UNIVERSIDADE FEDERAL DE MINAS GERAIS
Faculdade de Medicina
Programa de Pós-Graduação em Medicina Molecular

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Os impactos de técnicas não farmacológicas na impulsividade

Belo Horizonte
2023

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Tese de Doutorado apresentada ao Programa de Pós Graduação em Medicina Molecular, da Faculdade de Medicina da Universidade Federal de Minas Gerais, como parte dos requisitos para obtenção do título de Doutor em Medicina Molecular.

Orientador: Prof. Dr. Marco Aurélio Romano-Silva
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Belo Horizonte
2023

M149i

Machado, Yuri de Castro.
Os impactos de técnicas não farmacológicas na impulsividade [recursos eletrônicos]. / Yuri de Castro Machado. - - Belo Horizonte: 2023.
99f.: il.
Formato: PDF.
Requisitos do Sistema: Adobe Digital Editions.

Orientador (a): Marco Aurélio Romano Silva.
Coorientador (a): Débora Marques de Miranda.
Área de concentração: Psiquiatria.
Tese (doutorado): Universidade Federal de Minas Gerais, Faculdade de Medicina.

1. Comportamento Impulsivo. 2. Yoga. 3. Atenção Plena. 4. Estimulação Transcraniana por Corrente Contínua. 5. Estimulação Magnética Transcraniana. 6. Dissertação Acadêmica. I. Silva, Marco Aurélio Romano. II. Miranda, Débora Marques de. III. Universidade Federal de Minas Gerais, Faculdade de Medicina. IV. Título.

NLM: WM 192

Bibliotecário responsável: Fabian Rodrigo dos Santos CRB-6/2697

UNIVERSIDADE FEDERAL DE MINAS GERAIS
FACULDADE DE MEDICINA
PROGRAMA DE PÓS-GRADUAÇÃO EM MEDICINA MOLECULAR

FOLHA DE APROVAÇÃO

OS IMPACTOS DE TÉCNICAS NÃO FARMACOLÓGICAS NA IMPULSIVIDADE

YURI DE CASTRO MACHADO

Tese de Doutorado defendida e aprovada, no dia vinte e oito de junho de dois mil vinte e três, pela Banca Examinadora designada pelo Colegiado do Programa de Pós-Graduação Medicina Molecular da Universidade Federal de Minas Gerais constituída pelos seguintes professores doutores:

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Belo Horizonte, 28 de junho de 2023.

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Documento assinado eletronicamente por **Marco Aurelio Romano Silva**, **Professor do Magistério Superior**, em 29/06/2023, às 16:14, conforme horário oficial de Brasília, com fundamento no art. 5º do Decreto nº 10.543, de 13 de novembro de 2020.

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Agradecimentos

Aos meus pais que sempre colocaram a educação como algo primordial na família e me deram o “sangue no olho” para conquistar o que eu desejasse.

À minha esposa, companheira de todas as horas, que sempre me apoiou, comprou minhas brigas, me auxiliando até nas horas mais difíceis. Você me complementa e me equilibra. Obrigado por ser meu eterno "córtex acessório”.

Ao meu filho Olavo, motivo de muita alegria e motivação para finalizar essa etapa importante na minha vida. Obrigado por ceder tempo de qualidade que estaríamos juntos para finalização deste doutorado.

Aos meus alunos Mariana, Jogiely, Igor e Matheus. Vocês foram imprescindíveis na concretização desta pesquisa. Deram agilidade e qualidade ao processo e sou eternamente grato ao empenho de vocês.

Ao professor Marco, agradeço a confiança e oportunidades me dadas. As metas colocadas sempre foram audaciosas e fico feliz que você tenha acreditado em mim ao atribuir a responsabilidade a mim e ter tido a flexibilidade em mudar a rota da pesquisa quando as circunstâncias mudaram.

À professora Débora, meu ponto de suporte e acalento. Obrigado pela presteza em sempre acalmar e direcionar o trabalho para que pudesse ser mais eficiente no trabalho. Sou muito grato também à sua confiança e carinho.

Sinto-me lisonjeado pelas pessoas que passaram pela minha vida e me auxiliaram no processo de pesquisa. Peço desculpa se fugiu-me o nome de alguém mas, desde já, expresso a minha gratidão a todos e a todo processo que, de fato, fez-me não só um médico e pesquisador melhor mas, também, uma pessoa melhor.

“Importante não é ver o que ninguém nunca viu, mas sim pensar o que ninguém nunca pensou sobre algo que todo mundo vê” (SCHOPENHAUER, 1851)

Resumo

A impulsividade é um fenômeno multifacetado e é caracterizada por diferentes padrões cognitivos e comportamentais que podem levar a consequências disfuncionais imediatas e em médio/longo prazo. O tratamento da impulsividade tem sido um grande desafio na área da saúde mental, pois não há muitas ferramentas bem descritas e cientificamente validadas que sejam eficazes para a melhora do bem-estar geral desses indivíduos. Dentre as abordagens gerais que podem ser utilizadas para isso, destacam-se as intervenções farmacológicas, atividades físicas e abordagens psicoterápicas como a terapia cognitivo-comportamental (TCC), o treinamento de habilidades sociais e emocionais e a terapia de controle de impulsos. Neste estudo, iremos analisar outras três técnicas não farmacológicas promissoras para serem utilizadas no controle de impulso que são as técnicas de Yoga, Mindfulness e Neuromodulação não invasiva. Para isso, fizemos três revisões sistemáticas conduzidas em acordo com os critérios do PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). Os protocolos de revisão foram registrados no Registro Prospectivo Internacional de Revisões Sistemáticas (PROSPERO). Para escolha dos descritores que seriam utilizados na busca foi utilizado o Medical Subject Headings (MeSH). A pesquisa pelos artigos foi feita nas bases de dados da PubMed, Scopus, Science Direct e Embase. Só foram incluídos artigos em inglês e não houve delimitação de período de publicação dos artigos incluídos. Os artigos incluídos nesta revisão sistemática foram selecionados de forma independente por dois revisores distintos. Eles realizaram a seleção em duas etapas, sendo a primeira baseada na leitura dos títulos e resumos e a segunda com a leitura completa do texto e caso houvesse divergência na seleção dos artigos, um terceiro revisor foi acionado. A qualidade dos estudos incluídos nestas revisões sistemáticas foi avaliada utilizando a ferramenta Cochrane Risk of Bias tool. Ao final da seleção dos artigos, 6 artigos foram analisados no estudo sobre yoga, 18 no de Mindfulness e 18 no de Neuromodulação não invasiva (9 artigos sobre Estimulação Transcraniana por Corrente Contínua (ETCC) e 9 sobre Estimulação Magnética Transcraniana (EMT)) e foi realizada metanálise de seus dados. Com base nos resultados obtidos, as técnicas de Yoga e Mindfulness surgem como promissoras no tratamento da impulsividade, demonstrando efetividade em diversos testes psicométricos e escalas. Essas abordagens terapêuticas são de fácil implantação, escaláveis e apresentam baixo custo, o que as torna viáveis tanto para o contexto clínico quanto para a saúde pública. Por outro lado, os estudos sobre ETCC e EMT ainda carecem de evidências suficientes para embasar sua implementação no tratamento da impulsividade. A falta de padronização nos estímulos utilizados e a diversidade nos desenhos

de estudo dificultam a definição de protocolos efetivos. Portanto, futuras pesquisas serão necessárias para estabelecer parâmetros mais específicos e padrões de intervenção claros para essas técnicas de neuromodulação não invasiva no contexto da impulsividade.

Palavras-chave: impulsividade; yoga; mindfulness; estimulação transcraniana por corrente contínua; estimulação magnética transcraniana

Abstract

Impulsivity is a multifaceted phenomenon characterized by different cognitive and behavioral patterns that can lead to immediate and medium-to-long-term dysfunctional consequences. The treatment of impulsivity has been a major challenge in the field of mental health, as there are not many well-described and scientifically validated tools that are effective in improving the overall well-being of these individuals. Among the general approaches that can be used for this purpose, pharmacological interventions, physical activities, and psychotherapeutic approaches such as cognitive-behavioral therapy (CBT), social and emotional skills training, and impulse control therapy stand out. In this study, we will analyze three other promising non-pharmacological techniques for impulse control, namely Yoga, Mindfulness, and non-invasive neuromodulation. To do so, we conducted three systematic reviews in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) criteria. The review protocols were registered in the International Prospective Register of Systematic Reviews (PROSPERO). The Medical Subject Headings (MeSH) were used to select the descriptors for the search. The article search was conducted in the PubMed, Scopus, Science Direct, and Embase databases. Only articles in English were included, and there was no restriction on the publication period of the included articles. The articles included in this systematic review were independently selected by two different reviewers. They performed the selection in two stages, the first based on the reading of titles and abstracts, and the second with the full-text reading. In case of divergence in the article selection, a third reviewer was consulted. The quality of the studies included in these systematic reviews was assessed using the Cochrane Risk of Bias tool. At the end of the article selection process, 6 articles were analyzed in the Yoga study, 18 in the Mindfulness study, and 18 in the non-invasive neuromodulation study (9 articles on Transcranial Direct Current Stimulation (tDCS) and 9 on Transcranial Magnetic Stimulation (TMS)), and a meta-analysis of their data was performed. Based on the results obtained, Yoga and Mindfulness techniques emerge as promising in the treatment of impulsivity, demonstrating effectiveness in various psychometric tests and scales. These therapeutic approaches are easy to implement, scalable, and cost-effective, making them viable for both clinical and public health contexts. On the other hand, studies on tDCS and TMS still lack sufficient evidence to support their implementation in the treatment of impulsivity. The lack of standardization in the stimuli used and the diversity in study designs hinder the definition of effective protocols. Therefore, future research will be necessary to establish more specific parameters and clear intervention

standards for these non-invasive neuromodulation techniques in the context of impulsivity.

Keywords: impulsivity; yoga; mindfulness; transcranial direct current stimulation; transcranial magnetic stimulation.

Lista de Tabelas

Lista de abreviaturas e siglas

ADHD	Attention-Deficit/Hyperactivity Disorder
AUC	Área sob a curva
ASPD	Antisocial Personality Disorder
APA	Associação Americana de Psiquiatria
BART	Balloon Analogue Risk Task
BIS-11	Barratt Impulsiveness Scale 11
BPD	Borderline Personality Disorder
CCA	Córtex Cingulado Anterior
CNS	Conselho Nacional de Saúde
CPFDL	Córtex Pré-Frontal Dorsolateral
CPFVM	Córtex Pré-Frontal Ventromedial
CPT	Continuous Performance Task
cTBS	Estimulação Theta Burst de Baixa Frequência Contínua
DDT	Delay Discounting Task
DSM-5	Diagnostic and Statistical Manual of Mental Disorders (5ª edition)
EMT	Estimulação Magnética Transcraniana
ETCC	Estimulação Transcraniana por Corrente Contínua
fMRI	Functional Magnetic Resonance Imaging
GDT	Game of Dice Task
GNG	Tarefa Go/No-go
IGT	Iowa Gambling Task
IL	Interleucina
ISSN	International Standard Serial Number
IST	Information Sampling Task

iTBS	Estimulação Theta Burst de Alta Frequência Intermitente
MBCT	Mindfulness-Based Cognitive Therapy
MBPs	Programas Baseados em Mindfulness
MBSR	Mindfulness Based Stress Reduction
MeSH	Medical Subject Headings
NIBS	Estimulação Cerebral Não-Invasiva
NIRS	Near-Infrared Spectroscopy
PANAS	Escala de Afeto Positivo e Negativo
PET	Positron Emission Tomography
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROSPERO	Registro Prospectivo Internacional de Revisões Sistemáticas
RCTs	Randomized Controlled Trials
SCWT	Stroop Color Word Test
SUDs	Substance Use Disorders
SSRI	Selective Serotonin Reuptake Inhibitors
SST	Stop-Signal Task
TAB	Transtorno Afetivo Bipolar
TBS	Theta Burst Stimulation
TCC	Terapia Cognitiva Comportamental
TDAH	Transtorno de Déficit de Atenção e Hiperatividade
TDCS	Transcranial Direct Current Stimulation
TMS	Transcranial Magnetic Stimulation
TOD	Transtorno de Oposição Desafiante
TPB	Transtorno de Personalidade Borderline
UPPS	Escala de Comportamento Impulsivo

Sumário

INTRODUÇÃO

1.1 Impulsividade

A impulsividade é um fenômeno multifacetado e é caracterizada por diferentes padrões cognitivos e comportamentais que podem levar a consequências disfuncionais imediatas e em médio/longo prazo (MALLOY-DINIZ et al., 2010; DALLEY; EVERITT; ROBBINS, 2011). Ela tem sido objeto de análise de diversos estudos e permeia vários transtornos psiquiátricos como o Transtorno de Déficit de Atenção/Hiperatividade (TDAH), Transtorno de Oposição Desafiante (TOD), Transtorno Afetivo Bipolar (TAB), Transtorno de Personalidade Borderline (TPB) e a Esquizofrenia. No entanto, a impulsividade não está relacionada apenas a consequências disfuncionais e pode explicar diferenças individuais no funcionamento humano adequado (GOMES et al., 2017).

Embora a impulsividade seja mencionada explicitamente nos critérios de diagnóstico do Manual Diagnóstico e Estatístico de Transtornos Mentais (AMERICAN PSYCHIATRIC ASSOCIATION, 2013) para vários transtornos e implicitamente nos critérios de outros, até recentemente pouco trabalho foi feito para esclarecer o papel da impulsividade nos transtornos psiquiátricos. Da mesma forma, embora alguns exemplos de comportamento impulsivo sejam dados no DSM-V, a definição de impulsividade não é uniforme. Essa falta de especificidade em relação ao papel da impulsividade nos transtornos psiquiátricos resulta, em parte, de discordâncias na literatura sobre como definir e medir a impulsividade (MOELLER *et al.*, 2001).

Atualmente, existem três principais formas de medir a impulsividade: escalas gerais de impulsividade, testes psicométricos e potenciais cerebrais. Estas formas de mensuração são utilizadas em pesquisas e é importante entender as peculiaridades de cada uma das formas para entender suas limitações e saber o que, de fato, pode-se concluir de seus resultados.

1.1.1 Escalas Gerais de Impulsividade

A primeira escala geral de impulsividade desenvolvida foi a Escala de Personalidade de Eysenck, criada pelo psicólogo britânico Hans J. Eysenck em 1957. Essa escala incluía

itens que avaliavam diferentes dimensões da personalidade, incluindo extroversão, neuroticismo, psicoticismo e impulsividade (Eysenck, 1957). A dimensão da impulsividade era avaliada, originalmente, em 54 itens, que avaliavam a tendência do indivíduo a agir impulsivamente, tomar decisões precipitadas e ter dificuldade em adiar a gratificação. Os itens foram elaborados com base em observações comportamentais e autorrelatos de impulsividade. Essa escala foi amplamente utilizada em pesquisas e estudos sobre personalidade e comportamento impulsivo ao longo dos anos. No entanto, houve muitas críticas quanto à sua validade e confiabilidade em diferentes populações (Stadler et al., 2003). Ele acreditava que a impulsividade era parte dimensional de um sistema de personalidade.

Após o trabalho de Eysenck, outros pesquisadores e cientistas desenvolveram suas próprias escalas e medidas específicas para avaliar a impulsividade. A Escala de Impulsividade de Barratt (Barratt Impulsiveness Scale), criada por Ernest S. Barratt em 1959, é uma escala amplamente utilizada e reconhecida para avaliar a impulsividade (Barrat et al., 1959). Essa escala foi desenvolvida como uma medida separada da impulsividade, abordando diferentes aspectos e subcomponentes desse comportamento. Diferentemente da escala anterior, esta se concentra exclusivamente na avaliação da impulsividade, criando um instrumento de autorrelato para avaliar as suas diferentes dimensões. A versão mais comumente utilizada da Escala de Impulsividade de Barratt é a BIS-11, que possui 30 itens. Esses itens são agrupados em três subescalas principais:

1) Atuação Motora (Motor Impulsiveness): Essa subescala avalia a tendência de agir sem pensar, apresentando comportamentos impulsivos e ações rápidas. Exemplos de itens nessa subescala são: “Eu falo sem pensar” e “Eu tomo decisões rapidamente”.

2) Planejamento Cognitivo (Cognitive Impulsiveness): Essa subescala aborda a dificuldade em planejar, tomar decisões cuidadosas e refletir antes de agir. Exemplos de itens incluem: “Eu tenho dificuldade em tomar decisões” e “Eu planejo com antecedência”.

