2024a.

ZHANG, W. et al. Examining the effectiveness of motor imagery combined with non-invasive brain stimulation for upper limb recovery in stroke patients: a systematic review and meta-analysis of randomized clinical trials." *Journal of neuroengineering and rehabilitation,* v. 21, n. 1, p. 209, 2024b.

APÊNDICE A – ARTIGO ORIGINAL

Non-invasive brain stimulation for stroke-related motor impairment and disability: an umbrella review of systematic review and meta-analysis

Beatriz Rithiely[1#], Lívia Shirahige[1,2,3#], Patrícia L. F. Lima[1], Maira Souza[2,3], Deborah Marques[1,3], Rodrigo Brito[1,2,3], Adriana Baltar[1,2,3], Rafael Moreira[3,4], Gabriel Barreto[1,2,3], Rodrigo Fragoso[2,3,5], Kátia Nunes Sá[3,6], Abrahão Fontes Baptista[3,4,7], Daniele Piscitelli[8,9*], Kátia Monte-Silva[1,2,3]

[1] Universidade Federal de Pernambuco, Recife, Pernambuco, Brazil

[2] Applied Neuroscience Institute, Recife, Pernambuco, Brazil

[3] NAPeN Network (Núcleo de Assistência e Pesquisa em Neuromodulação), Brazil

[4] Universidade Federal do ABC, São Bernardo do Campo, SP, Brazil

[5] Universidade Federal do Ceará, Fortaleza, Ceará Brazil

[6] Escola Bahiana de Medicina e Saúde Pública, Salvador, Bahia, Brazil

[7] Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil

[8] Department of Kinesiology, University of Connecticut, Storrs, CT, USA

[9] School of Medicine and Surgery, University of Milano Bicocca, Milan, Italy

#These authors contributed equally to the development and writing of this manuscript.

* Correspondence:
Corresponding Author
daniele.piscitelli@uconn.edu

Abstract

Introduction: Non-invasive brain stimulation (NIBS) techniques, particularly repetitive transcranial magnetic stimulation (rTMS) and transcranial direct current stimulation (tDCS), have shown potential in stroke rehabilitation. However, systematic reviews often reach conflicting conclusions, underscoring the need for an umbrella review. **Objective:** To synthesize, based on the principal domains of the International Classification of Functioning, Disability and Health (ICF) framework, the best available evidence on the effectiveness and safety of NIBS for improving motor impairment and disability after stroke. **Methods:** We conducted an umbrella review (PROSPERO: CRD42021239577) that included meta-analyses of controlled trials investigating NIBS effects in stroke survivors, retrieved from PubMed/MEDLINE from February 2020 to July 2025. Methodological quality was appraised using AMSTAR-2 and certainty of evidence using GRADE. Outcomes were mapped to ICF body structure/function and activity domains. **Results:** Fifty-six studies were included (2–48 primary trials each; 54–1654 participants per meta-analysis). All included studies evaluated only rTMS and tDCS; no meta-analyses of other NIBS modalities met inclusion criteria.

Methodological quality was high or moderate in 85.7% of the meta-analyses. Certainty of evidence was low or very low for 14/50 studies; only one rTMS review provided moderate-certainty evidence for activities of daily living. rTMS showed improvement in activities of daily living (ADL) (SMD= –0.82, 95%CI –1.05 to –0.59), upper-limb motor impairment (SMD= –0.32, 95%CI –0.55 to –0.09) and variable effects on mobility from small (SMD= –0.35, 95%CI –0.45 to –0.24) to large (SMD= –0.97, 95%CI –1.28 to –0.66). tDCS was supported by very-low-certainty evidence: small effects were found for motor impairment (SMD = –0.22, 95 % CI –0.32 to –0.12) and upper-limb activity (SMD= –0.31, 95%CI –0.55 to –0.01), while a much smaller subset of trials suggested a large effect (SMD= –1.54, 95%CI –2.78 to –0.29). Effects on ADL and mobility with tDCS were inconsistent and generally non-significant. **Conclusion:** rTMS was more frequently associated with moderate to high effect sizes for body structure/function outcomes, especially general neurological function. In contrast, tDCS showed small effects on motor recovery, though evidence certainty was very low due to heterogeneity, imprecision, and protocol variability. In the activity domain, NIBS had modest effects, with rTMS showing more consistent benefits for ADL. tDCS effects were generally limited and supported by low to very low certainty of evidence.

KEYWORDS

Stroke, transcranial magnetic stimulation, transcranial direct current stimulation, motor function, neurorehabilitation, recovery, neuroplasticity, evidence based.

1 INTRODUCTION

Stroke is a leading cause of motor impairment and disability worldwide, consistently exerting a significant impact on public health across many countries (Virani *et al.*, 2021). Non-invasive brain stimulation (NIBS) is a set of techniques that apply noninvasively electromagnetically-induced currents to modulate the excitability of the targeted brain areas and their networks (Brunoni *et al.*, 2019). NIBS approaches might enhance or drive adaptive plastic changes in the central nervous system (CNS) for the management of various stroke-related sensorimotor impairments and disabilities, including spasticity (Graef *et al.*, 2016a; McIntyre *et al.*, 2018a), upper or lower motor function (Zhang, Xing, Fan, *et al.*, 2017a; Kang, Weingart and Cauraugh, 2018; Vaz *et al.*, 2019a), balance impairments (Li *et al.*, 2018a; Ghayour-Najafabadi *et al.*, 2019a; Kang *et al.*, 2020a; Tien *et al.*, 2020a), mobility (Ghayour-Najafabadi *et al.*, 2019a; Tien *et al.*, 2020a) and difficulties with activities of daily living (Subramanian and Prasanna, 2018; Xiang *et al.*, 2019a; Ahmed, Yeldan and Mustafaoglu, 2022).

In recent decades, NIBS has been proposed as a possible adjuvant strategy to augment the efficacy of conventional rehabilitation treatments for sensorimotor impairments in neurological populations (Liew *et al.*, 2014). In the context of stroke rehabilitation, several NIBS modalities have been investigate (Kim; Park, 2024; Shen et al., 2022). However, repetitive transcranial magnetic stimulation (rTMS) and transcranial direct current stimulation (tDCS) have been the most extensively studied (Mahmoud *et al.*, 2024). Although the quality of available evidence remains limited, numerous clinical studies suggest that NIBS holds promise for enhancing motor recovery after stroke. Recently, several systematic reviews have synthesized the growing body of evidence on NIBS (Qi *et al.*, 2024; Barreto *et al.*, 2025a). However, the high number of reviews available may result in conflicting conclusions and hinder consensus on the effectiveness of NIBS. To address this challenge, umbrella reviews have become increasingly important, providing a qualitative meta-synthesis of systematic reviews or meta-analyses. By synthesizing evidence across multiple reviews, umbrella reviews can help resolve inconsistencies and provide a comprehensive overview of findings. Thus, they are considered one of the highest levels of evidence synthesis currently available and have been used to inform the adoption of specific clinical techniques in practice (Aromataris *et al.*, 2015; Liu, Hu and Yin, 2020).

Another important limitation of most existing reviews on NIBS for post-stroke motor recovery is their predominant focus on isolated clinical outcomes (e.g., motor scores or spasticity), without contextualizing the findings within a comprehensive functional framework that reflects real-world functioning. The International Classification of Functioning, Disability and Health (ICF) provides a comprehensive framework to address this gap by categorizing the consequences of stroke-related neurological damage across three core domains: impairments in body structures and functions, limitations in activity, and restrictions in participation (Leonardi and Fheodoroff, 2021). The ICF has become a standard for understanding and categorizing the multidimensional impact of health conditions such as stroke (Virani *et al.*, 2021).

In this context, we conducted an umbrella review to summarize the evidence on the use of NIBS techniques for motor recovery and disability reduction in stroke survivors, framing the synthesis within the core domains of the ICF. We conceptualize motor recovery as a multidimensional process that encompasses improvements in body structures and functions, as well as gains in activity performance. This umbrella review aims to enhance the clinical relevance of the synthesized findings and support more holistic interpretations of NIBS effects.

2 MATERIALS AND METHODS

2.1 Study design

This review is part of a series of umbrella reviews produced by the Working-Group on scientific evidence for the use of non-invasive brain stimulation within the NIBS Brazilian Guidelines Development Group of the NAPeN Network (www.neuromodulation-net.com). The protocol was registered in PROSPERO (CRD42021239577; February/2020) and subsequently published by Shirahige et al. (2022), following the recommendations of the preferred reporting items for overviews of reviews (PRIOR) statement (Gates *et al.*, 2022).

2.3 Search and eligibility criteria

Two independent reviewers (BR and PL) conducted a comprehensive literature search from February 2020 to July 2025 in PubMed/MEDLINE. Disagreements during the screening process were resolved through discussion to reach a consensus; if consensus could not be achieved, a third reviewer (LS) was consulted. The search strategy was developed and validated in consultation with specialists in scientific methodology and experts in NIBS. These experts reviewed the selection of keywords, controlled vocabulary terms, and Boolean operators to ensure the adequacy, sensitivity, and specificity of the search process in line with the aims of this umbrella review.

To enhance the comprehensiveness of the meta-analysis, the snowball method was also employed. This involved identifying additional relevant studies from the reference lists of selected articles, and through forward citation tracking, thereby ensuring robust inclusion of pertinent literature. We included meta-analyses of controlled trials (CTs) involving any NIBS technique used as a treatment for motor impairments and disability in stroke survivors. Searches were conducted using Medical Subject Headings (MeSH) terms. The NIBS techniques included were: transcranial direct current stimulation (tDCS), transcranial alternating current stimulation (tACS), transcranial random noise stimulation (tRNS), transcutaneous spinal direct current stimulation (tsDCS), transcutaneous auricular vagus nerve stimulation (taVNS), high-definition transcranial direct current stimulation (HD-tDCS), and repetitive transcranial magnetic stimulation (rTMS). The scope of the search was guided by the list of electrical and magnetic NIBS modalities most frequently reported in the scientific literature, as outlined by experts from the NAPeN Network Group. Eligibility criteria are summarized in Box 1. All strategies including respective MeSH terms and number of retrieved articles are described in Supplementary Table 1.

Box 1. Eligibility criteria for considering articles for the umbrella review.

Criteria	Inclusion	Exclusion
Population (P)	Adult subjects with stroke who have been treated with one of the NIBS techniques	Animal studies
Intervention (I)	tDCS, rTMS, tACS, tRNS, tsDCS, taVNS, and tsMS	Association of two or more active NIBS techniques in the same intervention
Comparison (C)	Sham NIBS or no intervention associated or not with another approach of treatment (i.e., physical therapy, occupational therapy, cognitive training,etc)	Comparison between two active NIBS techniques (ex. rTMS vs. tDCS)

Outcome (O)	Changes in outcome measurements	Surrogate outcomes
Study design (S)	Systematic reviews with meta-analysis of CT randomized or not; published in English	Meta-analysis without qualitative analysis Meta-analysis published before 2015 Network meta-analyses Studies from which it was not possible to extract or convert the data into SMD

Notes**:** rTMS - cerebellar repetitive transcranial magnetic stimulation; CT - clinical trials; HD-tDCS - high-definition transcranial direct current stimulation; NIBS - non-invasive brain stimulation; RCT - randomized clinical trials; rTMS - repetitive transcranial magnetic stimulation; tACS - transcranial alternating current stimulation; TBS - theta burst stimulation; tcDCS - transcranial cerebellar direct current stimulation; tDCS - transcranial direct current stimulation; tRNS - transcranial random noise stimulation; tsDCS - transcutaneous spinal direct current stimulation; taVNS - transcutaneous auricular vagus nerve stimulation.

2.4 Study Selection and Data Extraction

Titles, abstracts and full texts were screened by two independent reviewers (BR and PL) to assess study eligibility. Disagreements during screening were resolved through discussion to reach consensus; if consensus could not be reached, a third reviewer (LS) was consulted. The following data were extracted from each included study: (1) author/year of publication; (2) characteristics of patients from selected articles; (3) intervention protocols used in the articles; (4) number of patients, number of patients included in the meta-analysis, heterogeneity index, and p-value; (5) adverse effects: tissue damage, behavioral changes and vasovagal syncope; (6) outcome measures used in each meta-analysis.

Severe adverse events comprised incapacitant headaches, seizures, syncope, psychiatric and cognitive/neuropsychological changes, and tissue injury. Results of each meta-analysis were extracted separately for each outcome. All data were checked to ensure accuracy and consistency in two steps. Any discrepancies were resolved by consensus. Outcome measures were classified according to the principal domains of the ICF conceptual framework,body structure/function and activity, based on the approach proposed by Salter et al. (2019). In addition, we specified all outcome measures used in the included studies within the corresponding ICF subdomains, as detailed in Supplementary Table 2.

2.5 Assessment of meta-analyses methodological quality

The quality of the included systematic reviews was assessed using the AMSTAR-2 (A Measurement Tool to Assess Systematic Reviews) checklist (Shea *et al.*, 2017). This instrument evaluates 16 domains that evaluate methodological quality. Specifically, the following aspects were considered: inclusion of PICO components in the research question and eligibility criteria (Item 1); prospective registration of the review protocol and justification for deviations (Item 2); justification for the selection of study designs (Item 3); use of a comprehensive literature search strategy (Item 4); study selection performed in duplicate (Item 5); data extraction performed in duplicate (Item 6); listing and justification of excluded studies (Item 7); adequate description of included studies (Item 8); appropriate assessment of risk of bias in individual studies (Item 9); reporting of funding sources for the included studies (Item 10); use of appropriate methods for statistical combination of results (Item 11); consideration of risk of bias when interpreting results of the meta-analysis (Item

12); consideration of risk of bias in the discussion or interpretation of the review findings (Item 13); explanation of heterogeneity in the review results (Item 14); assessment of publication bias and its potential impact on findings (Item 15); and disclosure of conflicts of interest and funding for the review itself (Item 16).

Each item was rated as "Yes," "Partially yes," or "No," with emphasis placed on seven critical items that significantly impact the overall score (Shea *et al.*, 2017). The quality of each included meta-analysis was assessed by considering non-critical items (1, 3, 5, 6, 8, 10, 12, 14, and 16) and critical items (2, 4, 7, 9, 11, 13, and 15).

Based on ratings for critical and non-critical items, the systematic reviews were categorized into one of four quality levels: "high quality" (no or one non-critical weakness), "moderate quality" (more than one non-critical weakness), "low quality" (one critical flaw with or without non-critical weaknesses), and "critically low" (more than one critical flaw with or without non-critical weaknesses) (Shea *et al.*, 2017). Methodological quality assessments were performed independently by two researchers. Any disagreements were resolved through discussion, and if consensus was not reached, a third reviewer was consulted.

2.6 Assessment of evidence quality

Data were extracted into Summary of Finding tables using GRADEpro GDT (Grading of Recommendations Assessment, Development and Evaluation Guideline Development Tool; www.gradepro.org). Data was organized according to the main domains of the ICF. Separate tables were created for each NIBS technique addressing outcomes of ICF body structure/function and activity. The GRADE approach provides a quality rating for each outcome as high, moderate, low, or very low. *High-quality evidence* indicates that future studies are unlikely to change the effect size estimate; *moderate-quality evidence* suggests that future RCTs may have an impact on the effect size estimate; *low-quality evidence* indicates that there is a high probability that future studies will change the effect size estimate; and *very low-quality evidence* indicates that there is very little certainty about the effect size estimate.

2.7 Statistical analysis

Given the considerable variability in the NIBS protocols across studies and the use of different instruments to assess body structure/function, we used the standardized mean difference (SMD) as the treatment effect for continuous outcome measures. This approach allowed for the standardization of results across studies. Pooled SMDs were calculated as the overall treatment effect size in the meta-analyses (Gallardo-Gómez, Richardson and Dwan, 2024) We interpreted pooled SMDs using rules of thumb (< 0.40 = small, 0.40 to 0.70 = moderate, > 0.70 = large effect) according to the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins and Welch, 2024)

When original meta-analyses reported outcomes only as mean differences, we re-analyzed the post-intervention data by extracting the mean and standard deviation (SD) from each included study and generated new forest plots using SMDs. If means and SDs were not provided, median values were considered to be equal to mean values if data were normally distributed, and interquartile ranges were divided by 1.35 to obtain the SD (Higgins and Welch, no date). When necessary, we also derived the SD from confidence intervals, following the Cochrane Handbook (Higgins and Welch, no date). When the study only presented the results in graphs, we extracted the data using WebPlotDigitizer (available at https://apps.automeris.io/wpd/). All adjusted meta-analyses were performed using RevMan 5 software (Cochrane Information Management System).

To enhance the clinical interpretability of the effect sizes reported in our systematic review, we converted standardized mean differences (SMDs) into approximate estimates of the Number Needed to Treat (NNT), following the approach proposed by Furukawa and Leucht (2011). The conversion was performed using the following formula:

$$\mathrm{NNT} = \frac{1}{\Phi\left(\frac{\mathrm{SMD}}{\sqrt{2}}\right) - 0.5}$$

Where Φ is the cumulative distribution function (CDF) of the standard normal distribution, and SMD is the standardized mean difference for the outcome of interest. This approach allows for a rough but informative approximation of NNT from continuous outcomes. The resulting NNT values, along with their corresponding 95% confidence interval (NNT lower and higher), were added to a Supplementary Table 2 alongside the original SMD, to support clinical interpretation. Negative SMDs, where applicable, were interpreted in the context of the direction of benefit, and the sign was adjusted accordingly when calculating NNT.

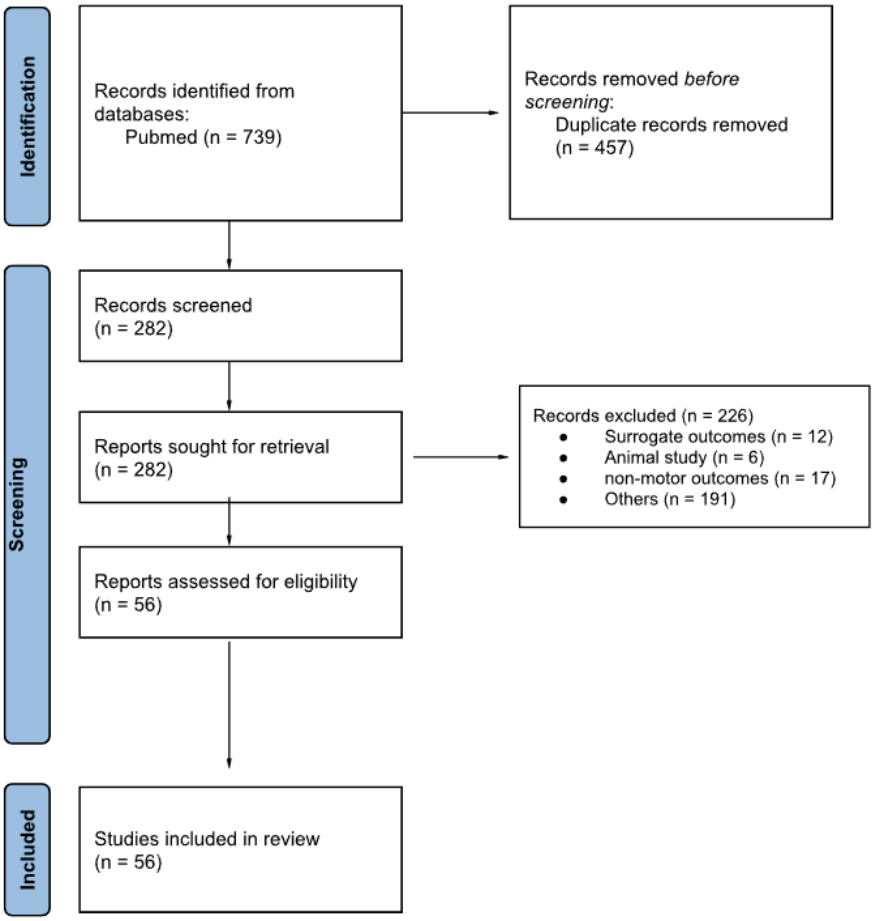
All statistical tests were two-sided, with significance set at $p \leq 0.05$. Homogeneity was evaluated by a heterogeneity test. A meta-analysis was considered homogeneous when the p-value was greater than 0.05 and the heterogeneity index (I^2) was up to 30%. When heterogeneity was greater than 30%, a random-effects model was used, whereas a fixed-effect model was used when I^2 was ≤ 30%. The Supplementary Table 2 provides the specific measure considered for each main domain of the ICF included in the meta-analyses.

3 RESULTS

3.1 Study selection and characteristics of included meta-analyses

A total of 56 systematic reviews with meta-analysis met the eligibility criteria and were included in the study. All retrieved studies focused exclusively on the efficacy of rTMS and tDCS, with no eligible meta-analyses found for other NIBS modalities. The screening strategy is shown in the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flowchart presented in Figure 1.

Figure 1. PRISMA Flowchart.



The included studies were published between 2016 (Elsner et al., 2016) and 2025 (Barreto et al., 2025). Of the 56 studies included, 35 evaluated the efficacy of rTMS (Graef *et al.*, 2016; Shen *et al.*, 2017, Wang *et al.*, 2025; Zhang, Xing, Fan, *et al.*, 2017a; Li *et al.*, 2018a; McIntyre *et al.*, 2018; Ghayour-Najafabadi *et al.*, 2019; Liu *et al.*, 2019; Tung *et al.*, 2019; van Lieshout *et al.*, 2019; Xiang *et al.*, 2019; Allida *et al.*, 2020; Shao *et al.*, 2021; Krogh *et al.*, 2022; Gao *et al.*, 2023; Hofmeijer, Ham and Kwakkel, 2023; X. Chen *et al.*, 2023a, 2023b; Xie *et al.*, 2023, 2025; Xi *et al.*, 2023; Zhou *et al.*, 2023; Chen, Sun and Zhuang, 2024; Daoud *et al.*, 2024; Jiang *et al.*, 2024; Zhang *et al.*, 2024; Wang *et al.*, 2024a, 2024b; Zeng *et al.*, 2024; Zhu *et al.*, 2024; Barreto *et al.*, 2025; Jia *et al.*, 2025; Ma *et al.*, 2025; Zhang *et al.*, 2025) whereas 16 evaluated that of tDCS (Elsner *et al.*, 2016, 2020; Tedesco Triccas *et al.*, 2016; Li *et al.*, 2018; Tien *et al.*, 2020; Van Hoornweder *et al.*, 2021; Comino-Suárez *et al.*, 2021; Reis *et al.*, 2021; Sun *et al.*, 2021; Huang *et al.*, 2022; Lima *et al.*, 2023, 2024; Zhang *et al.*, 2024; Tang *et al.*, 2024; Usman, Wong and Ng, 2024; Yu *et al.*, 2025). Notably, 5 meta-analyses evaluated both rTMS and tDCS within the same review (O'Brien *et al.*, 2018; Vaz *et al.*, 2019; Kang *et al.*, 2020; Ahmed *et al.*, 2023; Ren *et al.*, 2024). The number of primary studies included in each meta-analysis ranged from 2

(McIntyre *et al.*, 2018; Allida *et al.*, 2020; Ahmed *et al.*, 2023) to 48 (Zhou *et al.*, 2023), and the number of participants ranged from 54 (Xi *et al.*, 2023) to 1654 (Xie et al., 2025).

Control interventions included sham stimulation, or no intervention associated with physiotherapy, occupational therapy, task-oriented training, mirror therapy, treadmill training, usual care, constraint-induced movement therapy, or pharmacological interventions. The characteristics of the included meta-analyses are summarized in Table 1.

Table 1. Main characteristics of the included meta-analyses.

