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Citation: Beretta, Victor Spiandor, Santos, Paulo Cezar Rocha, Orcioli-Silva, Diego, Zampier, Vinicius Cavassano, Vitorio, Rodrigo and Gobbi, Lilian Teresa Bucken (2022) Transcranial direct current stimulation for balance rehabilitation in neurological disorders: a systematic review and meta-analysis. Ageing Research Reviews, 81. p. 101736. ISSN 1568-1637

Published by: Elsevier

<https://doi.org/10.1016/j.arr.2022.101736>

URL:

https://doi.org/10.1016/j.arr.2022.101736

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PII: S1568-1637(22)00178-7

DOI: https://doi.org/10.1016/j.arr.2022.101736

Reference: ARR101736

To appear in: Ageing Research Reviews

Received date:21 March 2022Revised date:14 September 2022Accepted date:14 September 2022

Please cite this article as: Victor Spiandor Beretta, Paulo Cezar Rocha Santos, Diego Orcioli-Silva, Vinicius Cavassano Zampier, Rodrigo Vitório and Lilian Teresa Bucken Gobbi, Transcranial direct current stimulation for balance rehabilitation in neurological disorders: a systematic review and meta-analysis, *Ageing Research Reviews*, (2022) doi:https://doi.org/10.1016/j.arr.2022.101736

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Transcranial direct current stimulation for balance rehabilitation in neurological disorders: a systematic review and meta-analysis

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Declarations of Interest: none.

ABSTRACT

Postural instability is common in neurological diseases. Although transcranial direct current stimulation (tDCS) seems to be a promising complementary therapy, emerging evidence indicates mixed results and protocols' characteristics. We conducted a systematic review and meta-analysis, on PubMed, EMBASE, Scopus, and Web of Science, to synthesize key findings of the effectiveness of single and multiple sessions of tDCS alone and combined with other interventions on balance in adults with neurological disorders. Thirty-seven studies were included in the systematic review and 33 in the meta-analysis. The reviewed studies did not personalize the stimulation

protocol to individual needs/characteristics. A random-effects meta-analysis indicated that tDCS alone (SMD = -0.44; 95%CI = -0.69/-0.19; p<0.001) and combined with another intervention (SMD = -0.31; 95%CI = -0.51/-0.11; p=0.002) improved balance in adults with neurological disorders (small to moderate effect sizes). Balance improvements were evidenced regardless of the number of sessions and targeted area. In summary, tDCS is a promising therapy for balance rehabilitation in adults with neurological disorders. However, further clinical trials should identify factors that influence responsiveness to tDCS for a more tailored approach, which may optimize the clinical use of tDCS.

Keywords: Brain stimulation, Postural balance, Parkinson's disease, Stroke, Ageing, tDCS.

1. INTRODUCTION

Several neurological diseases, such as Parkinson's disease (PD), stroke, cerebellar ataxia, and Alzheimer's disease, affect static, dynamic, and reactive postural control (Halmi et al., 2020; Mancini et al., 2020; Mesbah et al., 2017; Nonnekes et al., 2018; Tyson et al., 2006; van de Warrenburg et al., 2005). Neural impairments related to such diseases impair the sensory-motor system and neuromuscular control, leading to deficits in mechanical and muscular coordination during postural/balance tasks (Horak et al., 1997, 1992). Since adequate postural control is important to maintain balance during activities of daily living (Gandolfi et al., 2018), neurological-related impairments on postural control interfere with functional independence and quality of life, and increase the risk of falls (Nonnekes et al., 2018; Stolze et al., 2004). It is, therefore, reasonable that one major concern in the field refers to the development of enhanced

therapies to minimize postural impairments in neurological populations (Nonnekes et al., 2018).

The postural control and balance impairments are less responsive to drug therapy in neurological diseases (Curtze et al., 2015). Alternatively, complementary therapies have been proposed to improve postural control and balance (Beretta et al., 2020a, 2020b; de Moura et al., 2019; Morya et al., 2019; Vitório et al., 2019). Particularly, a growing body of evidence suggests transcranial direct current stimulation (tDCS) as a promising therapy for cognition and motor impairments such as postural control and balance (Andrade et al., 2017; Baharlouei et al., 2020; Beretta et al., 2020a; de Moura et al., 2019; Guo et al., 2020; Orrù et al., 2019; Sandrini et al., 2020; Sohn et al., 2013; Summers et al., 2016; Zandvliet et al., 2018). tDCS is a non-invasive brain stimulation technique that applies a weak electrical current (1–4 mA) over the scalp to modulate the spontaneous neuronal network activity (Brunoni et al., 2012; Farnad et al., 2021; Nitsche et al., 2008). The modulation of neuronal activity is dependent on tDCS polarity, in which anodal tDCS increases neuronal excitability whereas cathodal stimulation decreases neuronal excitability (Nitsche and Paulus, 2001, 2000).

Several mechanisms have been proposed for the postural improvements achieved with tDCS. For example, tDCS can modulate functional connectivity of different brain areas involved in the direct and indirect pathways of postural control (Beretta et al., 2020b; Morya et al., 2019; Schoellmann et al., 2019). Even deeper basal ganglia areas (e.g., caudate nucleus and striatum) involved in postural control have been shown to be modulated by tDCS in patients with neurological diseases (Filmer et al., 2020; Rudroff et al., 2022; Stagg et al., 2009; Tanaka et al., 2013). tDCS can also modulate the activity of cortical areas involved in compensatory mechanisms of executive control (Chan et al., 2021; Conceição et al., 2021). Additionally, specifically

for neurological diseases characterized by asymmetric brain damage, such as PD and stroke (Agius Anastasi et al., 2017; Brunoni et al., 2012; Cosentino et al., 2017), tDCS may improve the equilibrium in imbalanced neural networks between brain hemispheres (Cosentino et al., 2017; Fregni and Pascual-Leone, 2007). However, although promising, mixed results have been reported about the effect of tDCS on balance (Forogh et al., 2018; Manenti et al., 2016; Seo et al., 2017), likely due to the heterogeneity of the stimulation characteristics (Beretta et al., 2020a; Madrid and Benninger, 2021; Morya et al., 2019; Orrù et al., 2019). Therefore, systematically reviewing the literature might help to understand whether the potential tDCS benefits on postural control are consistently and functionally relevant in the context of neurological diseases.

Although systematic reviews on the topic exist (Beretta et al., 2020a; Broeder et al., 2015; de Moura et al., 2019; Dong et al., 2021; Lee et al., 2019; Liu et al., 2021; Oliveira et al., 2022), the knowledge is limited. Specifically, there is no consensus regarding the effects of tDCS on postural control in specific neurological populations, such as stroke and PD (Dong et al., 2021; Liu et al., 2021; Oliveira et al., 2022). In addition, the optimum tDCS montage (i.e., target area and electrodes position) and dosage have not been established for protocols targeting postural rehabilitation (Liu et al., 2021; Orrù et al., 2019). For example, current intensity and the number of sessions (e.g., single vs. multiple session(s) of tDCS) may influence the effects of tDCS on postural tasks (Beretta et al., 2020b; Orrù et al., 2019; Workman et al., 2020), but the evidence is limited, thus making solid conclusions difficult (Orrù et al., 2019). Also, it has not been established which brain area should be targeted for optimal benefits. Furthermore, it remains unclear whether the combination of tDCS with an additional physical/motor or cognitive intervention may enhance benefits to balance/posture.

These factors together indicate relevant niches to examine and verify the use of tDCS as a potential complementary therapy for posture and balance in neurological populations (Santos Ferreira et al., 2019; Vitório et al., 2019). Therefore, the primary aim of this study was to analyze the effect of single and multiple sessions of tDCS, as a stand-alone intervention and when combined with other interventions, on postural control and balance in adults with different neurological disorders. We also examined the influence of specific parameters of the stimulation protocol (i.e., target area, outcome domain, and type of neurological diseases) on the effect of tDCS on postural control and balance.

2. MATERIAL AND METHODS

The present systematic review and meta-analysis was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO; CRD42021254481) and written following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021).

2.1 Eligibility criteria

Inclusion criteria followed PICOS: (1) adults with neurological disorders (i.e., young and older adults), (2) tDCS alone or combined with another intervention, (3) presence of sham stimulation or control group (CG) (without active tDCS condition), (4) included at least one measurement of postural control or balance as an outcome, and (5) randomized and non-randomized controlled trials, observational studies, and experimental designs. We excluded manuscripts written in a non-English language, pre-print, any open-label studies, review articles, book chapters, commentaries, conference abstracts, study protocols, and manuscripts with the population composed of children.

For the synthesis of the information, the postural control and balance outcomes were grouped in main domains according to the characteristics of the test: static (e.g., posturography during standing or seated), dynamic/functionality (e.g., Berg Balance Scale-BBS, Timed Up and Go test-TUG, etc), and postural adjustments (e.g., parameter of the anticipatory and reactive postural adjustments). We considered the definition for the outcomes (balance and posture) as it was originally described by their respective authors.

2.2 Search strategy

The following databases (PubMed, EMBASE, Scopus, and Web of Science) were searched for articles until May 27th, 2021. One of the authors (VSB) created the search strategy, reviewed by a librarian (Institute of Biosciences, São Paulo State University, Rio Claro), and approved by all authors. The search strategy was presented in Table 1. Also, additional articles were included by screening reference lists from other systematic reviews on similar topics.

Insert Table 1

2.3 Selection process

Duplicates of the manuscripts identified by the databases search were excluded using a reference manager software and the remaining titles were then summarized into a table. Two independent authors (VSB and PCRS) screened the titles and abstracts and checked for the eligibility of the studies. Full texts were reviewed when titles and abstracts information was not clear. A third author (RV) made the final decision in case of inconsistencies between the two authors.

2.4 Data collection process

Data from each study were extracted by two authors independently, confirmed by a third, and synthesized into a table format. All authors (VSB, PCRS, DOS, VCZ, RV, and LTBG) participated in the data extraction process. The WebPlotDigitizer software (Drevon et al., 2017; Rohatgi, 2020) was used to extract data from figures for the meta-analysis. In addition, if results were not conclusive reported, we emailed the corresponding author of the respective study requesting data. Data included were summarized using the PICOS (population, intervention, comparison, outcomes, and study design) and also including the main results. The study details (author's name, publication year, type of neurological disease, sample size, and study design), participant's characteristics (groups, age, and sex), intervention details (characteristics of the tDCS protocol and the presence of additional intervention), comparison/control, outcome measures (main and additional outcomes, and measurement times) and key findings were tabulated.

2.5 Methodological quality assessment risk of bias

Two authors (VSB and PCRS) assessed, independently, the methodological quality and the risk of the bias of the included studies using the Physiotherapy Evidence Database (PEDro) rating scale (Maher et al., 2003) and the Cochrane risk of bias assessment (Higgins et al., 2020, 2011), respectively, and a third author solved inconsistencies (RV). The PEDro scale estimated study methodological quality using a checklist of 11 items regarding the group allocation, blinding, attrition, statistical analyses, and data variability. However, the first item is not used to calculate the score (Baharlouei et al., 2020; Maher et al., 2003). Studies with scores 9-10 were considered with excellent methodological quality, 6-8 good, 4-5 fair, and <4 poor (Baharlouei et al., 2020; de Morton, 2009). The Cochrane risk of bias assessment includes seven

domains (Higgins et al., 2020): random sequence allocation, allocation concealment, blinding of participants and personnel, blinding of outcome assessors, incomplete outcome data, selective reporting, and other sources of bias. Review Manager 5.4 software (The Cochrane Collaboration, 2020) was used to evaluate the risk of bias assessment which has three levels in each domain: low risk, high risk, and unclear.

2.6 Meta-analysis

We conducted the meta-analysis using Review Manager 5.4 (The Cochrane Collaboration, 2020). The standardized mean difference (SMD) and standard error (SE) were calculated to quantify individual effect sizes due to the differences in the data nature (outcomes and tests) (Lee et al., 2019; Murad et al., 2019). Statistical analysis was performed using the generic inverse variance method for the comparison between the effects of the active tDCS vs. sham tDCS and between the experimental group (i.e., active tDCS combined with another intervention) vs. CG on postural control and balance. The included data on meta-analysis are detailed in Supplementary Table S1. To address the aims of this study we conducted subgroup analysis for single and multiple sessions with tDCS for each comparison. In addition, we collapsed the studies of tDCS alone and combined with another intervention, and performed subgroup analysis to investigate possible differences of tDCS effect regarding the characteristics of the target area stimulated, the outcome domain, and the population characteristics. Negative SMD indicated a favoring for active tDCS/experimental group and a positive value indicated a favoring for sham/CG. For that, in the parameters whose higher value reflects better performance (e.g., BBS), a transformation was carried out by multiplying by -1. We interpreted the SMD values similar to Cohen's d (≤ 0.2 as small, around 0.5 as moderate, and > 0.8 as large effects) (Cohen, 1998).

A random-effect model was used in all comparisons due to heterogeneity in participant, intervention, and outcome characteristics of the included studies (de Moura et al., 2019; Lee et al., 2019). Also, the heterogeneity between the studies was assessed using the I² statistics which represents the percentage of the heterogeneity (I² > 50% indicate a substantial heterogeneity between studies that difficult the interpretation of the results) (Higgins and Thompson, 2002). Thus, when the heterogeneity threshold is above 50%, we performed a sensitivity analysis to control the heterogeneity by excluding one study at a time (Dong et al., 2021). For that, we investigate the presence of possible publication bias by the funnel plot observation (Supplementary material).

3. RESULTS

3.1 Study selection

The PRISMA flow diagram shows the information regarding the different steps of the search and screening process (Figure 1). Initially, our database search identified 1585 potential studies. Eight hundred and ninety-eight duplicates were removed. After reviewing titles and abstracts, 51 studies were included, and five additional studies (Forogh et al., 2018; Geroin et al., 2011; Madhavan et al., 2020; Manenti et al., 2016; Tahtis et al., 2014) were included from other systematic reviews on similar topics. After full text review, 19 studies were excluded due to the following reasons: without sham/CG (n = 9) (Alexoudi et al., 2018; Dumont et al., 2015; Hadoush et al., 2018; Mohammadi et al., 2021; Naro et al., 2020; Pilloni et al., 2019; Rezaee et al., 2020; Ricci et al., 2019; Solanki et al., 2021), another population (n = 3) (Jafarzadeh et al., 2019; Maldonado and Bernard, 2021; Manor et al., 2018), another intervention (n = 1) (Koganemaru et al., 2019), and another outcome (n = 6). Finally, 37 articles were included for the systematic reviews and 33 for the meta-analysis (two studies were excluded from the meta-analysis because of the design (case reports) and two due to incomplete data) (Costa et al., 2020; Forogh et al., 2018; Kaski et al., 2014a; Verheyden et al., 2013).

Insert Figure 1

3.2 Study characteristics

Table 2 presents the characteristics of the 37 included studies in the systematic review. The studies were published from 2011 to 2021. Of the 37 included studies, 19 were conducted with people with stroke (Andrade et al., 2017; Babyar et al., 2018, 2016; Chang et al., 2015; Coppens et al., 2019; Danzl et al., 2013; Fruhauf et al., 2017; Geroin et al., 2011; Liang et al., 2020; Madhavan et al., 2020; Manji et al., 2018; Ojardias et al., 2020; Prathum et al., 2021; Saeys et al., 2015; Seo et al., 2017; Sohn et al., 2013; Tahtis et al., 2014; Yang et al., 2021; Zandvliet et al., 2018), 10 with PD (Beretta et al., 2020b; Costa-Ribeiro et al., 2017; Forogh et al., 2018; Kaski et al., 2014b, 2014a; Lattari et al., 2017; Lu et al., 2018; Manenti et al., 2016; Verheyden et al., 2013; Workman et al., 2020), three with cerebellar ataxia (Barretto et al., 2019; Benussi et al., 2015; Grimaldi and Manto, 2013), one with multiple sclerosis (Costa et al., 2020), one with vestibular dysfunction (Saki et al., 2020), one with Mal de debarquement syndrome (Cha et al., 2016), one with Leukoaraiosis (Kaski et al., 2013), and one with Spinal cord injury (Raithatha et al., 2016). Regarding the target area, 26 studies applied active tDCS (anodal current) over motor cortex (Andrade et al., 2017; Barretto et al., 2019; Beretta et al., 2020b; Chang et al., 2015; Coppens et al., 2019; Costa-Ribeiro et al., 2017; Costa et al., 2020; Danzl et al., 2013; Fruhauf et al., 2017; Geroin et al., 2011; Kaski et al., 2014b, 2014a, 2013; Liang et al., 2020; Lu et al., 2018;

Madhavan et al., 2020; Manji et al., 2018; Ojardias et al., 2020; Prathum et al., 2021; Raithatha et al., 2016; Saeys et al., 2015; Seo et al., 2017; Sohn et al., 2013; Tahtis et al., 2014; Verheyden et al., 2013; Yang et al., 2021), five over prefrontal cortex (PFC) (Cha et al., 2016; Forogh et al., 2018; Lattari et al., 2017; Manenti et al., 2016; Saki et al., 2020), four over the cerebellum (Benussi et al., 2015; Grimaldi and Manto, 2013; Workman et al., 2020; Zandyliet et al., 2018), and two over parietal-insular vestibular cortex (PIVC) (Babyar et al., 2018, 2016). For the characteristics of stimulation, the current intensity ranged from 0.6 to 4 mA, with 2 mA being the most commonly used intensity (n = 25 studies) (Andrade et al., 2017; Babyar et al., 2018, 2016; Barretto et al., 2019; Benussi et al., 2015; Beretta et al., 2020b; Chang et al., 2015; Coppens et al., 2019; Costa-Ribeiro et al., 2017; Costa et al., 2020; Danzl et al., 2013; Fruhauf et al., 2017; Kaski et al., 2014b, 2014a, 2013; Lattari et al., 2017; Liang et al., 2020; Manenti et al., 2016; Ojardias et al., 2020; Prathum et al., 2021; Raithatha et al., 2016; Saki et al., 2020; Seo et al., 2017; Sohn et al., 2013; Tahtis et al., 2014). The stimulation duration ranged from 7 to 40 minutes, with 20 minutes of stimulation applied in 21 studies (Babyar et al., 2016; Benussi et al., 2015; Beretta et al., 2020b; Cha et al., 2016; Costa et al., 2020; Danzl et al., 2013; Forogh et al., 2018; Fruhauf et al., 2017; Grimaldi and Manto, 2013; Lattari et al., 2017; Liang et al., 2020; Manji et al., 2018; Ojardias et al., 2020; Prathum et al., 2021; Raithatha et al., 2016; Saeys et al., 2015; Saki et al., 2020; Seo et al., 2017; Workman et al., 2020; Yang et al., 2021; Zandvliet et al., 2018). Among all the included articles, there were 15 studies that applied tDCS as a standalone intervention (Babyar et al., 2018, 2016; Barretto et al., 2019; Benussi et al., 2015; Beretta et al., 2020b; Coppens et al., 2019; Grimaldi and Manto, 2013; Lattari et al., 2017; Lu et al., 2018; Ojardias et al., 2020; Sohn et al., 2013; Tahtis et al., 2014; Verheyden et al., 2013; Workman et al., 2020; Yang et al., 2021), and 22 combined

tDCS with other interventions (Andrade et al., 2017; Cha et al., 2016; Chang et al., 2015; Costa-Ribeiro et al., 2017; Costa et al., 2020; Danzl et al., 2013; Forogh et al., 2018; Fruhauf et al., 2017; Geroin et al., 2011; Kaski et al., 2014a, 2013, 2014b; Liang et al., 2020; Madhavan et al., 2020; Manenti et al., 2016; Manji et al., 2018; Prathum et al., 2021; Raithatha et al., 2016; Saeys et al., 2015; Saki et al., 2020; Seo et al., 2017; Zandvliet et al., 2018). Regarding tDCS alone, 14 studies applied a single session (Babyar et al., 2018, 2016; Benussi et al., 2015; Beretta et al., 2020b; Coppens et al., 2019; Grimaldi and Manto, 2013; Lattari et al., 2017; Lu et al., 2018; Ojardias et al., 2020; Sohn et al., 2013; Tahtis et al., 2014; Verheyden et al., 2013; Workman et al., 2020; Yang et al., 2021) and one conducted five sessions (Barretto et al., 2019). Five studies applied a single session of tDCS combined with other interventions (Fruhauf et al., 2017; Kaski et al., 2014b, 2013; Liang et al., 2020; Zandvliet et al., 2018), and 17 conducted multiples (2 to 36) sessions (Andrade et al., 2017; Cha et al., 2016; Chang et al., 2015; Costa-Ribeiro et al., 2017; Costa et al., 2020; Danzl et al., 2013; Forogh et al., 2018; Geroin et al., 2011; Kaski et al., 2014a; Madhavan et al., 2020; Manenti et al., 2016; Manji et al., 2018; Prathum et al., 2021; Raithatha et al., 2016; Saeys et al., 2015; Saki et al., 2020; Seo et al., 2017). Most studies conducted motor/physical interventions combined with tDCS (n = 20) (Andrade et al., 2017; Chang et al., 2015; Costa-Ribeiro et al., 2017; Costa et al., 2020; Danzl et al., 2013; Forogh et al., 2018; Geroin et al., 2011; Kaski et al., 2014b, 2014a, 2013; Liang et al., 2020; Madhavan et al., 2020; Manenti et al., 2016; Manji et al., 2018; Prathum et al., 2021; Raithatha et al., 2016; Saeys et al., 2015; Saki et al., 2020; Seo et al., 2017; Zandvliet et al., 2018). In relation to the postural control and balance outcomes, among the 37 articles included, 22 analyzed parameters related to the domain of dynamic/functionality of balance