3) Atenção Perseverante (Non-Planning Impulsiveness): Essa subescala mede a tendência de não manter a atenção em tarefas e atividades por longos períodos de tempo, apresentando dificuldade em se concentrar e perseverar. Exemplos de itens nessa subescala são: “Eu tenho problemas para me concentrar em uma tarefa” e “Eu facilmente me canso de uma tarefa”.

Cada item da escala apresenta uma declaração relacionada ao comportamento impulsivo e o avaliado deve indicar o grau de concordância ou frequência do comportamento descrito, utilizando uma escala de resposta que varia de “raramente/ nunca” a “quase sempre/ sempre”. A pontuação total na escala é obtida somando-se os escores de cada item. Pontuações mais altas indicam maior impulsividade. Além das subescalas, a escala também pode fornecer uma pontuação global de impulsividade.

Whiteside e Lynan (2001) ampliaram a análise da natureza multifacetada da impulsividade e criaram uma ferramenta eficaz de mensurar e classificar suas diferentes dimensões: a escala de comportamento impulsivo UPPS. A sigla UPPS vem dos termos em inglês de Urgência, (falta de) Premeditação, (falta de) Perseverança e Busca por Sensações que são os quatro eixos principais de mensuração da impulsividade. Essa escala mede quatro dimensões: a urgência negativa, definida como a tendência a agir precipitadamente diante de contextos emocionais negativos e intensos; a falta de premeditação, definida como a tendência a não levar em conta as consequências de um ato antes de se envolver nele; a falta de perseverança, definida como a incapacidade de permanecer focado em uma tarefa que pode ser chata e/ou difícil; e a busca de sensação, definida como uma tendência para desfrutar e realizar atividades emocionantes e abertas a novas experiências. Mais recentemente, um componente adicional foi adicionado modelo UPPS original, referente a ações impulsivas em contextos emocionais positivos intensos e rotulado como urgência positiva (CYDERS; SMITH, 2008; CYDERS *et al.*, 2007), modificando, assim, a sigla da escala para UPPS-P.

A impulsividade em adultos e crianças se apresenta de maneiras distintas, e para mensurar e classificar os parâmetros de impulsividade de crianças e adolescentes, foi necessária a criação de uma adaptação desta escala (ZAPOLSKI; SMITH, 2013). Devido ao processo de tomada de decisão e controle de impulsos estar relacionado a áreas específicas do cérebro, como o córtex frontal (ROMINE; REYNOLDS, 2005), essas habilidades são modificadas ao longo do ciclo vital. As crianças de 3 anos costumam ser mais impulsivas, tendem a responder por informações mais consistentes e recompensas mais imediatas (KERR; ZELAZO, 2004). A impulsividade na adolescência apresenta um componente de procura de sensações, próprio dessa fase do desenvolvimento (CASEY et al., 2008). A maior impulsividade nessa faixa etária pode estar relacionada ao consumo precoce de drogas, desregulação emocional, uso abusivo de jogos e transtornos psicológicos (STEINBERG, 2008)

Para melhor caracterizar a impulsividade na faixa etária de 7 a 17 anos, Zapolski e

Smith (2013), Zapolski *et al.* (2009) criaram a versão para crianças e adolescentes da escala UPPS-P, com 40 itens. Essa escala, consegue ampliar a análise de impulsividade, subdividindo-a em 5 subescalas. Há oito itens para cada um dos eixos de análise e o escore total se dá por meio da soma simples do resultado dos itens. Essa é uma escala espectral autorreferida, não existindo um valor de corte para ser considerado impulsivo, e quanto maior for o valor do escore, mais impulsiva a pessoa será considerada.

As escalas de impulsividade desempenham um papel fundamental, permitindo uma avaliação sistemática e quantitativa, intervenções clínicas e no desenvolvimento teórico do constructo. A utilização dessas escalas permite uma medição padronizada e quantitativa da impulsividade, permitindo comparações entre indivíduos e grupos e quantificar as diferenças individuais desse comportamento. Isso é crucial para compreender como a impulsividade varia em diferentes populações e contextos. Elas podem ser úteis no contexto clínico para avaliar o impacto funcional e monitorar mudanças ao longo do tempo durante a intervenção ou tratamento. Elas auxiliam os profissionais de saúde a planejar e avaliar estratégias terapêuticas direcionadas à impulsividade.

1.1.2 Testes Psicométricos

Os testes neuropsicológicos podem ser usados para medir comportamentos impulsivos em um contexto experimental. Esses testes são projetados para avaliar diferentes aspectos da impulsividade, como inibição de resposta, tomada de decisão impulsiva e planejamento de ações. A escolha do teste depende do objetivo específico da pesquisa e das características do constructo de impulsividade que se pretende avaliar (BARI; ROBBINS, 2013)

A utilização desse tipo de análise de comportamento nos permite uma medida mais objetiva e quantificável da impulsividade. A informação é frequentemente detalhada, uma vez que cada teste neuropsicológico se concentra em aspectos específicos da impulsividade, como inibição de resposta, tomada de decisão ou flexibilidade cognitiva (VERDEJO-GARCÍA; LAWRENCE; CLARK, 2008). As características auxiliam na correlação do comportamento medido com áreas específicas do cérebro que estão envolvidas com aquele comportamento evidenciado no teste (BARI; ROBBINS, 2013). Entretanto, os testes psicométricos não são

bons para mensurar a impulsividade em todos os seus aspectos (CYDERS; SMITH, 2008).

Estes testes devem ser bem padronizados, possuindo instruções consistentes e procedimentos definidos. Isso garante que os resultados sejam comparáveis e replicáveis em diferentes estudos. Entretanto, a maior crítica aos dados é que por serem realizados em ambiente controlado de laboratório e através de tarefas específicas, os valores medidos podem diferir do que geralmente ocorre com a pessoa em um ambiente natural (HAMILTON et al., 2015).

É importante considerar esses benefícios e limitações ao utilizar testes neuropsicológicos para medir comportamentos impulsivos. Compreender as características e os limites dos testes ajuda a interpretar os resultados de forma adequada e a integrá-los em uma perspectiva mais abrangente da impulsividade

Tabela 1. Síntese dos principais testes psicométricos de impulsividade

Testes	Descrição da Tarefa
Balloon Analogue Risk Task (BART) LJUEZ et al. (2002)	O Balloon Analogue Risk Task (BART) é uma tarefa computadorizada que mede o comportamento de tomada de risco. Os participantes podem ganhar dinheiro se bombearem um balão virtual. Uma recompensa por clicar na bomba é fornecida até que o balão exploda, o que é determinado por um limite individual de cada balão. A cada clique, a recompensa potencial aumenta, assim como o risco de perder todo o dinheiro ganho até então. Os participantes podem optar por parar de bombear e coletar o dinheiro a qualquer momento. A medida de resultado é o número médio ajustado de bombeadas em balões não explodidos.

Testes	Descrição da Tarefa
Continuous Performance Task (CPT) ROSVOLD et al. (1956)	A Continuous Performance Task (CPT) é uma medida de atenção seletiva e sustentada, bem como dá uma indicação de impulsividade. Os participantes são apresentados a um estímulo alvo que ocorre com pouca frequência, sobre o qual eles precisam reagir e inibir as respostas aos não alvos. Os estímulos podem ser, por exemplo, símbolos, números ou sons. As pontuações que podem ser obtidas do CPT são detecção correta, tempo de reação, erros de comissão e erros de omissão. O Teste de Desempenho Contínuo de Conner CCPT é um tipo específico de Tarefa de Desempenho Contínuo que foi usado em Ni et al. (2017), onde os participantes são solicitados a responder a letras como estímulos-alvo, exceto a letra não-alvo "X" (CONNORS, 2000).
Delay Discounting Task (DDT) CHO et al. (2012)	O Delay Discounting Task (DDT) mede a tomada de decisão impulsiva. Uma série de opções de recompensas (como ganhos monetários) são apresentadas ao participante com valores de recompensas variando de baixo a alto e a recompensa sendo dada variando de imediata a atrasada. Ao longo da tarefa, as recompensas mais altas e atrasadas são sistematicamente diminuídas, enquanto as recompensas mais baixas e imediatas são sistematicamente aumentadas. Outra versão alternativa seria que os prazos e valores sejam adaptados à escolha subjetiva do participante. A medida de resultado é o chamado ponto de indiferença, onde a quantidade imediata e a quantidade de recompensas atrasadas têm aproximadamente um valor equivalente. A partir de uma série de pontos de indiferença, pode-se calcular uma curva individualizada,

bem como taxa de desconto.

Testes	Descrição da Tarefa
Game of Dice Task (GDT) BRAND et al. (2005)	O Game of Dice Task (GDT) é usado para medir a tomada de decisão arriscada. Os participantes são convidados a fazer uma previsão sobre os resultados de uma jogada de dados e maximizar seus ganhos. Eles precisam escolher entre várias opções que variam de baixa probabilidade e alto retorno em oposição a alta probabilidade e baixo retorno. As probabilidades e valores que podem ser perdidos ou ganhos com cada escolha são explicitamente apresentados aos participantes. Após cada lançamento de dados, os participantes recebem a recompensa se sua previsão estiver correta e perdem a quantia se o palpite estiver incorreto. Durante o jogo, o capital muda devido à quantidade atual de ganhos e perdas. A pontuação do resultado é a média das apostas seguras.
Go/No-go (GNG) task	A tarefa Go/No-go (GNG) é projetada para medir o controle inibitório, a capacidade de controlar respostas motoras impulsivas e prepotentes. Uma série de estímulos com alvo e não alvo é apresentada aos participantes. Os participantes são instruídos a reagir o mais rápido e preciso possível com uma resposta motora ao estímulo-alvo, por exemplo, pressionando um botão, e inibir sua resposta a estímulos não-alvo. As medidas de resultado são o tempo de reação, o número de tentativas corretas, erros de comissão e omissão GNG afetivo (usado em BOGGIO et al. (2007)). A tarefa afetiva Go/No-go avalia a inibição comportamental em conexão

	com uma modulação da inibição devido ao processamento emocional. Durante a tarefa, um conjunto de palavras é apresentado. O participante é atribuído a uma categoria-alvo afetiva (positiva, negativa ou neutra) e é instruído a responder a uma palavra quando corresponder à categoria atribuída. A tarefa go/no-go afetiva mede os erros de omissão e comissão, bem como a latência (velocidade de resposta). Carta de frutas GNGN (usada em COSMO et al. (2015)) Imagens de letras e fotos de várias frutas são usadas como estímulos. As medidas de resultado foram o número de respostas corretas, impulsividade e erros de omissão.

Testes	Descrição da Tarefa
Risk Task ROGERS et al. (1999)	A Tarefa de Risco (Risk Task) mede a tomada de decisão arriscada. Os participantes recebem caixas vermelhas e azuis sob as quais um token está oculto. Eles são recompensados com pontos se encontrarem o token. A proporção das caixas coloridas determinava a probabilidade de encontrar o token e, portanto, refletia o nível de risco envolvido. As medidas de resultado são a porcentagem média do tempo em que os participantes decidem sobre a opção de alto risco.
Stroop Colour Word Test (SWCT) STROOP (1935)	

	O Stroop Color Word Test (SCWT) avalia a capacidade de inibir a interferência cognitiva, que ocorre durante o processamento de dois recursos de estímulo que interferem um no outro. Além da inibição da interferência cognitiva, a tarefa SWCT é vista como uma medida de outras funções executivas, como velocidade de processamento, flexibilidade cognitiva e atenção. Na versão original do teste Stroop, a condição incongruente exige que os participantes nomeiem a cor da tinta e ignorem o nome impresso incongruente da cor (condição cor-palavra). O participante precisa inibir o desejo de ler a palavra colorida impressa, mas nomear a cor da tinta, que é um processo cognitivo menos automatizado. As medidas de resultado são o tempo de reação, o tempo de interferência e as taxas de erro.
	Tarefa Stroop numérica (usada em DEL FELICE et al. (2016))
	A tarefa Stroop numérica é uma modificação da tarefa SWCT original. O participante é apresentado com dois dígitos diferentes. Na condição incongruente, o valor numérico e o tamanho físico são incongruentes. Por exemplo, um par incongruente de dígitos seria um 3, que é apresentado em tamanho maior que um 9. Dependendo da condição, os participantes são obrigados a comparar o tamanho físico e ignorar o valor numérico ou são obrigados a comparar o valor numérico e ignorar o tamanho físico.

Testes	Descrição da Tarefa
Temporal Discounting (TD) Task WEBER et al. (2007)	A tarefa de desconto temporal é muito semelhante à tarefa de desconto de atraso e mede a impulsividade de escolha temporal. Os participantes são convidados a escolher entre uma pequena recompensa imediata ou uma grande recompensa atrasada. Um “ponto de indiferença” individual e uma função hiperbólica podem ser calculados, valores menores na análise AUC (área sob a curva) representam tomada de decisão impulsiva, enquanto valores maiores representam tomada de decisão menos impulsiva. As medidas de resultado também podem ser um fator de desconto global, que pode ser calculado a partir da média dos fatores de desconto de aceleração e atraso.

1.1.3 Potencial Cerebral

O comportamento humano nada mais é que a expressão do funcionamento cerebral. E, portanto, compreender o comportamento humano envolve a investigação dos processos neurais subjacentes que governam as ações, emoções, cognição e tomada de decisão (Pessoa et al., 2014). O comportamento impulsivo, por exemplo, é influenciado por várias áreas cerebrais que desempenham papéis no controle cognitivo, regulação emocional e tomada de decisão (FRITH; FRITH, 2012). As principais regiões cerebrais envolvidas no comportamento impulsivo são:

1) Córtex Pré-Frontal: O córtex pré-frontal, em particular o córtex pré-frontal dorsolateral (CPFDL) e o córtex pré-frontal ventromedial (CPFVM), desempenham um papel crucial no controle cognitivo e inibição de respostas impulsivas. Essas regiões estão envolvidas na avaliação de consequências, tomada de decisão ponderada, regulação emocional e no ajuste de comportamentos de acordo com metas de longo prazo.

2) Córtex Cingulado Anterior: O córtex cingulado anterior (CCA) desempenha um papel fundamental na detecção de conflitos cognitivos e na regulação emocional. Está envolvido no monitoramento de erros, na resolução de conflitos entre respostas automáticas e controladas, e na modulação da atividade de outras regiões cerebrais envolvidas no controle impulsivo.

3) Estriado: O estriado, que inclui o núcleo accumbens e o corpo estriado, está associado à recompensa, motivação e aprendizado. Alterações na atividade do estriado podem levar a comportamentos impulsivos, especialmente quando há uma preferência por recompensas imediatas em detrimento de recompensas de longo prazo.

4) Amígdala: A amígdala desempenha um papel crucial no processamento e regulação emocional. A hiperativação da amígdala pode levar a respostas emocionais intensas e impulsividade emocional.

5) Cerebelo: Embora seja tradicionalmente associado ao controle motor, o cerebelo

também desempenha um papel na regulação do comportamento impulsivo. Estudos recentes têm mostrado sua contribuição para o controle cognitivo, planejamento e tomada de decisões.

Essas são áreas cerebrais envolvidas no comportamento impulsivo, que envolve interações complexas entre diferentes regiões cerebrais. A interconectividade entre essas regiões e a regulação adequada das funções executivas são fundamentais para o controle efetivo do comportamento impulsivo.

E, para medir a atividade destas áreas em determinadas tarefas ou situações, é necessário o uso de exames de neuroimagem funcional. Exames de neuroimagem funcional são técnicas utilizadas para visualizar e mapear a atividade cerebral durante a execução de tarefas cognitivas ou em repouso. Esses exames permitem estudar a relação entre a função cerebral e diferentes processos mentais, como percepção, memória, emoção, linguagem e tomada de decisão.

Existem várias modalidades de neuroimagem funcional, sendo as mais comuns a ressonância magnética funcional (fMRI, do inglês functional Magnetic Resonance Imaging), a tomografia por emissão de pósitrons (PET, do inglês Positron Emission Tomography) e a Espectroscopia no Infravermelho-próximo (NIRS, do inglês Near-Infrared Spectroscopy). Esses exames de neuroimagem funcional têm sido amplamente utilizados em pesquisas para investigar a atividade cerebral em diversas condições, como transtornos neuropsiquiátricos, doenças neurodegenerativas e em estudos sobre o comportamento humano. Eles fornecem informações valiosas sobre as bases neurais dos processos cognitivos e emocionais, auxiliando na compreensão dos mecanismos subjacentes ao funcionamento cerebral.