Name / Year	Outcomes	I^2 / Heterogeneity p-value	Adverse events	Stimulation target	Stimulation protocol	Number of sessions	Measures	Comparison group
Elsner et al., 2016	Motor function - tDCS	82%; <0.01	Not reported	atDCS (affected M1) or ctDCS (unaffected) or Bi-tDCS	I: 0.5-2mA, D: 13-20min ES: 18-35cm²	15-30	MAS	Sham tDCS or Sham tDCS + virtual reality or physical therapy
Graef et al., 2016	Motor function - TMS	0%; 0.44	No	M1 (unaffected side)	F: 1Hz; T: 1; P:240-1800; MT(%):90	10-22	FMA-UL	Sham rTMS + repetitive facilitation exercises or CIMT or Physical therapy
Graef et al., 2016	Upper limb activity - TMS	52%; 0.02	No	M1 (unaffected or affected side)	F: 1-20Hz; T: 1-50; P:1200-2000; MT(%):90-110	8-22	WMFT	Sham rTMS + task-oriented training or Physical therapy or CMIT or occupational therapy
Triccas et al., 2016	Motor function - tDCS	0%; 0.99	Yes (Headache and dizziness)	atDCS (affected M1), ctDCS (unaffected M1) or bihemispheric M1	I: 1-2mA, D: 13-40min ES: NR	5-30	FMA-UL	Sham tDCS + physical therapy or occupational therapy or CIMT or virtual reality
Triccas et al., 2016	ADL - tDCS	33%; 0.20	Yes (Headache and dizziness)	atDCS (affected M1), ctDCS (unaffected M1) or bihemispheric M1	I: 2mA, D: 20-25min ES: NR	15-30	BI	Sham tDCS + occupational therapy or CIMT or virtual reality

Shen et al., 2017	General neurological function - TMS	53%; 0.05	Yes (Headache, gastrointestinal reaction, tinnitus and feel weak)	lDLPFC or rDLPFC or M1 or bilateral DLPFC	F: 0.5-10Hz; T: 30; P: 1500; MT(%): 60-110	7-24	NIHSS	Regular treatment or sham rTMS + regular treatment or antidepressant
Shen et al., 2017	ADL - TMS	89%; <0.01	Yes (Headache, gastrointestinal reaction, tinnitus and feel weak)	lDLPFC or rDLPFC or M1 or bilateral DLPFC	F: 0.5-10Hz; T:20-30; P:NR; MT(%):60-100	10-60	BI	Sham rTMS + antidepressant or fluoxetine or sertraline or mirtazapine or regular treatment
Zhang et al., 2017a	Motor function - TMS	52%; 0.04	Not reported	M1 (unnafected side)	F: 1Hz; T: NR; P:600-1800; MT(%):80-130	10-24	FMA-UL; Pinch force; Hand grip	Sham rTMS + physical therapy or occupational therapy or functional task practice or task-oriented training
Zhang et al., 2017a	Upper limb activity - TMS	0%; 0.46	Not reported	M1 (unaffected side)	F: 1Hz; T:NR; P:600-1800; MT(%):90-100	1-24	JTT; NHPT; WMFT	Sham rTMS + rehabilitation or task-oriented training or functional task practice or occupational therapy or extensor activity
Zhang et al., 2017b	Motor function - TMS	0%;0.02	Yes (Headache, anxiety, nausea, tingling and dizziness)	M1 (unaffected or affected side)	F: 1-50Hz; T:20-50; P: 160-2000; MT(%):80-130	1-24	FMA-UL; Pinch force; Hand grip; Complex hand movement	Sham rTMS isolated or sham rTMS + regular treatment
Li et al, 2018 a	Motor function - TMS	0%; 0.72	Not reported	M1 (unaffected or affected side) of the leg area	F: 1-20Hz; T:1-30; P:600-2000; MT(%):90	1-40	FMA-LL	Sham rTMS or sham rTMS + task-oriented training

Li et al, 2018 a	Mobility - TMS	0%; 0.53	Not reported	M1 (unaffected or affected side) of the leg area	F: 1-20Hz; T: 1-30; P:600-2000; MT(%):90	1-40	TUG; 10MWT; Gait analysis	Sham or sham + MI + rehab or sham + rehab
Li et al., 2018 b	Mobility - tDCS	0%; 0.71	No	atDCS(affected M1), ctDCS (unaffected M1)	I: 1.5-2mA D: 7-20min ES: 35cm2	10 weeks	TUG; 6MWT; 10MWT	Sham tDCS + rehabilitation
Li et al., 2018 b	Motor function - tDCS	82%; <0.01	No	atDCS(affected M1), ctDCS (unaffected M1)	I: 2mA D: 10-25min ES: 7.07-35cm2	6-10 weeks	Lower limb motricity index; MRC	Sham tDCS + physical therapy or rehabilitation
McIntyre et al., 2018	Motor function - TMS	42%; NR	No	M1 (unaffected)	F: 1Hz; T: 1; P:240-1500; MT(%):90	10 weeks	MAS	Sham rTMS + physical therapy or occupational therapy
O'Brien et al., 2018	Upper limb activity - TMS	67%;<0.01	Not reported	M1 or PMd (unaffected or affected side)	F: 1-20Hz; T:NR; P:600-2000; MT(%):90-110	1-10 weeks	BBT; JTT; NHPT; PPT	Sham rTMS or sham rTMS + motor training or CIMT or Brunnstrom hand manipulation
O'Brien et al., 2018	Upper limb activity - tDCS	34%; 0.11	Not reported	M1 or PMd (unaffected or affected side)	I: 1-1.5mA D: 10-40 min ES: 25-35cm2	1-10 weeks	ARAT	Sham tDCS or Sham tDCS + occupational theerapy or robot assisted training
Ghayour-Najafabadi et al., 2019	Motor function - TMS	77%; <0.01	No	M1 (unaffected or affected side) of the leg area or Cerebellum	F: 1-10Hz; T: NR; P:900-2000; MT(%):90-130	5-140	FMA-LL	Without stimulation or Sham rTMS or Sham rTMS + physical therapy or mirror therapy or rehabitilitation

Ghayour-Najafabadi et al., 2019	Mobility - TMS	0%; 0.62	No	M1 (unaffected or affected side) of the leg area or Cerebellum	F: 1-10Hz; T: NR; P:900-2000; MT(%):90-130	5-140	BBS; TUG	Without stimulation or Sham rTMS or Sham rTMS + physical therapy or mirror therapy or rehabitilitation
Liu et al., 2019	General neurological function - TMS	0%; 0.94	Yes (Headache and anxiety)	LDLPFC	F: 10Hz; T: NR; P: NR; MT(%):80-110	10-20	NIHSS	Fluoxetine or Citalopram or Sertraline/Deanxit or Sham stimulation
Liu et al., 2019	ADL - TMS	89%; <0.01	Yes (Headache and anxiety)	LDLPFC	F:10Hz; T:NR; P:NR; MT(%):60-90	10-60	BI	General treatment or general treatment + citalopram/fluoxetine
Tung et al., 2019	Motor function - TMS	0%; 0.56	Yes (dizziness and tingling)	M1 (unaffected or affected side) of the leg area or Cerebellum or LDLPFC	F: 1-20Hz; T: NR; P:600-1500; MT(%):90-130	10-15	FMA-LL; brunnstrom recovery stage for lower limb; plantarflexion peak torque; lower limb motricity index	Sham rTMS or sham rTMS + Task-oriented training or treadmill training or ankle strengthening exercise or movement therapy or physical therapy
Tung et al., 2019	Mobility - TMS	35%; 0.18	Yes (dizziness and tingling)	M1 (unaffected or affected side) of the leg area or Cerebellum or LDLPFC	F: 1-10Hz; T:NR; P:600-1000; MT(%):90-110	5-40	BBS; FAC; Walking speed; ABMS II	Sham rTMS or sham rTMS + Task-oriented training or treadmill training or ankle strengthening exercise or movement therapy or physical therapy

Van Lieshout et al., 2019	Motor function - TMS	66%; <0.01	NR	M1 or PMd (unaffected or affected side)	F: 1-5Hz; T: NR; P:240-1800; MT(%):80-120	5-24	FMA-UL	Sham rTMS + conventional therapy or virtual reality or physical therapy or functional task practice
Van Lieshout et al., 2019	Upper limb activity - TMS	49%; <0.01	NR	M1 or PMd (unaffected or affected side)	F: 1-5Hz; T:NR; P:240-1800; MT(%):80-120	5-24	ARAT; JTT; BBT; NHPT; PPT	Sham rTMS + conventional therapy or virtual reality or physical therapy or functional task practice
Vaz et al., 2019	Mobility - TMS	0%; 0.72	NR	M1 (unaffected or affected side) of the leg area	F: 1-10Hz; T:NR; P:600-2000; MT(%):90-100	10-30	10m-WT; 3-D gait analysis; 6MWT; FAC; Motricity Index	sham rTMS or sham rTMS + physical therapy or task oriented training
Vaz et al., 2019	Mobility - tDCS	25%;0.16	NR	M1 (unaffected or affected side) of the leg area	I:1-2.5 mA D: 7-20 min ES: NR	7-12	10m-WT; 3-D gait analysis; 6MWT; FAC	sham tDCS + gait training or physical therapy
Xiang et al., 2019	Motor function - TMS	0%; 0.68	Yes (headaches, fatigue, drowsiness, neck pain, anxiety, cast irritation, and neurocardiogenic syncope)	M1 (unaffected or affected side)	F: 1-25Hz; T: NR; P:150-1800; MT(%):80-130	1-24	BRS; JTT; NHPT; PPT; WMFT; FMA-LL	Sham rTMS
Xiang et al., 2019	ADL - TMS	0%; 0.78	Yes (headaches, fatigue, drowsiness, neck pain, anxiety, cast irritation, and	M1 (unaffected or affected side)	F: 1-25Hz; T: NR; P:150-1800; MT(%):80-130	1-24	BI; Activity Index	Sham rTMS

			neurocardiogenic syncope)					
Allida et al., 2020	ADL - TMS	99%; <0.01	No	LDLPFC or M1 (unaffected side)	F:1-10Hz; T:NR; P:1960; MT(%):80%	10-28	BI	Sham rTMS + usual care
Allida et al., 2020	General neurological function - TMS	93%; <0.01	No	LDLPFC or RDLPFC or M1 (unaffected side)	F: 1-10Hz; T:20-50; P:800-2500; MT(%):80-90	20-28	NIHSS	Sham or usual care
Elsner et al., 2020	Upper limb activity - tDCS	0%; 0.84	No	M1 (affected or unaffected side)	I: 0,5-2mA D: 7-40min ES: NR	10-30	ARAT	Sham tDCS + physical therapy or occupational therapy or mirror therapy or virtual reality
Elsner et al., 2020	Mobility - tDCS	31%; 0.14	No	M1 (affected or unaffected side)	I: 0,5-2mA D: 7-40min ES: NR	10-30	FAC; Walking velocity; Walking capacity	Sham tDCS + physical therapy or occupational therapy or mirror therapy or virtual reality
Elsner et al., 2020	Motor function - tDCS	42%; 0.01	No	M1 (affected or unaffected side)	I: 0,5-2mA D: 7-40min ES: NR	10-30	MAL; FMA-UL	Sham tDCS + physical therapy or occupational therapy or mirror therapy or virtual reality
Elsner et al., 2020	ADL - tDCS	0%; 0.87	No	M1 (affected or unaffected side)	I: 0,5-2mA D: 7-40min ES: NR	10-30	Barthel Index; FIM	Sham tDCS + physical therapy or occupational therapy or mirror therapy or virtual reality

Kang et al., 2020	Mobility - TMS	37%; NR	NR	M1 (unaffected or affected side) of the leg area or Cerebellum	F: 1-10Hz; T:NR; P:900-1000; MT(%):90-130	5-20	BBS; Tinetti Test; Trunk Control	Sham rTMS + physical therapy or mirror therapy or rehabilitation
Kang et al., 2020	Mobility - tDCS	59%; NR	NR	M1 (unaffected or affected side)	I: 1-2mA D: 10-20 min ES: 7.07-35 cm²	1-16	FMA;BBS	Sham tDCS + robotic training or physical therapy or rehabilitation or occupational therapy
Tien et al., 2020	Mobility - tDCS	0%; 0.57	No	Noncephalic areas; premotor cortex; M1 (unaffected or affected side)	I: 1-2 mA, D: 7-20 min ES: 10-35 cm²	1-20	RAG; TRT BBS	Sham tDCS
Comino-Suárez et al., 2021	Motor function - tDCS	0%; 0.61	Yes (headache, fatigue, and tingling)	atDCS (affected M1), ctDCS (unaffected M1)	I:1-2mA D: 7-30min ES:25-35cm²	2-36	FMA	Sham tDCS + robot assisted training or Lokomat or upper limb robotic assisted training
Comino-Suárez et al., 2021	Upper limb activity - tDCS	0%; 0.80	Yes (headache, fatigue, and tingling)	atDCS (affected M1), ctDCS (unaffected M1)	I:1-2mA D: 7-30min ES:25-35cm²	2-36	FMA	Sham tDCS + robot assisted training or Lokomat or upper limb robotic assisted training
Comino-Suárez et al., 2021	ADL - tDCS	0%; 0.66	Yes (headache, fatigue, and tingling)	atDCS (affected M1), ctDCS (unaffected M1)	I:1-2mA D: 7-30min ES:25-35cm²	2-36	FMA	Sham tDCS + robot assisted training or Lokomat or upper limb robotic assisted training
Reis et al., 2021	Upper limb activity - tDCS	0%; 0.45	NR	NR	I: NR D: 20-30min ES: NR	1-36	ARAT; BBT; WMFT	Sham + robotic assisted training

Shao et al., 2021	General neurological function - TMS	33%; 0.23	No	NR	NR	7-20	Modified Scandinavian Stroke Scale; modified Brunnstrom Classification; NIHSS	Routine treatment or Fluoxetine or Sham rTMS or Sham rTMS + deanxit
Sun et al., 2021	Motor function - tDCS	NR; NR	NR	Bihemispheric tDCS (affected and unaffected M1), atDCS (affected M1), ctDCS (affected M1)	I: 1-2 mA D: 13-40 min ES:35 cm^2	6-20	FMA-UL	Sham tDCS + rehabilitation or virtual reality or phisical therapy or occupational therapy
Van Hoornweder et al., 2021	Motor function - tDCS	68%; 0.01	NR	atDCS (affected M1, PMd & SMA), ctDCS (unaffected M1), bihemispheric tDCS (affected M1+unaffected M1)	I:1-2mA D: 9-30min ES:16-35cm^2	5-30	FMA-UL	Sham tDCS + CIMT or robot assisted training or virtual reality or occupational therapy
Huang et al., 2022	Motor function - tDCS	87%; <0.01	No	atDCS (affected M1), ctDCS (unaffected M1/S1)	I: 0,5-2 mA D: 13-30 min ES:16-35 cm^2	10-40	MAS	Sham tDCS + physical therapy or virtual reality or CIMT or robot-assisted trainimg or Electroacupuncture or Exercise training
Krogh et al., 2022	Mobility - TMS	0%; 0.62	NR	M1 (unaffected or affected side)	F: 1-10Hz; T:15-50; P:900-2000; AMT(%):90-130	5-20	TUG, PASS, 10MWT, BBS, Gait velocity during non-standard gait analysis	Sham rTMS or Sham rTMS + motor imagery or physical training or treadmill training

Krogh et al., 2022	Motor function - TMS	9%; 0.24	NR	M1 (unaffected or affected side)	F: 1-10Hz; T:15-50; P:900-2000; AMT(%):90-130	5-20	FMA-LL	Sham rTMS or Sham rTMS + motor imagery or physical training or treadmill training
Ahmed et al., 2023	Motor function - TMS	37%; 0.14	NR	M1 (unaffected or affected side)	F: 1-10Hz; T: NR; P: NR; MT(%): NR	10-24	FMA	Sham rTMS + Physical therapy or Occupational therapy or rehabilitation
Ahmed et al., 2023	ADL - TMS	84%; 0.01	NR	M1 (unaffected or affected side)	F: 1-10Hz; T:NR; P:NR; MT(%):NR	10-24	BI, FIM, MAL	Sham rTMS + Physical therapy or Occupational therapy or rehabilitation
Ahmed et al., 2023	Motor function - tDCS	81%; <0.01	NR	atDCS (affected M1), ctDCS (unaffected M1)	I:1-20mA D: 10-30min ES: NR	9-36	FMA-UL	Sham tDCS + robot assisted training or virtual reality or occupational therapy or physical therapy or CIMT
Ahmed et al., 2023	ADL - tDCS	73%; 0.02	NR	atDCS (affected M1), ctDCS (unaffected M1)	I:1-20mA D: 10-30min ES: NR	9-36	BI, FIM, MAL	Sham tDCS + robot assisted training or virtual reality or occupational therapy or physical therapy or CIMT
Chen et al., 2023 a	Motor function - TMS	81%; <0.01	Yes (Headache and dizziness)	M1 (unaffected or affected side) of the leg area	F: 1-10Hz; T: NR; P: NR; MT(%):80-100	10-20	FMA-LL	Rehabilitation therapy + medical treatment or Physical therapy + medical treatment or sham rTMS + Rehabilitation therapy + medical treatment

Chen et al., 2023 a	General neurological function - TMS	68%; <0.01	Yes (Headache and dizziness)	M1 (unaffected or affected side) of the leg area	F: 1-10Hz; T: NR; P: NR; MT(%):80-100	10-20	NIHSS	Rehabilitation therapy + medical treatment or Physical therapy + medical treatment or sham rTMS + Rehabilitation therapy + medical treatment
Chen et al., 2023 a	ADL - TMS	97%; <0.01	Yes (Headache and dizziness)	M1 (unaffected or affected side) of the leg area	F: 1-10Hz; T:NR; P:NR; MT(%):80-100	10-20	BI	Rehabilitation therapy + medical treatment or Physical therapy + medical treatment or sham rTMS + Rehabilitation therapy + medical treatment
Chen et al., 2023 b	ADL - TMS	84%; <0.01	Yes (headaches, dizziness, palpitation, anxiety, gastrointestinal symptoms)	DLPFC (Left or affected side)	F: 3-10 Hz; T: NR; P: NR; MT(%): 80-120	20-48	MBI; BI	Sham rTMS + cognitive training or routine medication treatment or rehabilitation or hyperbaric oxigen therapy or accupunture or occupational therapy
Gao et al., 2023	ADL - TMS	0%; NR	Yes (Headache and dizziness)	DLPFC (Left side)	F: 1-10Hz; T: NR; P: 900-2000; MT(%): 80-100	10-20	MBI	NR
Hofmeijer et al., 2023	Mobility - TMS	69%; 0.02	NR	M1 (affected or unaffected side)	F: 1-10Hz; T: NR; P: 1000-1200; MT(%): 90	5-21	FAC; BBS	Sham rTMS + rehabitilation or physical therapy or virtual reality

Hofmeijer et al., 2023	Motor function - TMS	83%; <0.01	NR	M1 (affected or unaffected side)	F: 1-10Hz; T: NR; P: 100-1800; MT(%): 80-90	10-24	FMA-UL	Sham rTMS + rehabitilation or physical therapy or virtual reality
Hofmeijer et al., 2023	ADL - TMS	80%<0.01	NR	M1 (affected or unaffected side)	F: 1-20Hz; T: NR; P: 900-1200; MT(%): 80-130	5-24	BI; FIM	Sham rTMS + rehabitilation or physical therapy or virtual reality
Lima et al., 2023	Motor function - tDCS	76%; <0.01	NR	M1 (affected or unaffected side)	I: NR D: NR ES: NR	NR	FMA-LL	Sham tDCS + PT or OT
Lima et al., 2023	Mobility - tDCS	0%; 0.79	NR	M1 (affected or unaffected side)	I: NR D: NR ES: NR	NR	TUG; BBS	Sham tDCS + PT or robot assisted training
Xi et al., 2023	Upper limb activity - TMS	0%; NR	NR	M1 (affected or unaffected side)	F: 1-20Hz; T: NR; P: 1200-1500; MT(%): 90-110	8-20	BBT	Sham rTMS + task-oriented training
Xi et al., 2023	Motor function - TMS	0%; NR	NR	M1 (affected or unaffected side); left posterior parietal cortex	F: 1-10Hz; T: NR; P: 200-2000; MT(%): 80-90	24-48	FMA-UL	Sham rTMS + task-oriented training or Physical therapy or rehabilitation

Xi et al., 2023	ADL - TMS	39.9%; NR	NR	M1 (affected or unaffected side); left posterior parietal cortex	F: 1-10Hz; T: NR; P: 600-2000; MT(%): 80-90	24-42	BI	Sham rTMS + task-oriented training
Xie et al., 2023	ADL - TMS	36%; 0.21	No	DLPFC (Left, bilateral or unaffected side)	F: 1-10Hz; T: NR; P: NR MT(%): 80-120	20	MBI	Sham rTMS or no intervention
Zhou et al., 2023	Mobility - TMS	0%; 0.99	No	M1 (affected and unaffected side); supplementary motor area; DLPFC; cerebellum	F: 0.5-50Hz; T: NR; P: 450-3000; MT(%): 80-130	1-15	BBS; TUG; Walking performance	Sham rTMS
Chen et al., 2024	Motor function - TMS	79%; <0.01	No	M1 (affected and unaffected side); cerebellum	F: 5 Hz; T: 20-40; P: 600-1200; MT(%): 70-100	10-30	FMA-LL	Sham rTMS + rehabilitation or suspension exercise
	Mobility - TMS	78%; 0.01	No	M1 (affected and unaffected side); cerebellum	F: 5 Hz; T: 20-40; P: 600-1200; MT(%): 70-100	10-30	BBS; TUG; 10MWT	Sham rTMS + rehabilitation or suspension exercise

	ADL - TMS	0%; 0.80	No	M1 (affected and unaffected side); cerebellum	F: 5 Hz; T: 20-40; P: 600-1200; MT(%): 80-100	10-20	MBI	Sham rTMS + rehabilitation or suspension exercise
Daoud et al., 2024	ADL - TMS	0%; 0.48	No	DLPFC (left)	F: 5 Hz; T: 20-40; P: 600-1200; MT(%): 56-80	20-30	BI; MBI	Sham rTMS or sham rTMS + cognitive training
Jiang et al., 2024	Motor function - TMS	65%; <0.01	No	M1 (affected and/or unaffected side); cerebellum (ipsilesional)	F: 5Hz; T: 1-40; P: 600-1200; MT(%): 60-110	9-30	FMA-UL; FMA-LL; MAS	Sham TBS + PT or rehabilitation or virtual reality or RAT
	Upper limb activity - TMS	94%; <0.01	No	M1 (affected or unaffected side)	F: 5Hz; T: 1-20; P: 600; MT(%): 80-90	10	NHPT; ARAT	Sham TBS + PT or rehabilitation
	Mobility - TMS	59%; 0.08	No	M1 (affected and unaffected side); cerebellum (ipsilesional)	F: 5Hz; T: 20-40; P: 600-1200; MT(%): 80-100	10-30	BBS	Sham TBS + PT or rehabilitation

Lima et al., 2024	Motor function - tDCS	0%; 1.00	No	M1 (affected and unaffected side)	I:1-2 mA D: 10-30 min ES: NR	NR	FMA-UL	Sham tDCS + Robot assisted training
Ren et al., 2024	Motor function - TMS	86%; <0.01	No	M1 (affected and unaffected side)	F: 1-10 Hz; T: NR; P: 900-1000; MT(%): 80-120	15-30	FMA-UL	Sham rTMS
	Motor function - tDCS	0%; 0.75	No	M1 (affected and unaffected side)	I:NR D: 20-30 min ES: NR	5-20	FMA-UL	Sham tDCS
Tang et al., 2024	Motor function - tDCS	49%; <0.01	No	M1 (affected and unaffected side); supplementary motor area; DLPFC; cerebellum	I:1-2 mA D: 9-40 min ES: 16-35 cm²	5-60	FMA-UL; ARAT	NR
	ADL - tDCS	37%; 0.07	No	M1 (affected and unaffected side)	I:1.5-2 mA D: 10-30 min ES: 22-35 cm²	10-60	BI	NR
Wang et al., 2024 a	Mobility - TMS	69%; <0.01	Yes (Vertigo)	Cerebellum (contra or ipsilesional)	F: 1-10Hz; T: NR; P: 600-1200; MT(%): 80-100	10-21	BBS, TUG	Sham + PT or rehabilitation or mirror therapy

	ADL - TMS	80%; <0.01	No	Cerebellum (contra or ipsilesional)	F: 5-10Hz; T: 20-40; P: 600-1200; MT(%): 80-110	10-24	BI, MBI	Rehabilitation or sham rTMS + rehabilitation or sham + PT or sham +rehabilitation + accupunture
Wang et al., 2024 b	Motor function - TMS	0%; NR	NR	M1 (affected and unaffected side)	F: 1-10Hz; T: 1-NR; P: 1000-1200; MT(%): 80-90	15-40	FMA-UL	Rehabilitation or sham rTMS + rehabilitation
	ADL - TMS	0%; NR	NR	M1 (affected and unaffected side)	F: 1-10Hz; T: 1-NR; P: 1000-1200; MT(%): 80-90	15-40	BI, MBI	Rehabilitation or sham rTMS + rehabilitation
Zeng et al., 2024	Motor function - TMS	0%; 0.42	NR	Cerebellum (contralesional)	F: 1-10Hz; T: 1-NR; P: 600-1600; MT(%): 80-110	10-20	FMA-LL	Sham + PT or rehabilitation
	Mobility - TMS	76%; <0.01	NR	Cerebellum (contra or ipsilesional)	F: 1-10Hz; T: 1-NR; P: 600-1000; MT(%): 80-110	5-21	BBS	Sham + PT or rehabilitation

Zhang et al., 2024a	ADL - tDCS	0%; 0.356	NR	M1 (unaffected side)	I: 2 mA D: 20-30 min ES: NR	10-15	MBI	Sham tDCS + VR or rehabilitation
Zhang et al., 2024b	Motor function -TMS	76.2%; <0.01	NR	M1 (affected or unaffected side)	F: 5Hz; T: 20-40; P: 600-1200; MT(%): 60-110	9-30	FMA-UL	Sham + rehabilitation or PT or RAT or VR
	Upper limb activity - TMS	34.2%; 0.07	NR	M1 (affected or unaffected side)	F: 5Hz; T: 20-40; P: 600-1200; MT(%): 60-110	9-30	ARAT; WMFT; JTT	Sham + rehabilitation or PT or RAT or VR
Zhu et al., 2024	ADL - TMS	52.6%; 0.12	No	DLPFC (left or unaffected side)	F: 1-10Hz; T: 1-20; P: 600-1000; MT(%): NR	5-30	MBI	NR
Barreto et al., 2025	Motor function - TMS	81%; <0.01	NR	M1 (affected or unaffected side); left posterior parietal cortex	F: 1-20Hz; T: NR; P: 200-2000; MT(%): 60-120	5-24	FMA-UL; WMFT; ARAT	Sham rTMS + physical therapy or occupational therapy or virtual reality or electrotherapy or Brunnstrom hand manipulation or CIMT or task oriented training
Jia et al., 2025	Motor function - TMS	35%; 0.07	NR	M1 (affected and/or unaffected side); left DLPFC	F: 1-20Hz; T: NR; P:	5-21	FMA-LL	NR