(Andrade et al., 2017; Benussi et al., 2015; Cha et al., 2016; Chang et al., 2015; Costa-

Ribeiro et al., 2017; Costa et al., 2020; Danzl et al., 2013; Forogh et al., 2018; Geroin et al., 2011; Kaski et al., 2014a; Lattari et al., 2017; Madhavan et al., 2020; Manenti et al., 2016; Manji et al., 2018; Prathum et al., 2021; Raithatha et al., 2016; Saeys et al., 2015; Saki et al., 2020; Seo et al., 2017; Tahtis et al., 2014; Verheyden et al., 2013; Workman et al., 2020), eight analyzed static postural control (Babyar et al., 2018, 2016; Barretto et al., 2019; Fruhauf et al., 2017; Grimaldi and Manto, 2013; Ojardias et al., 2020; Sohn et al., 2013; Zandvliet et al., 2018), and seven analyzed parameters of postural adjustments (Beretta et al., 2020; Coppens et al., 2019; Kaski et al., 2014b, 2013; Liang et al., 2020; Lu et al., 2018; Yang et al., 2021).

Insert Table 2

3.3 Methodological quality assessment (risk of bias)

The methodological quality, rated with PEDro score, ranged from 2 to 10, and the included studies were classified (percentage of the studies) as excellent (40.54%), good (51.35%), fair (5.41%), and poor (2.70%) methodological quality (Table 3).

Insert Table 3

Most included studies demonstrated some potential risk for bias (34/37) according to Cochrane's recommendation.(Higgins et al., 2011) Our assessment of the risk of bias revealed that 48.65% of the studies presented a low risk of randomization bias, allocation concealment (48.65% of studies), blinding of participants and personnel (89.19% of studies), blinding of outcome assessors (70.27% of studies), incomplete outcome data (86.49% of studies) and other sources of bias (78.38% of studies). Also,

most studies presented an unclear risk of bias for selective reporting (83.78%). Figure 2 shows the risk of bias with Cochrane's recommendation (Higgins et al., 2011).

Insert Figure 2

3.4 Meta-analysis results

The data of each study inserted on meta-analysis are shown in Supplementary Table S1.

3.4.1 Single and multiple sessions of tDCS alone

As reported above, multiple sessions of tDCS alone were conducted in only one study (Barretto et al., 2019). Thus, we collapsed the studies with single and multiple sessions of tDCS for the meta-analysis. The analysis of 15 studies indicated a significant improvement on postural control and balance after active tDCS compared with sham/CG (SMD = -0.44 (moderate); 95% CI = -0.69 to -0.19; Z = 3.48; p < 0.001). There is no heterogeneity between the included studies ($I^2 = 21\%$; p = 0.22) (Figure 3a).

3.4.2 Single and multiple sessions of tDCS combined with another intervention

Five studies performed a single session of tDCS and 17 conducted multiples sessions. Thus, we performed a subgroup analysis for single and multiple sessions of tDCS. The analysis indicated no significant subgroup effect (p = 0.66), suggesting that the number of tDCS sessions does not influence the effect of the tDCS in experimental group compared with CG (SMD = -0.43 (moderate); 95% CI = -0.71 to -0.14; Z = 2.90; p = 0.004). However, heterogeneity was significant among studies in the multiple session's subgroup ($I^2 = 66\%$; p = 0.0003) (Figure S1a). Thus, a sensitivity analysis was

performed by the funnel plot observation (Figure S1b-c) and one study (Andrade et al., 2017) was excluded achieving $I^2 = 24\%$ for multiple sessions subgroup and $I^2 = 9\%$ (p = 0.34) for overall analysis. The analysis continued showing no subgroup differences (p = 0.90) indicating a significant improvement on postural control and balance for experimental group compared with CG (SMD = -0.31 (moderate); 95% CI = -0.51 to - 0.11; Z = 3.04; p = 0.002) (Figure 3b) when single and multiple sessions were combined with another intervention.

Insert Figure 3

3.4.3 tDCS for postural control and balance

As there were no statistical differences between single and multiple sessions of tDCS for postural control and balance, we collapsed the studies to investigate the effect of tDCS alone and combined with other interventions. Fifteen studies were included for the tDCS alone subgroup and 19 in tDCS combined with another intervention subgroup. The analysis indicated no significant subgroup effect (p = 0.93), suggesting that the combination (or not) with another intervention does not influence the effect of the tDCS in experimental group compared with CG (SMD = -0.44 (moderate); 95% CI = -0.63 to -0.24; Z = 4.43; p<0.001). However, there was significant heterogeneity among the included studies in tDCS combined with another intervention subgroup ($I^2 = 57\%$; p = 0.001) (Figure S2a). After the sensitivity analysis (Figure S2b-c), one study (Andrade et al., 2017) was excluded achieving $I^2 = 9\%$ for tDCS combined with another intervention subgroup and $I^2 = 14\%$ (p = 0.24) for overall analysis. The analysis continued indicating no subgroup differences (p = 0.42), revealing significant improvements on postural

control and balance for experimental group compared with CG (SMD = -0.37 (moderate); 95% CI = -0.52 to -0.21; Z = 4.63; p<0.001) (Figure 4).

Insert Figure 4

3.4.4 Target area

We collapsed the studies of tDCS alone and combined with another intervention (due to the lack of difference between these factors on the overall effect of tDCS on postural control) to investigate the influence of the target area that the tDCS was applied. Four subgroups were included regarding the stimulated target area: motor cortex (n = 23), PFC (n = 4), cerebellum (n = 4) and PIVC (n = 2 studies). The metaanalysis indicated no significant subgroup effect (p = 0.87), suggesting that the target area does not influence the greater effect observed for the experimental group compared with CG (SMD = -0.45 (moderate); 95% CI = -0.64 to -0.25; Z = 4.48; p<0.001) (Figure S3a). A significant heterogeneity was revealed for motor cortex ($I^2 = 51\%$; p = 0.003) and PIVC ($I^2 = 83\%$; p = 0.02) subgroups (Figure S3b-c). After the sensitivity analysis, one study (Andrade et al., 2017; Babyar et al., 2018) was excluded for each subgroups achieving $I^2 = 5\%$ for motor cortex and because the number of study remaining in PIVC (n = 1) this subgroup was excluded from the analysis. The heterogeneity for overall analysis was $I^2 = 14\%$ (p = 0.24). The analysis continued revealing no subgroup differences (p = 0.68) indicating a significant improvement on postural control and balance in experimental group vs. CG (SMD = -0.36 (moderate); 95% CI = -0.51 to -0.21; Z = 4.69; p<0.001) (Figure 5) regardless of stimulated area.

Insert Figure 5

3.4.5 Outcome domain of postural control and balance

Three subgroups were included regarding the outcome of postural control and balance: static (n = 8), dynamic/functionality (n = 18), and postural adjustments (n = 7)studies). No significant subgroup effect was revealed (p = 0.88) suggesting that the outcome does not influence the greater effect observed for the experimental group compared with CG (SMD = -0.45 (moderate); 95% CI = -0.64 to -0.25; Z = 4.48; p<0.001) A significant heterogeneity (Figure S4a). indicated for was dynamic/functionality subgroup ($I^2 = 57\%$; p = 0.002) (Figure S4b-c). After the sensitivity analysis, one study (Andrade et al., 2017) was excluded achieving $I^2 = 1\%$ for dynamic/functionality and $I^2 = 15\%$ (p = 0.23) for overall analysis. The analysis continued revealing no subgroup differences (p = 0.44) indicating a significant improvement on postural control and balance in experimental group vs. CG (SMD = -0.38 (moderate); 95% CI = -0.54 to -0.22; Z = 4.67; p<0.00001) regardless of outcome domain (Figure 6).

Insert Figure 6

3.4.6 Type of neurological disorders

Three subgroups were included regarding the type of neurological disorders: PD (n = 7), stroke (n = 19), and cerebellar ataxia (n = 3 studies). No significant subgroup effect were indicated (p = 0.75) suggesting that the type of neurological disorders does not influence the greater effect of tDCS on balance observed for the experimental group compared with CG (SMD = -0.40 (moderate); 95% CI = -0.61 to -0.20; Z = 3.79; p = 0.0002) (Figure S5a). Heterogeneity was significant for stroke subgroup (I² = 59%; p =

0.0005) (Figure S5b-c). One study(Andrade et al., 2017), after the sensitivity analysis, was excluded achieving $I^2 = 22\%$ for stroke and $I^2 = 10\%$ (p = 0.32) for overall analysis. The analysis continued indicating no subgroup differences (p = 0.97) and improvement in experimental group compared with CG remained significant in all neurological disorders (SMD = -0.32 (moderate); 95% CI = -0.48 to -0.16; Z = 3.91; p<0.0001) (Figure 7).

Insert Figure 7

Figure 8 summarizes the main findings of the effect size (i.e., SMD) from the meta-analysis regarding the primary and secondary aims of the study.

Insert Figure 8

4. DISCUSSION

The present study primarily aimed to analyze the effect of single and multiple sessions of tDCS, as a stand-alone intervention and when combined with other interventions, on postural control and balance in adults with neurological disorders. We also examined the influence of specific parameters of the stimulation protocol (i.e., target area, outcome domain, and type of neurological disease) on the effect of tDCS on postural control and balance. Overall, tDCS effects on balance and postural tasks were small to moderate (SMD ranged from -0.28 to -0.58) and consistent (heterogeneity \leq 21% after sensitivity analysis). Those tDCS effects were non-specific for single and multiple sessions alone and combined with physical/motor therapy and regardless of the neurological disease subgroups (i.e., PD, Stroke, Cerebellar ataxia). In addition, it is important to highlight that studies included in the current review presented substantial

diversity in terms of tDCS protocols, additional combined interventions, and populations, which might blur solid conclusions (Table 2) (Fregni et al., 2021; Orrù et al., 2019).

4.1 Single and Multiple sessions of tDCS (potential mechanisms)

Single and multiple sessions of tDCS moderately improved postural control. These findings signal tDCS as a relevant intervention to treat postural control deficits in adults with neurological diseases. Potentially, the observed effects might be related to tDCS capacity to modulate/improve cortical excitability (Nitsche and Paulus, 2001, 2000) and brain functional connectivity (Hordacre et al., 2018; Morya et al., 2019; Polanía et al., 2011). Single sessions of tDCS may enhance the equilibrium and functioning of imbalanced neural brain networks (Cosentino et al., 2017; Fregni and Pascual-Leone, 2007) and pathways involved in postural control (Beretta et al., 2020b; Nonnekes et al., 2014). tDCS has been shown to modulate the NMDA receptors' activities and the calcium levels improving the strength of the neuronal synapsis (Islam et al., 1995; Nitsche et al., 2004; Polanía et al., 2011) and favoring neuroplasticity (Chan et al., 2021; Nitsche et al., 2008; Polanía et al., 2011). In addition, tDCS changes blood flow, increasing the oxygenation of the neurons and enhancing excitability, functionality, and functional connectivity of the target area (Zheng et al., 2011). A cumulative effect on cortical excitability was evidenced after five consecutive days of anodal tDCS applied over the motor cortex (Ho et al., 2016). The long-term improvements of functional connectivity are factors of the motor circuits reorganization (Ward, 2011) which may influence the motor function recovery (Fregni and Pascual-Leone, 2007). In summary, both single and multiple sessions of tDCS on cortical excitability and motor impairments, such as postural control and balance, may suggest

possible therapeutic applications in healthy older adults and adults with neurological diseases (Fregni et al., 2021; Fregni and Pascual-Leone, 2007; Lüdemann-Podubecká et al., 2014; Morya et al., 2019; Tatti et al., 2016).

4.2 tDCS alone and tDCS combined with another intervention

tDCS improved postural control and balance in adults with neurological diseases regardless of being applied as a stand-alone intervention or combined with another intervention. Although the meta-analysis indicated no subgroup effect (stand-alone vs. combination with another intervention), findings suggested a slightly superior effect size of tDCS as a stand-alone intervention when compared with tDCS combined with other interventions (SMD = -0.44 vs. -0.31, Figure 4). This may be due to methodological differences in study design, which allows more room for change when tDCS is applied alone. Studies investigating tDCS as a stand-alone intervention usually have no-intervention control groups/conditions (i.e., sham vs. active tDCS). On the other hand, studies investigating the effects of tDCS vs. exercise + sham); in the later scenario, findings favoring tDCS represent effects that go beyond those observed with the combined intervention. This observation makes tDCS very attractive for postural control and balance rehabilitation as the tDCS can enhance benefits achieved with conventional interventions.

4.3 Target areas

Surprisingly, our results indicated no subgroup differences across stimulated brain areas. In summary, tDCS over the motor cortex, PFC and cerebellum improve balance in adults with neurological diseases (Figure 5). Because postural control

involves several cortical and subcortical areas (Mancini et al., 2020; Peterson and Horak, 2016; Takakusaki, 2017), studies investigating the effect of tDCS on postural control have stimulated different encephalic areas (Babyar et al., 2018; Beretta et al., 2020b; Lattari et al., 2017; Workman et al., 2020). Although most studies included in our review stimulated motor cortex (i.e., 70.3%), our results indicate a slightly superior positive effect of tDCS applied over PFC on balance (SMD = -0.58 vs. -0.32, Figures 8). The positive effects of tDCS over PFC on postural control reinforce the compensatory role of PFC due to deficits in movement automaticity in adults with neurological disorders (Beretta et al., 2020b; Herold et al., 2017; St George et al., 2021). However, our results may have been influenced by the low number of studies included in the PFC subgroup (n = 4), hence results should be considered carefully.

Because neurological diseases may affect the function of several brain areas involved in postural control, some studies have explored the effects of multi-target stimulation (Benninger et al., 2010; Dagan et al., 2018; Hadoush et al., 2018; Orrù et al., 2019). Multi-target stimulation (applied over both PFC and motor cortex) has shown superior effects (relative to mono-target) on motor function in patients with PD (Benninger et al., 2010; Dagan et al., 2018; Hadoush et al., 2018; Orrù et al., 2019). A possible explanation for the superior effect of multi-target is the improved communication between PFC and motor cortex and subcortical structures (Dagan et al., 2018; Vaseghi et al., 2015). Thus, future studies should consider investigating multi-target stimulation for postural control.

4.5 Postural control and balance outcomes

tDCS improved balance in adults with neurological disorders regardless of the outcome domain. In short, tDCS can improve static and dynamic/functional balance as

well as postural adjustments in situations with external perturbation. Despite the statistical analysis indicating no difference between the subgroups, our results suggested that dynamic/functionality had a lower effect size induced by tDCS (SMD = -0.28, Figure 8). This finding may be explained, at least in part, by differences in the "nature" of the outcome measures used across the different subgroups. Functional measures generally obtained by field tests may be less sensitive to detect the effectiveness of tDCS in postural control than kinetic, kinematic, and neuromuscular parameters analyzed in other balance domains (e.g., static and postural adjustments to perturbation) (Duarte and Freitas, 2010). Although field tests, such as the TUG and BBS, are valid and widely used, they involve the subjectivity of the evaluator (e.g., starting and stopping the stopwatch, and judging the level of functionality based on eye observation of behavior) and may indicate a ceiling effect (Sabchuk et al., 2012). On the other hand, kinetic, kinematic, and neuromuscular parameters are measures that do not involve the evaluator's subjectivity and ceiling effect and, therefore, can be more sensible to detect subtle differences in postural control induced by the tDCS (Quijoux et al., 2020; Sabchuk et al., 2012)

4.6 Neurological diseases condition

Curiously, tDCS indicated similar sensibility as a complementary therapy to balance for people with PD, stroke, and cerebellar ataxia. Although particular aspects of these diseases differently affect postural control, it should be highlighted that the tDCS in overall improved balance in adults with neurological disorders (SMD = 0.32). The benefits on balance may be due to improved functional connectivity of brain areas involved in postural control (Beretta et al., 2020b; Morya et al., 2019). Non-invasive brain stimulation can improve cortical and subcortical dysfunction in adults with neurological disorders (Fregni and Pascual-Leone, 2007; Nonnekes et al., 2014; Takakusaki, 2017). Specifically for PD and stroke (asymmetric brain disease) (Agius Anastasi et al., 2017; Brunoni et al., 2012; Cosentino et al., 2017), tDCS may improve the equilibrium in imbalanced neural networks between the brain hemispheres (Cosentino et al., 2017; Fregni and Pascual-Leone, 2007).

4.7 Existing limitations in the literature and future directions

Various aspects that may influence tDCS responsiveness remain poorly understood. The included studies did not investigate the level of baseline characteristics of the individuals that best respond to the tDCS. To date, individual characteristics have been shown to influence the effects of tDCS on motor and cognitive functions in healthy individuals and patients with PD (Beretta et al., 2021; Dagan et al., 2018; Li et al., 2015; Mizuguchi et al., 2018). Patients with PD with worse balance (Beretta et al., 2021) and more severity of freezing of gait (Dagan et al., 2018) at baseline showed greater improvement after tDCS protocol, while the clinical characteristics (disease duration and motor impairments) of PD seem to not influence the responsiveness to tDCS (Beretta et al., 2021; Fregni et al., 2006). Also, there is an unmet need for studies investigating optimal protocols by directly comparing specific tDCS parameters as well as studies applying a more tailored approach (Albizu et al., 2020), accounting for individual characteristics such as level of disease severity/stage. The typically applied "one size fits all" approach may result in some participants not receiving appropriate stimulation, which ultimately may lead to non-optimal effects. In addition, it should be noted that a high number of studies were excluded from this systematic review due to the lack of a CG or sham stimulation (n = 9) making the interpretation of the tDCS effect for postural control and balance in these neurological populations more difficult

24

(Ekhtiari et al., 2019). Thus, we encourage future studies to investigate the characteristics of the stimulation and patients that may increase the response to tDCS, and also report the information and include a CG/sham condition in the experimental design.