1.2 Tratamento da impulsividade

O tratamento da impulsividade tem sido um grande desafio na área da saúde mental, pois não há muitas ferramentas bem descritas e cientificamente validadas que sejam eficazes para a melhora do bem-estar geral desses indivíduos (AMORIM NETO; TRUE, 2011). Dentre as abordagens gerais que podem ser utilizadas para isso, destacam-se as intervenções farmacológicas, atividades físicas e abordagens psicoterápicas como a terapia

cognitivo-comportamental (TCC), o treinamento de habilidades sociais e emocionais e a terapia de controle de impulsos (KENDALL; FINCH, 1978). Neste estudo, iremos analisar outras três técnicas não farmacológicas promissoras para serem utilizadas no controle de impulso que são as técnicas de Yoga, Mindfulness e Neuromodulação não invasiva.

A utilização de psicofármacos para o auxílio do tratamento de transtornos com componente impulsivo importante, por muitas vezes, é necessária (AMERICAN PSYCHIATRY ASSOCIATION, 2013). Várias classes medicamentosas podem ser usadas com esse intuito como: antipsicóticos, estabilizadores de humor, antidepressivos/ansiolíticos e, até mesmo, psicoestimulantes, entretanto a tolerabilidade e eficácia de cada um dos fármacos varia dependendo da classe, patologia tratada e peculiaridades individuais do paciente (BANDELOW et al., 2015; GRANT; CHAMBERLAIN, 2016) e, por muitas vezes, é insatisfatória. Devido à importância do componente impulsivo em vários transtornos psiquiátricos e às limitações na eficácia e tolerabilidade das medicações usadas na impulsividade, as técnicas não farmacológicas para controle de impulso são tão importantes e precisam ser mais bem estudadas.

A atividade física regular pode desempenhar um papel importante na melhoria da impulsividade (ZHANG et al., 2022). Vários estudos científicos sugerem que a prática regular de exercícios físicos está associada a uma redução na impulsividade e a uma melhoria no controle dos impulsos (KOTBAGI et al., 2017; KLEIN; DEFFENBACHER, 1977). Ludyga, Gerber e Brand (2020) analisaram os efeitos da atividade física na impulsividade em adultos. Os resultados mostraram que a prática regular de exercícios estava relacionada a níveis mais baixos de impulsividade. Os participantes que se envolviam em atividades físicas moderadas a intensas apresentavam uma maior capacidade de autorregulação, controle dos impulsos e tomada de decisões mais conscientes. Os mecanismos neurobiológicos envolvidos na melhora da impulsividade com a prática regular de exercícios tem associação com alterações na estrutura e funcionamento do cérebro, incluindo o aumento da atividade do córtex pré-frontal (BASSO; SUZUKI, 2017).

A terapia cognitivo-comportamental (TCC) também é uma abordagem muito usada no tratamento da impulsividade. De acordo com Baric´, Ristic´-Dimitrijevic´ e Zlatic´ (2019), a TCC visa identificar e modificar os padrões de pensamento distorcidos associados à impulsividade. Por meio da reestruturação cognitiva e do desenvolvimento de estratégias comportamentais, a TCC ajuda os indivíduos a adquirirem habilidades para a regulação

emocional e tomada de decisões mais ponderadas. A TCC tem se mostrado eficaz na redução dos comportamentos impulsivos e na promoção do autocontrole.

O treinamento de habilidades sociais e emocionais também desempenha um papel importante no tratamento da impulsividade. Essa abordagem envolve o desenvolvimento de habilidades de comunicação assertiva, resolução de problemas e regulação emocional (BANDELOW; MICHAELIS; WEDEKIND, 2017). Ao adquirir essas habilidades, os indivíduos impulsivos podem melhorar sua capacidade de lidar com situações desafiadoras, diminuindo a probabilidade de comportamentos impulsivos. O treinamento de habilidades sociais e emocionais tem se mostrado efetivo na melhoria das relações interpessoais e na promoção de um melhor ajustamento psicossocial.

Outra abordagem psicoterápica no tratamento da impulsividade é a terapia de controle de impulsos. Essa terapia busca identificar os gatilhos que desencadeiam os comportamentos impulsivos e desenvolver estratégias para evitá-los ou lidar com eles de forma mais saudável (PONTILLO; PANDOLFO; ALVARENGA, 2020). A terapia de controle de impulsos pode envolver técnicas como o treinamento em habilidades de resistência, manejo do tempo e controle de estímulos. Essa abordagem tem se mostrado eficaz na redução dos comportamentos impulsivos e no fortalecimento do autocontrole.

As técnicas de Yoga, Mindfulness e Neuromodulação não invasiva serão abordadas de modo pormenorizado posteriormente, mas foram escolhidas por serem técnicas bem estudadas e que são utilizadas terapeuticamente para várias doenças.

1.2.1 Yoga

A filosofia do Yoga tem uma origem milenar e foi construída sobre um conjunto complexo de elementos que envolve, não só uma grande exigência física, mas até um certo envolvimento espiritual, visando essencialmente oferecer ao homem um caminho de viver a sua existência com propósito e plenitude. Por constituir um sistema de práticas, ao longo da história várias modalidades foram criadas para melhorar sua execução. De maneira geral, todas se baseiam nos seguintes pilares: técnica de respiração e desenvolvimento do autoconhecimento; treinamento postural incluindo exercícios de alongamento e posturas específicas (asana); atividades de relaxamento corporal e práticas meditativas focadas no

controle cognitivo e atenção no presente. Nas culturas ocidentais, posturas, autoconsciência e meditação são ensinadas com mais frequência, deixando para trás parte do código ético e moral relacionado à filosofia (KHANNA; GREESON, 2013).

Diversos ensaios clínicos e meta-análises disponíveis sobre o tema mostram que a utilização do yoga como intervenção complementar aos tratamentos convencionais, sejam eles farmacológicos ou não, e pode gerar uma série de benefícios para a qualidade de vida dos indivíduos, assim como melhorar a sua aptidão física (FIELD, 2011) e também o seu estado emocional (HARTFIEL et al., 2011; MOADEL et al., 2007). Efeitos fisiológicos do corpo, em decorrência do yoga, demonstram redução do consumo de oxigênio (TELLES; DESIRAJU, 1991) e regulação da atividade cerebral (HOFFMANN, 1999). Compreender a suposta relação entre a atividade de yoga e o funcionamento cerebral, especialmente relacionado à cognição, é de grande importância para condições clínicas associadas à impulsividade. Um grupo de praticantes da yoga submetidos a um exame de Ressonância Magnética Funcional durante a realização de um teste de Stroop, apresentou, ao final do processo, uma maior reatividade do córtex pré-frontal dorsolateral direito (FROELIGER et al., 2012).

Evidências convergentes sugerem que a atividade cerebral intrínseca e os comportamentos impulsivos estão profundamente relacionados. Na ausência de relatos significativos sobre os possíveis efeitos adversos da prática de yoga (BALASUBRAMANIAM; TELLES; DORAISWAMY, 2013), além de seu baixo custo de implementação, tem sido um bom argumento validar a literatura sobre o seu efeito potencial como tratamento adjunto em condições que envolvem problemas de controle de impulso (HU et al., 2015; ZHAO et al., 2017).

1.2.2 Mindfulness

Esta técnica pode ser definida como um estado de atenção e consciência ao que está acontecendo no momento presente, interna e externamente (KABAT-ZINN, 1982; BROWN; RYAN, 2003; KABAT-ZINN, 1990). A definição do mindfulness já foi alvo de várias interpretações ao longo dos anos, sendo interpretada como uma simples dinâmica espiritual atrelada ao budismo (STEDHAM; SKAAR, 2019), até mesmo sendo absorvido pelas mais diversas ferramentas contemporâneas voltadas para a modificação do comportamento e

ressignificação da subjetividade dos indivíduos. Tomamos cuidado com os conceitos de mindfulness em cada um dos artigos escolhidos e faremos, inclusive, uma análise comparativa das técnicas usadas entre os experimentos. O conceito padronizado neste estudo é que o Mindfulness é a habilidade que utiliza do foco no momento presente para aumentar o autocontrole e integrar de forma harmônica os conteúdos das emoções com uma postura racional.

Os programas baseados em mindfulness (MBPs) apresentam como principal finalidade o desenvolvimento desta atenção plena, e, consequentemente, outras habilidades são desenvolvidas no processo, como: a capacidade de perceber a divagação da mente (monitoring faculty), de mudar o foco atencional entre objetos distintos (switching), de selecionar as informações mais importante para o processamento cognitivo (atenção seletiva) e de se manter focado por grandes períodos (atenção sustentada) (CHIESA; CALATI; SERRETTI, 2011). Seja intermediado pela união da Terapia Cognitivo-Comportamental (TCC) e as características da atenção plena que constrói uma metodologia centrada na regulação e consciência emocional (HÖLZEL et al., 2011) chamada Mindfulness-Based Cognitive Therapy (MBCT), pela Mindfulness Based Stress Reduction (MBSR) (LARSON; STEFFEN; PRIMOSCH, 2013) ou as diversas ramificações dos programas baseados em Mindfulness (MBPs) como o escaneamento corporal e a respiração meditativa, o autocontrole está no centro (DIAMOND; LEE, 2011) e auxilia na redução da reatividade e, promissoramente, da própria impulsividade.

1.2.3 Neuromodulação não-invasiva (NIBS)

A neuromodulação não invasiva refere-se a um conjunto de técnicas terapêuticas que visam modular a atividade cerebral por meio de estímulos externos, sem a necessidade de intervenção cirúrgica ou invasiva. Essas técnicas envolvem a aplicação de estímulos elétricos, magnéticos ou de outros tipos de energia para modular a atividade neuronal e promover efeitos terapêuticos em diversas condições neurológicas e psiquiátricas (BIKSON et al., 2016).

As técnicas mais estudadas e que foram encontradas em estudos sobre impulsividade em nossas buscas foram a Estimulação Transcraniana por Corrente Contínua (ETCC ou, do inglês, tDCS) e a Estimulação Magnética Transcraniana (EMT ou, do inglês, TMS). Essas técnicas são

amplamente utilizadas em humanos e possuem número maior de estudos avaliando o seu efeito na impulsividade. Ao visar regiões cerebrais implicadas na impulsividade, como o córtex pré-frontal e o córtex cingulado anterior, a estimulação cerebral não invasiva pode melhorar o controle dos impulsos e reduzir os comportamentos impulsivos (LEFAUCHEUR et al., 2017).

Uma das técnicas de neuromodulação não invasiva mais populares e amplamente estudada é a ETCC, que envolve a aplicação de uma corrente elétrica de baixa intensidade através de eletrodos posicionados no couro cabeludo sobre áreas específicas do cérebro. A corrente elétrica aumenta ou diminui a diferença de potencial elétrico da membrana plasmática do neurônio, dependendo se está mais próxima do ânodo ou do cátodo. O estímulo pode facilitar a condução elétrica do neurônio, estimulando as áreas próximas ao ânodo, reduzindo estresse oxidativo e estimulando a neurogênese e a sinaptogênese. Por ser uma técnica barata e facilmente aplicada, sua utilização tem sido investigada em uma variedade de transtornos neuropsiquiátricos, como depressão, esquizofrenia, transtorno de déficit de atenção/hiperatividade (TDAH) e transtornos do espectro autista, entretanto, sua utilidade clínica ainda precisa ser mais bem estabelecida.

A EMT utiliza pulsos magnéticos para estimular ou inibir regiões específicas do cérebro. O mecanismo de ação desta técnica se difere da anterior, pois utiliza-se de um pulso magnético para gerar a despolarização da célula neuronal. Existe, também, uma variação na técnica da EMT, chamada Theta Burst Stimulation (TBS) que também utiliza-se de pulsos magnéticos mas em altas frequências e em períodos menores.

A TMS tradicional envolve a aplicação de pulsos magnéticos únicos de curta duração em uma região específica do cérebro. Esses pulsos são geralmente entregues de forma intermitente, com intervalos regulares entre eles. A TMS é usada para modular a excitabilidade cortical e pode resultar em efeitos tanto excitatórios quanto inibitórios na atividade neuronal, dependendo da frequência de pulsos utilizados. Por outro lado, a TBS utiliza padrões de estimulação em alta frequência (theta bursts) para modular a atividade cerebral. Existem dois tipos principais de TBS: iTBS (estimulação theta burst de alta frequência intermitente) e cTBS (estimulação theta burst de baixa frequência contínua). Na iTBS, são entregues trens de theta bursts intermitentes de curta duração, repetidos a cada 10 segundos. Esse padrão de estimulação é considerado excitatório e tem sido associado a um aumento transitório na excitabilidade cortical. Na cTBS, os trens de theta bursts são entregues de forma contínua, ao longo de um período de 40 a 60 segundos. Esse padrão de estimulação é

considerado inibitório e tem sido associado a uma diminuição transitória na excitabilidade cortical.

A escolha entre TMS tradicional e TBS depende das necessidades específicas da pesquisa ou do tratamento clínico, bem como dos efeitos desejados na excitabilidade cortical. Nos artigos incluídos no nosso estudo, a técnica de TMS tradicional foi mais utilizada, entretanto, ambas técnicas têm sido exploradas em uma variedade de condições neuropsiquiátricas e continuam sendo objeto de pesquisa e desenvolvimento. A EMT tem sido investigada principalmente no tratamento da depressão uni e bipolar, transtorno obsessivo-compulsivo, dor crônica e acidente vascular cerebral.

A neuromodulação não invasiva tem como objetivo alterar a excitabilidade neuronal, neuroinflamação, plasticidade sináptica e atividade de redes cerebrais específicas, oferecendo assim um potencial terapêutico para diversas condições neurológicas e psiquiátricas (LEFAUCHEUR et al., 2020). Os parâmetros de intensidade, frequência, duração dos estímulos técnicas, áreas estimuladas e vários outros podem ser ajustados para otimizar os efeitos terapêuticos e minimizar os efeitos adversos. Entretanto essa grande variabilidade é um dos grandes dificultadores na realização de pesquisas pois dificulta a comparação, criação de protocolos e tomadas de condutas clínicas.

1.3 Síntese e apresentação dos estudos

Os diferentes conceitos apresentados anteriormente sobre impulsividade evidenciam o quão complexo é esse constructo mental e o quão difícil é o seu estudo e tratamento. Contudo, entendendo a importância e o impacto da impulsividade na vida de pessoas que possuem transtornos psiquiátricos com componente impulsivo importante e a limitação das intervenções tradicionalmente utilizadas, estudos que esclarecem a função de técnicas terapêuticas potencialmente redutoras de impulsividade são importantes.

Essa temática faz parte de uma parceria internacional Brasil-Índia-China que visa criar protocolos de aplicação prática dessas técnicas não farmacológicas em grupos clínicos com respostas parciais ou inadequadas. A padronização e a correta aplicação das técnicas é importante para melhorar a qualidade dos estudos e para serem melhor comparáveis em estudos posteriores.

Dessa forma, avaliamos o que há de evidência científica acerca da eficácia na prática de Yoga e Mindfulness e aplicação de técnicas de neuromodulação não-invasiva (NIBS) para melhora dos sintomas impulsivos em vários transtornos psiquiátricos. Faremos isso por meio de revisões sistemáticas com busca em várias bases de dados de seleção de artigos como a PubMed, Scopus, Science Direct e Embase.

O esclarecimento do potencial terapêutico dessas técnicas será importante para direcionar o tratamento clínico de pacientes com transtornos do controle de impulso, de forma a potencializar a ação dos fármacos, melhorar a adesão e satisfação do paciente ao tratamento e minimizar os efeitos colaterais associados ao uso de medicamentos.

2 OBJETIVOS

O objetivo geral da presente tese é avaliar qual o papel das intervenções não farmacológicas como Yoga, Mindfulness e Neuromodulação não invasiva no tratamento da impulsividade. Os objetivos específicos associados a este estudo envolvem:

1) Definição objetiva de impulsividade (outcome) e padronização (definição de grupos de comparação) das intervenções de Yoga, Mindfulness e Neuromodulação não invasiva.

2) Realização de revisões sistemáticas sobre os temas.

3) Realizar metanálise dos tamanhos de efeitos para os desfechos padronizados e com o tamanho de efeito geral das intervenções.

4) Análise comparativa de quais estratégias, técnicas, protocolos e aplicações foram efetivas no controle da impulsividade e suas peculiaridades.

5) Realizar uma metanálise sobre o impacto da prática de Yoga no controle da impulsividade, avaliando os efeitos em diferentes populações e identificando possíveis moduladores desses efeitos.

6) Realizar uma metanálise sobre os efeitos do treinamento de Mindfulness na redução da impulsividade, investigando a eficácia em diferentes contextos (como clínicas, escolas, ambientes de trabalho) e analisando as intervenções mais efetivas.

7) Realizar uma metanálise sobre o efeito da neuromodulação não invasiva (com enfoque nas técnicas de Estimulação Transcraniana por Corrente Contínua - ETCC e Estimulação Magnética Transcraniana - TMS) no controle da impulsividade, examinando os resultados em diferentes regiões cerebrais-alvo e identificando fatores que possam influenciar a resposta terapêutica.