					600-1600; MT(%): 80-130			
	Mobility - TMS	20%; 0.28	NR	M1 (affected and/or unaffected side); left DLPFC	F: 1-20Hz; T: NR; P: 600-1600; MT(%): 80-100	5-11	10mWT; BBS	NR
Ma et al., 2025	Motor function - TMS	87%; <0.01	NR	M1 (affected and/or unaffected side); affected DLPFC	F: 1-10Hz; T: NR; P: NR; MT(%): 80-100	10-20	NR	Sham rTMS or rehabilitation or accupunture or ganglion block or cold water bath therapy
Usman et al., 2025	Mobility - tDCS	0%; 0.89	No	M1 (affected and/or unaffected side)	I:1-2 mA D: 15-20 min ES: 1.75-25 cm^2	4-12	Gait speed	Sham tDCS or sham tDCS + HIIT
Wang et al., 2025	Mobility - TMS	20%; 0.25	No	Cerebellum (contra or ipsilesional)	F: 1-5Hz; T: 1-40; P: 600-1200; MT(%): 80-100	5-15	BBS; TUG; 10mWT	Sham + PT
	Motor function - TMS	67%; 0.05	No	Cerebellum (contralesional)	F: 5Hz; T: 20-40; P: 600-1200; MT(%): 80	10	FMA-LL	Sham + PT

	ADL - TMS	0%; 0.67	No	Cerebellum (contralesional)	F: 5Hz; T: 20-40; P: 600-1200; MT(%): 80	10-20	BI, MBI	Sham + PT or rehabilitation
Xie et al., 2025	Motor function - TMS	35%; 0.02	Yes (seizure, headache, drowsiness)	M1 (affected and/or unaffected side); left DLPFC; premotor cortex (contralateral); cerebellum (ipsilateral)	F: 0.1-20Hz; T: NR; P: 200-7500; MT(%): 80-130	5-40	FMA-UL; FMA-LL	Sham + rehabilitation or PT or OT or rehabilitation
	General neurological function - TMS	81%; <0.01	Yes (seizure, headache, drowsiness)	M1 (affected and/or unaffected side)	F: 1-10Hz; T: NR; P: 900-1800; MT(%): 80-120	5-20	NIHSS	Sham + rehabilitation or PT
	ADL - TMS	83%; <0.01	Yes (seizure, headache, drowsiness)	M1 (affected and/or unaffected side)	F: 0.5-10Hz; T: NR; P: 200-1200; MT(%): 80-130	5-40	MBI	Sham + rehabilitation or PT or OT or rehabilitation
Yu et al., 2025	Motor function - tDCS	86%; <0.01	Yes (headache, tingling, burning, itching)	M1 (affected side)	I: 1-2 mA D: 20-45 min ES: 25-50 cm^2	5-36	FMA-UL	Sham tDCS + rehabilitation or accupunture or PT or RT

	Upper limb activity - tDCS	17%; 0.30	No	M1 (affected side)	I: 1-2 mA D: 20-45 min ES: 25-50 cm²	12-24	WMFT	Sham tDCS + rehabilitation or accupunture or PT
	ADL - tDCS	88%; <0.01	Yes (headache, tingling, burning, itching)	M1 (affected side)	I: 1-2 mA D: 20-45 min ES: 25-50 cm²	5-36	BI	Sham tDCS + rehabilitation or accupunture or PT or RT
Zhang et al., 2025	Motor function -TMS	86%; <0.01	NR	M1 (affected and unaffected side); cerebellum (ipsilesional); premotor cortex (unaffected side); S1 (affected side)	F: 1-20Hz; T: NR; P: 500-2000; MT(%): 20-120	5-20	FMA-UL	Sham + PT or OT

Abbreviations: 10MWT, 10-metre walking test; 6MWT, 6-minute Walk Test; 9HPT, 9-Hole Peg Test; AT, The albert test; ABMS-II, Ability for Basic Movement Scale II; ARAT, Action Research Arm Test; AS, Ashworth spasticity; b-tDCS, bilateral-tDCS; BDLPFC, bilateral dorsolateral prefrontal cortex; Bi, bilateral (anodal + cathodal); B&B, Box & block teST; BBS, Berg Balance Scale; BBT, Box and Block Test; BI, Barthel Index; BRS, Brunnstrom Recovery Stages; C3/C4/F3, according to the 10–20 international electroencephalography system; CIMT, Constraint-induced movement therapy; cTBS, continuous theta burst stimulation; D, duration of stimulation; ES, electrodes size; F, frequency; FAC, functional ambulation category; FIM, functional independence measure; FMA, Fugl-Meyer Assessment Scale; FMA-LL, Fugl-Meyer Assessment Scale Lower Limb; FMA-UL, Fugl-Meyer Assessment Scale Upper Limb; FTP, Functional task practice; FTT, Finger Tapping Test; HF-rTMS, high frequency repetitive transcranial magnetic stimulation; I: current intensity; iTBS, intermittent theta burst stimulation; JTT, Jebsen Taylor Test; l-DLPFC, left dorsolateral prefrontal cortex; LF-rTMS, high frequency repetitive transcranial magnetic stimulation; LLMI, lower limb motricity index; MEPs, Motor evoked potentials; HADS, Hospital anxiety ans depression

scale; MAL, motor activity log; M1, primary motor cortex; MAS, modified ashworth scale; MRC, Medical Research Council Motor Power Score; mSSS, modified Scandinavian Stroke Scale; MT, Motor Training; MT(%), percentage of motor threshold; MFT, Manual Function Test; NHPT, Nine Hole Peg Test; NIHSS, National Institutes of Health Stroke Scale; NMES, neuromuscular electrical stimulation; NA, not applied; NNT, number needed to treat; NR, not reported; NEADL, Nottingham Extended Activities of Daily Living Scale; OT, Occupational Therapy; P: pulses per train; PASS, Postural Assessment Scale for Stroke Patients; PMd, dorsal premotor cortex; PPT, Purdue Pegboard Test; PT, Physical therapy; PS, pinch strength; RAAT, Robot Assisted Arm Training; RAGT, Robot-assisted gait training; RAT, Robot Assisted Training; r-DLPFC, right dorsolateral prefrontal cortex; RT, rehabilitation treatment; RNS, vagus nerve stimulation; ROM, range of motion; RS, Rankin Scale; S1, primary sensory cortex; SIS, Stroke Impact Scale; SIAS: Stroke Impairment Assessment Set; T: number of trains; TRT, task-related training; TUG, Timed Up-and-Go test; VR, Virtual Reality; WMFT, Wolf Motor Function Test; TI – Tinetti test; TIS – Trunk Impairment Scale; LDLPFC, left dorsolateral prefrontal cortex; RDLPFC, right dorsolateral prefrontal cortex.

3.2 Results of the methodological quality (AMSTAR)

AMSTAR scores ranged from 8 (McIntyre *et al.*, 2018; Kang *et al.*, 2020; Sun *et al.*, 2021) to 16 points (Allida *et al.*, 2020; Elsner *et al.*, 2020; Barreto *et al.*, 2025). Twenty three studies (41.1%) were considered to be of high quality (Elsner *et al.*, 2016, 2020; O'Brien *et al.*, 2018; Liu *et al.*, 2019; Vaz *et al.*, 2019; Allida *et al.*, 2020; Comino-Suárez *et al.*, 2021; Reis *et al*., 2021; Shao *et al*., 2021; Huang *et al*., 2022; Krogh *et al*., 2022; Gao *et al*., 2023; Lima *et al.*, 2023; Xie *et al*., 2023; Jiang *et al*., 2024; Lima *et al*., 2024; Zhang *et al*., 2024; Tang *et al*., 2024; Usman, Wong and Ng, 2024; Zeng *et al*., 2024; Barreto *et al*., 2025; Jia *et al*., 2025), 25 studies (44.6%) were considered to be of moderate quality (Graef *et al*., 2016; Tedesco Triccas *et al*., 2016; Zhang *et al*., 2017a; Li *et al*., 2018a, 2018b; Ghayour-Najafabadi *et al*., 2019; Tung *et al*., 2019; van Lieshout *et al*., 2019; Xiang *et al*., 2019; Tien *et al*., 2020; Hofmeijer, Ham and Kwakkel, 2023; Xi *et al*., 2023; Chen *et al*., 2023a; Zhou *et al*., 2023; Chen, Sun and Zhuang, 2024; Daoud *et al*., 2024; Zhang *et al*., 2024; Wang *et al*., 2024; Ren *et al*., 2024; Wang *et al.*, 2024, 2025; Ma *et al*., 2025; Xie *et al*., 2025; Zhang *et al*., 2025), two study (3.6%) were considered as "low quality"(Zhang *et al.*, 2017b; Zhu *et al.*, 2024), and 6 studies (10.7%) were classified as critically low quality (McIntyre *et al.*, 2018; Kang *et al.*, 2020; Sun *et al.*, 2021; Ahmed *et al.*, 2023; Chen *et al.*, 2023b; Yu *et al.*, 2025).

The items with the highest scores across reviews were: "PICO Components" (item 1); "study designs for inclusion in the review" (item 3); "perform data extraction in duplicate" (item 6); risk of bias (RoB) in individual studies that were included in the review" (item 9); "appropriate methods for statistical combination of results" (item 11); "quantitative synthesis did the review authors carry out an adequate investigation of publication bias" (item 15) and "potential sources of conflict of interest, including any funding they received for conducting the review" (item 16). Conversely, the items with the highest proportion of studies presenting risk of bias were "whether the review and report justified any significant deviation from the protocol" (item 2); "authors use a comprehensive literature search strategy" (item 4) and "funding for the studies included in the review" (item 10). The AMSTAR ratings are presented in Table 2.

Table 2. AMSTAR ratings.

Study	1	2*	3	4*	5	6	7*	8	9*	10	11*	12	13	14	15*	16	Total Score (classification of quality)
Elsner et al., 2016	Y	Y	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	14 points (High)
Graef et al., 2016	Y	N	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	12 points (Low)
Triccas et al., 2016	Y	N	Y	PY	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	13 points (Moderate)
Shen et al., 2017	Y	Y	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	14 points (High)
Zhang et al., 2017a	Y	Y	Y	PY	Y	Y	Y	PY	Y	N	Y	Y	N	Y	Y	Y	12 points (Moderate)
Zhang et al., 2017b	Y	N	Y	PY	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	12 points (Low)
Li et al., 2018a	Y	N	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	13 points (Moderate)
Li et al., 2028b	Y	N	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	12 points (Moderate)
McIntyre et al., 2018	Y	N	Y	PY	N	Y	N	Y	Y	N	N	N	Y	N	Y	Y	8 points (Critically low)
O'Brien et al., 2018	Y	Y	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	13 points (High)

Ghayour-Najafabadi et al., 2019	Y	Y	Y	PY	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	14 points (Moderate)
Liu et al., 2019	Y	Y	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	14 points (High)
Tung et al., 2019	Y	N	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	13 points (Moderate)
Van Lieshout et al., 2019	Y	N	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	13 points (Moderate)
Vaz et al., 2019	Y	Y	Y	PY	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	15 points (High)
Xiang et al., 2019	Y	N	Y	PY	Y	Y	Y	PY	Y	N	Y	Y	Y	Y	Y	Y	12 points (Moderate)
Allida et al., 2020	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	16 points (High)
Elsner et al., 2020	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	16 points (High)
Kang et al., 2020	Y	N	Y	PY	N	Y	Y	PY	N	N	Y	N	N	Y	Y	Y	8 points (Critically low)
Tien et al., 2020	Y	N	Y	PY	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	12 points (Moderate)
Comino-Suárez et al., 2021	Y	Y	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	13 points (High)
Reis et al., 2021	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	15 points (High)
Shao et al., 2021	Y	Y	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	14 points (High)

Sun et al., 2021	Y	N	Y	PY	Y	N	Y	PY	Y	N	Y	N	N	N	Y	Y	8 points (Critically low)
Van Hoornweder et al., 2021	Y	N	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	13 points (Moderate)
Huang et al., 2022	Y	Y	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	14 points (High)
Krogh et al., 2022	Y	PY	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	14 points (High)
Ahmed et al., 2023	Y	N	Y	PY	Y	Y	Y	PY	Y	N	Y	N	N	Y	Y	Y	10 points (Critically low)
Chen et al., 2023a	Y	Y	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	Y	12 points (Moderate)
Chen et al., 2023b	Y	N	Y	PY	Y	Y	Y	PY	Y	N	Y	Y	Y	N	N	Y	10 points (Critically low)
Gao et al., 2023	Y	Y	Y	PY	Y	Y	Y	PY	Y	N	Y	Y	Y	Y	Y	Y	13 points (High)
Hofmeijer et al., 2023	Y	Y	Y	PY	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	13 points (Moderate)
Lima et al., 2023	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	15 points (High)
Xi et al., 2023	Y	Y	Y	PY	N	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	12 points (Moderate)
Xie et al., 2023	Y	Y	Y	PY	Y	Y	Y	PY	Y	N	Y	Y	Y	Y	Y	Y	13 points (High)

Zhou et al., 2023	Y	N	Y	PY	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	12 points (Moderate)
Chen et al., 2024	Y	Y	Y	PY	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	13 points (Moderate)
Daoud et al., 2024	Y	Y	Y	PY	N	N	Y	Y	Y	N	Y	Y	N	Y	Y	Y	11 points (Moderate)
Jiang et al., 2024	Y	Y	Y	PY	Y	Y	Y	PY	Y	N	Y	Y	Y	Y	Y	Y	13 points (High)
Lima et al., 2024	Y	Y	Y	Y	Y	Y	Y	PY	Y	N	Y	Y	Y	Y	Y	Y	14 points (High)
Ren et al., 2024	Y	Y	Y	PY	Y	Y	Y	Y	Y	N	Y	N	N	Y	Y	Y	12 points (Moderate)
Tang et al., 2024	Y	Y	Y	PY	N	Y	Y	PY	Y	N	Y	Y	Y	Y	Y	Y	12 points (High)
Wang et al., 2024a	Y	N	Y	PY	Y	Y	Y	PY	Y	N	Y	Y	Y	Y	Y	Y	12 points (Moderate)
Wang et al., 2024b	Y	Y	Y	PY	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	14 points (Moderate)
Zeng et al., 2024	Y	Y	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	14 points (High)
Zhang et al., 2024a	Y	N	Y	PY	Y	Y	Y	PY	Y	N	Y	Y	Y	Y	Y	Y	13 points (High)
Zhang et al., 2024b	Y	Y	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	Y	N	N	Y	12 points (Moderate)

Zhu et al., 2024	Y	Y	Y	PY	N	Y	Y	PY	Y	N	Y	N	N	N	Y	Y	9 points (Low)
Barreto et al., 2025	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	16 points (High)
Jia et al., 2025	Y	Y	Y	PY	Y	Y	Y	PY	Y	N	Y	Y	Y	Y	Y	Y	13 points (High)
Ma et al., 2025	Y	Y	Y	PY	Y	Y	Y	PY	Y	N	Y	N	N	Y	Y	Y	11 points (Moderate)
Usman et al., 2025	Y	Y	Y	Y	Y	Y	Y	PY	Y	N	Y	Y	Y	Y	Y	Y	14 points (High)
Wang et al., 2025	Y	Y	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	13 points (Moderate)
Xie et al., 2025	Y	Y	Y	PY	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	13 points (Moderate)
Yu et al., 2025	Y	N	Y	PY	Y	Y	Y	PY	Y	N	Y	Y	N	N	Y	Y	10 points (Critically low)
Zhang et al., 2025	Y	Y	Y	PY	Y	N	Y	PY	Y	N	Y	Y	Y	Y	N	Y	12 points (Moderate)

*: critically points; Y: yes; N: no; PY: partially yes.

3.3 Grading of Evidence Results (GRADE)

Based on the GRADE assessment, we categorized the evidence according to each NIBS technique. Table 3a and 3b present a Summary of Findings (SoF) and evidence quality for each meta-analysis on rTMS for body structure/function and activity domains, respectively, while Table 4a and 4b provide the same for tDCS meta-analyses.

For rTMS, the majority of meta-analyses were rated as low or very low certainty of evidence, with the exception of Xiang et al. (2019), which evaluated rTMS effects on activities of daily living (ADL) post-stroke and were rated as having moderate certainty of evidence. For tDCS, all studies demonstrated low or very low certainty of evidence. Many of the meta-analyses showed inconsistencies due to high variability in NIBS protocols and/or imprecision in results, attributed to small effect sizes or broad confidence intervals.

Table 3a. Summary of findings (SoF) and certainty of evidence regarding included studies that investigated the effects of repetitive transcranial magnetic stimulation (rTMS) in ICF body structure and function domains.

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	rTMS	sham rTMS	Relative (95% CI)	Absolute (95% CI)	
Shen et al., 2017 - General neurological function											
7	randomised trials	not serious	serious[a]	serious[b]	serious[c]	none	164	165	-	SMD **0.94 SD lower** (1.29 lower to 0.6 lower)	⊕◯◯◯ Very low[a,b,c]
Liu et al., 2019 - General neurological function											
4	randomised trials	not serious	not serious	serious[d]	serious[e]	none	111	110	-	SMD **0.91 SD lower** (1.19 lower to 0.63 lower)	⊕⊕◯◯ Low[d,e]
Allida et al., 2020 - General neurological function											
3	randomised trials	not serious	serious[f,g]	serious[b]	serious[h]	none	145	145	-	SMD **2.21 SD lower** (3.32 lower to 1.09 lower)	⊕◯◯◯ Very low[b,f,g,h]
Shao et al., 2021 - General neurological function											
3	randomised trials	not serious	not serious	not serious	very serious[h,i]	none	68	68	-	SMD **0.67 SD lower** (1.02 lower to 0.32 lower)	⊕⊕◯◯ Low[h,i]
Chen et al., 2023 a - General neurological function											
12	randomised trials	serious[i]	very serious[a,f]	serious[b]	not serious	none	278	180	-	SMD **0.94 SD lower** (1.33 lower to 0.54 lower)	⊕◯◯◯ Very low[a,b,f,i]
Xie et al., 2025 - General neurological function											

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	rTMS	sham rTMS	Relative (95% CI)	Absolute (95% CI)	
12	randomised trials	serious[i]	very serious[a,f]	not serious	very serious[i,k]	none	351	299	-	SMD **0.33 SD lower** (0.71 lower to 0.05 higher)	⨁◯◯◯ Very low[a,f,i,j,k]

Graef et al., 2016 - Motor Function

4	randomised trials	serious[i]	serious[f]	not serious	very serious[k,l]	none	83	61	-	SMD **0.04 SD lower** (0.38 lower to 0.3 higher)	⨁◯◯◯ Very low[f,j,k,l]

Zhang et al., 2017a - Motor Function

8	randomised trials	serious[i]	serious[f]	not serious	serious[i]	none	150	151	-	SMD **0.29 SD lower** (0.64 lower to 0.06 higher)	⨁◯◯◯ Very low[f,i,l]

Zhang et al., 2017b - Motor function

27	randomised trials	very serious[m]	very serious[a,f]	not serious	serious[n]	none	470	199	-	SMD **0.49 SD lower** (0.68 lower to 0.29 lower)	⨁◯◯◯ Very low[a,f,m,n]

Li et al., 2018a - Motor function

3	randomised trials	serious[i]	not serious	not serious	very serious[h,k]	none	38	38	-	SMD **0.43 SD lower** (0.56 lower to 0.3 higher)	⨁◯◯◯ Very low[h,i,k]

McIntyre et al., 2018 - motor function

2	randomised trials	very serious[o]	very serious[p,q]	not serious	very serious[k,l]	none	28	28	-	SMD **0.34 SD lower** (0.97 lower to 0.3 higher)	⨁◯◯◯ Very low[k,l,o,p,q]

Ghayour-Najafabadi et al., 2018 - motor function

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	rTMS	sham rTMS	Relative (95% CI)	Absolute (95% CI)	
6	randomised trials	serious[i]	very serious[f,p]	not serious	very serious[h,k]	none	93	84	-	SMD **0.01 SD lower** (0.31 lower to 0.29 higher)	⨁◯◯◯ Very low[f,h,i,k,p]

Tung et al., 2019 - motor function

7	randomised trials	serious[i]	serious[f,p]	not serious	serious[h,i]	none	73	70	-	SMD **0.66 SD lower** (1 lower to 0.32 lower)	⨁◯◯◯ Very low[f,h,i,p]

van Lieshout et al., 2019 - motor function

15	randomised trials	serious[i]	very serious[f,p]	not serious	very serious[h,i]	none	289	244	-	SMD **0.46 SD lower** (0.84 lower to 0.09 lower)	⨁◯◯◯ Very low[f,h,i,p]

Xiang et al., 2019 - motor function

43	randomised trials	serious[i]	serious[p,q]	not serious	not serious	none	739	743	-	SMD **0.5 SD lower** (0.6 lower to 0.39 lower)	⨁⨁◯◯ Low[i,p,q]

Krogh et al., 2022 - Motor function

5	randomised trials	not serious	serious[a,f]	not serious	very serious[k,l]	none	77	78	-	SMD **0.19 SD lower** (0.51 lower to 0.13 higher)	⨁◯◯◯ Very low[a,f,k,l]

Ahmed et al., 2023 - Motor function

8	randomised trials	very serious[o]	very serious[a,f]	not serious	serious[k]	none	246	169	-	SMD **0.04 SD lower** (0.24 lower to 0.16 higher)	⨁◯◯◯ Very low[a,f,k,o]

Chen et al., 2023 - Motor function

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	rTMS	sham rTMS	Relative (95% CI)	Absolute (95% CI)	
8	randomised trials	serious[i]	very serious[a,f]	serious[b]	not serious	none	330	217	-	SMD **1.22 SD lower** (1.7 lower to 0.73 lower)	⨁◯◯◯ Very low[a,b,f,j]
Hofmeijer, et al 2023 - Motor function											
10	randomised trials	serious[i]	very serious[a,f]	not serious	serious[n]	none	323	219	-	SMD **0.94 SD lower** (1.43 lower to 0.45 lower)	⨁◯◯◯ Very low[a,f,j,n]
Xi et al 2023 - motor function											
8	randomised trials	serious[i]	serious[a,f]	not serious	not serious	none	245	241	-	SMD **1.07 SD lower** (0.88 lower to 1.25 lower)	⨁⨁◯◯ Low[a,f,j]
Chen et al., 2024 - Motor function											
5	randomised trials	serious[i]	serious[f]	not serious	very serious[c,k]	none	83	83	-	SMD **0.37 SD lower** (1.07 lower to 0.34 higher)	⨁◯◯◯ Very low[c,f,j,k]
Jiang et al., 2024 - Motor function											
18	randomised trials	not serious	very serious[a,f]	not serious	not serious	none	226	219	-	SMD **0.59 SD lower** (0.93 lower to 0.25 lower)	⨁⨁◯◯ Low[a,f]
Ren et al., 2024 - Motor function											
2	randomised trials	serious[i]	very serious[a,f]	not serious	very serious[c,k]	none	36	34	-	SMD **0.83 SD lower** (2.16 lower to 0.51 higher)	⨁◯◯◯ Very low[a,c,f,j,k]
Wang et al., 2024b - Motor function											

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	rTMS	sham rTMS	Relative (95% CI)	Absolute (95% CI)	
3	randomised trials	serious[i]	serious[a]	not serious	serious[c]	none	50	44	-	SMD **0.89 SD lower** (1.31 lower to 0.48 lower)	⨁◯◯◯ Very low[a,c,i]
Zeng et al., 2024 - Motor function											
4	randomised trials	not serious	very serious[a,f]	not serious	serious[c]	none	93	94	-	SMD **0.89 SD lower** (1.19 lower to 0.58 lower)	⨁◯◯◯ Very low[a,c,f]
Zhang et al., 2024c - Motor function											
14	randomised trials	serious[i]	very serious[a,f]	serious[r]	serious[c]	none	197	182	-	SMD **0.65 SD lower** (1.08 lower to 0.21 lower)	⨁◯◯◯ Very low[a,c,f,j,r]
Barreto et al., 2025 - Motor function											
35	randomised trials	not serious	serious[a,f]	not serious	serious[n]	none	897	700	-	SMD **0.57 SD lower** (0.82 lower to 0.32 lower)	⨁⨁◯◯ Low[a,f,n]
Jia et al., 2025 - Motor function											
18	randomised trials	not serious	very serious[a,f]	not serious	not serious	none	362	361	-	SMD **0.45 SD lower** (0.65 lower to 0.25 lower)	⨁⨁◯◯ Low[a,f]
Ma et al., 2025 - Motor function											
10	randomised trials	serious[i]	very serious[a,s]	not serious	not serious	none	255	259	-	SMD **1.14 SD lower** (1.69 lower to 0.58 lower)	⨁◯◯◯ Very low[a,j,s]
Wang et al., 2025 - Motor function											

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	rTMS	sham rTMS	Relative (95% CI)	Absolute (95% CI)	
3	randomised trials	serious[j]	serious[f]	not serious	very serious[c,k]	none	45	45	-	SMD **0.38 SD lower** (0.81 lower to 0.04 higher)	⨁◯◯◯ Very low[c,f,j,k]

Xie et al., 2025 - Motor function

36	randomised trials	serious[j]	very serious[a,f]	not serious	not serious	none	878	776	-	SMD **0.49 SD lower** (0.59 lower to 0.39 lower)	⨁◯◯◯ Very low[a,f,j]

Zhang et al., 2025 - Motor function

37	randomised trials	serious[j]	very serious[a,f]	not serious	not serious	none	773	712	-	SMD **0.65 SD lower** (0.95 lower to 0.36 lower)	⨁◯◯◯ Very low[a,f,j]

CI: confidence interval; **SMD:** standardised mean difference

Explanations

a. There is a high variability between the rTMS protocols in included studies

b. Control groups of the some included studies comprised medications intake

c. The sample size of the present meta-analysis was smaller than the required

d. Control groups of the some included studies comprised medications intake

e. The sample size of the present meta-analysis was smaller than the required

f. There is a critical difference in time since stroke of populations included in different studies

g. There is a high variability between the rTMS protocols in included studies

h. The sample size of the present meta-analysis was smaller than the required

i. The meta-analysis effect size did not cross the mCID cut-off

j. The meta-analysis study was classified as "moderate" according to the AMSTAR assessment

k. Imprecise due to the diamond touches the null line

l. The sample size of the present meta-analysis was smaller than the required

m. The meta-analysis study was classified as "low quality" acording AMSTAR assessment.

n. The meta-analysis presented a high variability in effect size among the included studies.

o. The meta-analysis study was classified as "critically low quality" acording AMSTAR assessment.

p. There is a high variability between the rTMS protocols in included studies

q. There is a high variability between the design in included studies of the meta-analysis.

r. Control groups of the some included studies comprised other neuromodulation approaches

s. There is a lack of information about stroke characteristics and outcomes of the included studies

Table 3b. Summary of findings (SoF) and certainty of evidence regarding included studies that investigated the effects of repetitive transcranial magnetic stimulation (rTMS) in ICF activity and participation domains.