4.8 Strengths and limitations of the current study

Although we observed interesting findings, our study has limitations. The low number of studies included in some subgroup analyses may increase the risk of bias, making the indication of clinical applicability of these results less robust. The included studies are highly diversified in terms of tDCS protocol and additional intervention, population characteristics, and sample sizes. Such heterogeneity makes specific comparisons challenging. However, our analysis demonstrated good to excellent methodological quality and a generally low risk of bias (except for the reporting bias) for the reviewed studies. We also carefully checked all potential heterogeneity, excluding studies from the analysis in cases where heterogeneity was reached. We did not include studies published in the non-English language and the grey literature which could decrease the number of evidence about this topic. Also, we were unable, due low number of studies, to compare between single and multiple sessions of tDCS alone and between all types of neurological diseases identified in the systematic review. In addition, we have not analyzed the effect of tDCS for longer follow-up periods after the end of the interventions, which may help to understand the long-lasting tDCS effects on postural control and balance in adults with neurological disease.

5. CONCLUSION

tDCS is a promising complementary therapy to improve postural control and balance in adults with neurological disorders. The number of sessions, target area, combination or not with another intervention, the outcome measure, and type of neurological disease did not influence the effects of tDCS on postural control and balance. There is an unmet need for the development of tailored tDCS protocols and the identification of predictors of response, which may optimize the clinical use of tDCS. Also, future studies should investigate the effect of multiple sessions of tDCS alone on postural control and balance.

Acknowledgments

Funding: This work was supported by the São Paulo Research Foundation (FAPESP) [grant number #2018/07385-9]; National Council for Scientific and Technological Development (CNPq) [grant number #429549/2018-0, #309045/2017-7]; and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) [Finance Code 001].

Systematic Review Registration: International Prospective Register of Systematic Reviews (PROSPERO). Registration number (CRD42021254481).

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Figure Captions







Figure 2. Risk of bias assessment.

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-	
-	

			Active tDCS	Control		Std. Mean Difference	Std. Mean Difference
Study or Subgroup	Std. Mean Difference	SE	Total	Total	Weight	N, Random, 95% Cl	IV, Random, 95% Cl
Babyar et al. (2016)	0.0667	0.4716	9	9	5.9%	0.07 (-0.86, 0.99)	
Betwar et al. (2016)	-1.6616	0.5347	10	10	4.8%	-1.66 (-2.71, -0.61)	
Berreto et al. (2019)	-1.0263	0.5814	7	7	4.1%	-1.03 F-2.17, 0.11	
Benussi et al. (2015)	-0.2494	0.3258	19	19	10.3%	-0.25 (-0.89, 0.39)	
Regate et al. (2020)	.0.8289	0.3019	24	24	11.4%	-0.836142-0.24	
Comprise at al. (2019)	.0.0531	0.3923	13	13	7.9%	-0.05 L0.82, 0.72	
Grinoaldi & Mardo (2013)	.0.0777	0.5777	6	6	4,295	-0.086121.109	
Koski et al. (2014)	0.0497	0.5004	9	ä	5 4 96	0.056.0.93 1.03	
Latini at pl. (2017)	0.0400	0.9496	17	17	0.00	-0.14C0.01.0.03	
Londol (2010)	-0.1400	0.3433	10	10	E 496	-0.14[-0.01, 0.03]	
Direction at al. (2020)	-0.1001	0.4404	10	10	0.4%	-0.13[1.01,0.04]	
Childran Bran (2020)	-0.1014	0.004	10	10	0.4.78	-0.13 (-0.83, 0.06)	
Sonn et al. (2013)	-1.1212	0.4654	11	11	6.0%	-1.12[-2.03,-0.21]	
Tantis et al. (2014)	-0.465Z	0.5445	r	r	4.0%	-0.47 [-1.53, 0.60]	
Workman et al. (2020)	-0.2136	0.5366	7	7	4.8%	-0.21 [-1.27, 0.84]	
Yang et al. (2021)	-1.1141	0.4885	10	10	5.6%	-1.11 [-2.07, -0.16]	
Total (95% CI)			174	174	100.0%	0.441.0.69. 0.191	•
Hatempeneity Tag? = 0.05	CM*=1778 df=14/8	= 0.225	I*= 71%		10000	Party Construction	++
Test for overall effect 7 = 3	4B (P = 0.0005)	- 0.550					-4 -2 0 2 4
TANKIN PININ PININ M- P							Favours (Active tDCS) Favours (control)
6							
· · · · · · · · · · · · · · · · · · ·			Experimenta	Control		Std. Mean Difference	Std. Mean Lifterance
Study or Subgroup	518. Mean Difference	- 52	Tot	al Tota	I Weight	IV, Random, 95% CI	IV, Raidon, 95% Cl
6.1.1 Single session							
Pruhautetal (2017)	-1.2119	0.3663	1	9 15	5 5.3%	-0.21 [-0.93, 0.91]	
Kaski et al. (2013)	-1.5958	D.4 B46		9 5	8 4.1%	-0.60 [-1.55, 0.35]	
Kaski et al. (2014b)	-1.6201	0.6167		8 6	8 3.7%	-0.62 [-1.63, 0.39]	
Liang et al. (2020)	1.2591	0.4495	1	0 10	4.1%	0.261-0.62.1.141	
Zandviatet al. (201B)	-1.5698	0.3736	1	5 15	5 8.7%	-0.57 [-1.31, 0.16]	
Suborar (1994-Ci)		411 H - 1	-	er 34	20.25	-waat-waat-	
Heterogenery, Taur = 0.00,	UNF = 2.80, M = 4.0° = 0.	08, F=1	196				
THE REPORT OF PRESENCE 2. 4 1.1	/a (/· = 0.0d)						
6.1.2 Multiple session							
Andrade et al. (2017)	-2.2879	0.4045	3	0 18	5	Not estimable	
Cha et al. (2016)	-1.8726	0.4521	1	2 10	4.7%	-0.87 [-1.78, 0.81]	
Chang et al. (2015)	-1.3778	0.4129	1	2 12	5.6%	-0.38 1.19, 0.43	
Costa-Ribeiro et al. (2017)	1.3911	0.4313	1	1 11	5,1%	0.391-0.45, 1.241	
Danzi et al. (2013)	1.0311	0.7072		4 4	2.1%	0.03 -1.35, 1.42	
Gergin et al. (2011)	-1.2695	0.4497	1	0 10	4.6%	-0.27 -1.15, 0.61	
Madhavan et al. (2020)	-1.0832	0.3164	. 3	0 20	0 8.9%	-0.091-0.71.0.131	
Manent et al. (2018)	-1.1 229	0.4477	1	0 10	1.1%	-0.131-1.01-0.050	
Manii etal. (2018)	-1.0321	0.2582		a 30	12.5%	-0.031-0.54 0.471	
Profesion et al. (2021)	-1.3269	0.4115	1	2 15	5.6%	-0.33[-1.11], 0.48	
Rathatha et al. (2018)	-0.216	0.9735		ā 's	2 1.2%	-0.221-1.93 3 494	
Baevo et al. (2015)	-1.9217	0.3806	1	6 19	5 8,5%	-0.9211.67 -0.18	
Baki et al. (2020)	.1 1895	0.3639		8 16	2,6%	-1.16.61.880.45	
Sen et al. (2012)	1 3 7 9 3	0.4397		1 11	575	0.23 60.63 1.69	
Subtotal (95% CI)	8.6202	0.4001	17	0 154	73.8	.0.31 [.0.57, .0.05]	•
Heterogeneity, Tau ² =0.05	ChF=15.86. df=12.49 =	0.201: #	= 24%	- 7			•
Test for overall effect Z = 2	31 (P = 0.02)	a ang i r				· · ·	
							•
Total (55% CI)				7 221	100.05	-0.31 [-0.51, -0.11]	
Heterogeneity: Tau ^a = 0.02;	ChiF = 18.74, df = 17 (P =	0.340; P	= 9%				4 -2 0 2 4
Test for overall effect: Z = 3.	$04 \phi^2 = 0.002$					∇	Favours (experimental) Favours (control)
Test for subgroup difference	e:: Chi ^p = 0.03, df = 1 (P);	: D.9D). P	= 1%				

Haterogeneity: Tau² = 0.02; Chiř = 11.74, dř = 17.97 = 0.34(; ř = 9% Test for overall effect: Z = 3.04 (P = 0.002) Test for subarous differences: Chiř = 0.02; dř = 1 (P = 0.90; P = 0%)

Figure 3. Forrest plots of the meta-analysis. a) tDCS alone; b) single and multiple

sessions of tDCS combined with another intervention after sensitivity analysis.

			Experimental	Control		Std. Mean Difference	Std. Mean Difference
Study or Subgroup	Std. Mean Difference	SE	Total	Total	Weight	IV, Random, 95% Cl	IV, Random, 95% CI
15.1.1 tDCS alone							
Babyar et al. (2016)	0.0667	0.4716	9	9	2.5%	0.07 [-0.86, 0.99]	
Babyar et al. (2018)	-1.6616	0.5347	10	10	2.0%	-1.66 [-2.71, -0.61]	
Barreto et al. (2019)	-1.0263	0.5814	7	7	1.7%	-1.03 [-2.17, 0.11]	
Benussi et al. (2015)	-0.2494	0.3258	19	19	4.7%	-0.25 [-0.89, 0.39]	
Boretta et al. (2020)	-0.8289	0.3019	24	24	5.3%	-0.83 [-1.42, -0.24]	
Coppens et al. (2019)	-0.0531	0.3923	13	13	3.5%	-0.05 [-0.82, 0.72]	_ _
Grimaldi & Manto (2013)	-0.0777	0.5777	6	6	1.7%	-0.08 [-1.21, 1.05]	
Kaski et al. (2014b)	0.0497	0.5001	8	8	2.3%	0.05 [-0.93, 1.03]	
Lattari et al. (2017)	-0.1406	0.3435	17	17	4.3%	-0.14 [-0.81, 0.53]	— — —
Lu et al. (2018)	-0.1881	0.4484	10	10	2.7%	-0.19 [-1.07, 0.69]	
Ojardias et al. (2020)	-0.1314	0.354	16	16	4.1%	-0.13 [-0.83, 0.56]	
Sohn et al. (2013)	-1.1212	0.4654	11	11	2.6%	-1.12 [-2.03, -0.21]	
Tahtis et al. (2014)	-0.4652	0.5445	7	7	1.9%	-0.47 [-1.53, 0.60]	
Workman et al. (2020)	-0.2136	0.5366	7	7	2.0%	-0.21 [-1.27, 0.84]	
Yang et al. (2021)	-1.1141	0.4885	10	10	2.4%	-1.11 [-2.07, -0.16]	
Subtotal (95% CI)			174	174	43.7%	-0.44 [-0.69, -0.19]	•
Heterogeneity: Tau* = 0.05: 0	chi* = 17.78. df = 14 (P =	0.221:1	* = 21%				
Test for overall effect: Z = 3.4	8 (P = 0.0005)						
15.1.2 tDCS combined							
Andrade et al. (2017)	-2.2879	0.4046	30	15		Not estimable	
Cha et al. (2016)	-0.8726	0.4521	12	10	2.7%	-0.87 [-1.78, 0.01]	
Chang et al. (2015)	-0.3778	0.4126	12	12	3.2%	-0.38 [-1.19, 0.43]	
Costa-Ribeiro et al. (2017)	0.3911	0.4313	11	11	2.9%	0.39 [-0.45, 1.24]	
Danzi et al. (2013)	0.0311	0.7072	4	4	1.2%	0.03 [-1.35, 1.42]	
Fruhauf et al. (2017)	-0.2119	0.3663	15	15	3.9%	-0.21 [-0.93, 0.51]	
Geroin et al. (2011)	-0.2695	0.4497	10	10	2.7%	-0.27 [-1.15, 0.61]	
Kaski et al. (2013)	-0.5956	0.4846	9	9	2.4%	-0.60 [-1.55, 0.35]	
Kaski et al. (2014b)	-0.6201	0.5157	8	8	2.1%	-0.62 [-1.63, 0.39]	
Liang et al. (2020)	0.2591	0.4495	10	10	2.7%	0.28 [-0.62, 1.14]	
Madhavan et al. (2020)	-0.0932	0.3164	20	20	4.9%	-0.09 [-0.71, 0.53]	
Manenti et al. (2016)	-0.1228	0.4477	10	10	2.8%	-0.12 [-1.00, 0.75]	
Manji et al. (2018)	-0.0321	0.2582	30	30	6.6%	-0.03 [-0.54, 0.47]	
Prathum et al. (2021)	-0.3269	0.4115	12	12	3.2%	-0.33 [-1.13, 0.48]	
Raithatha et al. (2016)	-0.216	0.8725	4	2	0.8%	-0.22 [-1.93, 1.49]	
Saeys et al. (2015)	-0.9217	0.3806	16	15	3.6%	-0.92 [-1.67, -0.18]	
Saki et al. (2020)	-1.1635	0,3636	18	18	3.9%	-1.16 [-1.88, -0.45]	
Seo et al. (2017)	0.2282	0,4387	11	10	2.9%	0.23 [-0.63, 1.09]	_
Zandvliet et al. (2018)	-0.5698	0.3736	15	15	3.8%	-0.57 [-1.30, 0.16]	
Subtotal (95% CI)			227	221	56.3%	-0.31 [-0.51, -0.11]	•
Heterogeneity: Tau ² = 0.02; 0	chi ² = 18.74, df = 17 (P =	0.34); (² = 9%				
Test for overall effect: Z = 3.0	4 (P = 0.002)						
Total (95% CI)			401	395	100.0%	-0.37 [-0.52, -0.21]	•
Heterogeneity: Tau ² = 0.03: 0	chi ² = 37.28, df = 32 (P =	0.24):1	² = 14%				<u>t 1 1 1 1</u>
Test for overall effect: Z = 4.6	3 (P < 0.00001)				7		-4 -2 0 2 4
Test for subgroup differences	: Chi# = 0.64, df = 1 (P =	0.42), I	* = 0%				ravours [experimental] Pavours [control]

Figure 4. Forrest plots of the meta-analysis with the tDCS alone subgroup and tDCS combined with another intervention subgroup after sensitivity analysis.

			Experimental	Control		Std. Nean Difference	Std. Mean Difference
Study or Subgroup	Std. Mean Difference	55	Total	Total	Weight	IV, Random, 95% CI	IV, Random, 95% Cl
12.1.1 motor cortex							
Andrade et al. (2017)	-2.2870	0.4046	30	15		Not estimable	
Barrato et al. (2019)	-1.0263	0.5814	7	7	1.7%	-1.03 [-2.17, 0.11]	
Beretta et al. (2020)	-0.8289	0.3019	24	24	6.1%	-0.83 [-1.42, -0.24]	
Chang et al. (2015)	-0.3778	0.4126	12	12	3.3%	-0.38 [-1.19, 0.43]	
Coppens et al. (2019)	-0.0531	0.3923	13	13	3.7%	-0.05 [-0.02, 0.72]	
Costa-Ribeiro et al. (2017)	0.3911	0.4313	11	11	3.1%	0.39 [-0.46, 1.24]	
Denzi et al. (2013)	0.0311	0.7072	4	4	1.2%	0.03 [-1.36, 1.42]	
Fruhaut et al. (2017)	-0.2119	0.3663	15	15	4.2%	-0.21 [-0.93, 0.51]	
Geroin et al. (2011)	-0.2995	0.4497	10	10	2.8%	-0.27 [-1.16, 0.61]	
Kaski et al. (2013)	-0.5955	0.4848	9	9	2.4%	-0.60 [-1.55, 0.35]	
Kaski et al. (2014b)	-0.6201	0.5157			2.2%	-0.62 [-1.63, 0.38]	
Liang et al. (2020)	0.2591	0.4495	10	10	2.8%	0.28 [-0.62, 1.14]	
Lu et al. (2018)	-0.1881	0.4484	10	10	2.8%	-0.19 [-1.07, 0.65]	
Madhavan et al. (2020)	-0.0932	0.3164	20	20	5.0%	-0.09 [-0.71, 0.53]	_ _
Manii et al. (2018)	-0.0321	0.2582	30	30	8.1%	-0.03 [-0.54, 0.47]	
Ojardias et al. (2020)	-0.1314	0.354	16	16	4.5%	-0.13 [-0.63, 0.56]	
Prathum et al. (2021)	-0.3299	0.4115	12	12	3.3%	-0.33 [-1.13, 0.46]	
Reithetha of al. (2016)	-0.216	0.8725	4	2	0.8%	-0.22 [-1.93, 1.49]	
Speve et al. (2015)	-0.9217	0.3806	15	15	3.9%	-0.921-1.670.161	
Sec at al. (2017)	0.2282	0.4387	11	10	3.0%	0.23 [-0.63, 1.06]	+
Sohn et al. (2013)	-1.1212	0.4854	11	11	2.6%	-1.12[-2.03, -0.21]	
Tahtis et al. (2014)	-0.4952	0.5445	7	7	1.9%	-0.47 [-1.53, 0.60]	
Yang et al. (2021)	-1.1541	0.4885	10	10	2.4%	-1.111-2.070.16	
Subtotal (95% CI)			270	266	72.4%	-0.32 [-0.50, -0.14]	•
Heterogeneity: Tau? = 0.01: 0	hif = 22.07, df = 21 (P -	0.400:1	r = 5%				
Test for overall effect Z = 3.5	6 (P = 0.0004)						
Total Tar offering entropy as - 500	a h - connect						
12.1.2 PFC							
Cha et al. (2016)	-0.8728	0.4521	12	10	2.8%	-0.87 [-1.76, 0.01]	
Latteri et al. (2017)	-0.1408	0.3435	17	- 17	4.7%	-0.14[-0.81, 0.53]	
Mananti et al. (2016)	-0.1228	0.4477	10	10	2.8%	-0.121-1.00.0.751	
Saki et al. (2020)	-1.1635	0.3836	18	18	4.3%	1.18 [-1.88, -0.45]	
Subtotal (95% CI)	- 61 19999		57	55	14.5%	-0.58 [-1.11, -0.04]	◆
Heterogeneity: Tau? = 0.14: C	367 = 5.67, et = 3.62 = 0	126: P =	47%				-
Tast for overal effect 7 = 2 1	1 (P = 0.04)						
Contraction of the second seco							
12.1.3 cereballum							
Banussi et al. (2015)	-0.2484	0.3258	19	19	5.3%	-0.25 [-0.89, 0.39]	
Grimaldi & Manto (2013)	-0.0777	0.5777			1.7%	-0.08 [-1.2], 1.051	
Workman et al. (2020)	-0.9136	0.5364	7	7	2.0%	-0.21 [-1.27, 0.84]	
Zandyliet et al. (2018)	0.5884	0.3736	15	16	4.0%	-0.57[-1.30, 0.16]	
Subtotal (95% CI)	-6.06990		47	47	13.0%	-0.32 [-0.73, 0.09]	-
Heteropaneity: Tau ² = 0.00; C	2bF = 0.71, et = 3 (P = 0	675 P -	0%				
Tast for overal effect 7 = 1.4	4 dP = 0.125	are for the second					
Careful States and a 1/2	and a second						
12.1.4 PIVC							
Babyar et al. (2018)	0.0887	0.4718				Not estimable.	
Babyar et al. (2018)	-1,6516	0.5347	10	- 10		Not estimable	
Subtotal (95% CD	- 1,04 14	0.0041	a a	i i i		Not estimable	
Helerogeneity: Not applicable			-				
Test for overall effect Not and	niicabla						
concern present energy (was dis							
Total (95% CB)			374	368	100.0%	-0.36 [-0.51, -0.21]	•
Helenopeneity: Tau? = 0.01: 0	167 = 29.65, df = 29.42 s	0.4221	P = 3%				++
Tast for overal effect 2 - 4.4	8 (P < 0.00001)	a says					
Tast for suborners differences	ChP = 0.75, df = 2.42 -	0.685	P = 0%				Favours (experimental) Favours (control)
Control and the second second second		Sciently 1					▼

Figure 5. Forrest plots of the meta-analysis regarding the target area stimulated with the motor cortex subgroup, PFC subgroup, and cerebellum subgroup after sensitivity analysis. PFC: Prefrontal cortex; PIVC: parietal-insular vestibular cortex.