8) Comparar os efeitos da prática de Yoga, treinamento de Mindfulness e neuromodulação não invasiva na redução da impulsividade, analisando as diferenças nos resultados obtidos em cada uma dessas abordagens.

3 MATERIAIS E MÉTODOS

Este estudo realizou três revisões sistemáticas com o objetivo de analisar a eficácia de técnicas não farmacológicas para o controle da impulsividade. Foram feitas revisões sistemáticas analisando os temas de Yoga, Mindfulness e Neuromodulação não invasiva na impulsividade. Todas revisões sistemáticas foram conduzidas de acordo com os critérios do PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (MOHER et al., 2019). Os protocolos de revisão foram registrados no Registro Prospectivo Internacional de Revisões Sistemáticas (PROSPERO, números de registro: CRD42023389088, CRD42023413969 e CRD42023413684).

Para escolha dos descritores que seriam utilizados na busca foi utilizado o Medical Subject Headings (MeSH).

A pesquisa pelos artigos foi feita nas bases de dados da PubMed, Scopus, Science Direct e Embase. Só foram incluídos artigos em inglês e não houve delimitação de período de publicação dos artigos incluídos. A estratégia de busca de artigos utilizada foi a seguinte: (impulsivity OR impulsive behaviors OR impulsivities) AND yoga, para o artigo de yoga; (Impulsivity OR impulsive behaviors OR impulsivities) AND Mindfulness, para o artigo de Mindfulness e (“brain stimulation” OR “non-invasive brain stimulation” OR “non-invasive neuromodulation”) AND (“impulsivity” OR “impulsiveness” OR “impulsive behavior” e (“transcranial direct current stimulation” OR “tdcs” OR “tms” OR “transcranial magnetic stimulation” OR “tbs” OR “theta burst stimulation”) AND (“impulsivity” OR “impulsiveness” OR “impulsive behavior”) para o artigo de NIBS.

Os artigos incluídos nesta revisão sistemática foram selecionados de forma independente por dois revisores distintos. Eles realizaram a seleção em duas etapas, sendo a primeira baseada na leitura dos títulos e resumos e a segunda com a leitura completa do texto. Foram usados critérios de inclusão pré-estabelecidos para selecionar os artigos relevantes para esta revisão. Qualquer discordância entre os revisores foi resolvida por meio de uma discussão em consenso, com a inclusão de um terceiro revisor quando necessário. Utilizamos o site Rayyan para promover o cegamento e a seleção dos artigos de maneira independente.

A qualidade dos estudos incluídos nestas revisões sistemáticas foi avaliada utilizando a ferramenta Cochrane Risk of Bias Tool (Cochrane Collaboration, 2021). Dois revisores independentes avaliaram o risco de viés em cada estudo, considerando os seguintes domínios:

seleção dos participantes, alocação dos participantes, cegamento dos participantes e dos avaliadores, tratamento incompleto dos dados, relatório seletivo e outros riscos de viés. Para cada domínio, os estudos foram classificados como apresentando baixo risco de viés, risco incerto de viés ou alto risco de viés. Os artigos selecionados foram cuidadosamente avaliados, os dados principais de análise foram tabulados em tabela de extração padronizada e comparados para que fosse possível tirarmos conclusões acerca dos temas.

4 RESULTADOS

4.1 **Estudo 1 -** *"Effects of non-invasive brain stimulation on impulsivity in patients with and without mental disorders: a systematic review and meta-analysis of randomized clinical trials"*

1. Introduction

Impulsivity is a multidimensional construct and can be defined in various ways depending on the discipline and context in which it is studied (Evenden, 1999). Clinical definitions of impulsivity often focus on the negative consequences of impulsive behavior, such as substance abuse, risky sexual behavior, or self-harm. Overall, impulsivity can be defined as a tendency to act rashly or without foresight, which can lead to negative outcomes in a variety of domains. One way that impulsivity has been operationalized in psychology is through self-report questionnaires such as the Barratt Impulsiveness Scale (BIS-11). The BIS-11 measures three distinct factors of impulsivity: attentional impulsiveness, motor impulsiveness, and non-planning impulsiveness (PATTON; STANFORD; BARRATT, 1995).

Attentional impulsiveness refers to a tendency to act without thinking, while motor impulsiveness refers to a tendency to act without considering the consequences of one's actions. Non-planning impulsiveness refers to a lack of forethought or consideration of future outcomes. These three dimensions of impulsivity have been found to be related to different aspects of behavior, such as substance use, aggression, and risky behavior (WHITESIDE; LYNAM, 2001). Another way to conceptualize impulsivity is in terms of inhibitory control, or the ability to suppress prepotent responses. This definition is often used in neuroscience research, where impulsivity is measured through tasks such as the Go/No-Go task or the Stop Signal Task (LOGAN; SCHACHAR; TANNOCK, 1997). Impulsivity, either as a single domain or as multiple subdomains, plays a significant role in the symptomatology of several mental health disorders, such as attention-deficit/hyperactivity disorder (ADHD) (BARKLEY, 2018; (WILENS; SPENCER, 2010), borderline personality disorder (BPD) (MILLER; LYNAM, 2012), substance use disorders (SUDs) (VERDEJO-GARCÍA et al., 2008), bipolar disorder and antisocial personality disorder (ASPD) (AMERICAN PSYCHIATRIC, 2013; LINEHAN, 2015; SWANN et al., 2009).

Understanding these different definitions of impulsivity is essential for developing effective interventions and treatments for individuals who struggle with impulsive behavior. One promising approach is the use of non-invasive brain stimulation (NIBS) techniques, such as transcranial magnetic stimulation (TMS) and transcranial direct current stimulation (tDCS), to modulate brain activity and improve impulse control. TMS and tDCS work by applying a magnetic or electrical field to the scalp, which modulates the activity of neurons in the underlying brain region. By targeting brain regions implicated in impulsivity, such as the prefrontal cortex and anterior cingulate cortex, non-invasive brain stimulation can improve impulse control and reduce impulsive behaviors (LEFAUCHEUR et al., 2017).

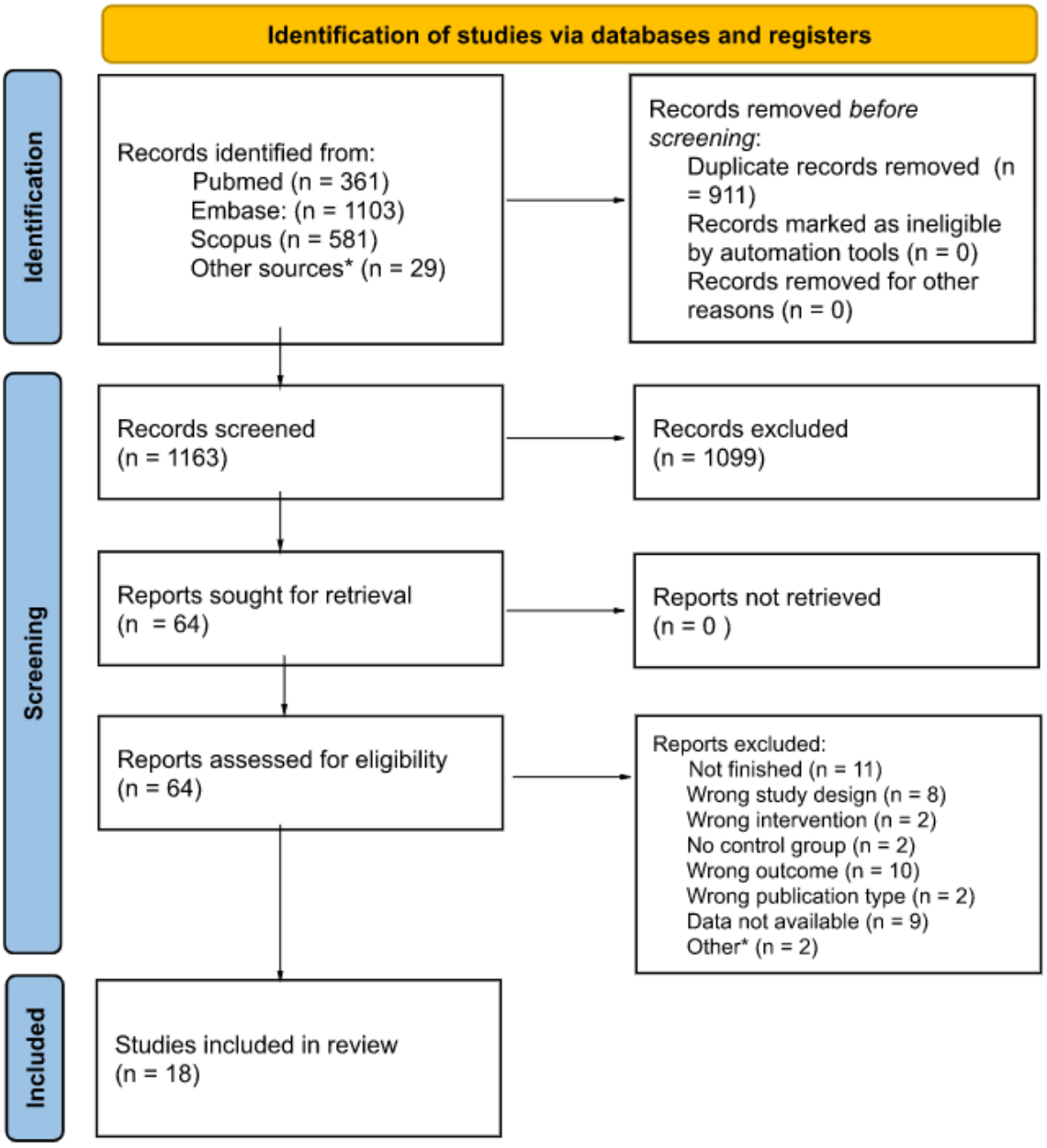
To our knowledge, there's only one meta-analysis that assessed the effects of NIBS on impulsivity (YANG et al., 2020). It examined the results from 11 studies using tDCS and 18 studies using rTMS and found that tDCS had a significant, albeit small, effect on modulating impulsivity (g = 0.29; 95% CI, 0.09 to 0.48; p = .004), while rTMS had no significant effect on impulsivity (g = 0.08; 95% Cl, 0.35 to 0.19; p = .550). The authors analyzed different populations with and without mental disorders that presented impulsivity as a symptom.

Our study aims to assess the effects of NIBS on impulsivity in both patients with and without mental disorders. We intend to add new articles to the existing literature and standardize the number of NIBS sessions used in the studies. By standardizing the number of NIBS sessions to be used in the studies, we aim to compare and evaluate the efficacy of different NIBS techniques on impulsivity in a consistent and reliable manner. Then, the main aim of our study was to provide a comprehensive and up-to-date analysis of the relationship between NIBS parameters, targeted brain regions, and specific subdomains of impulsivity.

2. Material and Methods

This systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Statement (PRISMA, 2021). The review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO, registration number: CRD42023413684).

Figura 1. Screening of the articles following the PRISMA Flowchart



2.1 Eligibility criteria

Inclusion in this meta-analysis was restricted to studies that met all the following eligibility criteria: (1) randomized trials; (2) comparing NIBS to placebo; (3) enrolling patients with and without mental disorders; and (4) with at least 10 sessions of any NIBS. In addition, studies were included only if they reported any of the clinical outcomes of interest. We excluded studies with no control group, with invasive brain stimulation and studies not

finished.

2.2 Search strategy and data extraction

We systematically searched PubMed, Scopus, and Embase from inception to April 2023. The search strategies are in Supplementary Table S1. The references from all included studies, previous systematic reviews and meta-analyses were also searched manually for any additional studies. Two authors (M.O. and M.M.) independently extracted the data following predefined search criteria and quality assessment. Disagreements between these authors were resolved by consensus or by a third author deliberation.

2.3 Endpoints and subanalyses

Efficacy outcomes included change in behavioral performance in the go/no go tasks, Conners Continuous Performance Task (CPT), Stop-signal task (SST), Stroop interference test (Stroop) and their variant versions for motor impulsivity, information sampling task (IST), Iowa Gambling Task (IGT) and Balloon Analogue Risk Task (BART) for reflection impulsivity. Definitions of impulsivity varied slightly between studies and are reported in Supplementary Table S2. Subgroup analyses included data restricted to rTMS parameters, including diagnosis group. For tdCS, we used included (1) electrode site, (2) diagnosis group and (3) impulsivity measuremeants.

2.4 Quality assessment

Quality assessment of RCTs was performed using the Cochrane Collaboration's tool for assessing risk of bias in randomized trials, in which studies are scored as high, low, or unclear risk of bias in 5 domains: selection, performance, detection, attrition, and reporting biases (HIGGINS et al., 2011). Publication bias was investigated by funnel-plot analysis of point estimates according to study weights, by Egger's regression test and by nonparametric rank correlation (Begg) test.

2.5 Statistical analysis

This systematic review and meta-analysis was performed in accordance with the Cochrane Collaboration and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement guidelines (MOHER et al., 2009). We extracted the data from individual studies using standardized mean differences for continuous outcomes, as given by Hedges' g. Unbiased Hedges' g with 95% confidence intervals (Cls) was used to define the effect size. Cochran Q test and I^2 statistics were used to assess for heterogeneity; P

values inferior to 0.10 and I^2>25% were considered significant for heterogeneity. We used a DerSimonian and Laird random-effects model for all outcomes due to high anticipated heterogeneity. When the study didn't have the mean nor the standard deviation, we used http://vassarstats.net/median_range.ht ml calculator to estimate the sample's mean and variance from its median and range.

Separate meta-analyses with the random-effects model were implemented to assess the effect of tDCS and rTMS. Additionally, studies involving the stimulation of multiple areas of the brain were separated for analysis. To reduce variability between studies, the outcome measures were primarily taken immediately after stimulation, especially when the study involved multiple assessments. When a study had multiple control groups or conditions, only the experimental and placebo groups were compared. When the study used multiple measurement scales, we prioritized BIS-11 and SST.

Review Manager 5.3 (Cochrane Centre, The Cochrane Collaboration, Denmark) and Stata BE (version 18.0, StataCorp, College Station, TX, USA) were used for statistical analysis.

3. Results

3.1 Study selection and characteristics

As detailed in Figure 1, the initial search yielded 2,074 results. After removal of duplicate records and ineligible studies, 64 remained and were fully reviewed based on inclusion criteria. Of these, a total of 18 studies were included, comprising 715 patients from 14 randomized controlled trials (RCTs) and 4 randomized crossover studies. A total of 424 (59,3%) patients received active tDCS or sham tDCS and 291 (40,7%) received active rTMS or sham rTMS. tDCS study characteristics are reported in Table 1 and rTMS, in Table 2.

Speer et al. 2004 and Cailhol et al. 2014 were not included due to the lack of other studies that presented the same scales used as the primary outcome, making comparison impossible. Wajdik et al. 2014, Novak et al. 2006, Hausmann et al. 2004, Boggio et al. 2010, Lim et al. 2017, Weidler et al. 2017 and Gilmore et al. 2018 were also not included in this meta-analysis due to the lack of numerical data related to the scales used.