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	rTMS	sham rTMS	Relative (95% CI)	Absolute (95% CI)	
Shen et al., 2017 - Activities of daily living											
7	randomised trials	not serious	serious[a]	serious[b]	not serious	none	331	329	-	SMD **1.2 SD lower** (1.72 lower to 0.68 lower)	⨁⨁◯◯ Low[a,b]
Liu et al., 2019 - Activities of daily living											
3	randomised trials	not serious	not serious	serious[b]	serious[c]	none	157	156	-	SMD **1.09 SD lower** (1.84 lower to 0.34 lower)	⨁⨁◯◯ Low[b,c]
Xiang et al., 2019 - Activities of daily living											
7	randomised trials	serious[d]	not serious	not serious	not serious	none	212	213	-	SMD **0.82 SD lower** (1.05 lower to 0.59 lower)	⨁⨁⨁◯ Moderate[d]
Allida et al., 2020 - Activities of daily living											
2	randomised trials	not serious	not serious	serious[b]	very serious[e,f]	none	104	104	-	SMD **1.84 SD higher** (5.08 higher to 1.4 lower)	⨁◯◯◯ Very low[b,e,f]
Ahmed et al., 2023 - Activities of daily living											
2	randomised trials	very serious[g]	very serious[a,h]	not serious	serious[c]	none	65	63	-	SMD **0.4 SD lower** (0.76 lower to 0.04 lower)	⨁◯◯◯ Very low[a,c,g,h]
Chen et al., 2023a - Activities of daily living											
8	randomised trials	serious[d]	serious[a]	serious[b]	serious[c]	none	205	125	-	SMD **1.28 SD lower** (1.55 lower to 1.02 lower)	⨁◯◯◯ Very low[a,b,c,d]

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	rTMS	sham rTMS	Relative (95% CI)	Absolute (95% CI)	
Chen 2023 b - Activities of daily living											
10	randomised trials	very serious[g]	not serious	not serious	not serious	none	330	328	-	SMD **1.15 SD lower** (1.57 lower to 0.73 lower)	⨁⨁◯◯ Low[g]
Gao et al., 2023 - Activities of daily living											
4	randomised trials	not serious	very serious[a,h]	not serious	serious[c]	none	61	56	-	SMD **0.42 SD lower** (0.06 lower to 0.78 lower)	⨁◯◯◯ Very low[a,c,h]
Hofmeijer et al., 2023 - Activities of daily living											
8	randomised trials	serious[d]	very serious[a,h]	not serious	serious[c]	none	160	105	-	SMD **1.72 SD lower** (2.48 lower to 0.96 lower)	⨁◯◯◯ Very low[a,c,d,h]
Xi et al., 2023 - Actitivies of daily living											
3	randomised trials	serious[d]	very serious[a,h]	not serious	serious[c]	none	100	97	-	SMD **0.74 SD lower** (1.03 lower to 0.45 lower)	⨁◯◯◯ Very low[a,c,d,h]
Xie et al., 2023 - Activities of daily living											
3	randomised trials	not serious	serious[a]	not serious	very serious[c,f]	none	58	56	-	SMD **0.03 SD lower** (0.5 lower to 0.44 higher)	⨁◯◯◯ Very low[a,c,f]
Chen et al., 2024 - Activities of daily living											
3	randomised trials	serious[d]	serious[h]	not serious	very serious[c,f]	none	47	47	-	SMD **0.31 SD lower** (0.72 lower to 0.1 higher)	⨁◯◯◯ Very low[c,d,f,h]
Daoud et al., 2024 - Activities of daily living											

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	rTMS	sham rTMS	Relative (95% CI)	Absolute (95% CI)	
4	randomised trials	serious[d]	serious[h]	not serious	serious[c]	none	120	117	-	SMD **0.82 SD lower** (1.08 lower to 0.55 lower)	⨁◯◯◯ Very low[c,d,h]

Wang et al., 2024a - Activities of daily living

6	randomised trials	serious[d]	very serious[a,h]	not serious	serious[c]	none	140	140	-	SMD **0.83 SD lower** (1.41 lower to 0.25 lower)	⨁◯◯◯ Very low[a,c,d,h]

Wang et al., 2024b - Activities of daily living

3	randomised trials	serious[d]	serious[a]	not serious	serious[e]	none	50	44	-	SMD **0.92 SD lower** (1.34 lower to 0.51 lower)	⨁◯◯◯ Very low[a,d,e]

Wang et al., 2025 - Activities of daily living

4	randomised trials	serious[d]	serious[h]	not serious	very serious[c,i]	none	60	60	-	SMD **0.37 SD lower** (0.74 lower to 0.01 lower)	⨁◯◯◯ Very low[c,d,h,i]

Zhu et al., 2024 - Activities of daily living

3	randomised trials	very serious[i]	serious[a]	not serious	serious[e]	none	68	58	-	SMD **0.76 SD lower** (1.3 lower to 0.22 lower)	⨁◯◯◯ Very low[a,e,i]

Xie et al., 2025 - Activities of daily living

20	randomised trials	serious[d]	very serious[a,k]	not serious	not serious	none	419	406	-	SMD **0.64 SD lower** (1 lower to 0.28 lower)	⨁◯◯◯ Very low[a,d,k]

Li et al., 2018a - Mobility

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	rTMS	sham rTMS	Relative (95% CI)	Absolute (95% CI)	
9	randomised trials	serious[d]	very serious[a,k]	not serious	very serious[c,j]	none	146	144	-	SMD **0.4 SD lower** (0.63 lower to 0.16 lower)	⨁◯◯◯ Very low[a,c,d,j,k]

Ghayour-Najafabadi et al.,2019 - Mobility

8	randomised trials	serious[d]	very serious[a,h]	not serious	serious[e]	none	133	136	-	SMD **0.55 SD lower** (0.93 lower to 0.16 lower)	⨁◯◯◯ Very low[a,d,e,h]

Tung et al., 2019 - Mobility

6	randomised trials	serious[d]	very serious[a,h]	not serious	serious[c]	none	75	60	-	SMD **0.66 SD lower** (1.11 lower to 0.21 lower)	⨁◯◯◯ Very low[a,c,d,h]

Vaz et al., 2019 - Mobility

6	randomised trials	not serious	very serious[a,h]	not serious	not serious	none	94	90	-	SMD **0.97 SD lower** (1.28 lower to 0.66 lower)	⨁⨁◯◯ Low[a,h]

Kang et al., 2020 - Mobility

9	randomised trials	very serious[g]	very serious[a,h]	not serious	serious[e]	none	146	134	-	SMD **0.48 SD lower** (0.76 lower to 0.19 lower)	⨁◯◯◯ Very low[a,e,g,h]

Krogh et al., 2022 - Mobility

9	randomised trials	not serious	very serious[a,h]	not serious	very serious[c,f]	none	134	117	-	SMD **0.2 SD lower** (0.45 lower to 0.05 higher)	⨁◯◯◯ Very low[a,c,f,h]

Hofmeijer et al., 2023 - Mobility

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	rTMS	sham rTMS	Relative (95% CI)	Absolute (95% CI)	
4	randomised trials	serious[d]	very serious[a,h]	not serious	very serious[c,f]	none	56	56	-	SMD **0.68 SD lower** (1.38 lower to 0.02 higher)	⨁◯◯◯ Very low[a,c,d,f,h]

Zhou et al., 2023 - Mobility

48	randomised trials	serious[d]	very serious[a,h]	not serious	serious[i]	none	317	300	-	SMD **0.35 SD lower** (0.45 lower to 0.24 lower)	⨁◯◯◯ Very low[a,d,h,i]

Chen et al., 2024 - Mobility

11	randomised trials	serious[d]	serious[h]	not serious	very serious[c,f]	none	169	169	-	SMD **0.36 SD lower** (0.85 lower to 0.12 higher)	⨁◯◯◯ Very low[c,d,f,h]

Jiang et al., 2024 - Mobility

3	randomised trials	not serious	very serious[a,h]	not serious	very serious[c,f]	none	42	42	-	SMD **0.6 SD lower** (1.32 lower to 0.1 higher)	⨁◯◯◯ Very low[a,c,f,h]

Wang et al., 2024a - Mobility

12	randomised trials	serious[d]	very serious[a,c]	not serious	not serious	none	270	260	-	SMD **0.65 SD lower** (0.98 lower to 0.32 lower)	⨁◯◯◯ Very low[a,c,d]

Zeng et al., 2024 - Mobility

8	randomised trials	not serious	very serious[a,h]	not serious	serious[c]	none	184	173	-	SMD **0.86 SD lower** (1.34 lower to 0.38 lower)	⨁◯◯◯ Very low[a,c,h]

Wang et al., 2025 - Mobility

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	rTMS	sham rTMS	Relative (95% CI)	Absolute (95% CI)	
10	randomised trials	serious[d]	very serious[a,c]	not serious	very serious[c,i]	none	164	139	-	SMD **0.29 SD lower** (0.52 lower to 0.05 lower)	⨁◯◯◯ Very low[a,c,d,i]

Jia et al., 2025 - Mobility

7	randomised trials	not serious	very serious[a,h]	not serious	very serious[c,f]	none	72	58	-	SMD **0.28 SD lower** (0.78 lower to 0.21 higher)	⨁◯◯◯ Very low[a,c,f,h]

Graef et al., 2016 - Upper limb activity

12	randomised trials	serious[d]	very serious[a,h]	not serious	very serious[c,f]	none	185	141	-	SMD **0.06 SD lower** (0.41 lower to 0.29 higher)	⨁◯◯◯ Very low[a,c,d,f,h]

Zhang et al., 2017a - Upper limb activity

9	randomised trials	serious[i]	serious[h]	not serious	very serious[e,i,j]	none	118	114	-	SMD **0.32 SD lower** (0.55 lower to 0.09 lower)	⨁◯◯◯ Very low[e,h,i,j,l]

O'Brien et al., 2018 - Upper limb activity

10	randomised trials	not serious	serious[a]	not serious	very serious[f,m]	none	109	102	-	SMD **0.46 SD lower** (0 to 0.92 lower)	⨁◯◯◯ Very low[a,f,m]

Lieshout et al., 2019 - Upper limb activity

20	randomised trials	serious[d]	very serious[a,h]	not serious	serious[f,j]	none	260	235	-	SMD **0.17 SD lower** (0.44 lower to 0.09 higher)	⨁◯◯◯ Very low[a,d,f,h,j]

Reis et al., 2021 - Upper limb activity

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	rTMS	sham rTMS	Relative (95% CI)	Absolute (95% CI)	
5	randomised trials	not serious	serious[h]	not serious	very serious[e,f]	none	83	82	-	SMD **0.03 SD lower** (0.33 lower to 0.28 higher)	⨁◯◯◯ Very low[e,f,h]
Xi et al., 2023 - Upper limb activity											
3	randomised trials	serious[d]	very serious[a,h]	not serious	very serious[e,f]	none	24	30	-	SMD **0.34 SD lower** (0.88 lower to 0.2 higher)	⨁◯◯◯ Very low[a,d,e,f,h]
Jiang et al., 2024 - Upper limb activity											
11	randomised trials	not serious	very serious[a,h]	not serious	very serious[c,f]	none	123	119	-	SMD **0 SD** (0.02 lower to 0.02 higher)	⨁◯◯◯ Very low[a,c,f,h]
Zhang et al., 2024c - Upper limb activity											
19	randomised trials	serious[d]	very serious[a,h]	serious[n]	not serious	none	264	223	-	SMD **0.5 SD lower** (0.73 lower to 0.27 lower)	⨁◯◯◯ Very low[a,d,h,n]

CI: confidence interval; **SMD:** standardised mean difference

Explanations

a. There is a high variability between the rTMS protocols in included studies

b. Control groups of the some included studies comprised medications intake

c. The sample size of the present meta-analysis was smaller than the required

d. The meta-analysis study was classified as "moderate" according to the AMSTAR assessment

e. The sample size of the present meta-analysis was smaller than the required

f. Imprecise due to the diamond touches the null line

g. The meta-analysis study was classified as "critically low" according to the AMSTAR assessment

h. There is a critical difference in time since stroke of populations included in different studies

i. The meta-analysis effect size did not cross the mCID cut-off

j. The meta-analysis study was classified as "low" according to the AMSTAR assessment

k. There is a critical difference in time since stroke of populations included in different studies

l. There is a critical difference between effect sizes of studies pooled in this forest plot

m. There is no available a meta-analysis graph in the study

n. Control groups of the some included studies comprised other neuromodulation approaches

Table 4a. Summary of findings (SoF) and certainty of evidence regarding included studies that investigated the effects of transcranial direct current stimulation (tDCS) in ICF body structure and fuction domains.

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	tDCS	sham tDCS	Relative (95% CI)	Absolute (95% CI)	
Elsner et al., 2016 - Motor function											
5	randomised trials	not serious	very serious[a,b]	not serious	very serious[c,d]	none	183	132	-	SMD **0.36 SD lower** (0.94 lower to 0.21 higher)	⊕◯◯◯ Very low[a,b,c,d]
Triccas et al 2016 - motor function											
7	randomised trials	serious[e]	very serious[a,b]	not serious	extremely serious[c,d]	none	129	90	-	SMD **0.11 SD lower** (0.38 lower to 0.17 higher)	⊕◯◯◯ Very low[a,b,c,d,e]
Li et al., 2018b - Motor Function											
4	randomised trials	serious[e]	very serious[a,b]	not serious	serious[d]	none	49	35	-	SMD **1.54 SD lower** (2.78 lower to 0.29 lower)	⊕◯◯◯ Very low[a,b,d,e]
Elsner et al., 2020 - Motor function											
24	randomised trials	not serious	serious[a]	not serious	very serious[c,f]	none	459	333	-	SMD **0.17 SD lower** (0.38 lower to 0.05 higher)	⊕◯◯◯ Very low[a,c,f]
Comino-Suàrez et al 2021 - Motor function											
10	randomised trials	not serious	very serious[a,b,g]	not serious	very serious[c,d]	none	186	156	-	SMD **0.05 SD lower** (0.16 lower to 0.27 higher)	⊕◯◯◯ Very low[a,b,c,d,g]

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	tDCS	sham tDCS	Relative (95% CI)	Absolute (95% CI)	
Sun et al 2021 - Motor function											
7	randomised trials	very serious[h]	very serious[a,b,g]	not serious	very serious[d,i]	none	74	73	-	SMD **0.47 SD lower** (0.78 lower to 0.16 lower)	⊕◯◯◯ Very low[a,b,d,g,h,i]
Van Hoornweder et al., 2021 - Motor function											
22	randomised trials	not serious	very serious[a,b]	not serious	very serious[i,j,k]	none	256	257	-	SMD **0.64 SD lower** (0.99 lower to 0.29 lower)	⊕◯◯◯ Very low[a,b,i,j,k]
Huang, et al 2022 - motor function											
12	randomised trials	not serious	very serious[a,b,g]	not serious	serious[i,k]	none	458	346	-	SMD **0.83 SD lower** (1.25 lower to 0.4 lower)	⊕◯◯◯ Very low[a,b,g,i,k]
Ahmed et al., 2023 - Motor function											
8	randomised trials	very serious[h]	very serious[a,b]	not serious	serious[f,l]	none	151	156	-	SMD **0.34 SD lower** (0.91 lower to 0.24 higher)	⊕◯◯◯ Very low[a,b,f,h,l]
Lima et al., 2023 - Motor function											
6	randomised trials	not serious	very serious[a,b]	not serious	very serious[c,d]	none	123	123	-	SMD **0.36 SD lower** (0.9 lower to 0.18 higher)	⊕◯◯◯ Very low[a,b,c,d]
Lima et al., 2024 - Motor function											

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	tDCS	sham tDCS	Relative (95% CI)	Absolute (95% CI)	
9	randomised trials	not serious	very serious[a,b]	not serious	very serious[c,d]	none	146	135	-	SMD **0.07 SD lower** (0.31 lower to 0.16 higher)	⊕◯◯◯ Very low[a,b,c,d]
Ren et al., 2024											
4	randomised trials	serious[e]	serious[b]	not serious	very serious[c,d]	none	53	49	-	SMD **0.24 SD lower** (0.63 lower to 0.15 higher)	⊕◯◯◯ Very low[b,c,d,e]
Tang et al., 2024 - Motor function											
42	randomised trials	not serious	very serious[a,b,g]	not serious	very serious[i,k,m]	none	807	789	-	SMD **0.22 SD lower** (0.32 lower to 0.12 lower)	⊕◯◯◯ Very low[a,b,g,i,k,m]
Yu et al., 2025 - Motor function											
9	randomised trials	very serious[h]	serious[b]	not serious	serious[i]	none	388	399	-	SMD **0.47 SD lower** (0.07 lower to 0.86 lower)	⊕◯◯◯ Very low[b,h,j]

CI: confidence interval; **SMD:** standardised mean difference

Explanations

a. There is a high variability between the tDCS protocols in included studies

b. There is a critical difference in time since stroke of populations included in different studies

c. Imprecise due to the diamond touches the null line

d. The sample size of the present meta-analysis was smaller than the required

e. The meta-analysis study was classified as "moderate quality" acording AMSTAR assessment.

f. The meta-analysis presented a high variability in effect size among the included studies.

g. Difference between outcomes (in duration of follow-ups)

h. The meta-analysis study was classified as "criticaly low quality" acording AMSTAR assessment.

i. Variation between effect sizes of studies

j. The meta-analysis effect size did not cross the mCID cut-off

k. not all confidence intervals overlap

l. confidence interval crossing in the minimally important difference

m. Imprecise due to confidence intervals included potential for important harm or benefit

Table 4b. Summary of findings (SoF) and certainty of evidence regarding included studies that investigated the effects of transcranial direct current stimulation (tDCS) in ICF activity and participation domains.

Table 4b. Summary of findings (SoF) and certainty of evidence regarding included studies that investigated the effects of transcranial direct current stimulation (tDCS) in ICF activity and participation domains.

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	tDCS	sham tDCS	Relative (95% CI)	Absolute (95% CI)	
Triccas et al., 2016 - Activities of daily living											
5	randomised trials	serious[a]	very serious[b,c]	not serious	very serious[d,e]	none	129	71	-	SMD **0.19 SD lower** (0.5 lower to 0.12 higher)	⊕◯◯◯ Very low[a,b,c,d,e]
Elsner et al., 2020a - Activities of daily living											
19	randomised trials	not serious	serious[b,c]	not serious	serious[f]	none	412	274	-	SMD **0.28 SD lower** (0.44 lower to 0.13 lower)	⊕⊕◯◯ Low[b,c,f]
Comino-Suárez et al., 2021 - Activities of daily living											
3	randomised trials	not serious	very serious[b,c]	not serious	very serious[d,e]	none	91	63	-	SMD **0.18 SD lower** (0.51 lower to 0.15 higher)	⊕◯◯◯ Very low[b,c,d,e]
Ahmed et al., 2023 - Activities of daily living											
3	randomised trials	very serious[g]	very serious[b,c]	not serious	not serious	none	70	71	-	SMD **0.87 SD lower** (1.66 lower to 0.08 lower)	⊕◯◯◯ Very low[b,c,g]
Tang et al., 2024 - Activities of daily living											
11	randomised trials	not serious	very serious[b,c]	not serious	not serious	none	283	289	-	SMD **0.37 SD lower** (0.53 lower to 0.2 lower)	⊕⊕◯◯ Low[b,c]
Zhang et al., 2024a - Activities of daily living											
2	randomised trials	not serious	not serious	not serious	very serious[d,e]	none	40	39	-	SMD **0.29 SD lower** (0.74 lower to 0.15 higher)	⊕⊕◯◯ Low[d,e]

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	tDCS	sham tDCS	Relative (95% CI)	Absolute (95% CI)	
Yu et al., 2025 - Activities of daily living											
9	randomised trials	very serious[g]	not serious	not serious	not serious	none	238	239	-	SMD **0.95 SD lower** (1.15 lower to 0.75 lower)	⊕⊕◯◯ Low[g]
Li et al., 2018b - Mobility											
8	randomised trials	serious[a]	serious[b]	not serious	very serious[d,e]	none	64	66	-	SMD **0.35 SD lower** (0.7 lower to 0.01 higher)	⊕◯◯◯ Very low[a,b,d,e]
Vaz et al., 2019 - Mobility											
19	randomised trials	not serious	very serious[b,c]	not serious	serious[d,e]	none	183	183	-	SMD **0.1 SD lower** (0.31 lower to 0.11 higher)	⊕◯◯◯ Very low[b,c,d,e]
Elsner et al., 2020 - Mobility											
12	randomised trials	not serious	serious[b,c]	not serious	very serious[d,f]	none	135	123	-	SMD **0.32 SD lower** (0.63 lower to 0.01 lower)	⊕◯◯◯ Very low[b,c,d,f]
Kang et al., 2020 - Mobility											
9	randomised trials	very serious[g]	serious[c]	not serious	very serious[d,e]	none	132	132	-	SMD **0.29 SD lower** (0.61 lower to 0.02 higher)	⊕◯◯◯ Very low[c,d,e,g]
Tien et al., 2020 - Mobility											
28	randomised trials	serious[a]	serious[h]	not serious	serious[f]	none	400	395	-	SMD **0.2 SD lower** (0.34 lower to 0.05 lower)	⊕◯◯◯ Very low[a,f,h]
Lima et al., 2023 - Mobility											

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	tDCS	sham tDCS	Relative (95% CI)	Absolute (95% CI)	
7	randomised trials	not serious	very serious[b,c]	not serious	very serious[d,f]	none	73	73	-	SMD **0.41 SD lower** (0.75 lower to 0.08 lower)	⊕◯◯◯ Very low[b,c,d,f]
Usman et al., 2025 - Mobility											
3	randomised trials	not serious	serious[b]	not serious	very serious[d,e]	none	65	63	-	SMD **0.25 SD lower** (0.59 lower to 0.1 higher)	⊕◯◯◯ Very low[b,d,e]
O'Brien et al., 2018 - Upper limb activity											
10	randomised trials	not serious	serious[b]	not serious	very serious[i]	none	86	81	-	SMD **0.31 SD lower** (0.55 lower to 0.08 lower)	⊕◯◯◯ Very low[b,i]
Elsner et al., 2020 - Upper limb activity											
24	randomised trials	not serious	serious[b,c]	not serious	serious[f]	none	459	333	-	SMD **0.31 SD lower** (0.45 lower to 0.16 lower)	⊕⊕◯◯ Low[b,c,f]
Comino-Suárez et al., 2021 - Upper limb activity											
3	randomised trials	not serious	very serious[b,c]	not serious	very serious[d,e]	none	50	84	-	SMD **0.06 SD lower** (0.34 lower to 0.46 higher)	⊕◯◯◯ Very low[b,c,d,e]
Zhang et al., 2024c - Upper limb activity											
19	randomised trials	serious[a]	very serious[b,c]	serious[j]	not serious	none	264	223	-	SMD **0.65 SD lower** (0.95 lower to 0.36 lower)	⊕◯◯◯ Very low[a,b,c,j]
Yu et al., 2025 - Upper limb activity											
3	randomised trials	very serious[g]	not serious	not serious	serious[d]	none	94	96	-	SMD **0.59 SD lower** (0.89 lower to 0.3 lower)	⊕◯◯◯ Very low[d,g]