Bindy of Rulearcos Biol. Mean Difference Bit Tatel Tatel Tatel Tatel Waiph M. M. Rudon, 495; Cl. Pri. Rundon, 495; Cl. Baryset et al. (2015) 0.0916 -1.095 0.517 0.0 0.001		Exp	erimental	Control		Std. Hean Difference	Std. Mean Difference
13.1.1 atkite Babyer et al. (2013) -0.097 0.4718 9 9 2.55 -0.07 [-0.00, 0.09] Babyer et al. (2013) -1.095 0.5341 7 1.0 9 9 2.55 -0.07 [-0.00, 0.09] Primade M Alexal (2010) -0.128 0.0341 13 15 4.55 -0.21 [-0.00, 0.21] Operation and (2010) -0.128 0.0431 15 15 4.56 -0.21 [-0.00, 0.21] Operation and (2010) -0.128 0.0431 11 14 4.56 -0.01 [-0.00, 0.21] Subotical (2010) -0.128 0.0431 11 14 4.56 -0.07 [-0.00, 0.21] Subotical (2016) -0.099 0.0376 15 3.85 -0.07 [-0.00, 0.21] Subotical (2016) -0.999 0.0376 15 Not estimate -0.07 [-0.00, 0.21] Subotical (2016) -0.299 0.4464 30 15 Not estimate -0.07 [-0.00, 0.21] Subotical (2017) -0.297 0.4248 12 2.25 -0.28 [-0.08, 0.31] -0.29 [-0.08, 0.31] Subotical (2015) -0.298 0.4313 11 11 3.25 -0.28 [-0.08, 0.31] -0.28 [-0.08, 0.31] <t< td=""><td>Study or Subgroup</td><td>Std. Mean Difference SE</td><td>Total</td><td>Total</td><td>Weight</td><td>IV, Random, #6% Cl</td><td>IV, Randem, 95% Cl</td></t<>	Study or Subgroup	Std. Mean Difference SE	Total	Total	Weight	IV, Random, #6% Cl	IV, Randem, 95% Cl
Balaye et al. (2015) Barvie et al. (2015) Barvie et al. (2015) 1.4954 0 65.0477 0 67 1.4956 1.495 0.405 Barvie et al. (2015) 1.4952 0.5347 7 7 1.5% 1.46 1.46 0.26 Barvie et al. (2015) 1.4952 0.5342 1 5 14 4.55 - 4.23 12.43, 0.51 Grival & Martis (2015) 1.4922 0.4334 0 15 14 4.55 - 4.23 12.43, 0.51 Grival & Martis (2015) 1.4922 0.4334 0 15 14 4.55 - 4.23 12.43, 0.51 Grival & Martis (2015) 1.4922 0.4334 0 15 14 4.55 - 4.23 12.43, 0.51 Jorden et al. (2017) 1.4922 0.4544 11 11 225 -4.1912.0.0, 0.21 Barvie et al. (2015) 1.492 0.4544 11 11 225 -4.1912.0.0, 0.21 Barvie et al. (2017) 1.492 0.4544 11 11 11 225 -4.1912.0.0, 0.21 Barvie et al. (2017) 1.492 0.4544 12 255 15 Net estimates Barvie et al. (2017) 1.432 0 paralithetic 1.43 0 paralithetic 1.41 0 parali	13.1.1 static						
Balayser (a) (2019) 1.0495 0.5447 10 02 2.1% -1.64 [2.71, 0.61] Profile (a) (2019) -2.225 0.5447 17 7 1.54 Profile (a) (2017) -0.2121 0.5445 11 11 2.25 Dimensional (a) (2020) -0.112 0.4645 11 11 2.25 Dimensional (a) (2018) -0.112 0.4645 11 11 2.25 Dimensional (a) (2018) -0.112 0.4 (d = 7 (P = 0.14); (P = 27); Total for overall effect (2 = 2.68 (P = 0.16); Dimensional (a) (2017) -0.2218 0.5446 10 15 Solutional (a) (2 = 2.58 (P = 0.14); (P = 27); Total for overall effect (2 = 2.68 (P = 0.16); Dimensional (a) (2015) -0.1278 0.4248 10 15 Solutional (a) (2 = 2.58 (P = 0.14); (P = 27); Total for overall effect (2 = 2.68 (P = 0.16); Dimensional (a) (2015) -0.2778 0.4248 10 15 Solutional (a) (2 = 0.14); (P = 27); Total for overall effect (2 = 2.68 (P = 0.14); (P = 27); Total for overall effect (2 = 2.68 (P = 0.14); (P = 27); Total for overall effect (2 = 2.68 (P = 0.14); (P = 27); Total for overall effect (2 = 2.68 (P = 0.14); (P = 27); Total for overall effect (2 = 2.68 (P = 0.14); (P = 27); Total for overall effect (2 = 2.68 (P = 0.14); (P = 27); Total for overall effect (2 = 2.68 (P = 0.14); (P = 27); Total for overall effect (2 = 2.68 (P = 0.14); (P = 27); Total for overall effect (2 = 2.68 (P = 0.14); (P = 27); Total for overall effect (2 = 2.68 (P = 0.14); (P = 27); Total for overall effect (2 = 2.68 (P = 0.14); (P = 2.68 (P = 0.14); (P = 2.68 (P = 0.14);	Babyar et al. (2016)	0.0967 0.4718	9	9	2.6%	0.07 [-0.66, 0.99]	
Barnico et al (2010) - 1.0283 0.8414 7 7 7 1.8% - 1.03 [-2.17, 0.11] Grivald 8 Marts (2013) - 0.218 0.3463 15 15 4.65 - 0.21 [4.0, 0.51] Grivald 8 Marts (2013) - 0.218 0.3463 15 15 4.65 - 0.21 [4.0, 0.51] Shin stat, (2023) - 1.1282 0.4544 11 11 2.6% - 1.03 [1.20, 0.42] Subdate (1.0016) - 0.1392 0.4544 11 11 2.6% - 1.03 [1.20, 0.42] Subdate (1.0016) - 0.1392 0.4544 11 11 2.6% - 0.51 [1.20, 0.42] Subdate (1.0016) - 0.1392 0.4544 11 11 2.6% - 0.51 [1.20, 0.42] Subdate (1.0016) - 0.1392 0.4454 11 11 2.6% - 0.51 [1.20, 0.42] Subdate (1.0017) - 0.140; P=0.140; P=0.7% Total troversel effect Z = 2.86 $p=0.000$ 13.1.2 dynamic/functionally Andread et al. (2010) - 0.2379 0.4046 30 15 Not estimates Analysis (1.0017) - 0.2379 0.4046 10 19 2.25% - 0.38 [1.20, 0.38] Grient at (2010) - 0.2779 0.4046 10 19 2.25% - 0.38 [1.20, 0.38] Grient at (2010) - 0.2799 0.4046 10 19 2.25% - 0.38 [1.20, 0.38] Grient at (2010) - 0.2799 0.4046 10 19 2.25% - 0.38 [1.20, 0.38] Grient at (2011) - 0.2486 0.4497 10 19 2.25% - 0.38 [1.42, 0.21] Harmoni et al. (2011) - 0.2486 0.4497 10 19 2.25% - 0.38 [1.42, 0.21] Madiman et al. (2023) - 0.0392 0.3448 20 20 6.0% - 0.09 [0.71, 0.61] Madiman et al. (2013) - 0.238 0.4497 10 19 2.25% - 0.38 [1.42, 0.47] Madiman et al. (2016) - 0.0231 0.2382 20 30 6.7% - 0.03 [1.43, 0.47] Madiman et al. (2016) - 0.0231 0.2382 20 30 6.7% - 0.03 [1.43, 0.47] Madiman et al. (2016) - 0.0231 0.2382 20.487 11 19 2.25% - 0.38 [1.42, 0.25] Madiman et al. (2016) - 0.2321 0.2382 20.487 17 19 2.22% - 0.38 [1.42, 0.25] Madiman et al. (2015) - 0.2320 0.445 17 19 2.25% - 0.32 [1.43, 0.46] Madiman et al. (2016) - 0.2321 0.2382 20.487 11 19 2.25% - 0.38 [1.42, 0.25] Madiman et al. (2015) - 0.2320 0.445 17 19 2.25% - 0.32 [1.43, 0.46] Madiman et al. (2015) - 0.2320 0.445 17 19 2.25% - 0.32 [1.42, 0.25] Madiman et al. (2015) - 0.3221 0.329 15 11 19 2.25% - 0.32 [1.42, 0.25] Madiman et al. (2015) - 0.329 0.445 17 19 2.25% - 0.32 [1.42, 0.25] Madiman et al. (2015) - 0.329 0.445 19 19 2.25% - 0.32 [1.42, 0.25]	Babyar et al. (2018)	-1.6616 0.5347	10	10	2.1%	-1.66 [-2.71, -0.61]	
Product at al. (2017) - 0-2118 0.3883 15 15 4.0% - 0.2114 03, 0.511 Gradual & M. (2023) - 0.1314 0.354 15 15 4.2% - 0.2114 03, 0.511 Gradual at al. (2023) - 0.1314 0.354 15 15 4.2% - 0.1314 03, 0.511 11 12 284 detail (2013) - 0.0488 0.3758 15 15 4.2% - 0.1314 03, 0.511 12 284 detail (2013) - 0.0488 0.3758 15 15 3.8% - 0.3714 0.301 13.12 dynamic functional	Barrelo et al. (2019)	-1.0263 0.5814	7	7	1.8%	-1.03 [-2.17, 0.11]	
Givesia & Auesia (2013) 0.0777 0.5777 6 4 1.4 1.48 0.08 [1.21, 1.65] Givesia & J. (2020) - 0.1312 0.4654 11 11 12.4.5 - 1.12 [-2.03, 0.21] Sabratic (2013) -1.1312 0.4654 11 11 12.25 - 1.12 [-2.03, 0.21] Substitutiopes (0) -0.6989 0.3736 15 5 8 0.458 0.457 (-3.0.16] Substitutiopes (-0.15) (-2.87 - 0.45) (P = 3.75) Total to overall effect Z = 2.26 (P = 0.057) 13.1.2 dynamic/Londienality Audies of al. (2017) -2.247 0.4404 12 12 12 2.25 - 0.23 [-4.00, 0.21] Banasis al. (2013) -0.3778 0.4426 12 12 12 2.258 -0.23 [-4.00, 0.21] Charge et al. (2015) -0.3778 0.4426 12 12 12 2.358 -0.23 [-4.00, 0.21] Charge et al. (2015) -0.3778 0.4426 12 12 12 2.358 -0.23 [-4.00, 0.21] Charge et al. (2015) -0.3778 0.4426 12 12 12 2.358 -0.23 [-4.00, 0.21] Charge et al. (2015) -0.3778 0.4426 12 12 12 2.358 -0.23 [-4.00, 0.21] Charge et al. (2017) -0.2498 0.4427 13 11 12 2.268 -0.227 [-1.50, 0.51] Charge et al. (2017) -0.2498 0.4427 13 10 2.268 -0.271 [-5.0, 0.31] Mathema et al. (2016) -0.0328 0.4467 13 12 12 2.358 -0.232 [-4.00, 0.32] Mathema et al. (2016) -0.0328 0.4467 13 12 12 2.358 -0.33 [-4.10, 0.52] Mathema et al. (2016) -0.0328 0.4467 13 12 12 2.358 -0.33 [-4.10, 0.52] Mathema et al. (2016) -0.0328 0.4467 13 12 12 2.358 -0.33 [-4.00, 0.78] Mathema et al. (2016) -0.0328 0.4467 13 12 12 2.358 -0.33 [-4.00, 0.78] Mathema et al. (2016) -0.0328 0.4467 13 12 12 2.358 -0.33 [-4.00, 0.78] Mathema et al. (2016) -0.0328 0.3458 17 17 2.258 -0.32 [-4.00, 0.78] Mathema et al. (2016) -0.0328 0.3458 15 15 4.205 -0.33 [-4.02, 0.18] Mathema et al. (2016) -0.0328 0.3458 17 19 0.2258 0.033 [-4.00, 0.18] Mathema et al. (2016) -0.0328 0.3458 15 15 4.205 -0.33 [-4.20, 0.48] Baberia et al. (2016) -0.0328 0.3458 15 15 4.205 -0.33 [-4.20, 0.48] Baberia et al. (2016) -0.0328 0.3458 15 15 4.205 -0.33 [-4.20, 0.48] Baberia et al. (2017) -0.038 0.3458 15 13 2.358 -0.33 [-4.20, 0.48] Baberia et al. (2017) -0.348 0.3458 15 13 2.358 -0.33 [-4.20, 0.48] Baberia et al. (2017) -0.348 0.3458 15 13 2.358 -0.33 [-4.20, 0.48] Baberia et al	Fruhaut et al. (2017)	-0.2119 0.3663	15	15	4.0%	-0.21 [-0.93, 0.51]	
Cjeutian et al. (2020) Cjeutian et al. (2021) Cjeutian et al. (2013) Cjeutian et al. (2013) Construction of the second of th	Grimeldi & Manto (2013)	-0.0777 0.5777	6		1.8%	0.08 [-1.21, 1.06]	
Sub et al. (2010)1:0:12: 0.4424 11 11 2.451:0:2: 0.20, -0:71 Sub the (2016) - 0.6989 0.3738 15 15 8.45 - 4.57 (-3.0, 0.16) B abota (2016) - 0.6989 0.3738 15 15 8.45 - 4.55 (-3.0, 0.16) B abota (2017) - 2:2979 0.4946 15 15 Net estimate Benual et al. (2017) - 2:2979 0.4946 15 15 Net estimate Benual et al. (2017) - 2:2979 0.4946 15 15 Net estimate Benual et al. (2017) - 2:2979 0.4946 15 15 Net estimate Benual et al. (2015) - 0.3778 0.4428 12 12 2.338 - 0.38 (-1.70, 0.51) Charge et al. (2015) - 0.3778 0.4428 12 12 3.38 - 0.38 (-1.70, 0.51) Deroit et al. (2015) - 0.3778 0.4428 12 12 3.38 - 0.38 (-1.70, 0.51) Deroit et al. (2015) - 0.3778 0.4428 12 12 3.38 - 0.38 (-1.70, 0.51) Deroit et al. (2017) - 0.4980 0.3435 17 17 4.45 - 0.28 (-1.70, 0.51) Deroit et al. (2017) - 0.4980 0.3455 17 17 4.45 - 0.491 (-2.0, 0.78) Material et al. (2017) - 0.4980 0.3455 17 17 4.45 - 0.491 (-2.0, 0.78) Material et al. (2017) - 0.3910 0.7922 44 2 0.256 - 0.09 (-7.10, 0.58) Material et al. (2017) - 0.3910 0.7922 45 - 0.27 (-1.00, 0.78) Material et al. (2017) - 0.2389 0.4147 10 10 2.256 - 0.29 (-7.10, 0.78) Material et al. (2017) - 0.2382 0.3146 20 20 5.056 - 0.09 (-7.10, 0.58) Material et al. (2017) - 0.3289 0.4115 12 12 2.356 - 0.23 (-1.62, 0.47) Parkum et al. (2028) - 0.3828 0.4115 12 12 2.356 - 0.23 (-1.62, 0.47) Parkum et al. (2015) - 0.3212 0.3168 15 15 3.756 - 0.33 (-1.53, 0.46) See et al. (2015) - 0.3223 0.328 17 10 10 2.256 - 0.23 (-1.57, 0.48) See et al. (2015) - 0.3224 0.4358 17 7 7 2.156 - 0.421 (-1.57, 0.48] Benut et al. (2015) - 0.3224 0.4358 17 7 7 2.156 - 0.43 (-1.53, 0.46) Heterogenety: Tax ² = 0.03 (-1.53, cf = 0.136); F = 0.236; F = 0.33 (-1.62, 0.25) Table et al. (2023) - 0.5281 0.3223 13 13 3.556 - 0.35 (-1.62, 0.27) Kaski et al. (2023) - 0.5281 0.3228 13 10 0 2.256 - 0.33 (-1.62, 0.25] Heterogenety: Tax ² = 0.04 (-2) ² = 0.446; F = 0.236; F	Ojardias et al. (2020)	-0.1314 0.354	16	16	4.2%	-0.13 [-0.83, 0.58]	
Zevel et al. (2014) -0.9988 0.728 15 5.8.8% -0.67 [-1.50, 0.14] Heterogeneity: Tax" = 0.11; Cb7 = 11.04, cf = (0 = 0.14); P = 37%. 99 92 22.8% -6.54 [-4.33, -4.16] Heterogeneity: Tax" = 0.11; Cb7 = 11.04, cf = (0 = 0.14); P = 37%. 70 15 Net estimates Antidie et al. (2017) -2.28% 0.4328 30 15 Net estimates Antidie et al. (2015) -0.3424 0.4228 19 4.5% -0.325 [-0.80, 0.36] Charg et al. (2015) -0.3726 0.4328 11 13 3.5% -0.37 [-1.50, 0.16] Charg et al. (2015) -0.3726 0.4315 11 13 3.5% -0.38 [-1.62, 0.14] Contra et al. (2017) -0.3816 0.4415 10 2.28% -0.37 [-1.50, 0.15] Machine et al. (2017) -0.2386 0.4417 10 12 2.6% -0.37 [-1.50, 0.15] Machine et al. (2017) -0.2386 0.4415 12 12 3.36 4.38 [-1.42, 0.24] Machine et al. (2016) -0.2321 0.238 1.35	Sohn et al. (2013)	-1.1212 0.4654	11	11	2.0%	-1.12[-2.03, -0.21]	
Subtraft (255 Ct) 99 22.8% -4.54 [-2.3, -2.16] Heteroganety: Tau ² = 0.15; Ch ² = 1.54, df = 7 (P = 0.14); P = 37% Test for overall effect. $Z = 2.68 \text{ (P} = 0.607$) 13.1.2 grownindaradisentity Andeds et al. (2015) -0.2444 0.2258 19 19 4.45% -0.25 [-4.80, 0.01] Cherry et al. (2015) -0.2444 0.2258 19 19 4.45% -0.25 [-4.80, 0.01] Cherry et al. (2015) -0.2478 0.4621 12 19 2.28% -0.37 [-1.50, 0.01] Cherry et al. (2015) -0.3778 0.4128 12 12 2.33% -0.38 [-1.10, 0.48] Dards et al. (2017) -0.2444 0.2358 17 17 4.4% -0.34 [-4.81, -4.14] Dards et al. (2013) -0.311 0.7372 4 4 1.2% 0.031 [-4.81, 14] Dards et al. (2013) -0.2315 0.7372 4 4 1.2% 0.031 [-4.81, 14] Dards et al. (2013) -0.2315 0.4147 19 19 2.2% -0.22 [-1.50, 0.61] Latter et al. (2017) -0.1406 0.3435 17 17 4.4% -0.14 [-4.10, 0.53] Massed et al. (2013) -0.2325 0.4147 19 19 2.25% -0.32 [-1.50, 0.61] Latter et al. (2013) -0.2325 0.4147 19 19 2.25% -0.32 [-1.50, 0.61] Massed et al. (2016) -0.2325 0.4145 12 12 3.3% -0.38 [-1.48, 0.48] Sec stal (2016) -0.2325 0.4145 12 12 3.3% -0.38 [-1.48, 0.48] Sec stal (2015) -0.2327 0.3368 16 15 3.7% -0.32 [-1.50, 0.46] Massed et al. (2015) -0.2327 0.3368 15 15 4.0% -1.16 [-1.88, 0.48] Sec stal (2015) -0.2329 0.3518 15 15 4.25 0.25% -0.32 [-1.50, 0.46] Workman et al. (2023) -0.2325 0.4445 17 7 2.5% -0.47 [-1.50, 0.66] Workman et al. (2023) -0.4259 0.3519 34 24 6.5% -0.38 [-1.42, 0.24] Workman et al. (2023) -0.4259 0.3519 34 2.25% -0.32 [-4.80, 0.56] Heteroganety: Tau ³ = 0.02(ch ² = 1.6, 16, cf = 16 (P = 0.24); P = 1%. Tath for workel effect.2 = 2.56 0, 0.5019 Tath for workel effect.2 = 2.56 0, 0.5001 Tath for workel effect.2 = -2.50 0, 0.5001 Tath for wo	Zandvliet et al. (2018)	-0.5998 0.3738	15	15	3.8%	-0.57 [-1.30, 0.16]	
$\begin{aligned} \text{Hatesgrawly } Tat^{-} T = 0:1; \ \text{CM}^{-} = 1:40, \ dr = 7 \ (p = 0.44); \ p = 37\% \\ \text{Text for overall effect \mathcal{L} = 2.86 \ p^{-} = 0.867) \\ \hline \text{Andmis eval} if \mathcal{L} = 2.86 \ p^{-} = 0.867) \\ \hline \text{Andmis eval} if \mathcal{L} = 2.05 \ p^{-} = 0.867) \\ \hline \text{Andmis eval} if \mathcal{L} = 2.167 \ p^{-} = 0.867) \\ \hline \text{Andmis eval} if \mathcal{L} = 2.167 \ p^{-} = 0.867) \\ \hline \text{Andmis eval} if \mathcal{L} = 2.167 \ p^{-} = 0.867) \\ \hline \text{Andmis eval} if \mathcal{L} = 2.177 \ p^{-} = 0.442; \ p^{-} = 1.287 \ p^{-} = 0.421; \ p^{-} = 0.287 \ p^{-} = 0.27 \ p^{-} = 0.287 \ p^{-} = 0.27 \ p^{-} = 0.287 \ p^{-} = 0.27 \ p^{-} = 0.27 \ p^{-} = 0.287 \ p^{-} = 0.27 \ p^{-} = 0.27 \ p^{-} = 0.287 \ p^{-} = 0.287 \ p^{-} = 0.27 \ p^{-} = 0.287 \ p^{-} = 0.287 \ p^{-} = 0.287 \ p^{-} = 0.287 \ p^{-} = 0.27 \ p^{-} = 0.287 \ p^{-} = 0.287 \ p^{-} = 0.28$	Subtotal (95% CI)		39	89	22.8%	-0.54 [-0.93, -0.14]	•
Test for overall effect: $2 = 2.85 \text{ g}^2 = 0.007$) 13.1.2 dynamic/functions/funct	Heterogeneity: Tau? = 0.11;	ChP = 11.04, df = 7 (P = 0.14); P = 37	56				
	Test for overall effect: Z = 2.	68 (P = 0.007)					
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $							
Addingle of al. (2017) Addingle of al. (2016) Charget (al. (2016) Charget (al. (2016) Charget (al. (2016) Charget (al. (2016) Charget (al. (2016) Charget (al. (2017) Council of (al. (2018) Council of (al. (2018)) Council of (al. (2018))	13.1.2 dynamic/functional	ty					
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	Andrade et al. (2017)	-2.2879 0.4046	30	15		Not estimable	
Che stal (2016) -0.3778 0.4521 12 12 3.3% -0.38 [1.18, 0.45] -0.38 [1	Benussi et al. (2015)	-0.2494 0.3258	19	19	4.8%	-0.25 [-0.89, 0.39]	 +
Charge et al. (2015) $-0.372 \pm 0.442 \pm 12 \pm 12 \pm 3.3 \pm -0.38 [-1.10, 0.43]$ Catal-Topics al. (2017) $-0.311 \pm 0.431 \pm 11 \pm 3.2 \pm 0.39 [-4.64, 1.34]$ Carcin et al. (2017) $-0.311 \pm 0.431 \pm 11 \pm 3.2 \pm 0.39 [-4.64, 1.34]$ Carcin et al. (2017) $-0.446 \pm 0.4417 \pm 10 \pm 0.28 \pm 0.27 [-1.50, 0.51]$ Madheam et al. (2017) $-0.314 \pm 0.4417 \pm 10 \pm 0.28 \pm 0.27 [-1.50, 0.51]$ Madheam et al. (2010) $-0.231 \pm 0.2382 \pm 20 \pm 0.655 \pm 0.491 \pm 0.71, 0.51]$ Manaet et al. (2010) $-0.323 \pm 0.2382 \pm 30 \pm 0.675 \pm -0.03 [-1.53, 0.47]$ Manaet et al. (2010) $-0.323 \pm 0.2382 \pm 30 \pm 0.675 \pm -0.03 [-1.53, 0.47]$ Manaet et al. (2010) $-0.323 \pm 0.2382 \pm 30 \pm 0.675 \pm -0.03 [-1.53, 0.47]$ Manaet et al. (2015) $-0.231 \pm 0.2382 \pm 30 \pm 0.675 \pm -0.03 [-1.53, 0.47]$ Save at al. (2015) $-0.232 \pm 0.3385 \pm 15 \pm 3.275 \pm 0.425 [-1.67, 0.41]$ Save at al. (2015) $-0.232 \pm 0.3385 \pm 15 \pm 3.275 \pm 0.23 [-1.67, 0.41]$ Save at al. (2015) $-0.232 \pm 0.3385 \pm 7 + 7 + 2.55 \pm 0.425 [-1.67, 0.41]$ Save at al. (2015) $-0.232 \pm 0.3385 \pm 7 + 7 + 2.55 \pm 0.425 [-1.67, 0.41]$ Save at al. (2015) $-0.232 \pm 0.3385 \pm 7 + 7 + 2.55 \pm 0.425 [-1.67, 0.41]$ Table at al. (2015) $-0.232 \pm 0.3385 \pm 7 + 7 + 2.55 \pm 0.425 [-1.67, 0.41]$ Table at al. (2015) $-0.232 \pm 0.3385 \pm 7 + 7 + 2.55 \pm 0.425 [-1.67, 0.41]$ Workman et al. (2015) $-0.232 \pm 0.3385 \pm 7 + 7 + 2.55 \pm 0.425 [-1.62, 0.24]$ Copperns at al. (2016) $-0.425 \pm 0.3315 \pm 22 \pm 2.4387 \pm 0.23 [-0.67, -0.41]$ Table at al. (2016) $-0.432 \pm 0.3315 \pm 3 \pm 4 \pm 4.56 \pm 0.035 [-1.62, 0.24]$ Copperns at al. (2010) $-0.235 \pm 0.3315 \pm 3 \pm 4 \pm 2.45 \pm 0.435 [-0.42, -0.26]$ Table at al. (2013) $-0.325 \pm 0.3315 \pm 3 \pm 4 \pm 2.45 \pm 0.435 [-0.42, -0.26]$ Table at al. (2013) $-0.325 \pm 0.3315 \pm 3 \pm 3 \pm 2.55 \pm 0.33 [-0.25, -0.32] $	Cha et al. (2016)	-0.8726 0.4521	12	10	2.8%	-0.87 [-1.76, 0.01]	