Table 1. Characteristics of eligible tDCS studies

First author (country) year	Patient features (diagnostic criteria; inventory ratings)	Study design	Age of patients (mean ± SD or range)	Nº, sex ratio (M/F)	Psychotropic medication (% of patients in medication)	Anodal tDCS (localization method)	Stimulation protocol (current intensity, duration, size of electrodes, number of sessions)	Sham method	Primary outcome of the study (Tasks and outcome measures included for meta-analysis)
BRUNONI et al (2016), Brazil	MDD (DSM-IV; HAMD-17 > 18 and low suicidal ideation)	RCT (DB)	42±12	120 (28/92)	BZD (19%)	LDLPFC	2 mA, 30 min, 25cm², 10 daily sessions	Applied for only 1 min	Neurocognitive tests SCWT (Golden version)
COSMO et al. (2015), Brazil	ADHD (DSM-IV; assessed with MINI and ASRS-18)	RCT (DB)	32.25 ± 10.89	60 (35/25)	ADHD-medication(18.3%)	LDLPFC	1 mA, 20 min, 35 cm2, 1 session	Applied for only 30 s	GNG: Correct responses, commission and omission errors GNG: Number of commission errors
ESKANDARI et al. (2021), Iran	OUD (DSM, axis I and II (SCID-I and SCID-II)	RCT (DB)	33.12±8.99	31 (31/0)	Methadone (100%)	LDLPFC RDLPFC	2 mA, 20 min, 10 daily sessions	NR	DDQ, IL-6 and TNF-a expression levels and BIS-11
LISONI et al. (2020), Italy	BPD (DSM-IV-TR BPD criteria)	RCT (DB)	40.3 ± 12.8	30 (12/18)	antidepressants, antipsychotics or mood stabilizers (100%)	RDLPFC	2 mA, 20 min, 35cm², daily sessions for 5 working days/week for 3 consecutive week	2 mA applied for 20 s	BIS-11, BP-AQ, DERS, VAS, IGT, HDRS, BDI and IDA
ALIZADEHGORADEL et al. (2020), Iran	MUD (DSM-V including at least 1-year history of methamphetamine use)	RCT (DB)	34.83±9.16	39 (39/0)	NR	LDLPFC	2 mA, 20 min, 35cm², 10 sessions	applied for only 30 s	WSCT, BART, GNG, DDQ and The N-back

ALLENBYe t al. (2018), USA	ADHD (DSM-V; assessed with SCID)	RCC T (DB)	31.7	37 (26/1 1)	ADHD-me dication (45.9%)	LDLPFC	2 mA, 20 min, 25 cm², 3 sessions on every other day	appli ed for only 30 s	CPT scores and SST
LOO et al. (2012), Australia	MDD (DSM-IV; MADRS >20, assessed with MINI)	RCT (DB)	48.2 ± 12.4	60 (32/2 8)	Antidepress ants (71.7%)	LDLPFC	2 mA, 20 min, 35 cm², 15 daily sessions in 3 weeks	1 mA appli ed for 30 s	Mood and cognition assessment
SOYATA et al. (2019), Turkey	Gambling disorder (DSM-V)	RCT (DB)	37.2 ± 10.3	20 (20/0)	0%	RDLPFC	2 mA, 20 min, 35 cm², 3 sessions on every other day	2 mA appli ed for only 30 s	IGT and Wisconsin Card Sorting Test
HOLLA et al. (2020), India	AUD (DSM-V)	RCT (DB)	39±7.5	21 (21/0)	0%	RDLPFC	2 mA, 20 min, 35 cm², 5 sessions	2 mA appli ed for 40 s	ACQ-SF-R and SSRT

Table 2. Characteristics of eligible rTMS studies

First author (country) year	Patient features (diagnostic criteria; inventory ratings)	Study desig n	Age of patient s (mean ± SD or range)	Nº, sex ratio (M/F)	Psychotropic medication (% of patients in medication)	Target area (localiza tion method)	Stimulation protocol (frequency, intensity, number of pulses per session, duration, number of sessions)	Sham metho d	Primary outcome of the study (Tasks and outcome measure s included for meta-ana lysis)
CONCE RTO et al. (2015), Italy	Non-psychot ic drug-resistant MDD (DSM-IV; HAMD-21	RCT (SB)	52 ± 6.6	30 (17/1 3)	Antidepressan ts (100%)	LDLPF C	10 Hz, 120% MT, 3000, 37,5 min, 20 daily sessions	coil tilted at 45°	HAMD, FAB, Stroop T and MADRS , SCWT

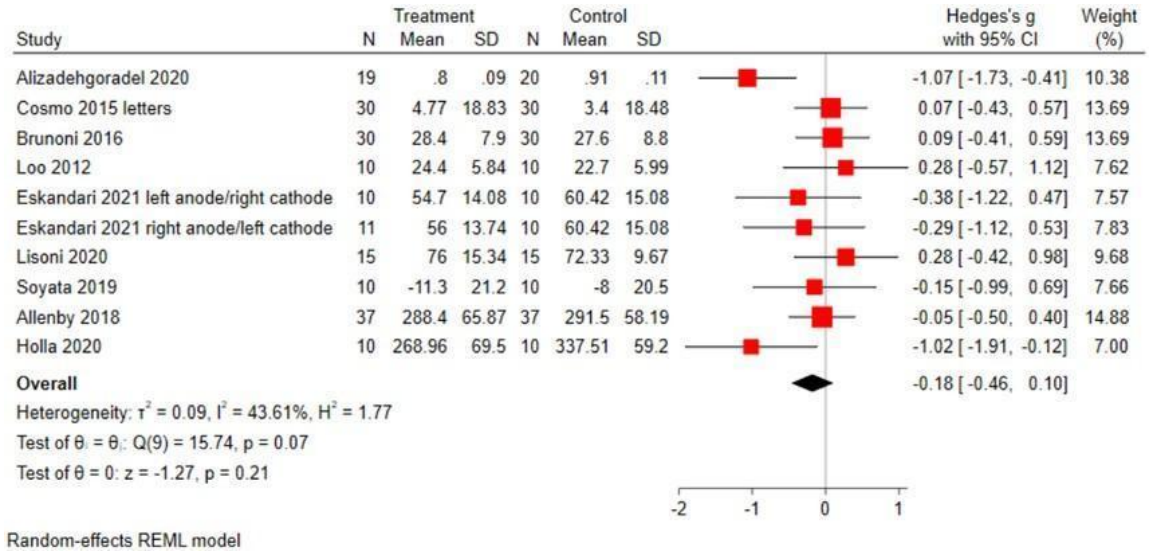
	or MADRS)								
MOGG et al. (2007), UK	Schizophrenia (DSM-IV; assessed with SCID, negative subscale of PANSS≥20)	RCT (DB)	41.7 ± 14.8	17 (16/1)	Antipsychotics (100%)	LDLPFC	10 Hz, 110% MT, 2000, 20 min, 10 sessions (on consecutive weekdays)	Sham coil	PANSS negative symptom score and SCWT
MOSIMANN et al. (2004), Switzerland	Treatment-resistant MDD (DSM-IV; assessed with SCAN)	RCT (DB)	62 ± 12	24 (14/10)	Antidepressants (100%), mood stabilizers (29%)	LDLPFC	20 Hz, 100% MT, 1600, 20 min, 10 (2 series of 5 sessions over 2 weeks)	coil tilted at 90°	HAMD, BDI and SCWT
CHEN et al. (2020), China	MUD (DSM-V)	RCT (DB)	31.64 ± 6.33	97 (76/21)	0%	LDLPFC	50 Hz, 100% MT, 900, 5 min, 5 days/week, 20 daily sessions	coil tilted at 180°	A battery of cognitive tests and BIS-11
LUZI et al. (2021), Italy	Obesity (BMI 30–45 Kg/m²)	RCT (DB)	48.8 ± 9.9	45 (12/33)	0%	LDLPFC RDLPFC Insula	18 Hz, 2880, 29.3 min, 15 session over 5 weeks	Sham coil	FCQ-T, BIS-11, STAI-y1 and STAI-y2 and BDI
CALDERÓN-MOCTEZUMA et al. (2020), Mexico	BPD (DSM-IV-R and DIB-R >7)	RCCT (SB)	26.03± 7.08	14 (5/9)	Pharmacological treatment (100%)	DMPFC	5 Hz, 100% MT, 1500, 15 sessions (once a day, five days a week)	Sham coil	BSL, CGI-BPD, BEST, HDRS, HARS, BIS, SST, WCST and IGT
GARZA-VILLAREALet al. (2021), Mexico	CUD (Cocaine use for at least 1 year, with current average use of at least 3 times a week)	RCT (DB)	34.55± 7.9	44 (38/6)	NR	LDLPFC	5 Hz, 100% MT, 5000, two daily sessions for 2 weeks and two weekly sessions for up to 6 m	Sham coil	A battery of cognitive tests, CCQ and BIS-11
FEFFER et al.	MDD, BPD (DSM-V,	RCCT	31.8± 12.6	16 (0/16)	antidepressant, antipsychotic	LDMPFC	20 Hz, 120% MT, 3000, 5 s	Sham coil	BIS-11, ZAN-BP

(2021), Canada	score >18 on the 17-item HamD)	(DB)			(100%)	RDMPFC	on and 10 s off, twice-daily session (five days per week for 3 weeks)		D
YANG et al. (2018) UK	Impulsivity (Barrett Impulsiveness Scale and UPPS-P Impulsiveness Scale)	RCCT (SB)	21.80± 1.85	20 (20/0)	NR	RIFG	10 Hz, 100% MT, 900, 2 s duration of each train	Sham coil	SST, IST

3.1 Pooled analysis of tDCS studies

The meta-analysis of effect sizes from ten tDCS studies on the effects of tDCS on impulsivity didn't show a significant effect (g=-0.18; 95% CI, -0.46–0.10; p=0.07; figure 2), however, it is important to note that the p-value is close to the threshold, suggesting a marginal level of significance. This analysis revealed significant heterogeneity among the included studies (Q(9) = 15.74, p = 0.07; I^2 = 43.61%; T^2 = 0.09; Figure 2).

Figure 2. Overview and visualization of effect sizes in tDCS studies through statistical summary and forest plot

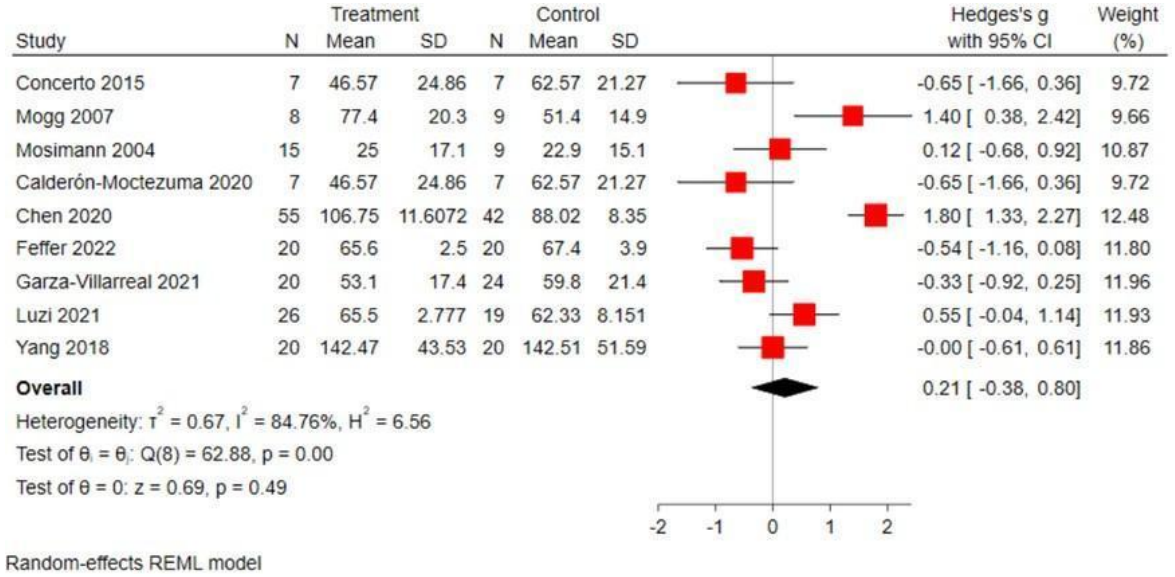


3.2 Pooled analysis of rTMS studies

The meta-analysis of effect sizes from ten tDCS studies investigating the effects of tDCS on impulsivity did not yield a statistically significant effect (g = 0.21; 95% CI -0.38 to

0.80; p = 0.49; see Figure 3). This analysis revealed significant heterogeneity among the included studies (Q(8) = 62.88; p = 0.00; I^2 = 84.76%; T^2 = 0.67; Figure 3).

Figure 3. Overview and visualization of effect sizes in rTMS studies through statistical summary and forest plot



3.3 Subanalyses in selected populations

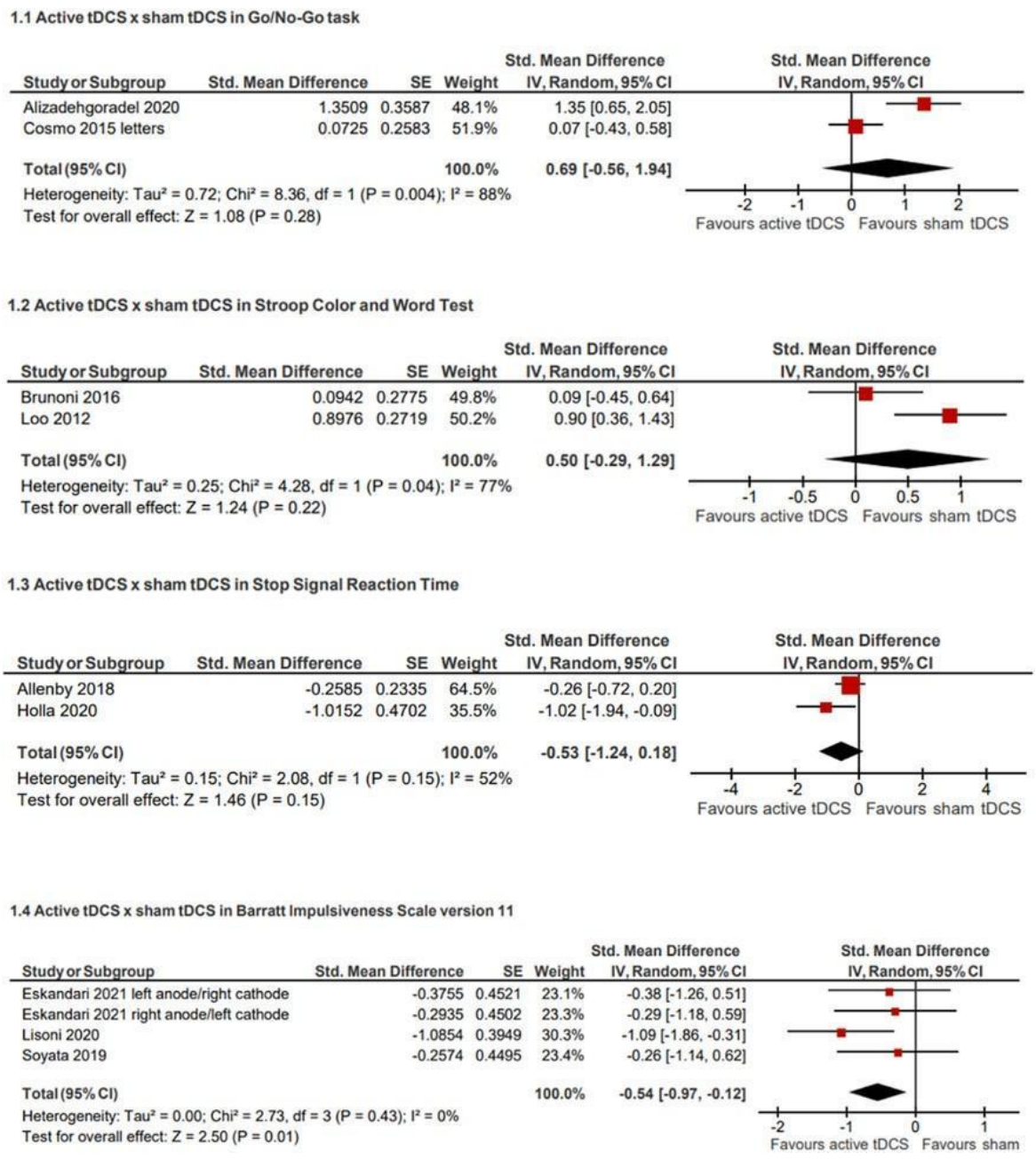
In a subanalysis of the tDCS studies, active tDCS x sham tDCS in RDLPFC (SMD 0.06; 95% CI -0.49–0.62; p=0.82; I2=0%) and LDLPFC (SMD -0.31; 95% CI -0.81–0.20; p=0.23; I^2=0%) were not significantly different in BIS-11 results post-stimulation, as shown in supplementary figure 3. Unfortunately, in the absence of patient-level data, the planned subanalysis including side effects of tDCS and rTMS was not possible due to the very limited number of studies relating them.

The overall subgroup analysis by diagnosis in tDCS studies (Supplementary figure 4) revealed a significant negative mean effect and moderate heterogeneity (SMD 0.10; 95% CI -0.09–0.29; p=0.02; I2=69.2%). However, it didn't show significant effect for the groups of ADHD (SMD -0.28; 95% CI -0.62–0.06; p=0.11; I^2=0%), substance use disorder (SMD 0.19; 95% CI -0.23–0.62; p=0.37; I^2=91%) and other diagnosis (SMD 0.08; 95% CI -0.31–0.47; p=0.68; I^2=0%). Specifically, depressive disorders (SMD 0.52; 95% CI 0.14–0.89; p=0.007; I^2= 77%) had a significant negative effect in active tDCS and a high heterogeneity.

When analyzing active tDCS over specified scales, The Barratt Impulsiveness Scale version 11 showed a trend towards improvement with active tDCS over placebo (g -0.54; 95%

CI -0.97– -0,12; p=0.01; I^2=0%; Figure 4). However, there was no statistically significant difference between groups in terms of Go/No-go Task (g 0.69; 95% CI -0.56–1.94; p=0.28; I^2=88%; Figure 4), Stroop Color and Word Test (g 0.50; 95% CI -0.29–1.29; p=0.22; I^2=77%; Figure 4) and Stop Signal Reaction Time results (g -0.53; 95% CI -1.24–0.18; p=0.15; I^2=52%; Figure 4).