CI: confidence interval; **SMD:** standardised mean difference

Explanations

a. The meta-analysis study was classified as "moderate" according to the AMSTAR assessment

b. There is a high variability between the tDCS protocols in included studies

c. There is a critical difference in time since stroke of populations included in different studies

d. The sample size of the present meta-analysis was smaller than the required

e. Imprecise due to the diamond touches the null line

f. The meta-analysis effect size did not cross the mCID cut-off

g. The meta-analysis study was classified as "critically low" according to the AMSTAR assessment

h. There is a high variability between the tDCS protocols in included studies

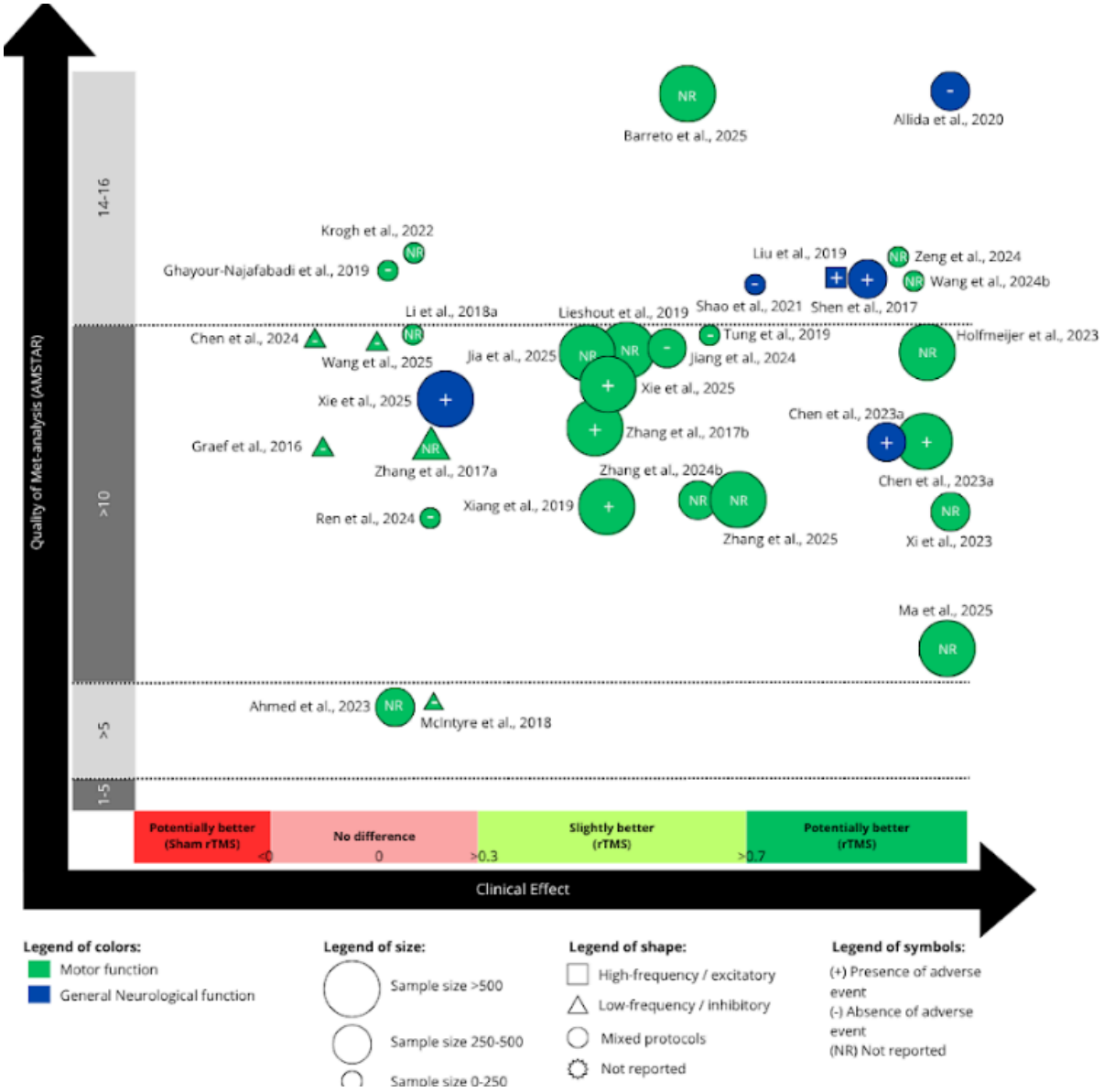
i. There is no meta-analysis graph available in the study

j. Control group of some studies comprises other approaches of neuromodulation

3.4 Efficacy of rTMS for body structure/function

Figure 2 and Figure 3 summarize the clinical efficacy of rTMS across meta-analyses, mapped according to SMD, methodological quality (AMSTAR score), outcome domain (classified according to the ICF framework), sample size, stimulation protocol, and adverse event reporting. Figure 2 presents outcomes related to body structure/function, while Figure 3, discussed in Section 3.5, refers to activity.

Figure 2. Evidence map for the use of repetitive transcranial magnetic stimulation (rTMS) on body structure and function. "Mixed protocols" indicates that various noninvasive brain stimulation (NIBS) protocols were included within the same meta-analysis.



Among the 56 included meta-analyses, 32 meta-analyses (57.1%), including between 2 RCT (56 patients) (McIntyre *et al.*, 2018a) and 36 RCT (1654 patients) (Xie et al., 2025), investigated the effect of rTMS on body structure and function domain of the ICF framework, primarily targeting motor function. These studies were categorized into two main outcome domains: motor function (mainly assessed through the Fugl-Meyer Assessment for upper limb- FMA-UL, Fugl-Meyer Assessment for Lower Limb - FMA-LL), and general neurological function (assessed through the National Institutes of Health Stroke Scale - NIHSS).

Of 26 meta-analyses that investigated the effects of rTMS in motor function, 16 (61.5%) observed that rTMS was effective in improving motor function after stroke (Zhang *et al.*, 2017; Tung *et al.*, 2019; van Lieshout *et al.*, 2019; Xiang *et al.*, 2019; Hofmeijer, Ham and Kwakkel, 2023; Xi *et al.*, 2023; Y. Chen *et al.*, 2023; Jiang *et al.*, 2024; Zhang *et al.*, 2024; Wang *et al.*, 2024; Zeng *et al.*,

2024; Barreto *et al.*, 2025; Jia *et al.*, 2025; Ma *et al.*, 2025; Xie *et al.*, 2025; Zhang *et al.*, 2025). These studies varied from a moderate (SMD: -0.45; CI: -0.65 to -0.25; Table 3a) (Jia et al., 2025) to high (SMD: -1.22; CI: -0.73 to -1.70; and Table 3a) effect size (Chen *et al*., 2023a) (Figure 2). The NNT varied from 8 to 3 (Supplementary table 2). In general, meta-analyses with larger sample sizes appeared to report results that are more favorable towards rTMS. Notably, the studies by Chen *et al*. (2023a), Xi *et al.* (2023), Hofmeijer *et al.* (2023) and Ma *et al.* (2025) reported the largest effect sizes. Five studies were classified as "low quality" of evidence for motor function (Xiang et al., 2019; Xi et al., 2023; Jiang et al., 2024; Barreto et al., 2025; Jia et al., 2025).

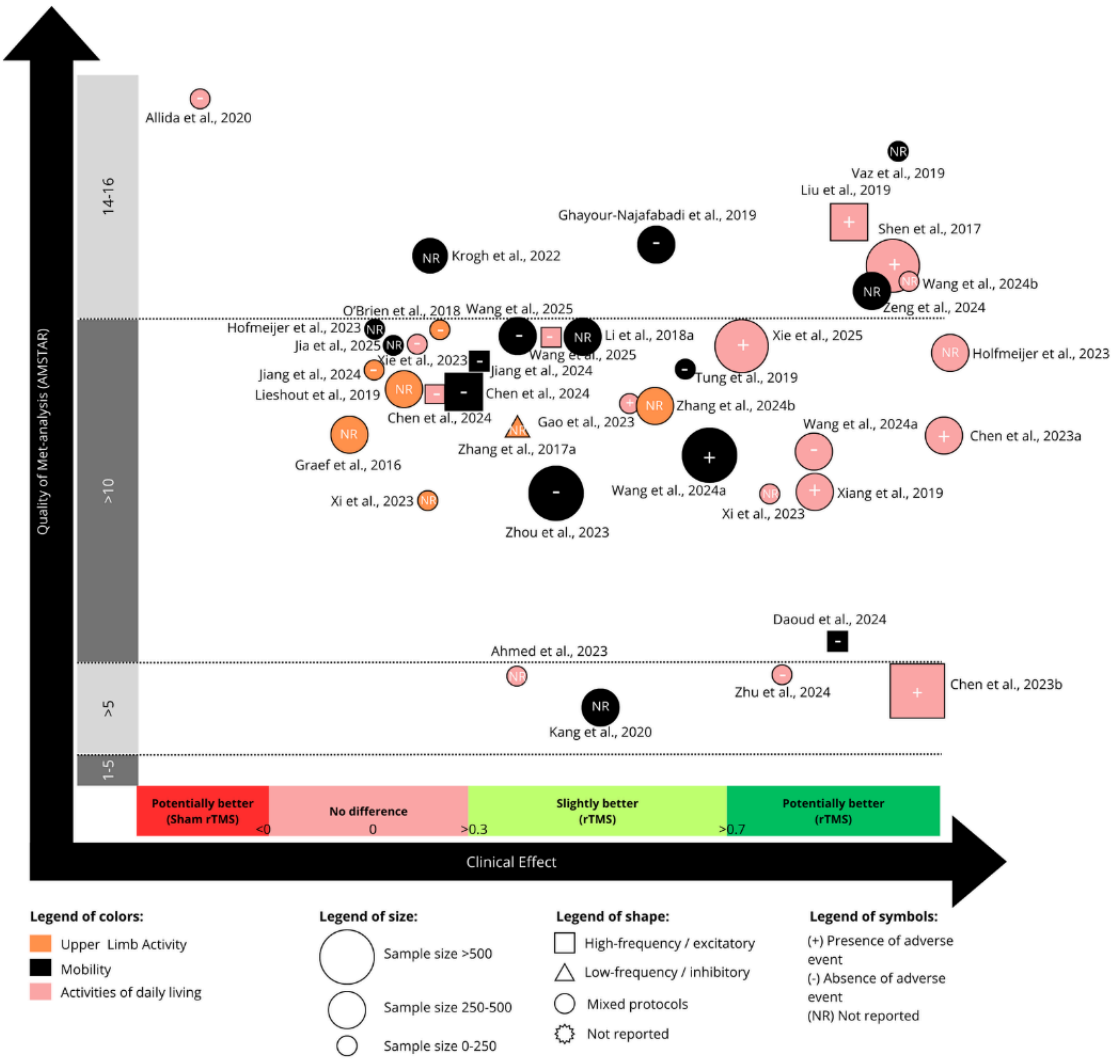
Six meta-analyses (100%) reported that general neurological function was slightly (Liu *et al.*, 2019; Allida *et al.*, 2020; Shao *et al.*, 2021; Y. Chen *et al.*, 2023) or potentially meaningful improvements after rTMS treatment (Figure 2). These studies varied from a moderate (SMD: -0.67; CI: -1.02 to -0.32, Table 3a) (Shao et al., 2021) to high (SMD: -2.21; CI: -3.32 to -1.09, Table 3a) (Liu *et al.*, 2019; Allida *et al.*, 2020) effect size. The NNT varied from 5 to 3 (Supplementary table 2). However, four of these studies reported high inconsistency and used control groups that included only medication intake, which contributed to their classification as "very low quality of evidence" (Table 1 and Table 3a). Only two studies were classified as "low quality of evidence" for general neurologic function (Liu et al., 2019; Shao et al., 2021).

3.5 Efficacy of rTMS for stroke activity

Thirty-nine meta-analyses, including between 2 studies (128 patients) (Ahmed et al., 2023) and 20 studies (825 patients) (Xie et al., 2025), investigated the effect of rTMS on outcomes related to ICF domain of activity (Figure 3). The outcomes considered from the studies comprised: (1) upper limb activities; (2) mobility, and (3) ADL. Full details of the outcome measures are available in Table 1.

Of the 39 studies, seven (17.9%) investigated the upper limb activity (Graef *et al.*, 2016; Zhang *et al.*, 2017b; O'Brien *et al.*, 2018; van Lieshout *et al.*, 2019; Chen *et al.*, 2023a; Xi *et al.*, 2023; Jiang *et al.*, 2024; Zhang *et al.*, 2024), 18 studies (46.2%) investigated performance in ADL (Liu *et al.*, 2019; Xiang *et al.*, 2019; Allida *et al.*, 2020; Ahmed *et al.*, 2023; Gao *et al.*, 2023; Hofmeijer, Ham and Kwakkel, 2023; Chen *et al.*, 2023b; Xie *et al.*, 2023, 2025; Xi *et al.*, 2023; Y. Chen *et al.*, 2023; Chen, Sun and Zhuang, 2024; Daoud *et al.*, 2024; Jiang *et al.*, 2024; Ren *et al.*, 2024; Wang *et al.*, 2024; Zhu *et al.*, 2024; Wang *et al.*, 2025) and 14 (35.9%) focused on mobility (Figure 3) (Li *et al.*, 2018; Ghayour-Najafabadi *et al.*, 2019; Tung *et al.*, 2019; Vaz *et al.*, 2019; Kang *et al.*, 2020; Krogh *et al.*, 2022; Hofmeijer, Ham and Kwakkel, 2023; Zhou *et al.*, 2023; Chen, Sun and Zhuang, 2024; Jiang *et al.*, 2024; Wang *et al.*, 2024; Zeng *et al.*, 2024; Wang *et al.*, 2025; Jia *et al.*, 2025). Of the seven studies on upper limb activity, only two (28.6%) reported that rTMS was effective in improving this outcome after stroke. These studies showed a low (SMD: -0.32; CI: -0.55 to -0.09) (Zhang *et al.*. 2017a) to moderate (SMD: -0.50; CI: -0.73 to -0.27) effect size, with low heterogeneity index (34.2%; p-value 0.07; Table 1) (Zhang et al,, 2024b). The NNT varied from 6 to 13 (Supplementary table 2). However, all studies that investigated the effects of rTMS in upper limb activity showed considerable variability in intervention protocols and lower sample sizes and a large CI (Table 3b), leading to an overall very low quality of evidence.

Figure 3. Evidence map for the use of repetitive transcranial magnetic stimulation (rTMS) on activity. "Mixed protocols" indicates that various noninvasive brain stimulation (NIBS) protocols were included within the same meta-analysis.



Of the 14 studies that investigated the rTMS effects on mobility, seven (50 %) studies (Li *et al.*, 2018; Ghayour-Najafabadi *et al.*, 2019; Tung *et al.*, 2019; Kang *et al.*, 2020; Zhou *et al.*, 2023; Wang *et al.*, 2024; Wang *et al.*, 2025) found that rTMS slightly and three (21.4%) potentially improved mobility outcomes (Figure 3) (Vaz *et al.*, 2019; Daoud *et al.*, 2024; Zeng *et al.*, 2024). These studies showed a low SMD: -0.29 (-0.52 to -0.05) (Wang *et al.*, 2025) to high (SMD: -0.97; CI: -1.28 to -0.66) (Vaz *et al.*, 2019) effect size, with low inconsistency indices (Table 1). The NNT varied from 4 to 13 (Supplementary table 2). The study with higher effect size was classified as "low quality of evidence" due to substantial variation in rTMS protocols and heterogeneity in participant characteristics, particularly regarding time since stroke (Table 4).

Finally, 15 (83.3%) of 18 studies reported that performance in ADL was potentially or sligthly improved after rTMS in stroke survivors (Figure 3) (Shen *et al.*, 2017; Liu *et al.*, 2019; Xiang

et al., 2019; Ahmed *et al*., 2023; Chen *et al*., 2023a; Chen *et a*l., 2023b; Gao *et al*., 2023; Hofmeijer *et al*., 2023; Xi *et al.*, 2023 Daoud *et al*., 2024; Ren *et al*., 2024; Zhu *et al*., 2024; Zhu *et al*., 2024; Wang *et al.*, 2024b; Xie *et al.*, 2025; Wang *et al*., 2025). One study was classified as moderate quality of evidence (Xiang *et al*., 2019). Besides the high effect size (SMD: -0.82; IC: -1.05 to -0.59; NNT: 5) with low heterogeneity index (0%, p-value: 0.78), we downgrade one point in risk of bias, because this study was classified as "moderate" in AMSTAR classification (Table 3b). Three studies (30%) were classified as "low quality of evidence" (Chen *et al*., 2023b; Shen *et al*., 2017; Liu *et al*., 2019), besides they presented high effect sizes (Supplementary Table 2 and Table 3b) and 14 (77.8%) studies were classified as "very low quality of evidence".

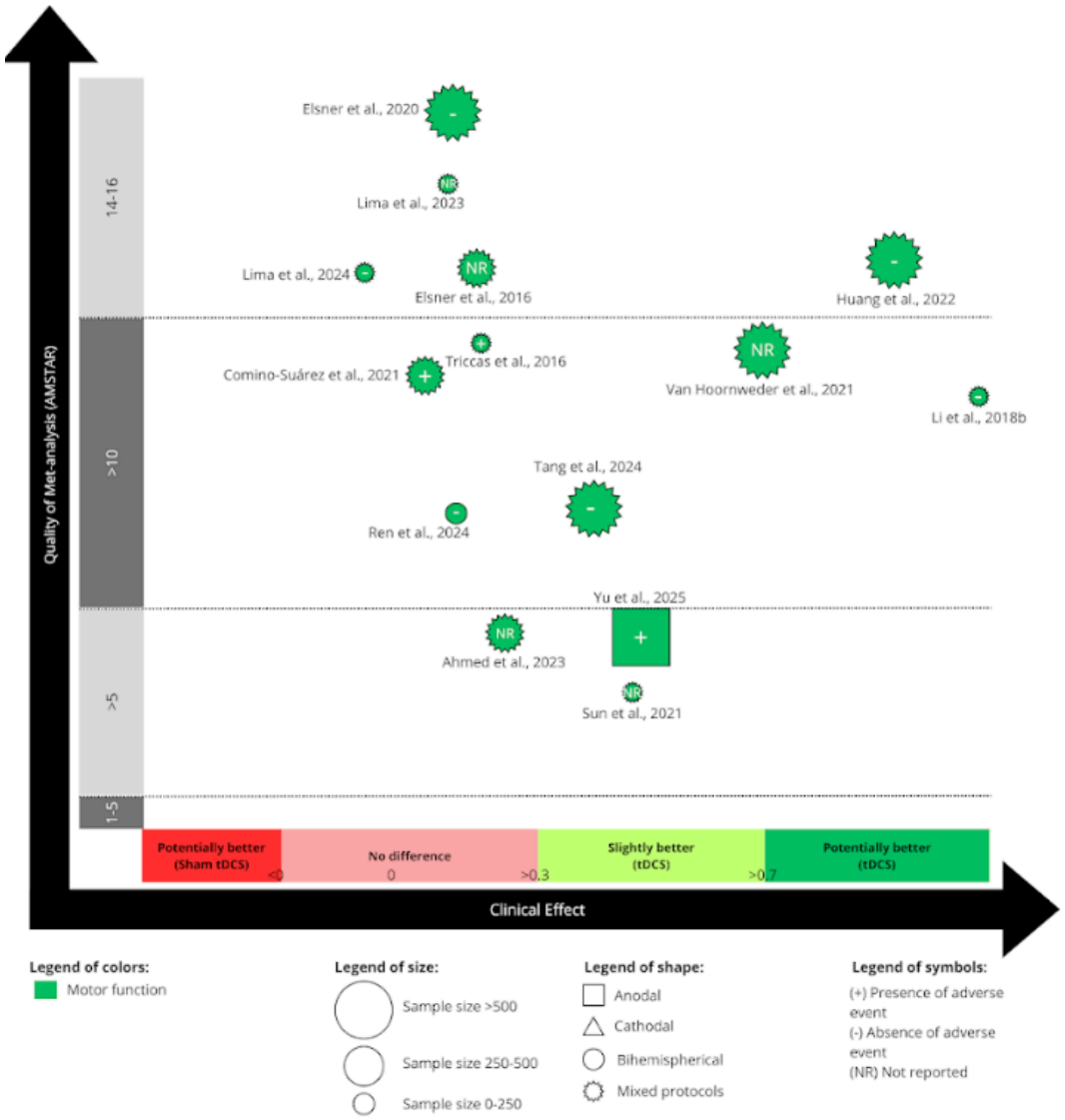
3.5 Efficacy of tDCS for body structure/function

Figure 4 and Figure 5 summarize the clinical efficacy of tDCS across meta-analyses, mapped according to SMD, methodological quality (AMSTAR score), outcome domain (classified according to the ICF framework), sample size, stimulation protocol, and adverse event reporting. Figure 4 presents outcomes related to body structure/function, while Figure 5, discussed in Section 3.6, refers to activity.

Fourteen meta-analyses, ranging from 4 studies (84 patients) (Li *et al.*, 2018b) to 42 studies (1596 patients) (Tang *et al.*, 2024), investigated the effect of tDCS on body structure and function. The outcome measures considered were: (1) FMA-UE, (2) FMA-LE, (3) MAS. Details on each measure are provided in Table 1.

Six of fourteen (42.9%) reported that tDCS was slightly or potentially effective in improving motor function after stroke (Figure 4) (Li *et al*., 2018b; Sun *et al.*, 2021; Van Hoornweder *et al*., 2021; Huang *et al*., 2022; Tang *et al*., 2024; Yu *et al*., 2025). These studies reported effect sizes ranging from low (SMD: -0.22; CI: -0.32 to -0.12) (Tang et al., 2024) to high (SMD: –1.54; 95% CI: –2.78 to –0.29) (Li et al., 2018b). The NNT varied from 3 to 17, with very serious inconsistency and imprecision issues, with higher heterogeneity indexes ($I^2 > 40\%$; p-value<0.01; Table 1). Thus, the overall quality of evidence for this outcome was deemed "very low" (Table 4a).

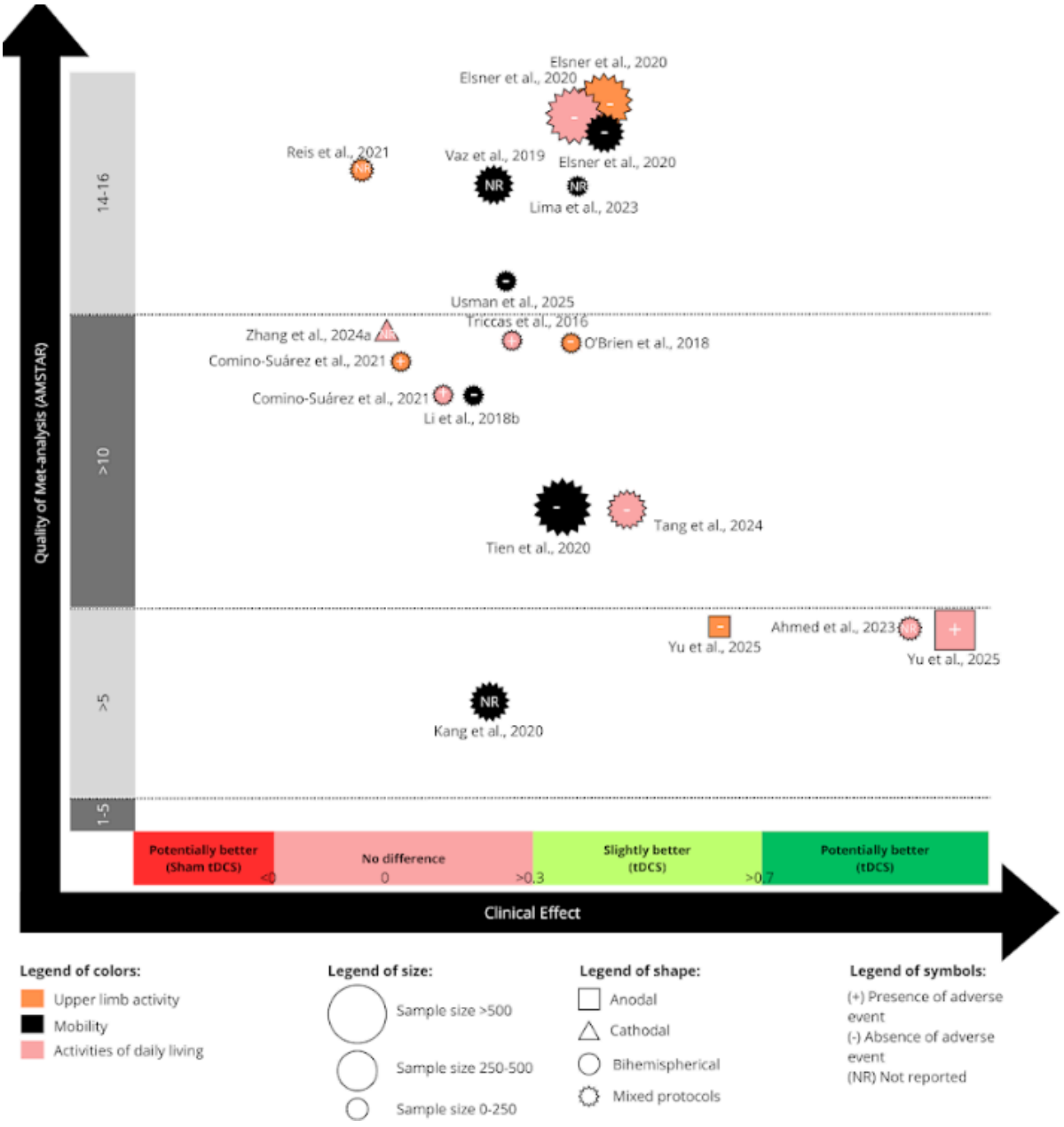
Figure 4. Evidence map for the use of transcranial direct current stimulation (tDCS) on body structure and function. "Mixed protocols" indicates that various noninvasive brain stimulation (NIBS) protocols were included within the same meta-analysis.