$ \begin{array}{c} Costa-Hisping of al. (2017) & 0.3911 0.4313 & 11 & 11 3.0% & 0.33 [-0.46, 1.24] \\ \mbox{Costa-Hisping of al. (2017) & 0.3911 0.7072 & 4 & 4 & 1.28 & 0.33 [-0.46, 1.24] \\ \mbox{Costa-Hisping of al. (2017) & -0.448 & 0.4415 & 17 & 17 & 4.48 & -0.44 [-0.81, 0.25] \\ \mbox{Lating in al. (2017) & -0.448 & 0.4415 & 17 & 17 & 4.48 & -0.44 [-0.81, 0.25] \\ \mbox{Lating of al. (2018) & -0.522 & 0.4477 & 10 & 10 & 2.58 & -0.42 [-1.5, 0.64] \\ \mbox{Maness of al. (2016) & -0.522 & 0.4477 & 10 & 10 & 2.58 & -0.42 [-1.53, 0.46] \\ \mbox{Harlewan of al. (2021) & -0.528 & 0.4477 & 10 & 10 & 2.58 & -0.32 [-1.53, 0.46] \\ \mbox{Harlewan of al. (2016) & -0.339 & 0.115 & 12 & 12 & 3.38 & -0.31 [-0.56, 0.47] \\ \mbox{Harlewan of al. (2015) & -0.224 & 0.475 & 12 & 0.58 & -0.22 [-1.53, 1.46] \\ \mbox{Harlewan of al. (2015) & -0.2327 & 0.386 & 16 & 15 & 3.75 & -0.22 [-1.53, 1.66] \\ \mbox{Harlewan of al. (2015) & -0.2322 & 0.4387 & 11 & 10 & 2.98 & -0.22 [-1.53, 1.66] \\ \mbox{Harlewan of al. (2015) & -0.2328 & 0.437 & 11 & 10 & 2.98 & -0.22 [-1.53, 1.66] \\ \mbox{Harlewan of al. (2023) & -0.2318 & 0.3386 & 17 & 7 & 2.056 & -0.22 [-1.52, 0.44] \\ \mbox{Harlewan of al. (2023) & -0.2318 & 0.3388 & 7 & 7 & 2.056 & -0.38 [-1.42, -0.24] \\ \mbox{Harlewan of al. (2023) & -0.2318 & 0.3388 & 7 & 7 & 2.16 & -0.38 [-1.42, -0.24] \\ \mbox{Harlewan of al. (2023) & -0.2321 & 0.5382 & 13 & 13 & 3.258 & -0.32 [-1.56, 0.35] \\ \mbox{Harlewan of al. (2023) & -0.4321 & 0.5187 & 8 & 8 & 2.256 & -0.38 [-1.42, -0.24] \\ \mbox{Harlewan of al. (2023) & -0.4321 & 0.5187 & 8 & 8 & 2.256 & -0.38 [-1.42, -0.24] \\ \mbox{Harlewan of al. (2023) & -0.321 & 0.5187 & 8 & 8 & 2.256 & -0.32 [-1.56, 0.35] \\ \mbox{Harlewan of al. (2023) & -0.321 & 0.258 & 10 & 10 & 2.456 & -1.11 [-2.07, 0.46] \\ \mbox{Harlewan of all (2023) & -0.321 & 0.2587 & 10 & 0.2587 & 0.321 [-0.56, 0.35] \\ \mbox{Harlewan of all (2023) & -0.321 & 0.2587 & 0.321 (-0.56, 0.35] \\ \mbox{Harlewan of all (2023) & -0.328 & 0.468 & 10 & 10 & 2.456 & -1.11 [-2.07, 0.46] \\ \mbox{Harlewan onesh (metrcwan of Her$	Chang et al. (2015)	-0.3778 0.4126	12	12	3.8%	0.38 [-1.10, 0.43]	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Costa-Ribeiro et al. (2017)	0.3911 0.4313	11		3.0%	0.391-0.45, 1.241	
	Denzi et al. (2013)	0.0311 0.7072		- 4	1.2%	0.03 [-1.35, 1.45]	
Latter et al. (2017) Latter et al. (2017) Auditeau et al. (2029) Auditeau et al. (2029) Auditeau et al. (2029) Auditeau et al. (2020) Auditeau et al. (2020) Auditeau et al. (2010) Auditeau et al. (2020) Auditeau et al. (2021) Auditeau	Geroin et al. (2011)	-0.2895 0.4497	10	10	2.8%	-0.27 [-1.15, 0.61]	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Letteri et al. (2017)	-0.1405 0.3435	17		4.4%	-0.54 L0.01 0.570	
$ \begin{array}{c} \text{manual of its (parset)} & -0.0228 & 0.4417 & 10 & 10 & 2.054 & -0.01 [-0.0, 0.08] \\ \text{Mangl et al. (2016)} & -0.0221 & 0.2528 & 0.4417 & 10 & 10 & 2.054 & -0.01 [-0.0, 0.08] \\ \text{Mangl et al. (2016)} & -0.0221 & 0.2528 & 2.442 & 2.085 & -0.22 [-1.00, 0.28] \\ \text{Rathware et al. (2015)} & -0.238 & 0.477 & 10 & 10 & 2.056 & -0.22 [-1.00, 0.28] \\ \text{Rathware et al. (2015)} & -0.231 & 0.2725 & 4 & 2 & 0.085 & -0.22 [-1.07, 0.16] \\ \text{Save et al. (2015)} & -0.232 & 0.3775 & 4 & 2 & 0.085 & -0.22 [-1.07, 0.16] \\ \text{Save et al. (2015)} & -0.432 & 0.3686 & 16 & 15 & 3.75 & -0.22 [-1.07, 0.16] \\ \text{Save et al. (2015)} & -0.432 & 0.3686 & 7 & 7 & 2.06 & -0.47 [-1.80, 0.66] \\ \text{Workman et al. (2016)} & -0.432 & 0.3448 & 7 & 7 & 2.056 & -0.47 [-1.80, 0.66] \\ \text{Workman et al. (2016)} & -0.0542 & 0.3448 & 7 & 7 & 2.056 & -0.47 [-1.80, 0.66] \\ \text{Workman et al. (2016)} & -0.0542 & 0.3448 & 7 & 7 & 2.056 & -0.47 [-1.80, 0.66] \\ \text{Workman et al. (2016)} & -0.0549 & 0.3448 & 9 & 2.256 & -0.05 [-0.82, 0.24] \\ \text{Tactif or voreal effect. 2 - 2.86 & 0.3018 & 2.44 & -0.05 [-0.82, 0.24] \\ \text{Tactif or voreal effect. 2 - 2.86 & 0.3018 & 2.44 & -0.05 [-0.82, 0.24] \\ \text{Tactif or voreal effect. 2 - 2.86 & 0.3018 & 2.456 & -0.05 [-0.82, 0.301 & 0.248] \\ \text{Tactif or voreal effect. 2 - 2.86 & 0.3018 & 0.4484 & 10 & 10 & 2.456 & -0.42 [-1.65, 0.36] \\ \text{Tactif are used at (2016)} & -0.3251 & 0.4484 & 10 & 10 & 2.456 & -0.42 [-1.65, 0.36] \\ \text{Tactif are used at (2021)} & -0.1141 & 0.4825 & 10 & 10 & 2.456 & -0.42 [-0.65, 0.36] \\ \text{Tactif are used at (2021)} & -0.1141 & 0.4825 & 10 & 10 & 2.456 & -0.42 [-0.50, 0.46] \\ \text{Tactif are used at (2021)} & -0.1141 & 0.4844 & 10 & 10 & 2.456 & -0.42 [-0.50, 0.36] \\ \text{Tactif are used at (2021)} & -0.1141 & 0.4825 & 10 & 10 & 2.456 & -0.42 [-0.50, 0.36] \\ \text{Tactif are used at (2021)} & -0.1141 & 0.485 & 10 & 10 & 2.456 & -0.42 [-0.54, -0.26] \\ \text{Tactif are used at (2021)} & -0.1141 & 0.485 & 10 & 10 & 2.456 & -0.44 [-0.45, -0.26] \\ \text{Tactif are used at (2021)} & -0.146 & (-0.26) (-1.76 & -0.26) (-1.76 & -$	Madhavan et al. (2020).	0.0902 0.3464			6.0%	-0.091-0.71 0.53	
$ \begin{array}{c} \text{Here tar (2010)} & -0.232 & 0.2510 & 25 & 32 & 0.75 & -0.21 & 2.54, 0.47 \\ \text{Parkare et al. (2011)} & -0.238 & 0.4115 & 12 & 23.38 & -0.31 & 2.54, 0.47 \\ \text{Parkare et al. (2015)} & -0.238 & 0.4115 & 12 & 23.38 & -0.32 & 1.50, 0.48 \\ \text{Sale et al. (2015)} & -0.232 & 0.5386 & 16 & 15 & 3.75 & -0.22 & 1.50, 1.48 \\ \text{Sale et al. (2017)} & 0.2232 & 0.4387 & 11 & 10 & 2.545 & 0.21 & 1.63, 0.48 \\ \text{Sale et al. (2017)} & 0.2232 & 0.4387 & 11 & 10 & 2.545 & 0.21 & 1.50, 0 \\ \text{Sale et al. (2017)} & 0.2232 & 0.4387 & 11 & 10 & 2.545 & 0.21 & 1.50, 0 \\ \text{Sale et al. (2017)} & 0.2232 & 0.4387 & 7 & 7 & 2.75 & -0.21 & 1.50, 0 \\ Heteragonely: Tau+ = 0.05, Chi+ = 16, 8, 6 & (6) = 0.044; (P = 1% \\ \text{Text for overall effect: Z = 2.80 & (7 = 0.054) \\ \text{Heteragonely: Tau+ = 0.05, Chi+ = 1.6, 6 & (7 = 0.25); (P = 1% \\ \text{Text for overall effect: Z = 2.280 & (7 = 0.044); (P = 1% \\ \text{Text for overall effect: Z = 2.280 & (7 = 0.044); (P = 1% \\ \text{Heteragonely: Tau+ = 0.05; Chi+ = 1.6, 6 & (7 = 0.28); (P = 20% \\ \text{Heteragonely: Tau+ = 0.05; Chi+ = 1.6, 6 & (7 = 0.28); (P = 20% \\ \text{Text for overall effect: Z = 2.55 & (P = 0.28); (P = 20% \\ \text{Text for overall effect: Z = 2.55 & (P = 0.28); (P = 20% \\ \text{Text for overall effect: Z = 2.55 & (P = 0.28); (P = 20% \\ \text{Text for overall effect: Z = 2.55 & (P = 0.28); (P = 20% \\ \text{Text for overall effect: Z = 2.55 & (P = 0.28); (P = 20% \\ \text{Text for overall effect: Z = 2.55 & (P = 0.28); (P = 20% \\ \text{Text for overall effect: Z = 2.55 & (P = 0.28); (P = 20% \\ \text{Text for overall effect: Z = 2.55 & (P = 0.28); (P = 20% \\ \text{Text for overall effect: Z = 2.55 & (P = 0.28); (P = 20% \\ \text{Text for overall effect: Z = 2.55 & (P = 0.28); (P = 20% \\ \text{Text for overall effect: Z = 2.55 & (P = 0.28); (P = 20% \\ \text{Text for overall effect: Z = 2.55 & (P = 0.28); (P = 20% \\ \text{Text for overall effect: Z = 2.55 & (P = 0.28); (P = 20% \\ \text{Text for overall effect: Z = 2.55 & (P = 0.28); (P = 20% \\ \text{Text for overall effect: Z = 2.55 & (P = 0.28); (P = 2.56); (P = 2.56) \\ \text{Text for overall e$	Managel of al. (2016).	.0.1238 0.4477	10	10	2.8%	-0.12[-1.00_0.28]	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Manifest al. (2018)	0.0324 0.2582	30		6.7%	-0.031-0.54, 0.471	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Broth an at al. (2010)	0.0000 0.0000	10		9.9%	0.2211110.040	
$ \begin{array}{c} \mbox{Total} \mbox{tot} \$	Relibeling of al. (2018).	0.216 0.8735			0.8%	-0.33 [-1.16, 0.46]	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Secure et al. (2015)	0.0217 0.3806			5.7%	-0.00 L 4 67 -0.481	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Sale of all (2010)	1 1935 0 3938	10		4.000	4 581.5 88 -0.45	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Res of all (2017)	-1.1000 0.0000	10		1.00	-1.10[-1.00, -0.40]	
$ \begin{array}{c} \text{Introduction}, (p 0 + 1) & 0 + 0 + 2 & 0 + 0 + 1 & 0 + 0 + 0 + 1 & 0 + 0 + 0 + 1 & 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0$	Deb et al. (2017) Table at al. (2014)	0.4052 0.4367	11		2.276	0.23 [-0.63, 1.00]	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Tartas et al. (2014)	-0.4932 0.5445			2.078	-0.47 [-1.50, 0.00]	
$\begin{array}{c} \mbox{Heatsagenety: Tax^{\mu} = 0.02; Chi^{\mu} = 16, R_{\mu} = 16, P = 0.44; P = 15; \\ \mbox{Text} To were affect: 2 = 2.85, P = 0.054; \\ \mbox{1.1, 3. postaral adjustments} \\ \mbox{Bervis at al. (2015)} & -0.8298 & 0.3019 & 24 & 24 & 6.45; \\ \mbox{Coppend at al. (2015)} & -0.8298 & 0.3019 & 24 & 24 & 6.45; \\ \mbox{Coppend at al. (2015)} & -0.8298 & 0.3019 & 24 & 24 & 6.45; \\ \mbox{Coppend at al. (2015)} & -0.8298 & 0.3019 & 24 & 24 & 6.45; \\ \mbox{Kavid et al. (2015)} & -0.8298 & 0.3019 & 24 & 24 & 6.45; \\ \mbox{Kavid et al. (2015)} & -0.8298 & 0.4812 & 0.4812 & 10 & 10 & 2.85; \\ \mbox{Kavid et al. (2015)} & -0.8291 & 0.4815 & 10 & 10 & 2.85; \\ \mbox{Lung et al. (2013)} & -0.8391 & 0.4484 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 2.45; \\ \mbox{Lung et al. (2013)} & -1.1141 & 0.4885 & 10 & 10 & 0.25; \\ \mbox{Lung et al. (2013)}$	Subtatal (95% CI)	-0.2130 0.3300	220	214	45.6%	-0.21 [-1.27, 0.64]	▲
$ \begin{array}{c} \mbox{transformetry: } 124 = 0.024; \ \mbox{transformetry: } 1$	Material (Market Col)	Chill - 10 10 10 10 10 10 - 0 110 10 - 1		214	44.476	served for served	•
$ \begin{array}{c} 130.15 \mbox{ overall attract_2} - 2.25 \mbox{ (7 = 0.004$)} \\ \hline 13.1.3 \mbox{ postural adjustments} \\ Bertha of al. (2120) & -0.8298 & 0.3019 & 24 & 24 & 6.4% & -0.83 \left[-1.42, -0.24\right] \\ Coppenn at al. (2019) & -0.0531 & 0.3292 & 13 & 13 & 3.25\% & -0.032 \left[-1.65, 0.32\right] \\ Kanil et al. (2073) & -0.0521 & 0.5157 & 8 & 8 & 2.2\% & -0.82 \left[-1.55, 0.38\right] \\ Lung et al. (2021) & -0.1291 & 0.4885 & 10 & 10 & 2.4\% & -0.84 \left[-4.21, 1.41\right] \\ Lung et al. (2021) & -0.1381 & 0.4484 & 10 & 10 & 2.4\% & -0.111 ($207, 0.161$] \\ Bachostic (257) & -1.1141 & 0.4885 & 10 & 10 & 2.4\% & -1.117 ($207, 0.161$] \\ Bachostic (257) & -1.1141 & 0.4885 & 10 & 10 & 2.4\% & -1.117 ($207, 0.161$] \\ Thetarraggenety: Tau* = 0.03; Ch* = 7.46, df = 6.49^{\circ} = 0.28; l^{\circ} = 0.2$	Test for everal effect 7 = 0	CRP = 16.16, 61 = 16 (P = 0.64); P = 1 80.40 - 0.0041					
13.1.3 postaral adjustments Bendia of al. (2020) -0.8298 0.3019 24 24 6.4% -0.83 [-1.42, -0.24] Coppend site (2021) -0.0531 0.3228 13 13 3.5% -0.05 [-0.82, -0.23] Kaski et al. (2013) -0.5966 0.4446 9 9.25% -0.05 [-0.82, -0.32] 14 15.6 0.491 [-0.50, 0.35] Kaski et al. (2016) -0.5986 0.4446 9 9.25% -0.02 [-0.80, 0.35] 14.8 10 15.24% -0.21 [-0.80, 0.46] 10 10 2.4% -0.491 [-0.70, 0.66] 14.9 10 10 2.4% -0.191 [-0.70, 0.66] 10.11 [-2.07, 0.16] 14.8 10 10 2.4% -0.41 [-0.26, 0.42] 10 10 2.4% -0.41 [-0.27, 0.16] 10.11 [-2.07, 0.16] 10.11 [-2.07, 0.16] 10.11 [-2.07, 0.16] 10.11 [-2.07, 0.16] 10.11 [-2.07, 0.16] 10.11 [-2.07, 0.16] 10.11 [-2.07, 0.16] 10.11 [-2.07, 0.16] 10.11 [-2.07, 0.16] 10.11 [-2.07, 0.16] 10.11 [-2.07, 0.16] 10.11 [-2.07, 0.16] 10.11 [-2.07, 0.16] 10.11 [-2.07, 0.16] 10.11 [-2.07, 0.16] 10.11 [-2.07, 0.16] 10.11 [-2.05] 10.11 [-2.05] <t< td=""><td>TWO TO OVER ENDOL 2 = 2</td><td>20 (J 0.004)</td><td></td><td></td><td></td><td></td><td></td></t<>	TWO TO OVER ENDOL 2 = 2	20 (J 0.004)					
$ \begin{array}{c} \mbox{transform} \label{eq:transform} \label{eq:transform} \label{eq:transform} \mbox{transform} \label{eq:transform} \label{eq:transform} \mbox{transform} transf$	13.1.3 postural adjustment						
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Bausta of of 19990				E 4 -	0.0011100.000	
$ \begin{array}{c} \text{Loggenerations} (p, Orlig) & -0.0521 & 0.2402 & 13 & 13 & 12.576 & -0.032 [0.056 1.55, 0.35] \\ \text{Kanki et al} (2053) & -0.0521 & 0.5157 & 8 & 8 & 2.256 & -0.052 [1.55, 0.35] \\ \text{Long et al} (2023) & 0.0525 & 0.0485 & 10 & 10 & 2.456 & -0.32 [-0.02, 1.56, 0.35] \\ \text{Long et al} (2023) & -0.1597 & 8 & 8 & 2.256 & -0.02 [-0.02, 0.16] \\ \text{Long et al} (2023) & -0.1587 & 0.0485 & 10 & 10 & 2.456 & -0.19 [-0.0, 0.66] \\ \text{Subback} (2023) & -1.1142 & 0.0485 & 10 & 10 & 2.456 & -1.1152.07, 0.16] \\ \text{Subback} (2023) & -1.1142 & 0.0485 & 10 & 10 & 2.456 & -0.19 [-1.07, 0.16] \\ \text{Subback} (2023) & -1.1142 & 0.0485 & 10 & 10 & 2.456 & -1.1152.07, 0.16] \\ \text{Subback} (2023) & -1.1142 & 0.0485 & 10 & 10 & 2.456 & -1.1152.07, 0.16] \\ \text{Test argonewity} Tau' = 0.031; Chi2 = 0.026; P = 0.260; P = 235; \\ \text{Test for overall effect: } 2 - 4.256 & q^0 = 0.250; P = 1555 \\ \text{Test for overall effect: } 2 - 4.26 & q^0 > 0.26001 \\ \text{Test for overall effect: } 2 - 1.65, q^0 = 2.26 = 0.0441; P = 0% \\ \end{array}$	Deress of al. (2020)	-0.8250 0.3010	24	24	5.4%	-0.65 [-1.42, -0.24]	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Coppens at al. (2019)	-0.0531 0.3923	13	13	0.5%	-0.05 [-0.62, 0.72]	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Naski et al. (2013) Konist et al. (2013)	-0.5956 0.4846			2.5%	-0.00 [-1.66, 0.36]	
$\begin{array}{c} \text{Larger an (polocy)} & \text{outsell} & $	Nativo et al. (20146)	-0.8201 0.5157			2.2%	-0.82 [-1.63, 0.30]	
$ \begin{array}{c} Lore = n \\ Lor$	Living et al. (2020)	0.2591 0.4495	10	10	2.0%	0.20 [-0.62, 1.14]	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Lu et al. (2018)	-0.1881 0.4484	10	10	2.8%	-0.19 [-1.07, 0.66]	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Yang of al. (2021) Subjected (2025), CD	-1.1141 0.4885	10	10	2.4%	-1.11[-2.07, -0.16]	
$ \begin{array}{c} \text{heterappendix}_{\mathcal{F}}, \text{ tau}^{-1} = 0.03; \text{ Ch}^{-1} = 7.46, \text{ off} = 6.0^{2} = 0.25; P = 2276 \\ \hline \text{Text for overall effect: \mathbb{Z} = 2.55 $0^{9} = 0.01$} \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} = 0.25; P = 15\% \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} < 0.05001$} \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} < 0.05001$} \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} < 0.05001$} \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} < 0.05001$} \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} < 0.05001$} \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} < 0.05001$} \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} < 0.05001$} \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} < 0.05001$} \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} < 0.040$, $P = 0\% $10^{9} $ \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} < 0.05001$} \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} < 0.040$, $P = 0\% $10^{9} $ \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} < 0.05001$} \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} < 0.040$, $P = 0\% $10^{9} $ \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} < 0.05001$} \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} < 0.040$, $P = 0\% $10^{9} $ \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} < 0.040$, $P = 0\% $10^{9} $ \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} $ \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} $ \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} $ \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} $ \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} $ \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} $ \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} $ \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} $ \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} $ \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} $ \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} $ \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} $ \\ \hline \text{Text for overall effect: \mathbb{Z} = 4.67 $0^{9} $ \\ $	annoar (sale ci)		. 94	04	21.0%	-even (-even, -even)	
Test for overall effect: $Z = 2.25$ ($p^{\circ} = 0.51$) Test (95% Cf) Test (95% Cf) Test for overall effect: $Z = 4.67$ ($p^{\circ} < 0.200$ ($p^{\circ} = 1.68$, ($q^{\circ} = 2.0^{\circ} = 0.44$), $p^{\circ} = 0.56$ Test for overall effect: $Z = 4.67$ ($p^{\circ} < 0.200$ ($p^{\circ} = 1.68$, $q^{\circ} = 2.0^{\circ} = 0.44$), $p^{\circ} = 0.56$ Test for subarrup differences: Chi ^o = 1.68, $q^{\circ} = 2.0^{\circ} = 0.44$), $p^{\circ} = 0.56$	Heterogeneity: Tau* = 0.04;	Chr = 7.46, df = 6 (P = 0.26); P = 205	•				
Total (95% CI) 393 387 199.0% -6.38 [-6.54, -4.22] Helarogeneity: Tau" = 0.03; Chi" = 36.58, eff = 31 (P = 0.25); P = 15% 387 199.0% -6.38 [-6.54, -4.22] Total (P5% CI) Total (P5% CI) 2 2 2 2 Total (P5% CI)	Test for overall effect: Z = 2.	55 (P = 0.01)					
$\begin{array}{c} \text{Tests (PS) C(I)} \\ \text{Test (arrow call effect) } \text{Test (}^{2} = 0.03; \text{Ch}^{2} = 36.86, \text{ eff} = 31 \ (p^{2} = 0.23); \ (p^{2} = 1956) \\ \text{Test for overall effect) } \text{Test (}^{2} = 0.02; \ (p^{2} = 0.23); \ (p^{2} = 1956) \\ \text{Test for overall effect) } \text{Test (}^{2} = 0.02; \ (p^{2} = 0.23); \ (p^{2} = 0.23); \ (p^{2} = 1956) \\ \text{Test for overall effect) } \text{Test (}^{2} = 0.02; \ (p^{2} = 0.44); \ (p^{2} = 0.36) \\ \text{Test for overall effect) } \text{Test (}^{2} = 0.02; \ (p^{2} = 0.44); \ (p^{2} = 0.36) \\ \text{Test for overall effect) } \text{Test (}^{2} = 0.02; \ (p^{2} = 0.44); \ (p^{2} = 0.36) \\ \text{Test for overall effect) } \text{Test (}^{2} = 0.02; \ (p^{2} = 0.44); \ (p^{2} = 0.36) \\ \text{Test for overall effect) } \text{Test (}^{2} = 0.02; \ (p^{2} = 0.44); \ (p^{2} = 0.36) \\ \text{Test for overall effect) } \text{Test (}^{2} = 0.02; \ (p^{2} = 0.44); \ (p^{2} = 0.36) \\ \text{Test for overall effect) } \text{Test (}^{2} = 0.02; \ (p^{2} = 0.44); \ (p^{2} = 0.36) \\ \text{Test for overall effect) } \text{Test (}^{2} = 0.02; \ (p^{2} = 0.44); \ (p^{2} = 0.36) \\ \text{Test for overall effect) } \text{Test (}^{2} = 0.02; \ (p^{2} = 0.44); \ (p^{2} = 0.36) \\ \text{Test for overall effect) } \text{Test (}^{2} = 0.02; \ (p^{2} = 0.44); \ (p^{2} = 0.36) \\ \text{Test for overall effect) } \text{Test (}^{2} = 0.02; \ (p^{2} = 0.44); \ (p^{2} = 0.36) \\ \text{Test for overall effect) } Test for $							
Heleogeneity: Tax" = 0.02; Chi" = 35.8; cf = 31.0 ² = 0.23; P = 15% Test for overall effect: Z = 4.67 (P < 0.00001)	Total (99% CI)		393	387	100.0%	-0.38 [-0.64, -0.22]	
Test for overall effect: Z = 4.67 (P < 0.00001) Test for subaroup differences: ChP = 1.88, et = 2.0P = 0.44), P = 0%	Heterogeneity: Tau ^a = 0.03;	ChP = 36.58, eF = 31 (P = 0.23); P = 1	5%				
Tost for subarous differences: ChP = 1.66, cf = 2.0P = 0.44), P = 0%	Test for overall effect: Z = 4.	67 (P < 0.00001)					Favours (experimental) Favours (control)
	Test for subaroup difference	s: ChP = 1.66, df = 2.0 ^o = 0.44), P = 0	96				· · · · · · · · · · · · · · · · · · ·