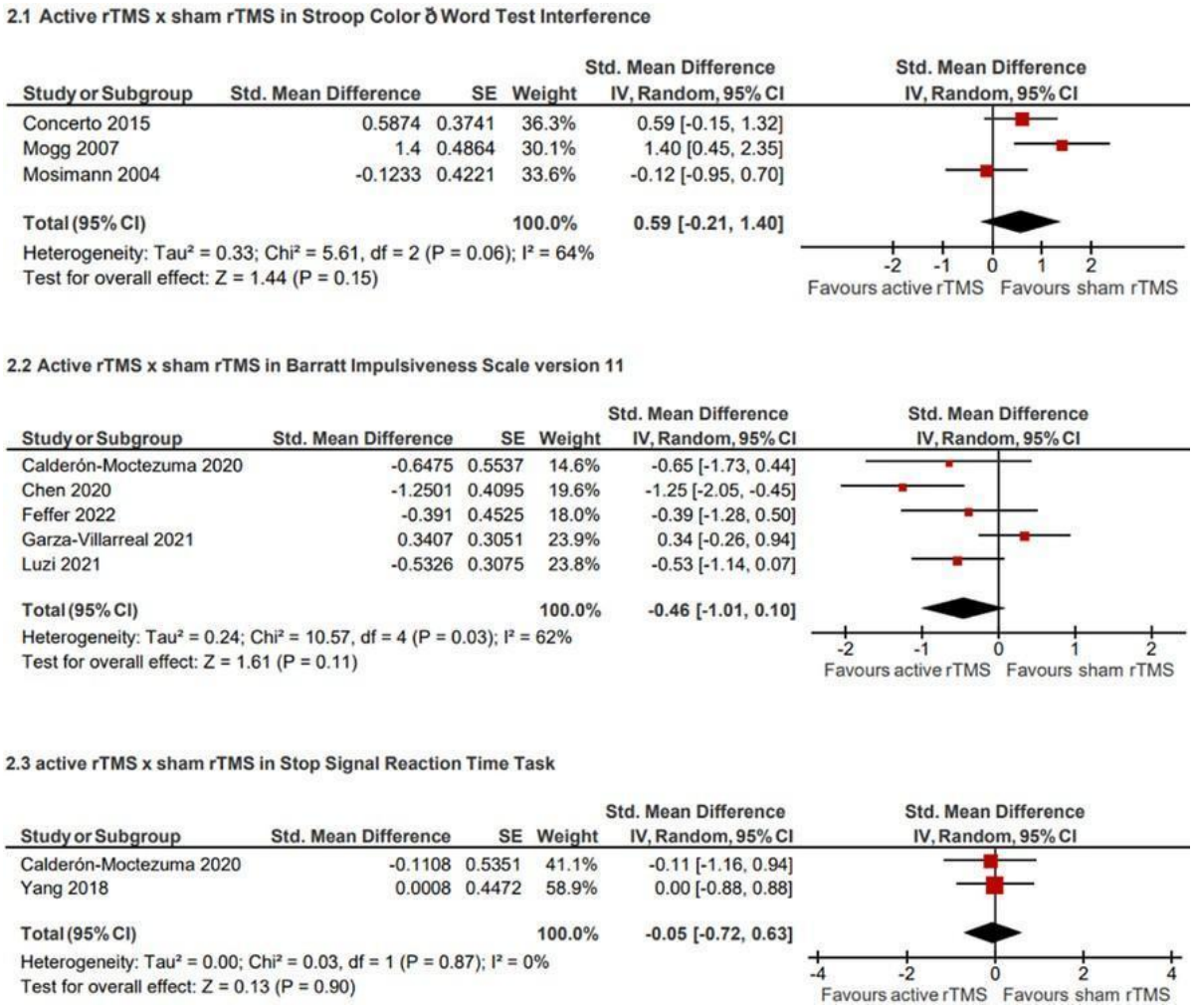
Figure 4. Statistical summary and forest plot of effect sizes for tDCS studies



On the otherside, the overall subgroup analysis by diagnosis in rTMS studies (Supplementary figure 5) didn't show statistical significance (SMD -0.53; 95% CI -1.28–0.22; p=0.16; I^2=86%); but presented a significant heterogeneity (p < 0.00001). In the same way, neither depressive disorders (SMD -1.82; 95% CI -4.20–0.57; p=0.14; I^2 =94%) nor other diagnosis (SMD -0.06; 95% CI -0.59–0.48; p=0.84; I^2=63%) presented significant effect.

Also, there was no statistically significant difference between groups in the three variables of the outcomes analyzed: Stroop Color and Word Test Interference (g 0.59; 95% CI -0.21–1.40; p=0.15; I^2=64%; Figure 5), Barratt Impulsiveness Scale version 11 (g -0.46; 95% CI -1.01–0.10; p=0.11; I^2=62%; Figure 5) and Stop Signal Reaction Time Task (g -0.05; 95% CI -0.72–0.63; p=0.90; I^2=0%; Figure 5).

Figure 5. Statistical summary and forest plot of effect sizes for rTMS studies



3.4 Quality assessment

As shown in Figure 6, there was no evidence suggestive of publication bias in tDCS. The funnel plot (Supplementary figure 1) and the Egger's test (beta1= -8.55; SE of beta1= 9.201; t=-0.93, P>|t|=0.3836) and the Begg's test (z=-1.07; p= 0.3711) did not show significant evidence of publication bias. The quality of evidence regarding the effects of tDCS on impulsivity was graded as moderate as some downgrading criteria were present.

The analysis of rTMS studies (Figure 7) reported two studies with overall risk of bias (CALDERÓN-MOCTEZUMA et al. 2020; YANG et al. 2018). The funnel plot (supplementary figure 2) and the Egger's test (beta1= 6.34.; SE of beta1= 3.639; t= 1.74, P>|t|=0.1318) and the Begg's test (z=-0.42; p= 0.8331) also did not show significant evidence of publication bias. The quality of evidence regarding the effects of tDCS on impulsivity was graded as some concerns as considerate downgrading criteria were present.

Figura 6. The overall risk-of-bias judgment of the reviewed tDCS studies

Study	Bias from randomization process	Bias due to deviations from intended interventions	Bias due to missing outcome data	Bias in measurement of the outcomes	Bias in selection of the reported result	Overall risk of bias
Brunoni 2016	Low	Low	Some concerns	Low	Low	Some concerns
Eskandari 2021	Low	Low	Some concerns	Low	Low	Some concerns
Lisoni 2020	Low	Low	Low	Low	Low	Low
Alizadehgoradel 2020	Low	Low	Some concerns	Low	Low	Some concerns
Allenby 2018	Low	Low	Low	Low	Low	Low
Loo 2012	Low	Low	Low	Low	Low	Low
Soyata 2019	Low	Low	Low	Low	Low	Low
Holla 2020	Low	Low	Low	Low	Low	Low

Figura 6.1. The overall risk-of-bias judgment of the reviewed rTMS studies

Study	Bias from randomization process	Bias due to deviations from intended interventions	Bias due to missing outcome data	Bias in measurement of the outcomes	Bias in selection of the reported result	Overall risk of bias
Concerto 2015	Low	Some concerns	Low	Low	Low	Some concerns
Mogg 2007	Low	Low	Some concerns	Low	Low	Some concerns
Mosimann 2004	Low	Low	Low	Low	Low	Low
Chen 2020	Low	Low	Low	Low	Low	Low
Luzi 2021	Low	Low	Some concerns	Low	Low	Some concerns
Calderón-Moctezuma 2020	Low	High	Some concerns	Low	Low	High
Garza-Villarreal 2021	Low	Low	Some concerns	Low	Low	Some concerns
Feffer 2022	Low	Low	Some concerns	Low	Low	Some concerns
Yang 2018	Low	High	Some concerns	Low	Low	High

4. Discussion

In this systematic review and meta-analysis of 18 studies and 715 patients, we compared NIBS (active tDCS and active rMTS) to placebo (sham tDCS and sham rTMS). The main findings with tDCS include the improvement in BIS-11 scale, however, there was no important and significant finding related to rTMS. The stimulation sites, number of sessions, protocols and sham methods, along with the measures of impulsivity subdomain, varied significantly across the studies that were examined in this review.

The meta-analysis of the impact of tDCS on impulsivity, which included 9 studies, a small yet significant positive effect was observed only in the BIS-11 scale. Among the various self- report questionnaires of impulsivity, the BIS-11 has been extensively studied and is considered one of the most reliable measures of impulsivity (KAPITÁNY-FÖVÉNY et al., 2020). When analyzing the results using the go/no go task scale, although not significant, it is possible to question its negative outcome. One disadvantage of the go/no-go task in impulsivity research is that it only captures one aspect of impulsivity, which is response inhibition (BEZDJIAN et al., 2009). Impulsivity is a multi-faceted construct, and there are other components of impulsivity, such as reward sensitivity, that are not measured by this task. Therefore, using only the go/no-go task may not provide a complete picture of an individual's

impulsivity. Additionally, the task can be subject to response biases, such as the tendency to respond quickly or slowly, which can affect the results (BEZDJIAN et al., 2009; CASWELL et al., 2015).

The same occurs in SCWT and SSRT, with both not being specific scales to access impulsivity. The first one may also measure other cognitive processes such as attention, cognitive flexibility, and inhibitory control. Additionally, the test is sensitive to cultural and linguistic differences, and may not be appropriate for all populations (SCARPINA; TANGINI, 2017). The second one also involves cognitive control processes such as inhibition and attention, being not a pure measure of impulsivity, and it may be influenced by individual differences in motor speed and general cognitive ability, which could confound the interpretation of results (ENCYCLOPEDIA OF BEHAVIORAL NEUROSCIENCE, 2010; VERBRUGGEN, LOGAN, 2008).

The meta-analysis of the impact of rTMS on impulsivity, which also included 9 studies, revealed a non-significant effect in none of the analyzed scales, even in BIS-11. The results found in this study were similar to those of a previous meta-analysis (YANG et al., 2020) in which weighted results were observed when applied tDCS and small or no effect on impulsivity control for rTMS, despite new studies being selected. The authors also provide further evidence that rTMS can reduce both temporal and motor impulsivity in non-clinical samples. However, this study demonstrates that rTMS has no significant effects on it. This same review demonstrates that the small number of studies and the different methods of assessing impulsivity make it difficult to draw more assertive conclusions.

Contradictorily, in a systematic review conducted by Brevet-Aeby and colleagues (2016), the authors found positive results of NIBS to regulate impulsivity. The majority of studies in this review found that impulsivity was decreased, particularly with the use of high-frequency rTMS or anodal tDCS targeting the right DLPFC. However, the authors explain that a crucial challenge for the therapeutic application of these techniques persists: the studies examined in this review primarily assess immediate or short-term effects. Besides, repeated sessions may prolong the duration of the effects and have clinical significance.

The assessment of impulsivity is done through different methods, such as questionnaires, behavioral tasks, and psychophysiological measures. However, the heterogeneity among these methods is extremely high, making it difficult to compare and generalize the results. It is possible to observe this when analyzing the Go/no Go test, which

showed an I^2 of 88%, and the Stroop Color and Word test, which showed an I^2 of 77%, when applied with tDCS. The assessment and comparison of results should take into account this heterogeneity.

This meta-analysis had a great advantage over previous ones, as it divided the analysis of outcomes using different scales. Although the evidence examined was of moderate quality, the review revealed several limitations in the studies that were analyzed, such as selection bias, small sample sizes, and a lack of consistency in design and outcome measures used.

Overall, the study provides some evidence for the potential effectiveness of tDCS and rTMS in reducing impulsivity, particularly in depressive disorders (LOO et al. 2012; MOSIMANN et al. 2004; CONCERTO et al. 2015). However, it is important to note that our results should be interpreted with caution, as there were some limitations, such as the lack of available patient-level data and the limited number of studies relating to side effects of tDCS and rTMS. The main limitation refers to the lack of available data from some articles (WAJDIK et al. 2014; NOVAK et al. 2006; HAUSMANN et al. 2004; BOGGIO et al. 2010; LIM et al. 2017; WEIDLER et al. 2017; GILMORE et al. 2018), which were excluded from the statistical analysis and could change our outcomes. This prevented a comparative analysis with a larger number of studies from being performed.

Another important limitation is the lack of consensus in the field of psychology and psychiatry regarding the structure of impulsivity. Different theoretical frameworks propose different subdomains or dimensions of impulsivity, leading to inconsistencies in how impulsivity is measured and conceptualized in research studies (CRESWELL et al., 2018; CYDERS; COSKUNPINAR, 2011; SHARMA et al., 2013). Besides, due to these variations, it's possible that our search strategy utilized may have excluded other relevant studies.

5. Conclusion

Based on the results of the comprehensive review conducted, it can be concluded that there is currently inadequate evidence to support the clinical use of rTMS or tDCS as a means of reducing impulsivity in individuals with mental health disorders. Despite the fact that some studies showed a trend towards improvement in impulsivity with the use of active tDCS over placebo, no statistically significant differences were observed between the groups in terms of several key outcomes analyzed, including the Go/No-go Task, Stroop Color and Word Test, and Stop Signal Reaction Time results.

Furthermore, the subgroup analyses conducted by diagnosis in both tDCS and rTMS studies did not show statistically significant effects, with the exception of depressive disorders in the tDCS studies. Unfortunately, due to a very limited number of studies relating to the side effects of tDCS and rTMS, a planned subanalysis in this regard was not possible. To standardize the results in future studies, it is important to establish clear and consistent protocols for administering tDCS or rTMS, including the stimulation parameters, duration, frequency, and electrode placement. It is also crucial to use standardized assessment tools and outcome measures to evaluate the effects of the interventions. In addition, future studies should strive to recruit participants with similar demographic and clinical characteristics, such as age, sex, diagnosis, and medication use. Moreover, reporting and addressing potential confounding factors, such as prior treatment history, comorbidities, and lifestyle factors, can help reduce heterogeneity and increase the reproducibility of the results.