3.6 Efficacy of tDCS for stroke activity

Nineteen meta-analyses investigated the effect of tDCS on outcomes related to ICF domain of activity. Of the 19 studies, five (26.3%) examined upper limb activity (O'Brien *et al.*, 2018; Elsner *et al.*, 2020; Comino-Suárez *et al.*, 2021; Reis *et al.*, 2021; Yu *et al.*, 2025), seven (36.8%) investigated mobility (Li *et al.*, 2018a; Vaz *et al.*, 2019; Elsner *et al.*, 2020; Kang *et al.*, 2020; Tien *et al.*, 2020; Lima *et al.*, 2023; Usman, Wong and Ng, 2024), and seven (33.3%) focused on ADL post-stroke (Tedesco Triccas *et al.*, 2016; Elsner *et al.*, 2020; Comino-Suárez *et al.*, 2021; Ahmed *et al.*, 2023; Zhang *et al.*, 2024; Tang *et al.*, 2024; Yu *et al.*, 2025) (Figure 5).

Figure 5. Evidence map for the use of transcranial direct current stimulation (tDCS) on activity. "Mixed protocols" indicates that various noninvasive brain stimulation (NIBS) protocols were included within the same meta-analysis



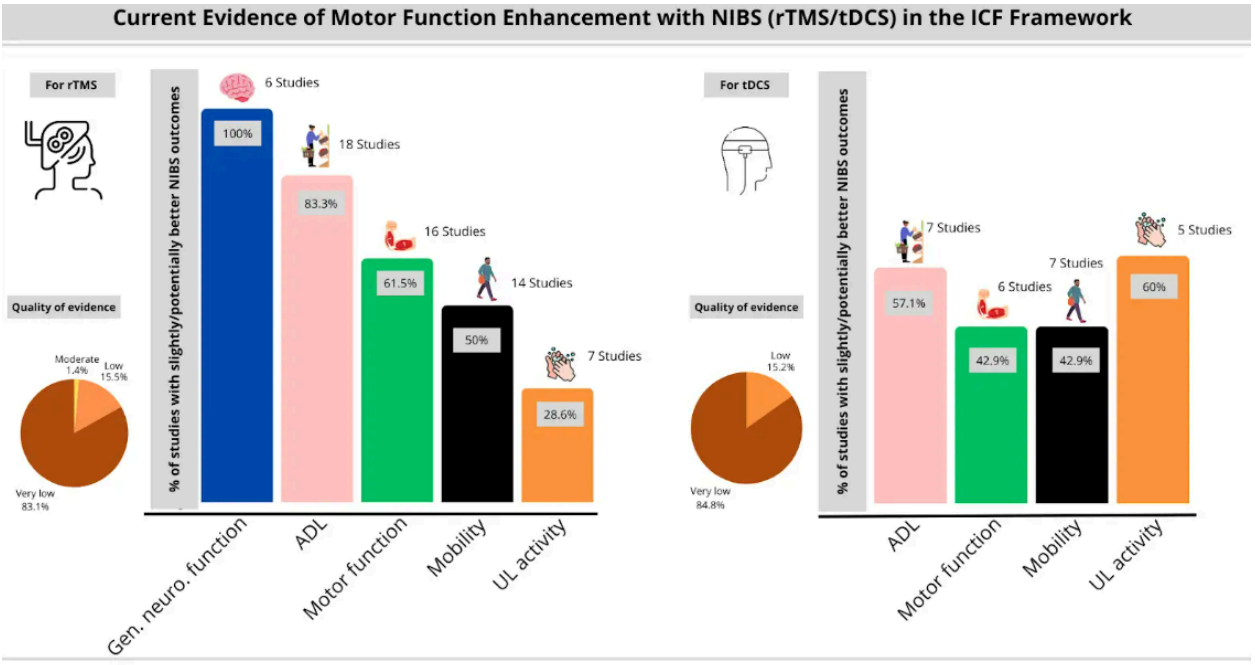
Three studies of five (60%) observed that tDCS was effective in improving upper limb activity. Reported effect sizes were low (SMD: -0.31; CI: -0.55 to -0.01 and SMD: -0.31; CI: -0.45 to -0.16; NNT: 12) or moderate (SMD: -0.59; CI: -0.89 to -0.30; NNT: 7), with low heterogeneity indices (O'Brien *et al.*, 2018; Elsner *et al.*, 2020; Yu *et al.*, 2025) (Table 1). However, the studies exhibited considerable variability in the included protocols and the time since stroke onset, then we downgraded one point in inconsistency. One study did not present a meta-analysis graph (O'Brien *et al.*, 2018), because of this, we downgraded two points for imprecision (For details, see the Table 4b).

Regarding mobility, three (Elsner *et al*., 2020; Tien *et al*., 2020; Lima *et al*., 2023) of seven studies (42.9%) reported slight improvements following tDCS (Figure 5). These studies showed a low effect size with low inconsistency indices. The NNT varied from 9 to 18. Overall, the studies were classified as "very low quality of evidence" because it presented high variability between tDCS protocols, included individuals with different times since stroke, presented a small sample size and larger CI intervals (Table 4b, Supplementary Table 2).

Finally, four of seven studies (57.1%) showed that the performance in ADL was slightly (Elsner *et al*., 2020; Tang *et al*., 2024) or potentially (Ahmed *et al*., 2023; Yu *et al*., 2025) increased following tDCS. The NNT varied from 5 to 13. The study with higher effect size was classified as "very low quality of evidence" because it was classified as "critically low" in AMSTAR, a high variability between tDCS protocols and included patients with different time since stroke (Table 4b).

We summarized the current evidence supporting motor function improvements with NIBS (rTMS/tDCS) within the principal domains of the ICF framework in Figure 6. This figure presents a visual synthesis of the motor functions most frequently reported as positively influenced by NIBS, accompanied by a rank-ordered list indicating the number and percentage of studies supporting each functional outcome.

Figure 6. A summary of the current evidence supporting the effects of repetitive transcranial magnetic stimulation (rTMS) and transcranial direct current stimulation (tDCS) within the ICF framework in post-stroke patients.



3.7 Safety of NIBS for stroke

Table 1 also reports the adverse events reported in the rTMS and tDCS studies. 10 (25.6%) meta-analyses of rTMS (Shen *et al*., 2017; Zhang, *et al*., 2017; Liu *et al*., 2019; Tung *et al*., 2019; Xiang *et al*., 2019; Gao *et al*., 2023; Chen *et al*., 2023a, 2023b; Wang *et al*., 2024; Xie *et al*.,

2025) and three (14.3%) of tDCS report the occurrence of severe adverse effects after the stimulation (Comino-Suárez *et al*., 2021; Triccas *et al*., 2016; Yu *et al*., 2025). For rTMS, commonly reported adverse effects include: headache, gastrointestinal reaction, tinnitus, feel weak, anxiety, nausea, tingling, dizziness, fatigue, drowsiness, neck pain, cast irritation, palpitation, and neurocardiogenic syncope. For tDCS, commonly reported adverse effects included: headache, dizziness, fatigue and tingling (Table 1). It is also important to highlight that some meta-analysis failed to report adverse effects in the results: thirteen for rTMS (37.1% of rTMS studies) (Zhang *et al.*, 2017a; Li *et al.*, 2018a; van Lieshout *et al.*, 2019; Krogh *et al.*, 2022; Hofmeijer, Ham and Kwakkel, 2023; Xi *et al.*, 2023; Wang *et al.*, 2024b; Zeng *et al.*, 2024; Zhang *et al*., 2024b; Barreto *et al.*, 2025; Jia *et al*., 2025; Ma *et al*., 2025; Zhang *et al.*, 2025), six for tDCS (37.5% of tDCS studies) (Elsner *et al.*, 2016; Reis *et al.*, 2021; Sun *et al*., 2021; Van Hoornweder *et al*., 2021; Lima *et al*., 2023; Zhang *et al*., 2024a) and four for rTMS and tDCS studies (80% of included meta-analyses) (O'Brien *et al.*, 2018; Vaz *et al.*, 2019; Kang *et al*., 2020; Ahmed *et al*., 2023).

4 DISCUSSION

This umbrella review is the first to synthesize and assess the quality of evidence from meta-analyses on NIBS in stroke rehabilitation, using the principal domains of ICF as a framework. Regarding the body structure/function domain, rTMS was more frequently associated with moderate to high effect sizes, particularly for general neurological function. In contrast, although some meta-analyses suggested that tDCS may have slight to potentially meaningful effects on motor function recovery, the certainty of this evidence was rated as very low due to serious concerns related to heterogeneity, imprecision, and variability in stimulation protocols. In the activity domain, both techniques showed modest effects, with rTMS demonstrating more favorable results for ADL than for mobility or upper limb activity. tDCS effects on activity-related outcomes were generally limited and supported by low to very low certainty of evidence across most outcomes. Furthermore, although no serious adverse events were reported across the meta-analyses, moderate adverse effects, including headache, fatigue, and occasional episodes of neurocardiogenic syncope, were documented. These findings indicate that while NIBS appears to have an acceptable safety profile, its tolerability may vary among individuals and should be carefully monitored in clinical applications.

When interpreting the magnitude of treatment effects observed in this umbrella review, it is important to consider thresholds for clinical relevance (Citrome, 2014). Although there is no universally accepted cutoff, we adopted a standardized mean difference (SMD) of 0.7 as a conservative benchmark for clinically meaningful effects, which is slightly above the conventional threshold for a moderate effect size (Rahlfs and Zimmermann, 2019; Zieliński, 2025). Effects at or above this level may reflect changes likely to translate into noticeable improvements in patient outcomes. However, it is important to recognize that the clinical significance of these effects can vary depending on the specific outcome assessed, the patient population, and the context of rehabilitation (Cuijpers *et al.*, 2014). Therefore, while effect sizes below this threshold should be interpreted with caution, clinical decision-making should also integrate factors such as feasibility, patient preferences, and safety (Page, 2014). Indeed, we found more consistent clinically meaningful effects for rTMS to improve motor function, general neurologic function and performance in ADL. For tDCS, the body of evidence remain uncertain, with few studies presenting clinically meaningful effects just for motor function and performance in ADL.

4.1 Methodological quality of meta-analyses

The methodological quality of the included meta-analyses, as assessed by the AMSTAR tool, was predominantly moderate to high, with over 80% of the studies meeting key methodological criteria. These findings suggest increasing adherence to rigorous review practices and a growing

methodological maturity in this research area. Only a small proportion were rated as low or critically low quality (14.6%), suggesting that some methodological inconsistencies remain yet.

There were some limitations regarding the quality of evidence of the studies included in this Umbrella Review, such as the variability of protocols, which limited comparisons between studies, and the relatively small sample sizes that may compromise statistical robustness and make the results more generalized. Furthermore, the predominance of "low" or "very low" certainty ratings according to GRADE reflects imprecision and inconsistency in effect estimates, largely due to heterogeneity in intervention protocols, risk of bias, and variability in outcome measures and evaluation methods. These factors combined reduce confidence in the reliability of the findings and highlight the need for more rigorous, standardized randomized controlled trials and meta-analyses to strengthen the evidence base and improve the clinical applicability of NIBS in stroke rehabilitation.

The most frequent sources of methodological concern were the lack of justification for deviations from the original review protocols, incomplete or insufficiently reported search strategies, and the omission of funding information for the primary studies. These issues have important implications for the interpretation of findings. Unreported protocol deviations reduce transparency and raise the risk of selective reporting, which may introduce bias in the synthesis process. Inadequate search strategies can lead to the exclusion of relevant studies, particularly negative trials, potentially inflating the estimated effects due to publication bias. Moreover, the failure to report funding sources of included studies limits the ability to assess conflicts of interest, which could compromise the neutrality of the evidence base. To address these issues, future reviews should aim to ensure compliance with all items outlined in the PRISMA 2020 guidelines, which are essential to enhance the credibility, transparency, and reproducibility of evidence syntheses in the field of NIBS.

4.2 Effects of rTMS on ICF domains in post-stroke rehabilitation

In our review, rTMS demonstrated the most consistent and clinically relevant effects within the ICF domain of body structure and function, particularly general neurological function. Almost all studies evaluating this outcome consistently reported positive effects of rTMS, with relatively low variability in terms of effect magnitude, ranging from moderate (Shao et al., 2021) to high (Allida et al., 2020). Similarly, among the 26 meta-analyses that investigated motor function, more than half reported significant improvements in stroke recovery, with effect sizes also ranging from moderate to high.

Although the overall body of evidence supports a beneficial effect of rTMS in improving outcomes within the ICF domain of body structure and function, the findings related to motor function were more heterogeneous in terms of effect magnitude. This variability likely reflects multiple contributing factors, including differences in stimulation protocols (e.g., frequency, intensity, target site), patient characteristics (e.g., time since stroke, severity), methodological quality, the variation in the number of studies synthesized within each meta-analysis. Meta-analyses with larger sample sizes, such as those by Chen et al. (2023), Xi et al. (2023), and Hofmeijer et al. (2023), tended to report stronger and relevant effect sizes. This observation is consistent with methodological recommendations highlighting the importance of adequately powered studies to reduce the risk of bias and enhance the precision of effect estimates (O'Neil et al., 2014).

It is important to note that, compared to motor function outcomes, the effects of rTMS on general neurological function (e.g., as measured by NIHSS) were more consistent across studies, despite variations in stimulation protocols. One possible explanation for this lower variability is that such outcomes are broader and more global in scope, capturing diffuse neurological changes that may occur across multiple functional systems. In contrast, motor function outcomes, particularly those assessing specific limb performance using tools like the FMA, are more narrowly focused and may be more susceptible to individual variability, such as lesion location, stroke severity, or rehabilitation context. This discrepancy highlights the importance of carefully selecting and clearly defining

outcome measures in neuromodulation trials. Notably, the methodological quality of the studies evaluating general neurological function was also higher (e.g., Allida et al., 2020; Liu et al., 2019; Shen et al., 2017), which may have contributed to more consistent results. Methodological rigor is known to influence the reliability of meta-analytic findings; systematic reviews with high AMSTAR-2 scores are more likely to produce valid and unbiased estimates (Shea et al., 2017).

Among the meta-analyses assessing activity outcomes, the effects of rTMS were generally less consistent and less robust than those observed for body structure and function, except for ADL. Sixteen out of eighteen studies evaluating ADL reported slight to potentially meaningful improvements following rTMS. Among them, only the study by Xiang et al. (2019) achieved moderate certainty of evidence and reported a high effect size with low heterogeneity, likely due to its use of subgroup analyses based on stroke population characteristics and the application of optimized stimulation parameters. In contrast, the evidence for mobility was less consistent. Although the majority of studies reported positive effects, effect sizes varied widely from low to high and all were rated as low or very low certainty of evidence, primarily due to heterogeneity in stimulation protocols and participant characteristics. The weakest evidence was observed for upper limb activity: only two out of seven studies demonstrated a statistically significant effect, and all were rated as very low certainty, largely also reflecting protocol inconsistencies.

While most meta-analyses evaluating rTMS for post-stroke rehabilitation report slight to potentially meaningful effects, especially for outcomes such as general neurological function and ADL, differences in stimulation parameters, patient characteristics, and outcome definitions likely obscure the consistency of the evidence and contribute to the predominance of low or very low certainty ratings in GRADE assessments. In many meta-analyses, the inclusion of trials with markedly divergent methodologies has reduced the consistency and precision of the pooled estimates, ultimately lowering the overall quality of the evidence.

At the same time, the NIBS field is moving toward increasingly personalized rTMS interventions, with growing efforts to tailor stimulation protocols based on lesion location, functional reserve, neurophysiological markers, and time since stroke (Hildesheim *et al.*, 2022). While this individualized approach holds promise for improving patient-level outcomes, it also introduces new layers of heterogeneity that may further complicate evidence synthesis. As protocols become more specific to individual profiles, future meta-analyses may face greater challenges in aggregating results, potentially reinforcing the trend of low certainty of evidence unless new strategies are developed to standardize personalization frameworks without compromising clinical relevance. Establishing clinical guidelines that accommodate inter-individual variability without compromising methodological rigor will be crucial.

When comparing the domains of body structure/function and activity, rTMS appears to have a stronger and more consistent effect on body structure and function outcome in comparison to the latter. As discussed earlier, the majority of meta-analyses evaluating motor and general neurological function reported moderate to high effect sizes with relatively lower variability. In contrast, outcomes related to activity, particularly those assessing mobility and upper limb use, demonstrated greater heterogeneity and lower certainty of evidence. One possible explanation is that improvements in impairment-level outcomes (e.g., motor function) may not directly translate into higher-level functional activities, particularly in the absence of structured, context-specific rehabilitation. Functional outcomes such as mobility and upper limb use often require meaningful behavior change, including the integration of newly recovered abilities into daily routines. Moreover, the relatively short duration of most NIBS protocols—typically limited to 10 to 20 sessions—may be insufficient to promote the sustained engagement and task-specific motor learning necessary to drive long-term functional gains in real-world settings.

4.3 Effects of tDCS on ICF domains in post-stroke rehabilitation

A substantial number of meta-analyses have examined the effects of tDCS on motor recovery and functional performance after stroke. However, findings across studies remain heterogeneous, particularly for outcomes related to body structure and function. While some reviews reported moderate to large effect sizes for motor improvements (Li *et al*., 2018b; Sun *et al*., 2021; Van Hoornweder *et al*., 2021; Huang *et al.*, 2022), the lack of consistency across meta-analyses and the predominance of low-certainty evidence hinder the establishment of clear clinical recommendations. In contrast, outcomes related to activity, especially ADL, showed more frequent reports of benefit (O'Brien *et al*., 2018; Elsner *et al*., 2020; Tien *et al*., 2020; Ahmed *et al*., 2023; Lima *et al.*, 2023; Tang *et al.*, 2024), though with lower effect sizes. These findings were also characterized by substantial methodological limitations, such as low quality of meta-analyses, inconsistency in methods of the included studies in each meta-analyses and imprecise results.

Meta-analyses with larger sample sizes (Huang *et al.*, 2022; Van Hoornweder *et al*., 2021; Tang *et al.*, 2024; Elsner *et al*., 2020) tended to report more robust and stable effect estimates, supporting the idea that sample size plays a pivotal role in the reliability of pooled outcomes. For instance, while Huang *et al*. (2022) and Van Hoornweder *et al.* (2021) reported high standardized mean differences, these were accompanied by very high inconsistency indices ($I^2 > 60\%$). This reinforces a known concern in complex interventions like NIBS: small, underpowered studies are more prone to random error and effect size inflation (Button *et al.*, 2013; Mitra *et al.*, 2019; Andrade, 2020) . The precision and reliability of effect estimates can be significantly improved by increasing sample size and ensuring methodological rigor.

Methodologically, the body of evidence on tDCS appears less robust than on rTMS. Most reviews were rated as low or critically low in quality, according to the AMSTAR-2 tool, and all but one were classified as having low or very low certainty of evidence by GRADE. These methodological limitations, such as lack of protocol registration, absence of publication bias assessment, and inconsistencies in risk of bias evaluation, undermine the reliability of the conclusions and emphasize the need for higher-quality evidence synthesis in this area (Shea *et al*., 2017).

Taken together, the findings suggest that while tDCS holds potential to improve motor recovery and functional performance in individuals with stroke, current evidence remains limited by small sample sizes, heterogeneous protocols, and methodological weaknesses. Future research should address these gaps through well-designed, adequately powered trials and rigorous evidence synthesis.

Importantly, the clinical heterogeneity observed across meta-analyses likely reflects, at least in part, the individualized nature of tDCS application. As a neuromodulation technique, tDCS is often tailored to the patient's specific clinical characteristics, such as stroke chronicity, lesion site, or level of impairment (Simonetta-Moreau, 2014; Baltar *et al.*, 2020), leading to some degree of protocol variability not only expected but necessary to accommodate diverse rehabilitation needs. While this variability complicates direct comparisons and evidence synthesis, it also highlights the importance of developing analytic strategies that can capture clinically relevant heterogeneity, rather than penalizing it as methodological weakness.

Although this overview selected the most representative meta-analyses for each outcome, many included subgroup analyses within their synthesis. While this strategy favors broader generalizability, it may also have obscured clinically meaningful effects associated with more individualized stimulation parameters. By aggregating heterogeneous data without stratification, the estimated results tend to reflect greater variability, which may lead to downgraded certainty of evidence and diluted effect sizes. The absence of subgroup analyses, despite their potential to identify more effective, tailored interventions, might contribute to underestimating the real therapeutic potential of tDCS in specific patient profiles. Consequently, the true clinical impact of tDCS may have been partially diminished by fragmented or overly specific analytical approaches, reinforcing the need for meta-analyses that balance granularity with statistical power.

4.4 Safety of NIBS for the stroke treatment

The reporting of adverse effects across the included meta-analyses was limited and inconsistent, which restricts the ability to comprehensively assess the safety of NIBS after stroke. Although some studies described mild to moderate side effects—such as headache, dizziness, fatigue, and tingling—severe adverse events were reported in a minority of meta-analyses (25.6% for rTMS and 14.3% for tDCS). The heterogeneity in types and frequencies of adverse effects likely reflects both real differences across protocols and populations, as well as variability in how primary studies monitor and report safety outcomes. Alarmingly, over one-third of the meta-analyses failed to mention adverse events at all. This underreporting points to a methodological limitation in the NIBS literature and highlights the urgent need for standardized reporting of safety data in future trials and evidence syntheses. Without such transparency, the clinical interpretation of risk–benefit ratios remains incomplete.

4.5 Limitations and future perspectives

As an umbrella review, this study plays an important role in promoting broader recognition of NIBS and informing professionals about its potential clinical benefits. However, few limitations must be acknowledged. First, the literature search was conducted exclusively in the MEDLINE (PubMed) database. Although PubMed is a widely recognized and comprehensive source for health-related research, restricting the search to a single database may have limited the retrieval of additional relevant meta-analyses. Additionally, although the search strategy was validated by experts in scientific methodology and NIBS, we did not include a medical librarian in the development of the search terms, which may have further optimized the process. Future updates should consider incorporating databases such as EMBASE, Scopus, and the Cochrane Library to enhance comprehensiveness and reduce publication bias.

Second, due to substantial heterogeneity in outcome measures and reporting, we were unable to provide a clear, exhaustive analysis of outcomes stratified by specific ICF domains and subdomains. This inconsistency—along with frequent overlap across domains—limited our ability to determine whether outcomes referred to walking, transfers, or other specific aspects of mobility. These limitations reflect variability in outcome reporting in the primary studies and meta-analyses. For example, it was not consistently possible to distinguish whether mobility-related outcomes referred specifically to walking, transfers, bed mobility, or community ambulation. While we recognize that such level of detail would enhance the clinical applicability of the findings, this limitation reflects the inconsistency in outcome reporting within the primary studies and meta-analyses synthesized.

This methodological variability limited also the ability to determine which specific configurations might be associated with greater therapeutic efficacy. Similarly, although clinical factors such as lesion location, time since stroke, and lesion extent are known to influence individual responsiveness to NIBS, the available evidence did not allow for a more granular analysis of these variables. Additionally, identifying predictors of treatment response—distinguishing responders from non-responders—would require access to individual participant data or consistent subgroup analyses, which were rarely provided across the reviews.

NIBS has evolved significantly in recent years, becoming a central intervention in the rehabilitation of post-stroke patients. The principle of personalization is fundamental in this approach because it allows protocols to be adapted based on individual clinical characteristics, such as stroke severity, lesion location and patient functional profile (Coêlho *et al.*, 2021). Personalized stimulation aims to adapt parameters, protocols and selection of the main characteristics of patients, optimizing treatment effectiveness and improving results in an individualized manner (Kesselheim *et al.*, 2023;

Wessel *et al.*, 2024).For this reason, techniques such as neuromodulation may yield suboptimal results when applied with “one size fits all” treatment, as lack of personalization that can limit the effectiveness of treatments (Ovadia-Caro *et al.*, 2019). Our umbrella review was not designed to investigate distinctions between specific stimulation protocols or patient characteristics. Therefore, a key aspect to be addressed in future reviews incorporating subgroup analyses is the identification of stimulation protocols associated with greater therapeutic efficacy, as well as the investigation of whether clinical factors such as lesion location, time since stroke, stimulation dose, and lesion extent can predict responsiveness to NIBS. Moreover, a larger number of studies with larger samples and long-term follow-up is needed to assess the durability of NIBS effects in post-stroke recovery.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

The Author Contributions section is mandatory for all articles, including articles by sole authors. If an appropriate statement is not provided on submission, a standard one will be inserted during the production process. The Author Contributions statement must describe the contributions of individual authors referred to by their initials and, in doing so, all authors agree to be accountable for the content of the work. Please see here for full authorship criteria.