Figure 6. Forrest plots of the meta-analysis regarding the outcome domain with the static subgroup, dynamic/functionality subgroup, and postural adjustments in situations with external perturbation subgroup after sensitivity analysis.

			Experimental	Control		Std. Mean Difference	Std. Mean Difference
Study or Subgroup	Std. Mean Difference	SE	Total	Total	Weight	IV, Random, 95% Cl	IV, Random, 95% Cl
14.1.1 Parkinson's disease							
Beretta et al. (2020)	-0.8289	0.3019	24	24	6.2%	-0.83 [-1.42, -0.24]	_ _
Costa-Ribeiro et al. (2017)	0.3911	0.4313	11	11	3.3%	0.39 [-0.45, 1.24]	
Kaski et al. (2014b)	-0.6201	0.5157	8	8	2.4%	-0.62 [-1.63, 0.39]	
Lattari et al. (2017)	-0.1406	0.3435	17	17	5.0%	-0.14 [-0.81, 0.53]	
Lu et al. (2018)	-0.1881	0.4484	10	10	3.1%	-0.19 [-1.07, 0.69]	
Manenti et al. (2016)	-0.1228	0.4477	10	10	3.1%	-0.12 [-1.00, 0.75]	
Workman et al. (2020)	-0.2136	0.5366	7	7	2.2%	-0.21 [-1.27, 0.84]	
Subtotal (95% CI)			87	87	25.2%	-0.30 [-0.61, 0.02]	◆
Heterogeneity: Tau ² = 0.01; C	hi ² = 6.48, df = 6 (P = 0	37); l ^a =	7%				
Test for overall effect: Z = 1.8	4 (P = 0.07)						
14.1.2 Stroke							
Andrade et al. (2017)	-2.2879	0.4046	30	15		Not estimable	
Babyar et al. (2016)	0.0667	0.4716	9	9	2.8%	0.07 [-0.86, 0.99]	
Babyar et al. (2018)	-1.6616	0.5347	10	10	2.2%	-1.66 [-2.71, -0.61]	
Chang et al. (2015)	-0.3778	0.4126	12	12	3.6%	-0.38 [-1.19, 0.43]	
Coppens et al. (2019)	-0.0531	0.3923	13	13	3.9%	-0.05 [-0.82, 0.72]	
Danzi et al. (2013)	0.0311	0.7072	4	4	1.3%	0.03 [-1.35, 1.42]	
Fruhauf et al. (2017)	-0.2119	0.3663	15	15	4.4%	-0.21 [-0.93, 0.51]	
Geroin et al. (2011)	-0.2695	0.4497	10	10	3.1%	-0.27 [-1.15, 0.61]	
Liang et al. (2020)	0.2591	0.4495	10	10	3.1%	0.26 [-0.62, 1.14]	
Madhavan et al. (2020)	-0.0932	0.3164	20	20	5.7%	-0.09 [-0.71, 0.53]	
Manji et al. (2018)	-0.0321	0.2582	30	30	8.0%	-0.03 [-0.54, 0.47]	
Ojardias et al. (2020)	-0.1314	0.354	16	16	4.7%	-0.13 [-0.83, 0.56]	
Prathum et al. (2021)	-0.3269	0.4115	12	12	3.6%	-0.33 [-1.13, 0.48]	
Seeys et al. (2015)	-0.9217	0.3806	16	15	4.1%	-0.92 [-1.67, -0.18]	
Seo et al. (2017)	0.2282	0.4387	11	10	3.2%	0.23 [-0.63, 1.09]	
Sohn et al. (2013)	-1.1212	0.4654	11	11	2.9%	-1.12 [-2.03, -0.21]	
Tahtis et al. (2014)	-0.4652	0.5445	7	7	2.1%	-0.47 [-1.53, 0.60]	
Yang et al. (2021)	-1.1141	0.4885	10	10	2.6%	-1.11 [-2.07, -0.16]	
Zandvliet et al. (2018)	-0.5698	0.3736	15	15	4.3%	-0.57 [-1.30, 0.16]	
Subtotal (95% CI)			231	229	65.6%	-0.33 [-0.55, -0.12]	•
Heterogeneity: Tau ^a = 0.05; C	hi ² = 21.68, df = 17 (P =	0.20);	² = 22%				
Test for overall effect: Z = 3.0	3 (P = 0.002)						
14.1.3 cerebellar ataxia							
Barreto et al. (2019)	-1.0263	0.5814	7	7	1.9%	-1.03 [-2.17, 0.11]	
Benussi et al. (2015)	-0.2494	0.3258	19	19	5.4%	-0.25 [-0.89, 0.39]	
Grimaldi & Manto (2013)	-0.0777	0.5777	6	6	1.9%	-0.08 [-1.21, 1.05]	
Subtotal (95% CI)			32	32	9.2%	-0.37 [-0.87, 0.13]	-
Heterogeneity: Tau ² = 0.00; C	thi² = 1.67, df = 2 (P = 0	.43); I² =	0%				
Test for overall effect: Z = 1.4	3 (P = 0.15)						
Total (DEV. OI)			0.50	2/2	100.00	0.001.040.040	▲
Total (95% CI)			350	348	100.0%	-0.32 [-0.48, -0.16]	· · · · · · · · · · · · · · · · · · ·
Heterogeneity: Tau ^x = 0.02; C	hi= = 29.87, df = 27 (P =	: 0.32); F	* = 10%				4 -2 0 2 4
Test for overall effect: Z = 3.9	1 (P < 0.0001)						Favours [experimental] Favours [control]
Test for subgroup differences	: Chi* = 0.06, df = 2 (P =	0.97), P	= 0%				

Figure 7. Forrest plots of the meta-analysis regarding the type of neurological disorders with the Parkinson's disease subgroup, Stroke subgroup, and Cerebellar ataxia subgroup after sensitivity analysis.