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7. Supplementary figures

Figura 7. Supplementary figure 1

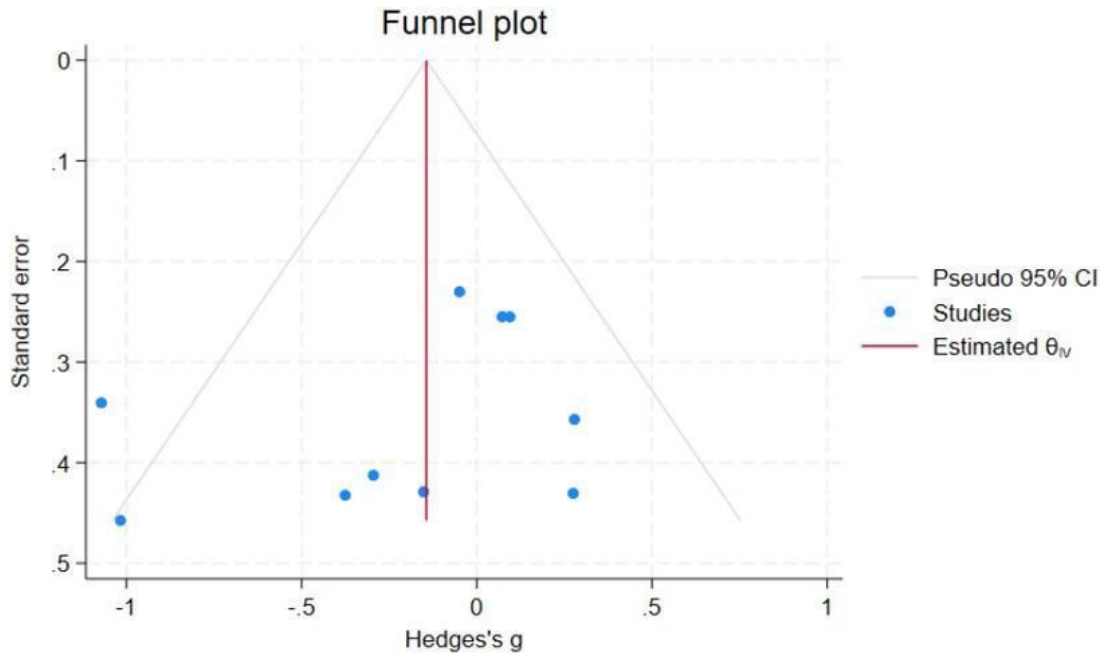


Figura 8. Supplementary figure 2

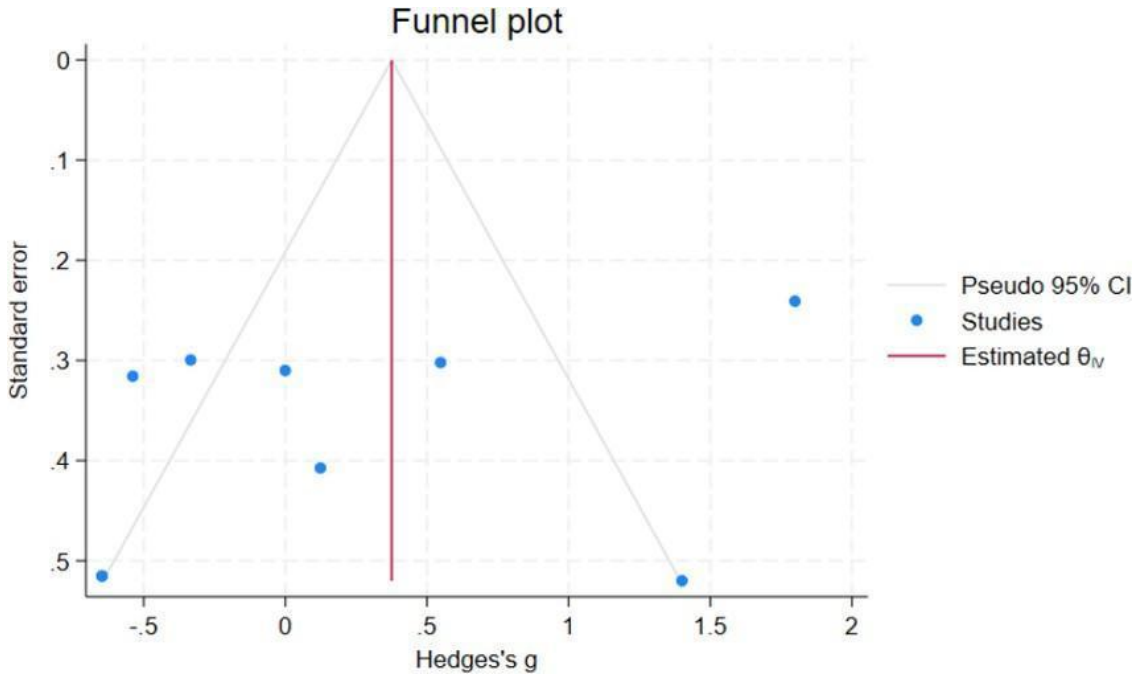


Figura 9. Supplementary figure 3

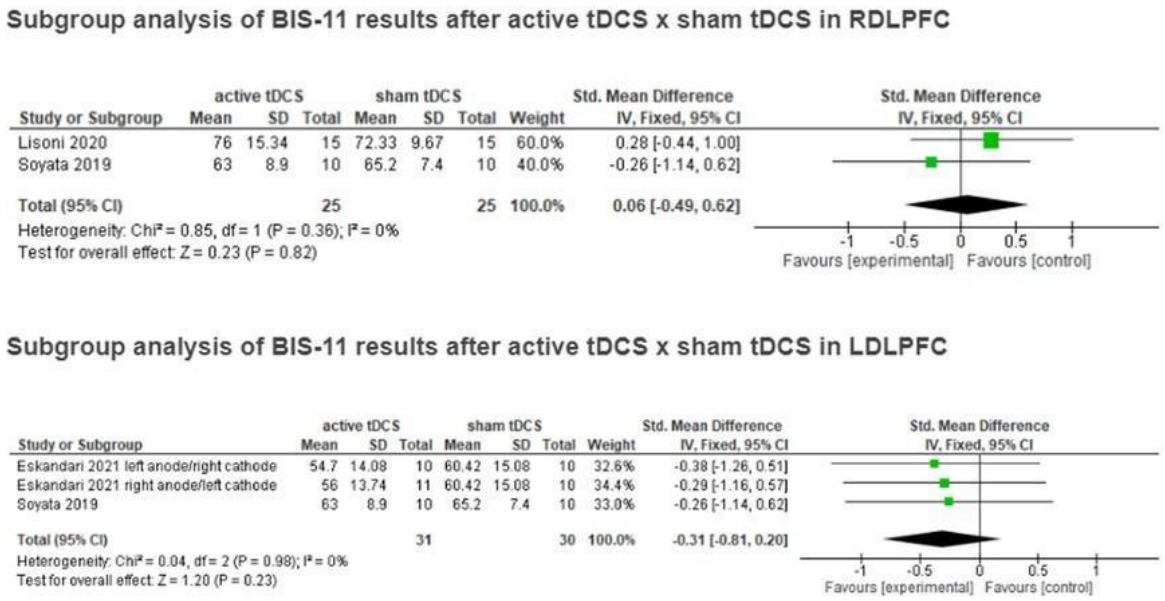


Figura 10. Supplementary figure 4

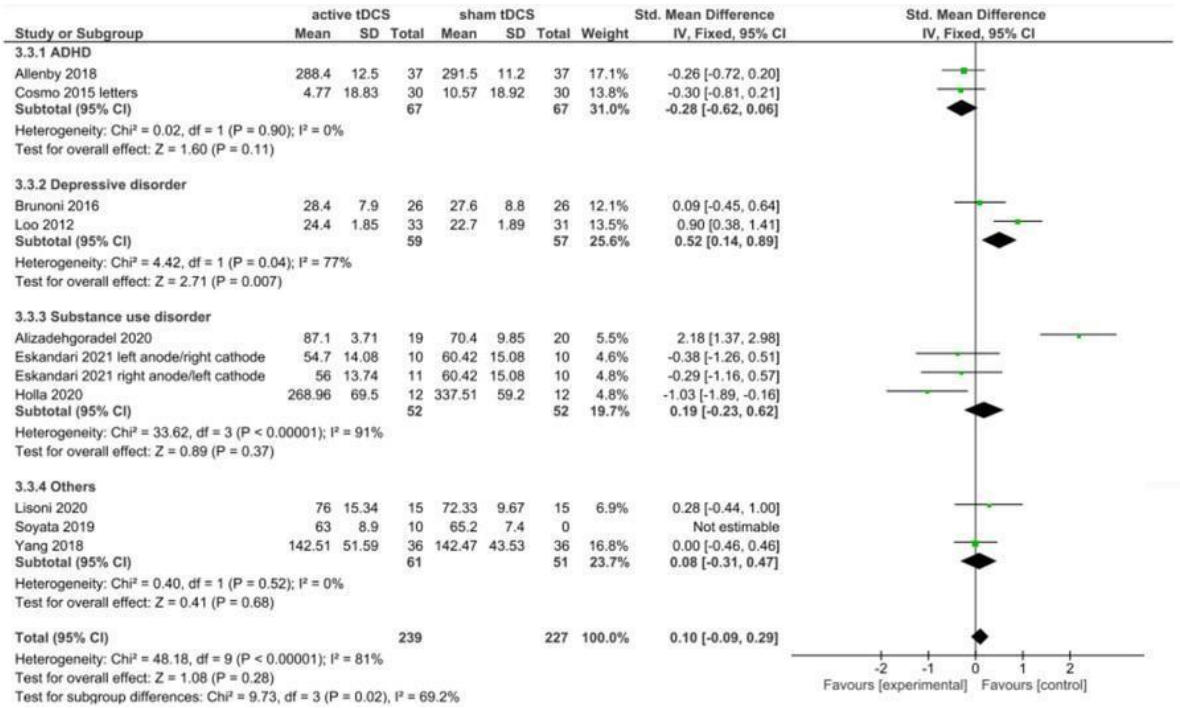
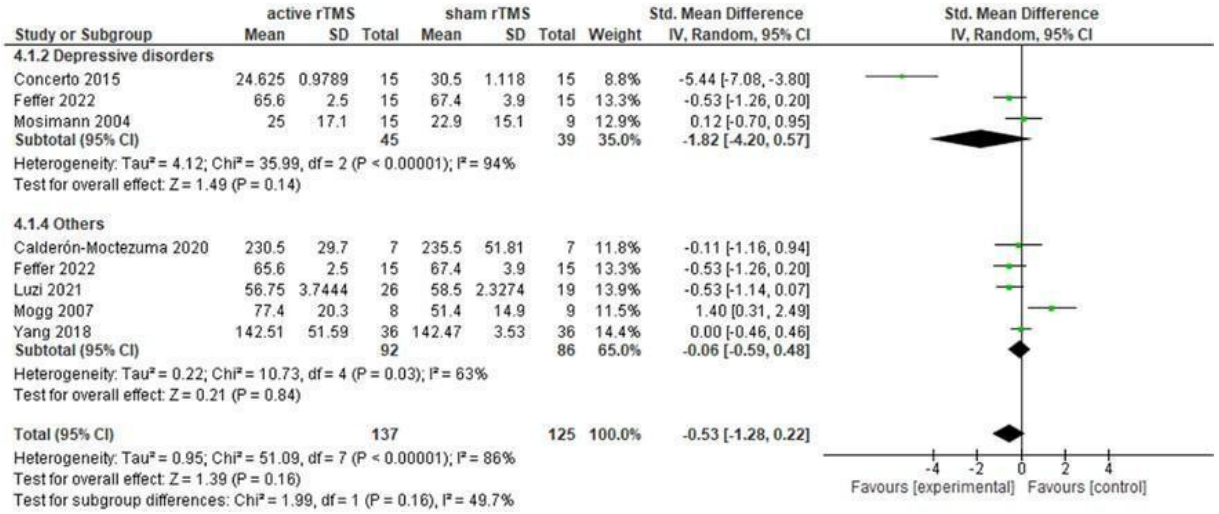


Figura 11. Supplementary figure 5



8. Supplementary table

Tabela 4. Supplementary table S1

EMBASE, PUBMED and SCOPUS until April 2023
("brain stimulation" OR "non-invasive brain stimulation" OR "non-invasive neuromodulation") AND ("impulsivity" OR "impulsiveness" OR "impulsive behavior"
("transcranial direct current stimulation" OR "tdcs" OR "tms" OR "transcranial magnetic stimulation" OR "tbs" OR "theta burst stimulation") AND ("impulsivity" OR "impulsiveness" OR "impulsive behavior")

EMBASE until April 2023
#1 (impulsiv* or "self-regulation" or "inhibitory control" or "impulse control" or "risk taking" or "response inhibition" or "information sampling" or "stop signal" or "discounting" or "stroop" or "inhibition" or "go-no-go" or "gambl*")
#2 (TMS or transcranial magnetic stimulation or TBS or theta burst stimulation or tDCS or transcranial direct current stimulation)

#3 (Schizo* or Psych* or Psychiatr* or Mental Health* or Mental Illness* or Mental Disorder* or Mental* or personality* or psychopath* or Mood or Depress* or Anxiet*)
#1 AND #2 AND #3
#4 AND 'human'/de AND [adult]/lim AND ('article'/it OR 'article in press'/it)

Tabela 05. Supplementary table S2 (From YANG et al. 2020)

Task	Description of task
Balloon Analogue Risk Task (BART) LEJUEZ et al. (2002)	The Balloon Analogue Risk Task (BART) is a computerised task, which measures risk-taking behaviour. Participants are offered to gain money if they pump a virtual balloon. A reward for clicking on the pump is provided up until the balloon explodes, which an individual threshold of each balloon determines. With each click, the potential reward is increased as well as the risk of losing all the money earned so far. Participants can choose to stop pumping and collect the money at any given time. Outcome measure is the adjusted average number of pumps on unexploded balloons.
Continuous Performance Task (CPT) ROSVOLD et al. (1956)	The Continuous Performance Task (CPT) is a measure of selective and sustained attention as well as it gives an indication of impulsivity. The participants are presented with an infrequently occurring target stimulus, which they need to react upon and inhibit responses to non-targets. Stimuli could be for instance symbols, numbers or sounds. Scores that can be obtained from the CPT are correct detection, reaction time, commission errors and omission errors. CCPT (used in NI et al. (2017)) The CCPT is a specific kind of Continuous Performance Task, the Conner's Continuous Performance Test (Connors, 2000), where participants are asked to respond to letters as target stimuli, except for the non-target letter "X".
Delay Discounting Task (DDT) CHO et al. (2012)	The Delay Discounting Task (DDT) measures impulsive decision-making. A series of choices of rewards (such as monetary gains) are presented to the participant with rewards amount ranging from low to high and the reward being given ranging from immediate to delayed. Throughout the task, the higher and delayed rewards are systematically decreased while the lower and immediate rewards are systematically increased. Another alternative version would be that the delays and amounts are adapted to the subjective choice of the participant. Outcome measure is a so-called indifference point, where immediate quantity and delayed rewards quantity approximately have an equivalent value. From a series of indifference points, an individualised curve as well as a discounting rate can be calculated.
Game of Dice Task (GDT) BRAND et al. (2005)	The Game of Dice Task (GDT) is used to measure risky decision-making. Participants are asked to make a prediction upon the results of a dice roll and maximize their winnings. They need to pick among various options ranging from low-probability and high payoff as opposed to high-probability and low payoff. The probabilities and amounts that could be lost or won with each choice are explicitly presented to the participants. After each dice roll, the participants get the reward if their prediction was correct and loose the amount if the guess was incorrect. During the game, the capital changes due to the current amount of gains and losses. Outcome score is the average of safe bets.
	The Go/No-go task (GNG) is designed to measure inhibitory control the ability to control impulsive, prepotent motor responses. A series of stimuli with a target and a non-target is presented to the participants.

Go/No-go (GNG) task	The participants are instructed to react as fast and as accurate as possible with a motor response to the target stimulus, for instance with a press of a button, and to inhibit their response to a non-target stimuli. Outcome measures are the reaction time, the number of correct go-trials, commission and omission errors Affective GNG (used in BOGGIO et al. (2007)) The affective Go/No-go task assesses behavioural inhibition in connection with a modulation of inhibition due to emotional processing. During the task, a set of words is presented. The participant is assigned to an affective target category (either positive, negative or neutral) and is instructed to respond to a word when it matches the assigned category. The affective go/No-go task measures errors of omission and commission as well as latency (speed of response). GNGN fruits letter (used in COSMO et al. (2015))Images of letters and pictures of various fruits are used as stimuli. Outcome measures were the number of correct responses, impulsivity and omission errors.
Risk Task ROGERS et al. (1999)	The Risk Task measures risky decision-making. Participants are presented with red and blue boxes under which a token is hidden. They are rewarded with points if they find the token. The ratio of the coloured boxes determined the probability of finding the token and therefore reflected the level of risk involved. Outcome measures are the average percent of the time that participants decide upon the high-risk option.
Stroop Colour Word Test (SWCT) STROOP (1935)	The Stroop Colour Word Test (SCWT) assesses the ability to inhibit cognitive interference, which occurs during the processing of two stimulus features that interfere with one another. In addition to the inhibition of cognitive interference, the SWCT task is seen as a measure of other executive functions such as processing speed, cognitive flexibility and attention. In the original version of the Stroop test, the incongruent condition requires the participants to name the colour of the ink and ignore the incongruent printed name of colour (colour-word condition). The participant needs to inhibit the urge to read out the printed colour word but name the ink colour, which is a less automated cognitive process. Outcome measures are the reaction time, the interference time and error rates. Numerical Stroop task (used in DEL FELICE et al. (2016)) The numerical Stroop task is a modification of the original SWCT task. The participant is presented with two different digits. In the incongruent condition, the numerical value and the physical size are incongruent. For instance, an incongruent pair of digits would be a 3, which is presented larger in size than a 9. Depending on the condition, participants are required to compare the physical size and ignore the numerical value or are required to compare the numerical value and ignore the physical size.
Temporal Discounting (TD) task WEBER et al. (2007)	The temporal discounting task is very similar to the delay discounting task and measures temporal choice impulsivity. Participants are asked to choose between a small immediate reward or a large delayed reward. An individual 'indifference point' and a hyperbolic function can be calculated, smaller values in the AUC (area under the curve) analysis represent impulsive decision making while larger values represent less impulsive decision making. Outcome measures can also be a global discount factor, which can be calculated from the mean of accelerate and delay discount factors.

4.2 Estudo 2 - *"The Effects of Mindfulness on Impulsivity in People With Mental Disorders: a systematic review and meta-analysis of randomized clinical trials"*

1. Introduction

The concept of impulsivity encompasses biological and neuropsychological aspects (CHAMBERLAIN & SAHAKIAN, 2007), as well as cognitive (CHUDASAMA et al., 2011). Within the psychopathological perspective, the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) characterizes the term as an immediate and unpremeditated reactive posture in the face of some stimuli, which may be from a personality trait perspective, assessment by tools such as the Scale of Barratt's Impulsivity (BIS-11) (STANFORD et al., 2009), or from a neuropsychological behavior linked to various aspects such as the response instinct, sensitivity to reward and disinhibition, acting without taking into account the consequences of their acts.