Funding

AFB is supported by CNPq/Brazil (Grant 314149/2018-0); KMS is supported by CNPq/Brazil (Grant 31 1224/2019-9); KNS is supported by FUNADESP/Brazil (Grant 60-123/2022) LS is is supported by CNPq/Brazil (Grant 371559/2024-3). This research was not supported by any funding source

Supplementary Material

Table S1. Search strategy and number of articles retrieved in the umbrella review

Table S2. Main characteristics of the included studies and the specific measure considered for each ICF outcome included in the meta-analyses.

Data Availability Statement

The datasets used and/or analyzed during the current study are available from the corresponding author [DP] upon reasonable request.

Acknowledgments

N/A

REFERENCES

Ahmed, I. *et al.* (2023) 'Does noninvasive brain stimulation combined with other therapies improve upper extremity motor impairment, functional performance, and participation in activities of daily living after stroke? A systematic review and meta-analysis of randomized controlled trial', *Topics in stroke rehabilitation*, 30(3), pp. 213–234.

Ahmed, I., Yeldan, I. and Mustafaoglu, R. (2022) 'The Adjunct of Electric Neurostimulation to Rehabilitation Approaches in Upper Limb Stroke Rehabilitation: A Systematic Review With Network Meta-Analysis of Randomized Controlled Trials', *Neuromodulation: journal of the International Neuromodulation Society*, 25(8), pp. 1197–1214.

Allida, S. *et al.* (2020) 'Pharmacological, psychological, and non-invasive brain stimulation interventions for treating depression after stroke', *Cochrane database of systematic reviews*, 1(1), p. CD003437.

Andrade, C. (2020) 'Sample Size and its Importance in Research', *Indian journal of psychological medicine*, 42(1). Available at: https://doi.org/10.4103/IJPSYM.IJPSYM_504_19.

Aromataris, E. *et al.* (2015) 'Summarizing systematic reviews: methodological development, conduct and reporting of an umbrella review approach', *International journal of evidence-based healthcare*, 13(3), pp. 132–140.

Baltar, A. *et al.* (2020) 'Baseline Motor Impairment Predicts Transcranial Direct Current Stimulation Combined with Physical Therapy-Induced Improvement in Individuals with Chronic Stroke', *Neural plasticity*, 2020, p. 8859394.

Barreto, G. *et al.* (2025) 'The impact of the number of sessions and stimulation parameters on repetitive transcranial magnetic stimulation efficacy for post-stroke upper extremity recovery: A systematic review and meta-analysis', *Clinical rehabilitation*, p. 2692155251328945.

Brunoni, A.R. *et al.* (2019) 'Noninvasive brain stimulation in psychiatric disorders: a primer', *Revista brasileira de psiquiatria (Sao Paulo, Brazil : 1999)*, 41(1), pp. 70–81.

Button, K.S. *et al.* (2013) 'Power failure: why small sample size undermines the reliability of neuroscience', *Nature reviews. Neuroscience*, 14(5). Available at: https://doi.org/10.1038/nrn3475.

Chen, K., Sun, M. and Zhuang, H. (2024) 'Effect of theta burst stimulation on lower extremity motor function improvement and balance recovery in patients with stroke: A systematic review and meta-analysis of randomized controlled trials', *Medicine*, 103(44), p. e40098.

Chen, X. *et al.* (2023a) ‘High-frequency repetitive transcranial magnetic stimulation (HF-rTMS) impacts activities of daily living of patients with post-stroke cognitive impairment: a systematic review and meta-analysis’, *Neurological sciences : official journal of the Italian Neurological Society and of the Italian Society of Clinical Neurophysiology*, 44(8), pp. 2699–2713.

Chen, Y. *et al.* (2023b) ‘Non-invasive brain stimulation for limb motor function and daily living activity improvement in acute stroke: A meta-analysis’, *Journal of stroke and cerebrovascular diseases: the official journal of National Stroke Association*, 32(4), p. 106982.

Citrome, L. (2014) ‘Quantifying clinical relevance’, *Innovations in clinical neuroscience*, 11(5-6), pp. 26–30.

Coêlho, M.L.S. *et al.* (2021) ‘Estimulações cerebrais não invasivas: as aplicações de Estimulação Transcraniana por Corrente Contínua (ETCC) e Estimulação Magnética Transcraniana (EMT) na aprendizagem e na clínica’, in *Tecnologias aplicadas em Educação e Saúde*. Memnon Edições Científicas, pp. 341–362.

Comino-Suárez, N. *et al.* (2021) ‘Transcranial direct current stimulation combined with robotic therapy for upper and lower limb function after stroke: a systematic review and meta-analysis of randomized control trials’, *Journal of neuroengineering and rehabilitation*, 18(1), p. 148.

Cuijpers, P. *et al.* (2014) ‘What is the threshold for a clinically relevant effect? The case of major depressive disorders’, *Depression and anxiety*, 31(5). Available at: https://doi.org/10.1002/da.22249.

Daoud, A. *et al.* (2024) ‘Efficacy of intermittent theta burst stimulation (iTBS) on post-stroke cognitive impairment (PSCI): a systematic review and meta-analysis’, *Neurological sciences : official journal of the Italian Neurological Society and of the Italian Society of Clinical Neurophysiology*, 45(5), pp. 2107–2118.

Elsner, B. *et al.* (2016) ‘Transcranial direct current stimulation for improving spasticity after stroke: A systematic review with meta-analysis’, *Journal of rehabilitation medicine*, 48(7), pp. 565–570.

Elsner, B. *et al.* (2020) ‘Transcranial direct current stimulation (tDCS) for improving activities of daily living, and physical and cognitive functioning, in people after stroke’, *The Cochrane database of systematic reviews*, 11(11), p. CD009645.

Gallardo-Gómez, D., Richardson, R. and Dwan, K. (2024) ‘Standardized mean differences in meta‐analysis: A tutorial’, *Cochrane Evidence Synthesis and Methods*, 2(3), p. e12047.

Gao, Y. *et al.* (2023) ‘Repetitive transcranial magnetic stimulation combined with cognitive training for cognitive function and activities of daily living in patients with post-stroke cognitive impairment: A systematic review and meta-analysis’, *Ageing research*

reviews, 87, p. 101919.

Gates, M. *et al.* (2022) 'Reporting guideline for overviews of reviews of healthcare interventions: development of the PRIOR statement', *BMJ (Clinical research ed.)*, 378, p. e070849.

Ghayour-Najafabadi, M. *et al.* (2019) 'Repetitive Transcranial Magnetic Stimulation for the Treatment of Lower Limb Dysfunction in Patients Poststroke: A Systematic Review with Meta-Analysis', *Journal of stroke and cerebrovascular diseases: the official journal of National Stroke Association*, 28(12). Available at: https://doi.org/10.1016/j.jstrokecerebrovasdis.2019.104412.

Graef, P. *et al.* (2016) 'Transcranial magnetic stimulation combined with upper-limb training for improving function after stroke: A systematic review and meta-analysis', *Journal of the neurological sciences*, 369, pp. 149–158.

Higgins, J. and Welch, V. (no date) *Cochrane Handbook for Systematic Reviews of Interventions*. Available at: https://training.cochrane.org/handbook (Accessed: 17 April 2025).

Hildesheim, F.E. *et al.* (2022) 'Predicting Individual Treatment Response to rTMS for Motor Recovery After Stroke: A Review and the CanStim Perspective', *Frontiers in rehabilitation sciences*, 3, p. 795335.

Hofmeijer, J., Ham, F. and Kwakkel, G. (2023) 'Evidence of rTMS for motor or cognitive stroke recovery: Hype or hope?', *Stroke; a journal of cerebral circulation*, 54(10), pp. 2500–2511.

Huang, J. *et al.* (2022) 'Efficacy and safety of transcranial direct current stimulation for post-stroke spasticity: A meta-analysis of randomised controlled trials', *Clinical rehabilitation*, 36(2), pp. 158–171.

ICD-11 (no date). Available at: https://icd.who.int/en/ (Accessed: 17 April 2025).

Jia, D.-M. *et al.* (2025) 'Therapeutic efficacy of repetitive transcranial magnetic stimulation on gait and limb balance function in patients with lower limb dysfunction post-cerebral infarction: a systematic review and meta-analysis', *BMC Neurology*, 25(1), pp. 1–18.

Jiang, T. *et al.* (2024) 'Theta burst stimulation: what role does it play in stroke rehabilitation? A systematic review of the existing evidence', *BMC Neurology*, 24(1), pp. 1–23.

Kang, N. *et al.* (2020) 'Functional Balance and Postural Control Improvements in Patients With Stroke After Noninvasive Brain Stimulation: A Meta-analysis', *Archives of physical medicine and rehabilitation*, 101(1), pp. 141–153.

Kang, N., Weingart, A. and Cauraugh, J.H. (2018) 'Transcranial direct current

stimulation and suppression of contralesional primary motor cortex post-stroke: a systematic review and meta-analysis', *Brain injury: [BI]*, 32(9), pp. 1063–1070.

Kesselheim, J. *et al.* (2023) 'Multipulse transcranial magnetic stimulation of human motor cortex produces short-latency corticomotor facilitation via two distinct mechanisms', *Journal of neurophysiology*, 129(2), pp. 410–420.

Kim, S., Park, H. (2024). Update on Non-invasive Brain Stimulation on Stroke Motor Impairment: A Narrative Review. *Brain Neurorehabil*. 17, 1-7.

Krogh, S. *et al.* (2022) 'Efficacy of repetitive transcranial magnetic stimulation for improving lower limb function in individuals with neurological disorders: A systematic review and meta-analysis of randomized sham-controlled trials', *Journal of rehabilitation medicine*, 54, p. jrm00256.

Leonardi, M. and Fheodoroff, K. (2021) 'Goal Setting with ICF (International Classification of Functioning, Disability and Health) and Multidisciplinary Team Approach in Stroke Rehabilitation', in T. Platz (ed.) *Clinical Pathways in Stroke Rehabilitation: Evidence-based Clinical Practice Recommendations*. Cham (CH): Springer.

van Lieshout, E.C.C. *et al.* (2019) 'Timing of Repetitive Transcranial Magnetic Stimulation Onset for Upper Limb Function After Stroke: A Systematic Review and Meta-Analysis', *Frontiers in neurology*, 10, p. 1269.

Liew, S.-L. *et al.* (2014) 'Non-invasive brain stimulation in neurorehabilitation: local and distant effects for motor recovery', *Frontiers in human neuroscience*, 8. Available at: https://doi.org/10.3389/fnhum.2014.00378.

Lima, E. de O. *et al.* (2024) 'Transcranial Direct Current Stimulation and Brain-Computer Interfaces for Improving Post-Stroke Recovery: A Systematic Review and Meta-Analysis', *Clinical rehabilitation*, 38(1), pp. 3–14.

Lima, E., de Souza Neto, J.M.R. and Andrade, S.M. (2023) 'Effects of transcranial direct current stimulation on lower limb function, balance and quality of life after stroke: a systematic review and meta-analysis', *Neurological research*, 45(9), pp. 843–853.

Liu, C. *et al.* (2019) 'Efficacy and Safety of High-Frequency Repetitive Transcranial Magnetic Stimulation for Poststroke Depression: A Systematic Review and Meta-analysis', *Archives of physical medicine and rehabilitation*, 100(10), pp. 1964–1975.

Liu, H.X., Hu, D.H. and Yin, H.Q. (2020) '[Umbrella review - a new method related to evidence-based medical analysis]', *Zhonghua liu xing bing xue za zhi = Zhonghua liuxingbingxue zazhi*, 41(2). Available at: https://doi.org/10.3760/cma.j.issn.0254-6450.2020.02.021.

Li, Y. *et al.* (2018a) 'Effects of Repetitive Transcranial Magnetic Stimulation on Walking and Balance Function after Stroke: A Systematic Review and Meta-Analysis', *American journal of physical medicine & rehabilitation*, 97(11), pp. 773–781.

Li, Y. *et al.* (2018b) 'Effects of transcranial direct current stimulation on walking ability after stroke: A systematic review and meta-analysis', *Restorative neurology and neuroscience*, 36(1), pp. 59–71.

Mahmoud, W. *et al.* (2024) 'Brain state-dependent repetitive transcranial magnetic stimulation for motor stroke rehabilitation: a proof of concept randomized controlled trial', *Frontiers in neurology*, 15, p. 1427198.

Ma, Z. *et al.* (2025) 'Systematic review of repetitive transcranial magnetic stimulation for post-stroke hemiplegic shoulder pain', *Neurological Sciences*, 46(5), pp. 2007–2017.

McIntyre, A. *et al.* (2018) 'A Systematic Review and Meta-Analysis on the Use of Repetitive Transcranial Magnetic Stimulation for Spasticity Poststroke', *PM & R: the journal of injury, function, and rehabilitation*, 10(3), pp. 293–302.

Mitra, S. *et al.* (2019) 'Statistical power estimation in non-invasive brain stimulation studies and its clinical implications: An exploratory study of the meta-analyses', *Asian journal of psychiatry*, 44. Available at: https://doi.org/10.1016/j.ajp.2019.07.006.

O'Brien, A.T. *et al.* (2018) 'Non-invasive brain stimulation for fine motor improvement after stroke: a meta-analysis', *European journal of neurology*, 25(8), pp. 1017–1026.

Ovadia-Caro, S. *et al.* (2019) 'Predicting the response to non-invasive brain stimulation in stroke', *Frontiers in neurology*, 10, p. 302.

Page, P. (2014) 'Beyond statistical significance: clinical interpretation of rehabilitation research literature', *International journal of sports physical therapy*, 9(5), pp. 726–736.

Qi, L. *et al.* (2024) 'Non-invasive brain stimulation in the treatment of generalized anxiety disorder: A systematic review and meta-analysis', *Journal of psychiatric research*, 178, pp. 378–387.

Rahlfs, V. and Zimmermann, H. (2019) 'Effect size measures and their benchmark values for quantifying benefit or risk of medicinal products', *Biometrical journal. Biometrische Zeitschrift*, 61(4), pp. 973–982.

Reis, S.B. *et al.* (2021) 'Effects of Robotic Therapy Associated With Noninvasive Brain Stimulation on Upper-Limb Rehabilitation After Stroke: Systematic Review and Meta-analysis of Randomized Clinical Trials', *Neurorehabilitation and neural repair*, 35(3), pp. 256–266.

Ren, M. *et al.* (2024) 'Effect of Dual-Site Non-Invasive Brain Stimulation on Upper-Limb Function After Stroke: A Systematic Review and Meta-Analysis', *Brain and Behavior*, 14(11), p. e70145.

Salter, K., Campbell, N., Richardson, M., et al. (2019). Outcome measures in stroke rehabilitation. In *Evidence-Based Review of Stroke Rehabilitation* (16th ed.). London,

England: Evidence-Based Review of Stroke Rehabilitation.

Shao, D. *et al.* (2021) 'Efficacy of repetitive transcranial magnetic stimulation for post-stroke depression: a systematic review and meta-analysis of randomized clinical trials', *Brazilian Journal of Medical and Biological Research*, 54(3), p. e10010.

Shea, B.J. *et al.* (2017) 'AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both', *BMJ (Clinical research ed.)*, 358, p. J4008.

Shen, Q., Hu, M., Feng, W., Li, K., Wang, W. (2022). Narrative Review of Noninvasive Brain Stimulation in Stroke Rehabilitation. *Med Sci Monit* 28, e938298.

Shen, X. *et al.* (2017) 'Repetitive transcranial magnetic stimulation for the treatment of post-stroke depression: A systematic review and meta-analysis of randomized controlled clinical trials' *Journal of Affective Disorders*, 211, pp. 65–74.

Simonetta-Moreau, M. (2014) 'Non-invasive brain stimulation (NIBS) and motor recovery after stroke', *Annals of physical and rehabilitation medicine*, 57(8), pp. 530–542.

Subramanian, S.K. and Prasanna, S.S. (2018) 'Virtual Reality and Noninvasive Brain Stimulation in Stroke: How Effective Is Their Combination for Upper Limb Motor Improvement?—A Meta-Analysis', *PM&R*, 10(11), pp. 1261–1270.

Sun, J. *et al.* (2021) 'Electrical Stimulation of the Motor Cortex or Paretic Muscles Improves Strength Production in Stroke Patients: A Systematic Review and Meta-Analysis', *PM & R : the journal of injury, function, and rehabilitation*, 13(2), pp. 171–179.

Tang, X. *et al.* (2024) 'Transcranial direct current stimulation for upper extremity motor dysfunction in poststroke patients: A systematic review and meta-analysis', *Clinical rehabilitation*, 38(6), pp. 749–769.

Tedesco Triccas, L. *et al.* (2016) 'Multiple sessions of transcranial direct current stimulation and upper extremity rehabilitation in stroke: A review and meta-analysis', *Clinical neurophysiology : official journal of the International Federation of Clinical Neurophysiology*, 127(1), pp. 946–955.

The international classification of functioning, disability and health (ICF): A unifying model for the conceptual description of the rehabilitation strategy (no date). Available at: https://doi.org/10.2340/16501977-0041.

Tien, H.-H. *et al.* (2020) 'Transcranial direct current stimulation for improving ambulation after stroke: a systematic review and meta-analysis', *International journal of rehabilitation research. Internationale Zeitschrift fur Rehabilitationsforschung. Revue internationale de recherches de readaptation*, 43(4), pp. 299–309.

Tung, Y.-C. *et al.* (2019) 'Repetitive transcranial magnetic stimulation of lower limb motor function in patients with stroke: a systematic review and meta-analysis of randomized

controlled trials', *Clinical rehabilitation*, 33(7), pp. 1102–1112.

Usman, J.S., Wong, T.W.-L. and Ng, S.S.M. (2024) 'Effects of treadmill training combined with transcranial direct current stimulation on mobility, motor performance, balance function, and other brain-related outcomes in stroke survivors: a systematic review and meta-analysis', *Neurological Sciences*, 46(1), pp. 99–111.

Van Hoornweder, S. *et al.* (2021) 'The effects of transcranial direct current stimulation on upper-limb function post-stroke: A meta-analysis of multiple-session studies' *Clinical Neurophysiology*, 132(8), pp. 1897–1918.

Vaz, P.G. *et al.* (2019) 'Noninvasive brain stimulation combined with other therapies improves gait speed after stroke: a systematic review and meta-analysis', *Topics in stroke rehabilitation*, 26(3), pp. 201–213.

Virani, S.S. *et al.* (2021) 'Heart disease and stroke statistics-2021 update: A report from the American Heart Association: A report from the American Heart Association', *Circulation*, 143(8), pp. e254–e743.

Wang, J. *et al.* (2024a) 'Cerebellar transcranial magnetic stimulation for improving balance capacity and activity of daily living in stroke patients: a systematic review and meta-analysis', *BMC Neurology*, 24(1), pp. 1–16.

Wang, Y. *et al.* (2024b) 'Repetitive peripheral magnetic stimulation alone or in combination with repetitive transcranial magnetic stimulation in poststroke rehabilitation: a systematic review and meta-analysis', *Journal of NeuroEngineering and Rehabilitation*, 21(1), pp. 1–16.

Wang, X. *et al.* (2025) 'Effects of cerebellar repetitive transcranial magnetic stimulation on stroke rehabilitation: A systematic review and meta-analysis', *Brain Research Bulletin*, 225, p. 111341.

Wessel, M.J. *et al.* (2024) 'Multi-focal stimulation of the Cortico-cerebellar loop during the acquisition of a novel hand motor skill in chronic stroke survivors', *Cerebellum (London, England)*, 23(2), pp. 341–354.

Xiang, H. *et al.* (2019) 'The effect and optimal parameters of repetitive transcranial magnetic stimulation on motor recovery in stroke patients: a systematic review and meta-analysis of randomized controlled trials', *Clinical rehabilitation* [Preprint]. Available at: https://doi.org/10.1177/0269215519829897.

Xie, G. *et al.* (2025) 'Repetitive transcranial magnetic stimulation for motor function in stroke: a systematic review and meta-analysis of randomized controlled studies', *Systematic Reviews*, 14(1), pp. 1–48.

Xie, H. *et al.* (2023) 'Efficacy and Safety of Repetitive Transcranial Magnetic Stimulation for Poststroke Memory Disorder: A Meta-Analysis and Systematic Review', *Journal of Integrative Neuroscience*, 22(5), p. 131.

Xi, X. *et al.* (2023) ‘Meta-analysis of repetitive transcranial magnetic stimulation combined with task-oriented training on upper limb function in stroke patients with hemiplegia’, *Medicine*, 102(22), p. e33771.

Yu, L. *et al.* (2025) ‘Efficacy of anodal transcranial direct current stimulation for upper extremity function after ischemic stroke: A systematic review of parallel randomized clinical trials’, *Journal of stroke and cerebrovascular diseases : the official journal of National Stroke Association*, 34(1), p. 108112.

Zeng, Y. *et al.* (2024) ‘Efficacy of Cerebellar Transcranial Magnetic Stimulation for Post-stroke Balance and Limb Motor Function Impairments: Meta-analyses of Random Controlled Trials and Resting-State fMRI Studies’, *The Cerebellum*, 23(4), pp. 1678–1696.

Zhang, J.J. *et al.* (2024) ‘Theta burst stimulation for enhancing upper extremity motor functions after stroke: a systematic review of clinical and mechanistic evidence’, *Reviews in the Neurosciences*, 35(6), pp. 679–695.

Zhang, J.J.Y. *et al.* (2025) ‘Repetitive Transcranial Magnetic Stimulation for Motor Recovery After Stroke: A Systematic Review and Meta-Analysis of Randomized Controlled Trials With Low Risk of Bias’, *Neuromodulation : journal of the International Neuromodulation Society*, 28(1), pp. 16–42.

Zhang, L., Xing, G., Shuai, S., *et al.* (2017a) ‘Low-Frequency Repetitive Transcranial Magnetic Stimulation for Stroke-Induced Upper Limb Motor Deficit: A Meta-Analysis’, *Neural plasticity*, 2017, p. 2758097.

Zhang, L., Xing, G., Fan, Y., *et al.* (2017b) ‘Short- and Long-term Effects of Repetitive Transcranial Magnetic Stimulation on Upper Limb Motor Function after Stroke: a Systematic Review and Meta-Analysis’, *Clinical rehabilitation*, 31(9), pp. 1137–1153.

Zhang, N. *et al.* (2024) ‘Impact of the combination of virtual reality and noninvasive brain stimulation on the upper limb motor function of stroke patients: a systematic review and meta-analysis’, *Journal of NeuroEngineering and Rehabilitation*, 21(1), pp. 1–16.

Zhou, J. *et al.* (2023) ‘The Effects of Repetitive Transcranial Magnetic Stimulation on Standing Balance and Walking in Older Adults with Age-related Neurological Disorders: A Systematic Review and Meta-analysis’, *The journals of gerontology. Series A, Biological sciences and medical sciences*, 78(5), pp. 842–852.

Zhu, M. *et al.* (2024) ‘The effect of transcranial magnetic stimulation on cognitive function in post-stroke patients: a systematic review and meta-analysis’, *BMC neurology*, 24(1), p. 234.

Zieliński, G. (2025) ‘Effect Size Guidelines for Individual and Group Differences in Physiotherapy’. *Arch Phys Med Rehabilitation*, 19(25), pp. 717-8. doi: 10.1016/j.apmr.2025.05.013. PMID: 4054369.

Figure Legends

Figure 1. PRISMA flowchart.

Figure 2. Evidence map for the use of repetitive transcranial magnetic stimulation (rTMS) on body structure and function. "Mixed protocols" indicates that various noninvasive brain stimulation (NIBS) protocols were included within the same meta-analysis.

Figure 3. Evidence map for the use of repetitive transcranial magnetic stimulation (rTMS) on activity. "Mixed protocols" indicates that various noninvasive brain stimulation (NIBS) protocols were included within the same meta-analysis.

Figure 4. Evidence map for the use of transcranial direct current stimulation (tDCS) on body structure and function. "Mixed protocols" indicates that various noninvasive brain stimulation (NIBS) protocols were included within the same meta-analysis.

Figure 5. Evidence map for the use of transcranial direct current stimulation (tDCS) on activity. "Mixed protocols" indicates that various noninvasive brain stimulation (NIBS) protocols were included within the same meta-analysis.

Figure 6. A summary of the current evidence supporting the effects of repetitive transcranial magnetic stimulation (rTMS) and transcranial direct current stimulation (tDCS) within the ICF framework in post-stroke patients.

ANEXO A - REGISTRO NO PROSPERO

NIHR | National Institute for Health and Care Research

PROSPERO
International prospective register of systematic reviews

Non-invasive brain stimulation for the treatment of neurological and psychiatric disorders and for improving physical performance of healthy subject

Lívia Shirahige, Maíra Souza, Adriana Baltar, Déborah Marques, Rodrigo Brito, Alexandre Okano, Adriana Leico, André Brunoni, Clarice Tanaka, Abrahão Baptista, Kátia Nunes Sá, Kátia Monte-Silva

To enable PROSPERO to focus on COVID-19 submissions, this registration record has undergone basic automated checks for eligibility and is published exactly as submitted. PROSPERO has never provided peer review, and usual checking by the PROSPERO team does not endorse content. Therefore, automatically published records should be treated as any other PROSPERO registration. Further detail is provided here.