51



Figure 8. Synthesis of the main findings of the effect of tDCS on postural control and balance in adults with neurological disease tDCS. Filled-up-oriented arrows indicate an overall positive effect in favor of tDCS and the Unfilled-up-oriented arrows indicate positive tDCS effects for each subgroup. SMDs are reported for group and subgroup analysis.

Table 1. Search	strategy	used to	identify	relevant	studies.
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	Search key terms								
tDCS	intervention:	"transcranial	direct	current	stimulation"	OR	"tDCS"	OR	

"transcranial electrical stimulation" OR "non-invasive brain stimulation" OR "transcranial current stimulation" (TITLE-ABS-KEY)

AND

Postural control/balance assessment: "postural control" OR "postural responses" OR "postural function" OR "postural stability" OR "static balance" OR "postural adjustments" OR "postural balance" OR "postural equilibrium" OR posturography OR stabilometry OR posture OR balance OR equilibrium OR "postural sway" OR sway OR standing (TITLE-ABS-KEY)

TITLE-ABS-KEY indicates a title, abstract, and keyword search.

First	Study	Populatio	Intervention	Compariso	Outcomes	Results
author	characteristi	n	(tDCS	n	1. Outcome domain	- Effect
(year)	cs	- Groups	characteristic	- (active vs	2. Measurement	of tDCS
	1. Population	or	s)	sham or	tool/Main outcomes	on main
	(type of	condition	1. Polarity of	experiment	3. Additional	outcome
	neurological	(n; age	stimulation	al vs CG)	outcomes (cortical	S
	disease)	(mean ±	current		activity)	
	2. Sample	standard	2. Target area		4. Measurement	
	size	deviation);	stimulated		time	
	3. Study	and sex)	3. Reference		5. Side effects of	
	design		electrode		active tDCS	
			4. Electrode			
			size			
			5. Duration			
			6. Intensity			
			7. Number of			
			sessions			
			8. Additional			
			intervention			
			(moment of			
			the			
			intervention in			
			relation to			
			tDCS -before,			
			together,			
			after))			
Androd	1 Stroko	4	1 Anodal and	Anodal	1	Anodal
e et al	2 60	Groups:	cathodal	vs cathodal	1. Dynamic/functional	- Anodal
(2017)	2.00 3 Parallel-	- Anodal-	2 M1 affected	vs bilateral	ity	and
(2017)	arms	tDCS	hemisphere	vs. sham-	2 Riodex Balance	hilateral_
	randomized	(n-15)	(anodal	tDCS	System/Overall	tDCS
	double-blind	6886+46	condition).	iDCb	Stability	nerforme
	sham-	6.8M/7F)	M1 unaffected		Index: BBS/lower	d better
	controlled	-	hemisphere		limb function.	the BBS
	controlled.	Bilateral-	(cathodal		FSST/balance	Overall
		tDCS	condition)		3. No	Stability
		(n=15:	3.		4. Pre. post. 1- and	Index
		69.06±4.4	Contralateral		3-months follow-up	and
		3; 9M/6F)	supraorbital		5. No adverse	FSST

Table 2. Methodological characteristics and main results of the reviewed studies.

-	area	effects	than
Cathodal-	4. 35 cm^2		sham.
tDCS	5. NR		
(n=15;	6. 2 mA		-
70.40±2.3	7. 10 sessions		Bilateral-
2; 8M/7F)	8. Yes.		tDCS
- Sham	Physical		further
(n=15;	rehabilitation		increased
68.00 ± 1.4	intervention.		the BBS
6;	Moment NR.		score
10M/5F)			compare
			d to
			anodal,
			cathodal
			and
			sham-
			tDCS.

Babyar et al. (2016)	1. Stroke 2. 9 3. Crossover, randomized, single- blind, sham- controlled.	- Bipolar balanced- tDCS; single-tDCS; GVS; sham- tDCS (n=9; NR; 5M/4F)	1. Anodal 2. Ipsilesional PIVC; PIVC contralesional side 3. Contralateral supraorbital area 4. 25 cm ² 5. 20 min 6. 2 mA 7. 1 session 8. No	- Bipolar active- tDCS vs single active- tDCS vs. sham	1. Static (seated) 2. Force plate/mean speed of CoP 3. No 4. Pre, 5-, 10- and 15-min during stimulation, and post 5. NR	 Bipolar active-tDCS increased the mean speed of CoP at 5 min compared to pre. Bipolar active-tDCS reflected a higher mean speed of CoP at 5 min than sham.
Babyar et al. (2018)	1. Stroke 2. 10 3. Crossover, sham- controlled	- HD-tDCS, GVS and sham-tDCS (n=10; 66±9.5; 6M/4F)	 Anodal PIVC Contralateral parietal cortex 3.14 cm² 15 min 2 mA sinusoidal 1 session No 	- Active- tDCS vs. sham	1. Static 2. Force plate (CoP velocity)/seated haptic 3. No 4. Pre, 5, 10 and 15 min during tDCS session 5. NR	- Greater CoP velocity in HD- tDCS compared to sham at 10 min.
Barretto et al. (2019)	1. Cerebellar ataxia 2. 7 3. Crossover,	- Active and sham-tDCS (n=7; 36.57±17.19; 3M/4F)	 Anodal Motor cortex Contralateral supraorbital 	- Active vs. sham- tDCS	1. Static 2. Wii Fit platform/CoP oscillation; CvMob software/total	 Active-tDCS increased the total gain of the CoP oscillation. No effect of

double-	area	trajectory of	active-tDCS on
blind,	4. 35 cm^2	the	the gain of the
sham-	5. 40 min (20	displacement	total trajectory
controlled	min for each	3. No	of the
	motor cortex)	4. Pre and post	displacement.
	6. 2 mA	5.37.5%	
	7. 5 sessions	reported	
	8. No	itching (27.5%	
		light intensity)	

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(Contir	nued).				<u>k</u>	
Benuss i et al. (2015)	 Cerebellar ataxia 19 Crossover, randomized, double- blind, sham- controlled 	- Active and sham- tDCS (n=19; 53.8± 18.4; 8M/11F)	1. Anodal 2. Cerebellum 3. Right deltoid muscle 4. 35 cm ² 5. 20 min 6. 2 mA 7. 1 session 8. No	- Active vs. sham-tDCS	1. Dynamic/functionali ty 2. ICARS/posture 3. No 4. Pre and post 5. NR	- Active tDCS decreased the ICARS score at post than sham.
Beretta et al. (2020b)	 Parkinson's disease 24 Crossover, randomized, double- blind, sham- controlled 	- Active and sham- tDCS (n = 24; 68.91±8.47 ; 14M/10F)	 Anodal M1 Contralater al supraorbital area 35cm² 20 min 2 mA 1 session No. 	- Active vs. sham-tDCS	 Postural adjustments EMG/MG onset latency; force plate/recovery time fNIRS/PFC activity After each tDCS condition without difference between active and sham 	- Decrease in MG onset latency and recovery time in active compared to sham- tDCS.
Cha et al. (2016)	1. Mal de debarqueme nt syndrome 2. 24 3. Parallel- arms, randomized, single-blind, sham- controlled	- r- TMS+tDC S (n=12) - r- TMS+sha m (n=10) (59.9±12.2 ; 24F)	 Anodal Dominant DLPFC Contralater al DLPFC 4. 35 cm² 5. 20 min 6. 1 mA 7. 20 sessions 8. Yes. rTMS before tDCS 	- Experiment al vs. CG	 Dynamic/functionali ty MdDS Balance Rating Scale/ rocking perception No Pre, 1-week post, 2-week post, 3-week post and 4-week Post No adverse effects 	- r- TMS+tDC S decreased the MdDS Balance Rating Scale at 4- week post compared to pre.

Chang et al. (2015)	1. Stroke 2. 24 (15M/9F) 3. Parallel- arms, randomize d, double- blind, sham- controlled	- Active- tDCS+conventio nal therapy (n=12;59.9±10.2) - Sham- tDCS+conventio nal therapy (n=12;65.8±10.6)	1. Anodal 2. M1 3. Contralater al supraorbital area 4. 7.07 cm ² 5. 10 min 6. 2 mA 7. 10 sessions 8. Yes. Convention al therapy during tDCS	- Experimen tal vs. CG	1. Dynamic/functiona lity 2. BBS/balance 3. TMS/MEP 4. Pre and post 5. NR	- No additional effect of active- tDCS + convention al therapy on BBS.
Coppe ns et al. (2019)	1. Stroke 2.13 3. Crossover , single- blind, sham- controlled	- Anodal, cathodal and sham-tDCS (n=13; 62±11.6; 12M/1F)	1. Anodal and cathodal 2. Ipsilesional M1 (anodal) and contralesio nal M1 (cathodal) 3. Contralater al supraorbital area 4. 35 cm ² 5. 15 min 6. 2 mA 7. 1 session 8. No	- Anodal vs. cathodal vs. sham- tDCS	1. Postural adjustments 2. EMG/TA onset latency; 8- camera 3D motion analysis system (Vicon)/Body sway-maximum displacement 3. No 4. After each tDCS condition 5. No adverse events	 No effect of anodal and cathodal tDCS on TA onset latency. Greater body sway in anodal- tDCS compared to cathodal and sham- tDCS.

Table 2. Methodological characteristics and main results of the reviewed	studies
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(Continued).

Table 2. Methodological characteristics and main results of the reviewed studies

(Continued).

Costa	1. Multiple	- Active	1. Anodal	-	1.Dynamic/functionalit	- No
et al.	sclerosis	tDCS+VR	2. M1	Experimenta	У	additional
(2020)	2.1	and Sham	3.	l vs. CG	2. BESTest/balance	effect of
	3.	tDCS+VR	Contralatera		3. No	active-
	Crossover,		1		4. Pre, post and 14-	tDCS+V
	case study,	(n=1;51;1M	supraorbital		days follow-up	R on

	single- blind, sham- controlled)	area 4. 25 cm ² 5. 20 min 6. 2 mA 7. 5 sessions 8. Yes. Balance training with Nintendo Wii VG during tDCS.		5. No adverse effects after sham and itching sensation after active tDCS	BESTest score.
Costa- Ribeir o et al. (2017)	 Parkinson' s disease 24 Parallel- arms, randomize d controlled trial, double- blind, sham- controlled. 	- Active- tDCS+gait training (n=11; 61.1±9.1; 8M/3F) - Sham- tDCS+gait training (n=11; 62.0±16.7; 7M/4F)	 Anodal Motor cortex Contralatera supraorbital area 35 cm² 13 min 2 mA 10 sessions Yes. Gait training with visual cues after tDCS. 	Experimenta l vs. CG	1.Dynamic/functionalit y 2. BBS/balance 3. No 4. Pre, post, 1-month follow-up 5. No adverse effects	- No additional effect of active- tDCS+gai t training on BBS score.

 Table 2. Methodological characteristics and main results of the reviewed studies

(Con	tinu	ed).
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Danz l et al. (2013)	1. Stroke 2. 8 3. Parallel- arms, randomiz ed, double- blind, sham- controlled	- Active- tDCS+RAGT (n=4; 64.75±14.86; 3M/1F) - Sham- tDCS+RAGT (n=4; 70.75±11.15; 1M/3F)	 Anodal Motor cortex Supraorbit al area 25 cm² 20 min 2 mA 12 sessions Yes. Locomoto r training with RAGT after tDCS 	- Experimen tal vs. CG	1.Dynamic/functio nality 2. BBS/balance; TUG/balance 3. No 4. Pre, post and 1- month follow-up 5. No adverse effect	 Active-tDCS trended to improve the TUG performance compared to sham. No effect of active-tDCS on BBS score.
Foro	1.	- Active-	1. anodal	-	1.Dynamic/functio	- No additional

gh et	Parkinson	tDCS+occupati	2. Left	Experimen	nality	effect of active-
al.	's disease	onal therapy	DLPFC	tal vs. CG	2. BBS/balance	tDCS+occupati
(2018	2.23	(n=12;	3. Right		3. No	onal therapy on
)	3.	61.33±NR;	forearm		4. Pre, post and 3-	BBS score.
	Parallel-	7M/7F)	4. 35 cm^2		months follow-up	
	arms,		5. 20 min		5. NR	
	randomiz	- Sham-tDCS+	6.0.6			
	ed,	occupational	mA/cm ²			
	double-	therapy	7.8			
	blind,	(n=11;	sessions			
	sham-	64.81±NR;	8. Yes.			
	controlled	7M/7F)	Occupatio			
			nal			
			therapy			
			after tDCS			

Table 2. Methodological characteristics and main results of the reviewed studies

(Continued).

Fruhau f et al. (2017)	1. Stroke 2. 30 3. Crossover, randomize d, double- blind, sham- controlled	- Active- tDCS+activ e-FES; active- tDCS+sham -FES; sham- tDCS+activ e-FES; and sham- tDCS+sham -FES (n=30;	1. Anodal 2. M1 3. Contralater al supraorbital area 4. 35 cm ² 5. 20 min 6. 2 mA 7. 1 session 8. Yes. FES on TA	- Experiment al vs. CG	 Static Force plate/static balance (sway velocity and sway frequency) No Pre and post NR 	- No effects of experimenta l conditions on postural control.
		61.0±9.7; 23M/7F)	muscle during tDCS			
Geroin et al. (2011)	1. Stroke 2. 30 3. Parallel- arms, randomize d, sham- controlled	- tDCS+RAG T (n=10; 63.6±6.7; 8M/2F) - Sham+RAG T (n=10; 63.3±6.4; 6M/4F) - overground walking exercises (n=10; 61.1±6.3; 9M/1F)	1. Anodal 2. M1 (leg area) 3. Contralater al supraorbital area 4. 35 cm ² 5. 7 min 6. 1.5 mA 7. 10 sessions 8. Yes. RAGT during tDCS	- Experiment al vs. CG	 Dynamic/functionali ty 6-min walk test/dynamic balance No Pre, post and 2- weeks follow-up No adverse effects 	 tDCS and sham+RAG T increased the distance in the 6-min walk test compared to overground walking exercises. No additional effect of active-tDCS on 6-min walk test.

Grimal di & Manto (2013)	1. Cerebellar ataxia 2. 9 3. Crossover, single- blind, sham- controlled	- Active and sham-tDCS (n=9; 51.3±14.0; 7M/2F)	 Anodal Cerebellu Contralater al supraorbita l area 20 cm² 20 min 1 mA 1 session No 	- Active vs. sham-tDCS	1. Static 2. FootScan pressure platform/AP, ML and total displacement 3. No 4. Pre, post-sham, post-active 5. NR	- No effect of active- tDCS on postural control.
Kaski et al. (2013)	1. Leukoaraio sis 2. 9 3. Crossover, randomized , double- blind, sham- controlled	- Active- tDCS+physi cal training; sham- tDCS+physi cal training (n=9; 79.4±5.5; 7M/2F)	1. Anodal 2. Motor cortex 3. Inion 4. 40 cm ² 5. 15 min 6. 2 mA 7. 1 session 8. Yes. Physical training during tDCS	- Experiment al vs. CG	 Dynamic/functiona lity and postural adjustments TUG/balance; retropulsion test- digitally-based angular-velocity transducers/recover y time No Pre and post NR 	- Active- tDCS+physi cal training decreased the TUG and recovery time at post compared to pre.
Kaski et al. (2014a)	1. Parkinson's disease 2. 1 3. Crossover, randomized , double- blind, sham- controlled, case study	- Dance + tDCS; Dance + sham (n=1; 79 years; 1M)	1. Anodal 2. Bilateral M1 and PMC 3. Inion 4. 40 cm ² 5 7 min 30 sec 6. 2 mA 7. 2 sessions 8. Yes. Dance- Tango (together with tDCS)	- Experiment al vs. CG	 Dynamic/functiona lity Digitally-based angular-velocity transducers/Angula r trunk velocity; Tinetti gait index/gait and balance No Trunk velocity (during tango); Tinetti Gait index (pre and post) NR 	- Dance+tDCS increased the trunk velocity and Tinetti gait index score compared to CG.

(Continued).

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Kaski et al. (2014b)	1. Parkinson's disease 2. 16 3. Randomize d, double- blind, sham- controlled	 Group I (active and sham- tDCS+physic al training) (n=8; NR; NR) Group II (active and sham-tDCS without (retring c) 	1. Anodal 2. Motor cortex 3. Inion 4. 40 cm ² 5. 15 min 6. 2 mA 7. 1 session 8. Yes. Physical training during	- Experiment al vs. CG	 Postural adjustments Pull test/recovery time (angular trunk movement) No Pre and post NR 	- tDCS+physic al training decreased the recovery time compared to tDCS without physical training.
		(n=8; NR; NR)			2100	effect of tDCS or physical training on recovery time.
Lattari et al. (2017)	1. Parkinson's disease 2. 17 3. Crossover, randomized , double- blind, sham- controlled	- active and sham-tDCS (n=17; 69.18±9.98; 13M/4F)	1. Anodal 2. Left DLPFC -3. Right orbitofront al cortex 4. 35 cm ² 5. 20 min 6. 2 mA 7. 1 session 8. No	- Active vs. sham-tDCS	 Dynamic/functional ity BBS/dynamic balance No After each tDCS condition NR 	- Active- tDCS had better scores on BBS compared to sham.
Liang et al. (2020)	1. Stroke 2. 10 3. Crossover, randomized , double- blind, sham- controlled	- active- tDCS+limits of stability training; sham- tDCS+limits of stability training (n=10; 58.96±9.56; 6M/4F)	 Anodal Motor cortex Contralater al supraorbita area 25 cm² 20 min 2 mA 1 session Yes. Limits of stability training during tDCS 	- Experiment al vs. CG	 Dynamic/functional ity and postural adjustments BBS/balance; force plate/reactive postural adjustments (Toes down = sway energy and backward translation = latency) No Pre and post NR 	 No additional effect of active- tDCS+limits of stability training on BBS. No additional effect of active- tDCS+limits of stability training on reactive postural adjustments.

(Continued).

Lu et al. (2018)	 Parkinson' s disease 10 Crossover, randomize double- blind, sham- controlled 	- Active and sham- tDCS (n=10; 66.3±9.9 ; 7M/3F)	1. Anodal 2. SMA 3. Forehead 4. 8.1 cm ² 5. 10 min 6. 1 mA 7. 1 session 8. No.	- Active vs. sham-tDCS	1. Postural adjustments (APA) 2. Force plate/Peak (magnitude and time) of CoP- ML; force plate/ground reaction forces- time to step peak loading 3. No 4. Pre, 0 min post, 12 min post, 24-min post, 36-min post, 48-min post and 60 min-pos 5. No adverse effects	- Active- tDCS demonstrate d lower time to step peak loading compared to sham.
Madhava n et al. (2020)	1. Stroke 2. 81 3. Parallel- arms, randomize d, sham- controlled	- CG (n=20; 58±10; 11M/9F) - Sham+ ankle motor tracking (n=20; 60±9; 15M/5F) - tDCS (n=21; 58±11; 14M/7F) - tDCS+ ankle motor tracking (n=20; 59±9; 15M/5F)	1. Anodal 2. M1 3. Contralater al supraorbital area 4. 12.5 cm ² 5. 15 min 6. 1 mA 7. 12 sessions 8. Yes. High- intensity speed-based treadmill training after tDCS (for all conditions)	- Experiment al vs. CG	1. Dynamic/functionalit y 2. BBS/balance; MiniBESTest/balanc e; ABC scale/balance 3. Corticomotor excitability 4. Pre, post and 3- months follow-up 5. No adverse effects	- No additional effect of tDCS on BBS, MiniBESTe st and ABC scale.

Table 2. Methodological characteristics and main results of the reviewed studies

N/ (1	A	1 4 1 1		1 0 1	NT
Manent	1.	- Active-	I. Anodal	-	1. Static and	- NO
i et al.	Parkinson'	tDCS+physica	2. DLPFC	Experiment	dynamic/functionalit	additiona
(2016)	s disease	l therapy	3.	al vs. CG	у	l effect
	2.20	(n=10;69.0±9.	Contralater		2. Standing stork	of tDCS
	3. Parallel-	1; 4M/6F)	al		test/ static balance;	on static
	arms,		supraorbital		FSST/dynamic	and

	randomize d, double- blind, sham- controlled	- Sham- tDCS+physica l therapy (n=10; 69.1±5.6; 7M/3F)	area 4. 35 cm ² 5. 25 min 6. 2 mA 7. 10 sessions 8. Yes. Physical therapy during tDCS		balance 3. No 4. Pre, post and 3- months follow-up 5. No adverse effects	dynamic balance.
Manji et al. (2018)	1. Stroke 2. 30 3. Crossover, randomize d, double- blind, sham- controlled	 Group A (active and sham- tDCS+body weight- supported treadmill training) (n=15; 62.2±10.1; 10M/5F) Group B (sham and active- tDCS+body weight- supported treadmill training) (n=15; 63.7±11.0; 11M/4F) 	1. Anodal 2. Motor cortex (SMA) 3. Inion 4. 25 cm ² 5. 20 min 6. 1 mA 7. 5 sessions (1 week) 8. Yes. Body weight- supported treadmill training during tDCS	Experiment al vs. CG	 Dynamic/functionali ty POMA/balance and gait function No Pre, post-test 1 and post-test 2 NR 	- No additiona l effect of the active- tDCS on POMA score.

Ojardia s et al. (2020)	1. Stroke 2. 18 3. Crossover, randomize d, double- blind, sham- controlled	- Active and sham- tDCS (n=18; 57.4±3.6; 12M/6F)	 Anodal Ipsilesional M1 cortex of the lower limb 3 Contralesion al orbitofrontal cortex 25 cm² 20 min 2 mA 1 session No 	- Active vs. sham-tDCS	 Static Force plate (CoP)/Excursion of CoP and CoP trajectory length with Eyes Open and Eyes Closed No Pre (during tDCS session) and post each tDCS session Minor adverse events with tDCS (1 participant reported headache and another participant reported transient 	- No effect of active- tDCS on postural control.
			6. NO		reported transient fatigue)	

Prathu	1. Stroke	- Active-	1. Anodal	-	1.	- Active-
m et al.	2.24	tDCS	2. M1	Experiment	Dynamic/functionali	tDCS
(2021)	3. Parallel-	(n=12;	(lesioned	al vs. CG	ty	decreased
	arms,	58.67±3.7	hemisphere)		2. TUG/dynamic	the time to
	randomize	0; 8M/4F)	3. M1 (non-		balance	perform
	d, double-		lesioned		3. No	TUG at
	blind,	- Sham-	hemisphere)		4. Pre, Post and 1-	Post and
	sham-	tDCS	4. 35 cm^2		month follow-up	follow-up
	controlled	(n=12;	5. 20 min		5. Mild tDCS-	periods
		56.83±3.5	6. 2 mA		related adverse	compared
		8; 8M/4F)	7.12		effects (tingling:	to pre.
			sessions		active-tDCS $=$	1
			8. Yes.		34.72% and sham-	- No
			Lower and		tDCS = 88.19%).	additional
			upper limb			effects of
			exercises			active-
			after tDCS			tDCS on
						TUG
						performanc
						e.

Raithath a et al. (2016)	1. Spinal cord injury 2. 15 3. Parallel- arms, randomize d, double- blind, sham- controlled	- Active- tDCS+ RAGT (n=9; 40.56±12.2 4; 5M/4F) - Sham- tDCS+ RAGT (n=6; 58±5.37 5M/1F)	1. Anodal 2. Motor cortex 3. Supraorbita 1 area 4. 25 cm ² 5. 20 min 6. 2 mA sinusoidal 7. 36 sessions 8. Yes. RAGT after tDCS session	Experiment al vs. CG	 Dynamic/functionali ty BBS/balance No Pre, post and 1- month follow-up No adverse events 	- No additional effect of active- tDCS+ RAGT on BBS score.
Saeys et al. (2014)	1. Stroke 2. 31 3. Crossover, randomize d, double- blind, sham- controlled	- Group 1: active and sham-tDCS (sequence) (n=16; 62±9.61; 9M/7F) - Group 2: sham-active tDCS (sequence) (n=15; 64.53±7.23; 8M/7F)	1. Anodal 2. M1 ipsilesional hemisphere 3. M1 intact hemisphere 4. 35 cm ² 5. 20 min 6. 1.5 mA sinusoidal 7. 16 sessions 8. Yes. Regular physical and	- Experiment al vs. CG	 Dynamic/functionali ty Tinetti/balance and gait No Pre, post-first tDCS condition (mild – 4 weeks) and post-second tDCS condition (post – 8 weeks) No adverse events 	- Active- tDCS increased the Tinetti score compared to sham.

			occupation al therapy. Moment NR			
Saki et	1.	-	1. Anodal	-	1.	-
al.	Vestibular	tDCS+VRT	2. Right	Experiment	Dynamic/functionali	tDCS+VR
(2020)	dysfunctio	(n=18;	DLPFC	al vs. CG	ty	Т
	n	72.11±5.09;	3. Left		2. ABC	increased
	2.36	10M/8F)	DLPFC		scale/balance	the score
	3. Parallel-		4. 35 cm^2		3. No	on ABC
	arms,	- VRT	5. 20 min		4. Pre, 1-week post,	scale.
	randomize	(n=18;	6. 2 mA		2-week post and 3-	
	d, double-	71.33±6.16;	7.18		week post	- Superior
	blind,	11M/7F)	sessions		5. 79.3% in	effect of
	controlled		8. Yes.		tDCS+VRT and	tDCS+VR
	trial		VRT after		53.3% in VRT	T on
			tDCS.		reported itching	balance
					(most common	compared
					adverse event)	to VRT.

Table 2. Methodological characteristics and main results of the reviewed studies

5

Seo et al. (2017)	1. Stroke 2. 21 3. Parallel- arms, randomized , double- blind, sham- controlled	- Active- tDCS+ RAGT (n=11; 61.1±8.9; 9M/2F) - Sham- tDCS+ RAGT (n=10; 62.9±8.9; 7M/3F)	1. Anodal 2. Motor cortex 3. Contralatera 1 supraorbital area 4. 35 cm ² 5. 20 min 6. 2 mA 7. 10 sessions 8. Yes. RAGT after tDCS	- Experimenta l vs. CG	 Dynamic/functionalit y 2. BBS/balance 3. Yes. Cortical excitability 4. Pre, post and 1- month follow-up 5. NR 	- No additiona l effects of active- tDCS on BBS score.
Sohn et al. (2013)	1. Stroke 2. 11 3. Crossover, randomized , single- blind	- Active and sham-tDCS (n=11; 58.45±14.55 ; 9M/2F)	1. Anodal 2. M1 affected hemisphere 3. Supraorbital area	- Active vs. sham-tDCS	 Static Biodex Balance System/postural stability indices (static balance, overall, AP and ML) No 	- Active- tDCS improved the overall, AP and ML
	sham- controlled		4. 25 cm ² 5. 10 min 6. 2 mA 7. 1 session 8. No		4. Pre and post 5. NR	postural stability indices compare d to sham.
Tahtis et al. (2014)	 Stroke 14 Parallel- arms, 	- Active- tDCS (n=7; 67.3±11.8;	 Anodal Affected M1 Non- 	- Active vs. sham-tDCS	1. Dynamic/functionalit y 2. POMA/balance	- No additiona l effects of active-

randomized	5M/2F)	affected M1	and gait function.	tDCS on
, double-		4. 25 cm ²	3. No	POMA
blind, sham- controlled	- Sham- tDCS (n=7; 56.4±12.3; 6M/1F)	5. 15 min 6. 2 mA 7. 1 session 8. No	4. Pre and post5. No adverse effects	score.

 Table 2. Methodological characteristics and main results of the reviewed studies

Verheyd	1.	- Active and	1. Anodal	-	1.	- No
en et al.	Parkinson	sham-tDCS	2. M1	Active	Dynamic/function	effect of
(2013)	's disease		3. Contralateral	vs.	ality	active-
	2.20	(n=20; 71±7;	supraorbital area	sham-	2. Functional	tDCS on
	3.	NR)	4. NR	tDCS	reach/balance;	functional
	Crossove	,	5. 15 min		TUG/balance	reach and
	r,		6. 1 mA		3. No	TUG
	randomiz		7.1 session		4. Pre, during and	performan
	ed,		8. No		post	ce.
	double-				5. NR	
	blind,					
	sham-					
	controlle					
	d					
Workma	1.	- Unilateral-2	1. Anodal	-	1. Static and	- No
n et al.	Parkinson	mA; bilateral-2	2. Cerebellum	Active	dynamic/function	effect
(2020)	's disease	mA; unilateral-	3. Contralateral	vs.	ality	active-
	2.7	2 mA; bilateral-	cerebellum	sham-	2. Force	tDCS
	3.	4 mA; and	hemisphere	tDCS	platform/CoP	conditions
	Crossove	sham	(bilateral)/contrala		area and CoP	on static
	r,		teral upper arm		Velocity;	posture.
	randomiz	(n=7; 72.4±	(unilateral)		BBS/balance	
	ed,	6.4; 5M/2F)	4. 35 cm^2		3. No	- Only
	double-		5. 20 min		4. After each	bilateral-4
	blind,		6. 2 mA and 4 mA		tDCS condition	mA
	sham-		7.1 session		5. Mild burning,	demonstra
	controlle		8. No		itching, tingling,	tes a
	d				and pins/needles	higher
					in all conditions	BBS score
					(without	than sham
					difference	for
					between	responder
					conditions)	s'
						patients.
Yang et	1. Stroke	- Cathodal	1. Cathodal and	-	1. Postural	- TA onset
al.	2.10	PMA and	anodal	Cathod	adjustments	latency
(2021)	3.	anodal M1	2. SMA-PMC	al	2. Force	was later
. ,	Crossove		(PMA)/M1	PMA	plate/CoP (APA-	in
	r,	(n=10;	(anodal)	(CG)	reach);	cathodal
	randomiz	69.13±7.61;7M	3. contralateral	vs.	EMG/onset	PMA than
	ed	/3F)	supraorbital area	anodal	latency (APA-	anodal
		,	4. 15 cm^2	M1	reach)	M1 of the
			5. 20 min		3. TMS/MEP	LAS time
			6. 1 mA		4. Pre and post	point-500
			7.1 session		5. NR	ms.
			8. No			

Zandvliet	1. Stroke	- Active-	1. Anodal	- Active-	1. Static	- Active-ctDCS
et al.	2.15	ctDCS	2.	ctDCS	2. Force plate	contra-lesional
(2018)	3.	contra-	Cerebellar	contra-	(CoP)/semi-	demonstrated
	Crossover,	lesional	(3 cm	lesional	tandem (range	lower range and
	randomized,	hemisphere;	lateral of	hemisphere	and velocity of	velocity of CoP
	single-	active-	the inion)	vs. active-	CoP)	at post period
	blind,	ctDCS ipsi-	3. Ipsilateral	ctDCS	3. No	compared to
	sham-	lesional	buccinators	ipsi-	4. Pre and post	sham-ctDCS.
	controlled	hemisphere;	muscles	lesional	each tDCS	
		and sham-	4. 3.14 cm^2	hemisphere	session	
		ctDCS	5. 20 min	vs. sham-	5.11 reported	
			6. 1.5 mA	tDCS	higher score	
		(n=15;	sinusoidal		on fatigue but	
		57.1±10.0;	7.1 session		without	
		12M/3F)	8. Yes. ML		difference	
			postural		between tDCS	
			tracking		conditions	
			task during			
			tDCS			

(Continued).

Note: tDCS = transcranial direct current stimulation; M = male; F = female; NR = not reported; CG = control group; EMG = electromyography; fNIRS = functional near-infrared spectroscopy; FSST = Four Square Step test; CoP = center of pressure; GVS = galvanic stimulation; ICARS = International Cooperative Ataxia Rating Scale; MdDS = mal de debarquement syndrome; r-TMS = repetitive transcranial magnetic stimulation; MG = medial gastrocnemius; TA = tibialis anterior; BBS = Berg Balance Scale; FES = functional electrical stimulation; RAGT = robot-assisted gait training; POMA = Performance Oriented Mobility Assessment; TUG = Timed up and Go test; VRT = vestibular rehabilitation therapy; ctDCS = cerebellar tDCS; M1 = primary motor cortex; TMS = transcranial magnetic stimulation; MEP = motor evoked potential; PIVC = parietal-insular vestibular cortex; SMA = supplementary motor area; PMC = premotor cortex; PMA= premotor area; DLPFC = dorsolateral prefrontal cortex; PFC = prefrontal cortex; LAS = loud acoustic stimulus; AP = anteriorposterior; ML = medio-lateral; APA = anticipatory postural adjustments; VR = virtual reality.

Table 3.	Methodo	logical o	quality	assessment.
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Studies		PEDro score - items											
		2	3	4	5	6	7	8	9	10	11	Total	
Andrade et al. (2017)		1	1	1	1	0	1	1	1	1	1	9	
Babyar et al. (2016)		1	0	1	1	0	0	1	1	1	1	7	
Babyar et al. (2018)		0	0	1	0	0	0	1	1	1	1	5	
Barretto et al. (2019)		0	0	0	1	0	1	1	1	1	1	6	
Benussi et al. (2015)		1	1	1	1	1	1	1	1	1	1	10	
Beretta et al. (2020b)		1	1	1	1	0	1	1	1	1	1	9	
Cha et al. (2016)		1	1	1	1	0	0	1	1	1	1	8	
Chang et al. (2015)	1	1	0	1	1	1	1	1	1	1	1	9	
Coppens et al. (2019)		0	0	1	1	0	0	1	1	1	1	6	
Costa et al. (2020)		0	0	0	1	0	0	0	1	0	0	2	
Costa-Ribeiro et al. (2017)		1	1	1	1	1	1	1	1	1	1	10	

Danzl et al. (2013)	1	1	1	1	1	1	1	0	1	1	1	9
Forogh et al. (2018)		1	0	1	1	0	1	1	1	1	0	7
Fruhauf et al. (2017)		1	1	1	1	0	1	1	1	1	1	9
Geroin et al. (2011)		1	0	1	0	0	1	1	1	1	1	7
Grimaldi & Manto (2013)		0	0	1	1	0	0	0	1	1	1	5
Kaski et al. (2013)	1	1	0	1	1	0	1	1	1	1	1	8
Kaski et al. (2014a)	1	1	1	0	1	0	1	0	1	1	1	7
Kaski et al. (2014b)	1	1	1	1	1	0	1	1	1	1	1	9
Lattari et al. (2017)	1	1	1	1	1	0	1	1	1	1	1	9
Liang et al. (2020)	1	1	0	1	1	0	1	1	1	1	1	8
Lu et al. (2018)	1	1	1	1	1	0	1	1	1	1	1	9
Madhavan et al. (2020)	1	1	1	1	1	0	1	1	1	1	1	9
Manenti et al. (2016)	1	1	0	1	1	1	1	1	1	1	1	9
Manji et al. (2018)	1	1	0	1	1	1	0	1	1	1	1	8
Ojardias et al. (2020)	1	1	1	1	1	1	0	1	1	1	1	9
Prathum et al. (2021)	1	1	1	1	1	1	1	1	1	1	1	10
Raithatha et al. (2016)	1	1	1	1	1	1	1	0	0	1	1	8
Saeys et al. (2015)	1	1	1	1	1	1	_1	1	1	1	1	10
Saki et al. (2020)	1	1	1	1	1	0	1	0	1	1	1	8
Seo et al. (2017)	1	1	1	1	1	1	1	1	1	1	1	10
Sohn et al. (2013	1	1	0	0	1	0	0	1	1	1	1	6
Tahtis et al. (2014)	1	1	0	1	1	0	1	1	1	1	1	8
Verheyden et al. (2013)	1	0	0	1	1	0	1	1	1	1	1	7
Workman et al. (2020)	0	1	1	0	1	0	1	1	1	1	1	8
Yang et al. (2021)	1	1	0	1	0	0	0	1	1	1	1	6
Zandvliet et al. (2018)	1	1	0	1	1	0	0	1	1	1	1	7

Note: PEDro = Physiotherapy Evidence Database rating scale.

Highlights

- tDCS as stand-alone therapy improved balance in adults with neurological disorders
- tDCS alone and combined with interventions are promising for balance rehabilitation
- tDCS improved balance regardless of the number of sessions
- Balance improvements were evidenced regardless of the brain area stimulated
- Reviewed studies did not personalize the protocol to individual characteristics