Citation
Lívia Shirahige, Maíra Souza, Adriana Baltar, Déborah Marques, Rodrigo Brito, Alexandre Okano, Adriana Leico, André Brunoni, Clarice Tanaka, Abrahão Baptista, Kátia Nunes Sá, Kátia Monte-Silva. Non-invasive brain stimulation for the treatment of neurological and psychiatric disorders and for improving physical performance of healthy subject. PROSPERO 2024 Available from https://www.crd.york.ac.uk/PROSPERO/view/CRD42021239577

ANEXO B - NON-INVASIVE BRAIN STIMULATION FOR STROKE-RELATED MOTOR IMPAIRMENT AND DISABILITY: AN UMBRELLA REVIEW OF SYSTEMATIC REVIEW AND META-ANALYSIS.

Dear Dr Lima

Your article has been accepted for publication.

After a rigorous review, your work has been recognized for its quality and contribution to Neuroscience

What happens next?
Your article will now enter the production phase, where our team will assist with typesetting and copyediting. This typically takes around 3-4 weeks. You'll receive updates from us, including billing or institutional funding information (if applicable).

If you have any unresolved queries, please use the chatbot to let us know before your manuscript's publication.

Please fill in this short survey to share your thoughts on your peer review experience. Your feedback helps us improve the process for other authors like you.

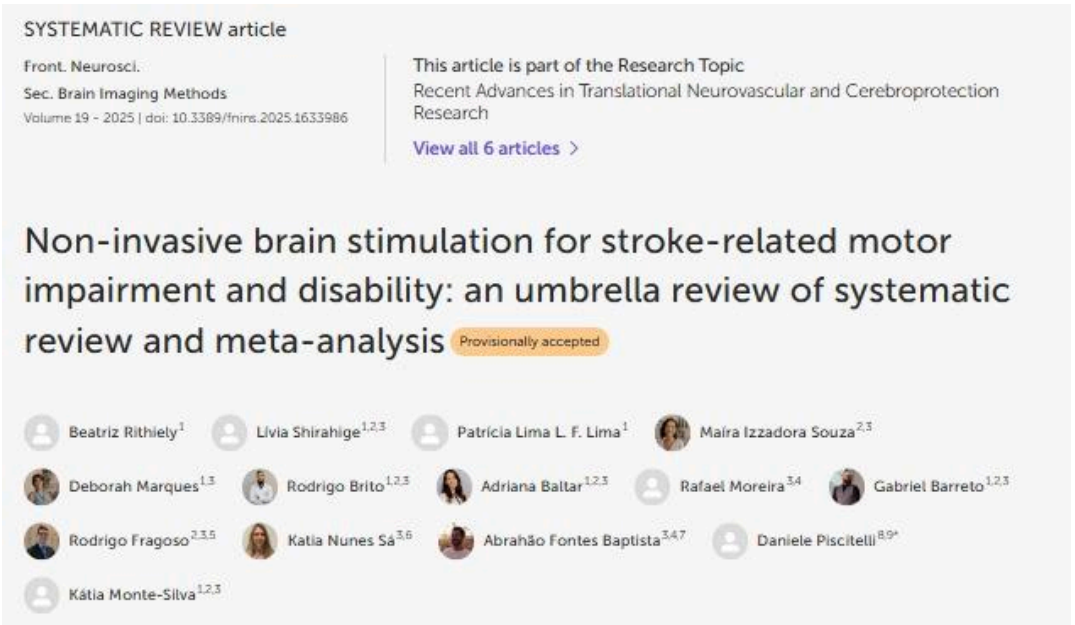
What could open science unlock for humanity?
While you're here, watch this video from our CEO and co-founder, Kamila Markram, reflecting on how the global transition to open science is accelerating scientific solutions for healthy lives on a healthy planet.

Thanks for choosing Frontiers. We hope to see you again soon.

Regards,

Best regards,
Your Frontiers in Neuroscience Team,

Frontiers | Editorial Office - Collaborative Peer Review Team
www.frontiersin.org
Avenue du Tribunal Fédéral 34
1005 Lausanne Switzerland



ANEXO C - TRANSCRANIAL DIRECT CURRENT STIMULATION ASSOCIATED WITH AEROBIC EXERCISE AS A STRATEGY FOR MANAGING FATIGUE AND PAIN IN LONG COVID: A FEASIBILITY

---------- Forwarded message ---------
De: **The Journal of Pain** <em@editorialmanager.com>
Date: qui., 21 de ago. de 2025 às 11:47
Subject: Submission Confirmation
To: Katia Monte-Silva <monte.silva@ufpe.br>

Dear Professor Monte-Silva,

Your submission entitled "Estimulação transcraniana por corrente contínua associada ao exercício aeróbico como estratégia para o manejo da fadiga e da dor na COVID longa: um estudo de previsão" has been received by The Journal of Pain.

You may check on the progress of your paper by logging on to the Elsevier Editorial System as an author. The URL is https://www.editorialmanager.com/jpain/.

Your username is: Katia Monte Silva
If you need to retrieve password details,
please go to: http://ees.elsevier.com/jpain/automail_query.asp

Your manuscript will be given a reference number once an editor has been assigned.

Thank you for submitting your work to this journal.

Kind regards,

Elsevier Editorial System
The Journal of Pain

ANEXO D – ATIVIDADES TÉCNICAS E CONTRIBUIÇÕES CIENTÍFICAS REALIZADAS DURANTE O PERÍODO DO MESTRADO

VII SIMPÓSIO INTERNACIONAL
De Neuromodulação Não Invasiva

CERTIFICADO

Certificamos, para os devidos fins, que o trabalho ESTIMULAÇÃO MAGNÉTICA TRANSCRANIANA REPETITIVA NA FUNÇÃO MOTORA PÓS-AVC: UMA REVISÃO GUARDA-CHUVA, dos autores **Rebeca Gomes Dias da Costa, Lívia Shirahige, Beatriz Rithiely Henrique Ramos da Silva, Rhayssa Muniz Albuquerque, Maria Paula Almeida Campos** e **Kátia Monte-Silva**, recebeu menção honrosa - 1º Lugar no VII SIMPÓSIO INTERNACIONAL DE NEUROMODULAÇÃO NÃO INVASIVA, realizado em São Paulo - SP, Brasil, nos dias 02 e 03 de agosto de 2025, organizado pela rede NAPEN - Núcleo de Assistência e Pesquisa em Neuromodulação.

São Paulo, 03 de agosto de 2025.

Adriana Leico Oda
Vice-presidente

Kátia Monte-Silva
Presidente

Lívia Shirahige
Presidente da Comissão Científica

Realização: NAPEN

ANEXO E – ATIVIDADES TÉCNICAS E CONTRIBUIÇÕES CIENTÍFICAS REALIZADAS DURANTE O PERÍODO DO MESTRADO

UFPE

PROExC
Pró-Reitoria de Extensão e Cultura

DECLARAÇÃO

Declaramos para os devidos fins que **Beatriz Rithiely Henrique Ramos da Silva** participou do Projeto de extensão "Núcleo de Estudos para Desenvolvimento Tecnológico e Inovação em Terapia Intensiva", com carga horária de 8 (oito) horas.

Outrossim, informamos que o referido Projeto está registrado no SIGPROJ – Sistema de Informação e Gestão de Projetos sob o nº: 364885.2130.83646.22032022, foi realizado no período de 29 de abril de 2022 a 29 de abril de 2023, com carga horária total de 320 (trezentas e vinte) horas, durante o(s) período(s) de 2022.1 a 2023.1, o que equivale a 3 (três) semestre(s) letivo(s), e foi coordenado por Shirley Lima Campos, docente lotado(a) no Departamento de Fisioterapia, do Centro de Ciências da Saúde da UFPE.

Recife, 29 de fevereiro de 2024.

Maria da Conceição dos Reis
Pró-Reitora de Extensão e Cultura
UFPE SIAPE 2584413

Av. Moraes Rego 1235|Cidade Universitária|50670-901|Recife PE Brasil|Fone 2126.8130|
|e-mail: certificados.proexc@ufpe.br

ANEXO F – ATIVIDADES TÉCNICAS E CONTRIBUIÇÕES CIENTÍFICAS REALIZADAS DURANTE O PERÍODO DO MESTRADO

Coordenação do Curso de Fisioterapia dFISIO | Departamento de Fisioterapia

UNIVERSIDADE FEDERAL DE PERNAMBUCO

DECLARAÇÃO

Declaro, para os devidos fins, que **BEATRIZ RITHIELY HENRIQUE RAMOS DA SILVA** orientou no semestre 2023.2 o Trabalho de Conclusão de Curso (Graduação em Fisioterapia) do(a) acadêmico(a) **PEDRO VANDERLEI DE SOUSA MELO** intitulado **"EFEITO DA TERAPIA DE LATERALIZAÇÃO AUTOMÁTICA NA VENTILAÇÃO PULMONAR PELA TOMOGRAFIA DE IMPEDÂNCIA ELÉTRICA ENTRE INDIVÍDUOS IDOSOS COM E SEM HISTÓRICO DE COVID-19",** defendido em19 de março de 2024.

Recife, 19 de março de 2024.

Universidade Federal de Pernambuco - UFPE
Centro de Ciências da Saúde
Profª Eduardo José Nepomuceno Montenegro
Coordenador do Curso de Fisioterapia
SIAPE 1243472
UFPE

Av. Jornalista Aníbal Fernandes, S/N Cidade Universitária Recife-PE CEP: 50740-560 Fone: (81) 2126-8492
coordenacao.fisio@ufpe.br | Curso reconhecido pelo Decreto nº 72213 de 11/05/1973

ANEXO G – ATIVIDADES TÉCNICAS E CONTRIBUIÇÕES CIENTÍFICAS REALIZADAS DURANTE O PERÍODO DO MESTRADO

DECLARAÇÃO

Declaro para os devidos fins que Beatriz Rithiely Henrique Ramos da Silva coorientou o Trabalho de Conclusão de Curso, intitulado **IMPACTO DA FISIOTERAPIA CARDIOVASCULAR SOBRE A QUALIDADE DE VIDA DE PACIENTES COM DOENÇA ARTERIAL CORONARIANA: UMA REVISÃO INTEGRATIVA,** da aluna Maria Clara Gomes Alves Coelho, no Centro Universitário Facol-UNIFACOL.

Vitória de Santo Antão, 31 de maio de 2024

Patrícia Murieles Brito
Coordenadora de TCC do Curso de Fisioterapia

ANEXO H – ATIVIDADES TÉCNICAS E CONTRIBUIÇÕES CIENTÍFICAS REALIZADAS DURANTE O PERÍODO DO MESTRADO

UNIVERSIDADE CATÓLICA DE PERNAMBUCO
ESCOLA DE SAÚDE E CIÊNCIAS DA VIDA
CURSO DE FISIOTERAPIA

DECLARAÇÃO

Declaramos para os devidos fins que a Fisioterapeuta Dra. Beatriz Rithiely Henrique Ramos da Silva orientou o Trabalho de Conclusão do Curso de Fisioterapia intitulado: Estudo comparativo do efeito agudo da liberação miofascial e do alongamento do músculo diafragma através da ultrassonografia, apresentado pela acadêmica Thalyta Marques dos Santos Silva.

Recife, 11 de junho de 2024.

Profª Dra. Erica Patricia Borba Lira Uchôa
Coordenadora da Disciplina TCC II

ANEXO I – ATIVIDADES TÉCNICAS E CONTRIBUIÇÕES CIENTÍFICAS REALIZADAS DURANTE O PERÍODO DO MESTRADO

ASSOBRAFIR Associação Brasileira de Fisioterapia Respiratória, Fisioterapia Cardiovascular e Fisioterapia em Terapia Intensiva

Certificamos que

BEATRIZ RITHIELY HENRIQUE RAMOS DA SILVA

Participou do **XXI Simpósio Internacional de Fisioterapia Respiratória, Cardiovascular e Terapia Intensiva – SIFR,** realizado nos dias 13, 14 e 15 de junho de 2024, no Centro Internacional de Convenções do Brasil – CICB, em Brasília-DF, com carga horária de 22 horas.

Brasília, 15 de junho de 2024.

Validação Online
Código:4Ax16lW7sO

Dr. Daniel da Cunha Ribeiro
Presidente da ASSOBRAFIR

Dra. Fernanda de Codorba Lanza
Diretora-científica da ASSOBRAFIR

Dr. Gerson Cipriano Júnior
Presidente do XXI SIFR

ANEXO J – ATIVIDADES TÉCNICAS E CONTRIBUIÇÕES CIENTÍFICAS REALIZADAS DURANTE O PERÍODO DO MESTRADO

XXV COBRAF
CONGRESSO BRASILEIRO DE FISIOTERAPIA
1 a 3 de agosto / 2024

Certificamos que o trabalho: **COMPARAÇÃO DO IMPACTO DA rTMS DE BAIXA FREQUÊNCIA SOBRE OS SINTOMAS MOTORES E NÃO MOTORES NA DP** de autoria de: **VINÍCIUS ALVES DA SILVA CIPRIANO**, coautores, **RHAYSSA MUNIZ ALBUQUERQUE**, **SÉRGIO VITOR CARVALHO GUERRA**, **DANIEL GOMES DE MELO**, **BEATRIZ RITHIELY HENRIQUE RAMOS DA SILVA**, **CAMILLA SANTOS ARAÚJO, LÍVIA SHIRAHIGE**, **KATIA MONTE-SILVA**, foi apresentado na modalidade **PÔSTER** no XXV COBRAF - Congresso Brasileiro de Fisioterapia realizado no período de 01 a 03 de agosto de 2024 no Centro de Convenções de Salvador na Bahia.

Salvador, 03 de agosto de 2024

Denise Flavio
Presidente da AFB

Lorena Rosa Almeida
Presidente do XXV COBRAF

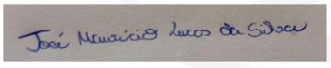
Elen Beatriz Pinto
Presidente da Comissão Científica

ANEXO K – ATIVIDADES TÉCNICAS E CONTRIBUIÇÕES CIENTÍFICAS REALIZADAS DURANTE O PERÍODO DO MESTRADO

DECLARAÇÃO

Declaro para os devidos fins que os professores Sabrina da Conceição Pereira, Gleydson Silva Moraes e Beatriz Rithiely Henrique Ramos da Silva participaram da banca examinadora da defesa do Trabalho de Conclusão de Curso, intitulado: **ATUAÇÃO FISIOTERAPÊUTICA NA GESTAÇÃO DE ALTO RISCO EM UNIDADE DE TERAPIA INTENSIVA: UMA REVISÃO INTEGRATIVA DA LITERATURA,** das alunas Apoliana Mikaelly da Silva Nascimento e Júlia Gabrielly Álvares Silva, no Centro Universitário Facol - UNIFACOL

Vitória de Santo Antão, 07 de dezembro de 2024



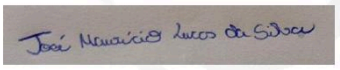
Coordenador de TCC do Curso de Fisioterapia

ANEXO L – ATIVIDADES TÉCNICAS E CONTRIBUIÇÕES CIENTÍFICAS REALIZADAS DURANTE O PERÍODO DO MESTRADO

DECLARAÇÃO

Declaro para os devidos fins que os professores Sabrina da Conceição Pereira, Everaldo Pereira de Melo Filho, Lisandra Delfino de Albuquerque Soares e Beatriz Rithiely Henrique Ramos da Silva participaram da banca examinadora da defesa do Trabalho de Conclusão de Curso, intitulado**: BENEFÍCIOS DA FISIOTERAPIA NA PROGRESSÃO DO TRABALHO DE PARTO NORMAL: UMA REVISÃO INTEGRATIVA,** da aluna Érika Maria da Silva Ferreira, no Centro Universitário Facol - UNIFACOL

Vitória de Santo Antão, 07 de dezembro de 2024



Coordenador de TCC do Curso de Fisioterapia

ANEXO M – ATIVIDADES TÉCNICAS E CONTRIBUIÇÕES CIENTÍFICAS REALIZADAS DURANTE O PERÍODO DO MESTRADO

IV SIMPÓSIO PPG FISIO
Universidade Federal de Pernambuco

VIRTUS IMPAVIDA

CERTIFICADO DE PARTICIPAÇÃO

IV SIMPÓSIO DO PROGRAMA DE PÓS-GRADUAÇÃO EM FISIOTERAPIA DA UFPE

Certificamos que **Beatriz Rithiely Henrique Ramos da Silva** participou do IV Simpósio do Programa de Pós-Graduação em Fisioterapia da UFPE, realizado nos dias 12 e 13 de dezembro de 2024, na cidade de Recife-PE, com uma carga horária total de 20 horas.

Recife, 20 de dezembro de 2024

Profa. Dra. Kátia Monte-Silva
Coordenadora PPGFisio UFPE

Profa. Dra. Graça Araújo
Vice-Coordenadora PPGFisio UFPE

PPG Fisioterapia
Pós-graduação em Fisioterapia - UFPE
Graduate program in Physiotherapy

ANEXO N – ATIVIDADES TÉCNICAS E CONTRIBUIÇÕES CIENTÍFICAS REALIZADAS DURANTE O PERÍODO DO MESTRADO

13º CONGRESSO INTERNACIONAL DE FISIOTERAPIA
21 a 24 de Set/2023
CentroSul - Florianópolis/SC

CERTIFICADO

Certificamos que o trabalho intitulado,

AVALIAÇAO DO NIVEL DE CONHECIMENTO E APLICABILIDADE DO PERME ESCORE DE MOBILIDADE EM UNIDADE DE TERAPIA INTENSIVA ENTRE FISIOTERAPEUTAS ATUANTES NA AREA NO ESTADO DE PERNAMBUCO

dos autores HARRISON EULLER VASCONCELOS QUEIROZ, Eudson José Santos do Monte, Augusto Cesar Bezerra Lopes, Beatriz Rithiely Henrique Ramos da Silva, Deivd Siqueira de Arruda, José Carlos Nogueira Nóbrega Júnior, Ery de Albuquerque Magalhães Neto, foi aprovado e apresentado no 13º Congresso Internacional de Fisioterapia, no dia 23/09/2023, forma de Apresentação BANNER, tendo como autor(a) apresentador(a) HARRISON EULLER VASCONCELOS QUEIROZ.

Florianópolis, 24/09/2023.

REALIZAÇÃO

APOIO

Para verificar a autenticidade deste certificado acesse: https://www.certificados.iweventos.com.br e use o código: ff5f00607e

ANEXO O – ATIVIDADES TÉCNICAS E CONTRIBUIÇÕES CIENTÍFICAS REALIZADAS DURANTE O PERÍODO DO MESTRADO

VIII COPEFIR
VIII Congresso Pernambucano de Fisioterapia Respiratória, Cardiovascular e em Terapia Intensiva da ASSOBRAFIR

23 a 25 de novembro de 2023 | Hotel Beach Class Convention

ASSOBRAFIR
Regional Pernambuco

CERTIFICADO

Certificamos que

BEATRIZ RITHIELY HENRIQUE RAMOS DA SILVA

participou do **VIII Congresso Pernambucano de Fisioterapia Respiratória, Cardiovascular e em Terapia Intensiva da Assobrafir (VIII COPEFIR),** realizada nos dias 23 a 25 de novembro de 2023, presencialmente, no Hotel Beach Class Convention, na qualidade de **Apresentadora e autora do trabalho** com o tema **RELAÇÃO ENTRE SARCOPENIA, FORÇA MUSCULAR RESPIRATÓRIA E FUNÇÃO PULMONAR EM IDOSOS COM DPOC AUTORES: RODRIGO VIANA CORREIA DE SOUZA; BEATRIZ RITHIELY HENRIQUE RAMOS DA SILVA; HELENA MEDEIROS ROCHA; DEIVD SIQUEIRA DE ARRUDA; HARRISON EULLER VASCONCELOS DE QUEIROZ; DAIARA THATIANA XAVIER NUNES; JULIANA FERNANDES DE SOUZA BARBOSA; DANIELLA CUNHA BRANDÃO; SHIRLEY LIMA CAMPOS; PATRÍCIA ÉRIKA DE MELO MARINHO; ARMÈLE DORNELAS DE ANDRADE**.

Promoção Assobrafir Regional Pernambuco.

Recife - PE, 23 de novembro de 2023.

Validação Online
Código: NM2EvHePY4

Dr. Daniel da Cunha Ribeiro
PRESIDENTE

Dr. Claudio Gonçalves de Albuquerque
DIRETOR - REGIONAL PERNAMBUCO

Dra. Fernanda de Córdoba Lanza
DIRETORA CIENTÍFICA GERAL

ANEXO P – ATIVIDADES TÉCNICAS E CONTRIBUIÇÕES CIENTÍFICAS REALIZADAS DURANTE O PERÍODO DO MESTRADO

VIII COPEFIR
VIII Congresso Pernambucano de Fisioterapia Respiratória, Cardiovascular e em Terapia Intensiva da ASSOBRAFIR

23 a 25 de novembro de 2023 | Hotel Beach Class Convention

ASSOBRAFIR
Regional Pernambuco

CERTIFICADO

Certificamos que

BEATRIZ RITHIELY HENRIQUE RAMOS DA SILVA

participou do Curso teórico prático: Utilização da estimulação elétrica neuromuscular: da UTI ao ambulatório, proferido pelo Prof. Francimar Ferrari | Crefito 1 – 25877-F, realizado em 23 de novembro de 2023, das 14h00 às 18h00, presencialmente, no Hotel Beach Class Convention. Carga horária total: 04 horas. Esta atividade é parte integrante do **VIII Congresso Pernambucano de Fisioterapia Respiratória, Cardiovascular e em Terapia Intensiva da Assobrafir (VIII COPEFIR).**

Promoção Assobrafir Regional Pernambuco.

Recife - PE, 23 de novembro de 2023.

Validação Online
Código: rD3Stnop8g

Dr. Daniel da Cunha Ribeiro
PRESIDENTE

Dr. Claudio Gonçalves de Albuquerque
DIRETOR - REGIONAL PERNAMBUCO

Dra. Fernanda de Córdoba Lanza
DIRETORA CIENTÍFICA GERAL

ANEXO Q – ATIVIDADES TÉCNICAS E CONTRIBUIÇÕES CIENTÍFICAS REALIZADAS DURANTE O PERÍODO DO MESTRADO

VIII COPEFIR
VIII Congresso Pernambucano de Fisioterapia Respiratória, Cardiovascular e em Terapia Intensiva da ASSOBRAFIR

23 a 25 de novembro de 2023 | Hotel Beach Class Convention

ASSOBRAFIR
Regional Pernambuco

CERTIFICADO

Certificamos que

BEATRIZ RITHIELY HENRIQUE RAMOS DA SILVA

participou do Curso teórico prático: Cateter Nasal de alto fluxo aplicado à pediatria, proferido pela Profa. Andrezza Lemos | Crefito 1 – 57968F, realizado em 23 de novembro de 2023, das 14h00 às 18h00, presencialmente, no Hotel Beach Class Convention. Carga horária total: 04 horas. Esta atividade é parte integrante do **VIII Congresso Pernambucano de Fisioterapia Respiratória, Cardiovascular e em Terapia Intensiva da Assobrafir (VIII COPEFIR)**.

Promoção Assobrafir Regional Pernambuco.

Recife - PE, 23 de novembro de 2023.

Validação Online
Código: xb4yvng62Q

Dr. Daniel da Cunha Ribeiro
PRESIDENTE

Dr. Claudio Gonçalves de Albuquerque
DIRETOR - REGIONAL PERNAMBUCO

Dra. Fernanda de Córdoba Lanza
DIRETORA CIENTÍFICA GERAL

ANEXO R – ATIVIDADES TÉCNICAS E CONTRIBUIÇÕES CIENTÍFICAS REALIZADAS DURANTE O PERÍODO DO MESTRADO

VIII COPEFIR
VIII Congresso Pernambucano de Fisioterapia Respiratória, Cardiovascular e em Terapia Intensiva da ASSOBRAFIR

23 a 25 de novembro de 2023 | Hotel Beach Class Convention

ASSOBRAFIR
Regional Pernambuco

CERTIFICADO

Certificamos que

BEATRIZ RITHIELY HENRIQUE RAMOS DA SILVA

participou do Curso teórico prático: Estratégias de utilização da ultrassonografia cinesiológica para fisioterapeutas, proferido pelo Prof. Wildberg Alencar | Crefito 1 - 17144F, realizado em 23 de novembro de 2023, das 8h00 às 12h00, presencialmente, no Hotel Beach Class Convention. Carga horária total: 04 horas. Esta atividade é parte integrante do **VIII Congresso Pernambucano de Fisioterapia Respiratória, Cardiovascular e em Terapia Intensiva da Assobrafir (VIII COPEFIR)**.

Promoção Assobrafir Regional Pernambuco.

Recife - PE, 23 de novembro de 2023.

Validação Online
Código: 4191QCljDw

Dr. Daniel da Cunha Ribeiro
PRESIDENTE

Dr. Claudio Gonçalves de Albuquerque
DIRETOR - REGIONAL PERNAMBUCO

Dra. Fernanda de Córdoba Lanza
DIRETORA CIENTÍFICA GERAL