Impulsive behavior is strongly associated with negative scenarios, for example, exposure to scenarios and acts that risk the individual's life (GABRIEL et al., 2019). A comparative study carried out in the city of Pittsburgh, with 81 patients diagnosed with borderline personality disorder and 77 with a major depressive disorder, showed a significant predictive association between impulsivity and a greater number of suicide attempts (MALONE et al., 2000). In parallel, the implications of an impulsive posture can generate more subtle damage, as studied in its connection with binge eating and the maintenance of obesity (MOBB et al., 2010).

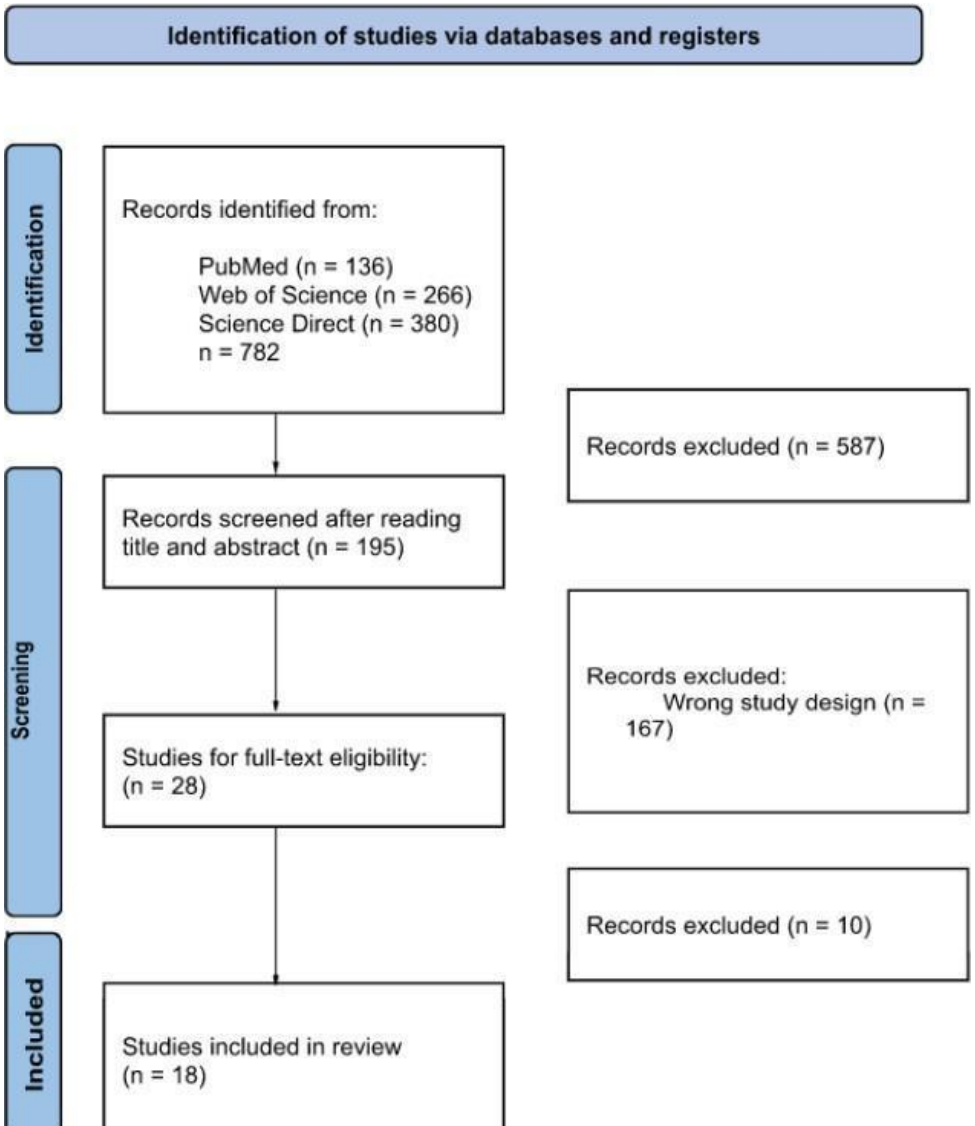
An alternative for this problem is the mindfulness technique. Mindfulness can be defined as nonjudgmental attention to the present moment. Therefore, this method is a state of being openly attentive to and aware of what is taking place in the present moment, internally and externally. This practice has results on mindfulness on self- and social awareness and on self- regulation of emotions and behaviors. The main techniques of mindfulness intervention include meditation, body scanning, walking meditation, breathing, and mindfulness yoga (STEDHAM; SKAAR, 2019).

The advancement of the pharmacological industry has brought several benefits to the

therapeutic process of mental disorders, offering specialized professionals a range of possibilities to choose from, increasing therapeutic success. However, in addition to having a limited effect, abusive use, dependence, and side effects are also harmful elements present in this scenario. Therefore, thinking about alternative solutions to pharmacological treatment is necessary and mindfulness practices appear as a promising option to assist in the care process, not only for individuals with common clinical conditions such as sleep disorders (GOODMAN et al., 2013), but also those with mental disorders, mainly pathologies based on the impulsivity trait, similar to borderline personality disorder and bipolar affective disorder (WILLIAMS et al., 2008) . Therefore, the present study aims to analyze the effect of mindfulness technique on patients with impulsivity.

2. Methods

This systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Statement (PRISMA, 2021). The review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO,



registration number: CRD42023413969).

Figura 1. Screening of the articles following the PRISMA Flowchart

2.1 Eligibility criteria

Inclusion in this systematic review was restricted to studies that met all the following eligibility criteria: (1) randomized trials; (2) those in patients with impulsivity (ADHD with impulsivity and Non-ADHD; borderline disorder; bipolar disorder; medication users; tabagists; addiction) doing mindfulness meditation; (3) those with control group (placebo or waitlist); and (4) those reporting any of the outcomes of interest (improvement of impulsivity with objective and subjective scales). Exclusion criteria was based on (1) studies without a control group.

2.2 Search strategy

We systematically searched PubMed, Scopus, and Science Direct in march 2023 using the following search strategy: (Impulsivity OR impulsive behaviors OR impulsivities) AND mindfulness. The search was restricted to articles published in English and the period of publication was not delimited.

2.3 Data extraction

Two authors (IL and JL) independently assessed the articles for inclusion and in case of disagreement, a third evaluator deliberated. This process was executed through Rayyan.ai - Intelligent Systematic Review. After the triage phase, both authors (IL and JL) independently extracted the data after predefined search criteria and quality assessment.

2.4 Endpoints and subanalyses

Efficacy outcomes included change behavioral performance- mindfulness, in Conners Continuous Performance Task (CPT), Stroop test, Conners' Parent Rating Scale (CPRS), Barratt Impulsiveness Scale 11 (BIS 11), Stop signal task (SST) and UPPS-P Impulsive Behavior Scale. Definitions of impulsivity varied slightly between studies and were reported in table 2. Subgroup analyses included (1) Type of intervention; (2) Session time; (3) Number of sessions; (4) Median follow up; (5) Analysis of scales results.

2.5 Quality assessment

Quality assessment of RCTs was performed with Cochrane Collaboration's tool for assessing bias in randomized trials (ROB-2) where in studies are scored as high, low, or some concerns of bias in 5 domains: randomization process, deviations from intended interventions, missing outcome data, measurement of the outcomes, and reporting, as shown in table 1 (COCHRANE, 2011). Publication bias was investigated by funnel-plot analysis of point estimates according to study wights and by Egger's regression test.

Table 1. Quality assessment of the studies using ROB-2

Study	Bias from randomization process	Bias due to deviations from intended interventions	Bias due to missing outcome data	Bias in measurement of the outcomes	Bias in selection of the reported result	Overall risk of bias
SOLER et al. (2016)	Low	Some concerns	Some concerns	Some concerns	Low	Some concerns
SCHOENBERG et al. (2014)	Low	Some concerns	Low	Low	Low	Low
SOLER et al. (2018)	Low	Low	Low	Low	Low	Low
ROUX et al. (2020)	Some concerns	Low	Low	Low	Low	Low
TARRASCH (2018)	Low	Some concerns	Some concerns	Low	Low	Some concerns
KIANI et al. (2016)	Low	Some concerns	Some concerns	Low	Low	Some concerns
SHEAD et al. (2020)	Low	Some concerns	Some concerns	Low	Low	Some concerns
SANZ et al. (2021)	Low	Some concerns	Some concerns	Low	Some concerns	Some concerns
SIEBELINK et al. (2022)	Low	Low	Low	Low	Low	Low
RON-GRAJALES et al. (2021)	Low	Low	Low	Low	Low	Low
SALMOIRAGO-BLOTCHER et al. (2019)	Low	Some concerns	Some concerns	Low	Low	Low
ALQARNI & HAMMAD (2021)	Low	Low	Some concerns	Low	Low	Some concerns
AMIRI et al. (2022)	Low	Low	Low	Low	Low	Low
DAVIS et al. (2019)	Low	Some concerns	Low	Low	Low	Low
FRANCO et al. (2016)	Low	Low	Some concerns	Low	Low	Some concerns
KORPONAY et al. (2019)	Low	Some concerns	Low	Low	Low	Low
VINCI et al. (2016)	Low	Some concerns	Low	Low	Low	Low

2.6 Statistical Analysis

This systematic review and meta-analysis was performed in accordance with the

Cochrane Collaboration and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement guidelines (MOHER et al., 2009). We extracted the data from individual studies using standardized mean differences for continuous outcomes, as given by Hedge´sg. Unbiased Hedges' g with 95% confidence intervals (Cls) was used to define the effect size. Cochran Q test and I^2 statistics were used to assess for heterogeneity; P values inferior to 0.10 and I^2>25% were considered significant for heterogeneity. We used a DerSimonian and Laird random-effects model for all outcomes due to high anticipated heterogeneity.

Separate meta-analyses with the random-effects model were implemented to assess the effect of mindfulness on impulsivity. We compared each scale separately to reduce study heterogeneity. When a study had multiple control groups or conditions, such as one group receiving mindfulness training at a control location and another receiving a placebo, the experimental and placebo groups were compared, however, studies comparing mindfulness and another intervention were compared too and applied on other table.

Review Manager 5.3 (Cochrane Centre, The Cochrane Collaboration, Denmark) was used for statistical analysis.

3. Results

3.1 Description of studies

After the screening process, 18 studies met the inclusion criteria. Study characteristics are summarized in Table 2. There were 1571 participants in the final results. Only one study involved the participation of beginners in meditation in contrast to long-term meditators (KORPONAY et al., 2019). Four studies were based on individuals diagnosed with ADHD or their family members: one involving children between 8 and 16 years old (SIEBELINK et al., 2022), a second with adult patients between 18 and 65 years old (SCHOENBERG et al., 2014), the third exclusively with female students in the 7th and 8th grades (KIANI et al., 2016) and the fourth with parents of children with ADHD (AMIRI et al., 2022).

Two studies involved patients diagnosed with Borderline Personality Disorder (SOLER et al., 2018; SOLER et al., 2016). One study involved male adolescents with behavioral disorders (ROUX et al., 2020). Two studies involved young offenders (RON-GRAJALES et al., 2021; SANZ et al., 2021). Two studies were based on individuals with a problem associated with substance use, one being specifically cigarette consumption

(SPEARS et al., 2017) and the second associated with substance use disorder (DAVIS et al., 2019). Two studies involved university students (SHEAD et al., 2020; VINCI et al., 2016). Two studies involved high school students, the first with 9th-grade students (SALMOIRAGO-BLOTCHER et al., 2019) and the second with adolescents between 12 and 19 years old (FRANCO et al., 2016).

One study focused on students with learning difficulties (ALQARNI & HAMMAD, 2021). One study involved primary school, first, fourth, and fifth-grade students (TARRASCH, 2018). In turn, the control group showed significant heterogeneity, both in the profile of the individuals and in the activities carried out or not, ranging from group exercises to developing interpersonal skills, passive waiting list, continuity with the usual treatments of each of the respective conditions, for example, psychotherapy and even listening to audiobooks.

Table 2. Characteristics of the selected studies

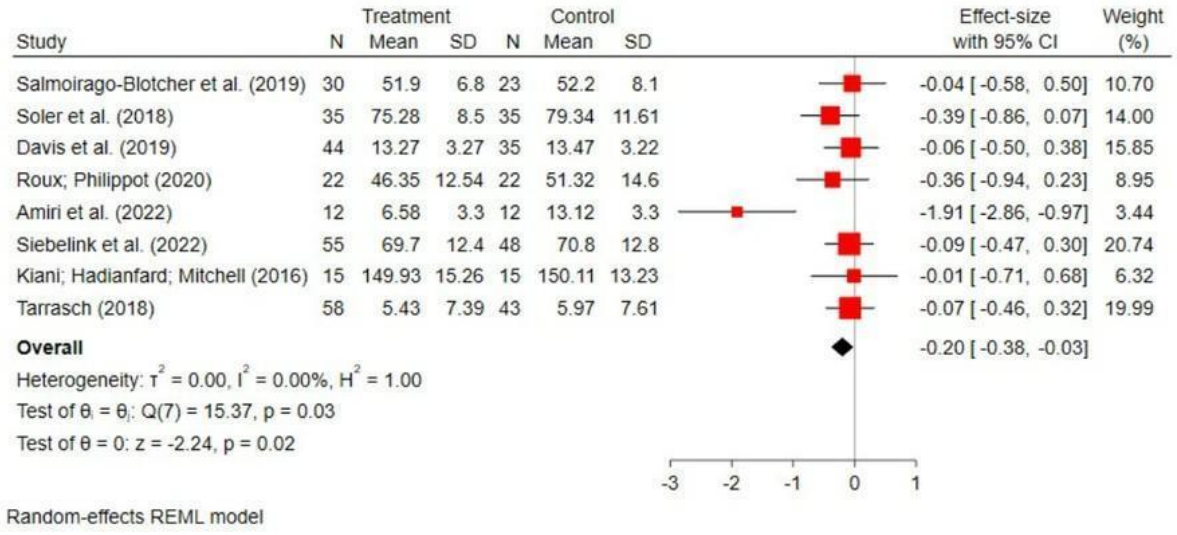
ARTICLE	Nº of patients	Population	Intervention	Session time	Nº of sessions	Control group	Median follow-up
SIEBELINK *et al.* (2022)	103	Children (aged 8–16 years) with a primary ADHD diagnosis and one of their parents were recruited.	Family mindfulness-based intervention	90 min	8 session + 1 session after 8 weeks	Participants with care-as-usual	8 week
RON-GRAJALES *et al.* (2021)	69	Juvenile ofenders	Mindfulness meditation training program	1 hour	10 session (1 session per week)	Juvenile ofenders that did not receive Mindfulness training	10 week
SPEARS *et al.* (2017)	412	Eligible participants were at least 18 years old and currently smoked cigarettes (at least 5 cigarettes/day for the past year)	Mindfulness-Based Addiction Therapy, Cognite Behavioral Treatment and Usual care intervention	30-45 min	5 session	Participants with care-as-usual	26 week
SALMOIRAGO-BLOTCHER et al. (2019)	53	High school participants that had to be 9th graders and English-speaking to be included in the study.	Health education session Mindfulness intervention Attention Control	15 min	8 weeks	HE-AC School	8 week
ALQARNI & HAMMAD (2021)	30	Students with learning disabilities attending inclusive schools in the Najran region for the first academic term 2019/2020	The experimental group participated in a weekly workshop held at 10 am through three sessions for ten-weeks.	60 min	10 weeks (3 session per week)	Students with learning disabilities	8 week
AMIRI et al. (2022)	48	Parents of children with ADHD	Mindfulness-based	-	8 session	Parents of children with ADHD	8 week

			parenting training				
DAVIS et al. (2019)	79	Pacients in substance use disorder treatment	Mindfulness-based relapse prevention	1.5 hour	8 session	Treatment as usual	8 week
FRANCO et al. (2016)	27	Students with ages from 12 to 19 years who were attending a public high school	Mindfulness training program "Meditación Fluir"	15 min	10 session (1 session per week)	Students with ages from 12 to 19 years who were attending a public high school	10 week
KORPONAY et al. (2019)	105	Naive meditation participants and long term meditators	Mindfulness-based stress reduction	30 min	1 session per day	Passive waitlist Participant of Health Enhancement Program	8 week
VINCI et al. (2016)	207	College student drinkers	Mindfulness intervention on affect and urge to drink in at-risk college student drinkers	10 min	8 session	College student drinkers	-
SOLER et al. (2016)	44	Patients diagnosed with Borderline Disorder aged 18 to 45 years	Experimental group underwent group mindfulness training for 10 weeks, associated with home practice of formal mindfulness exercises. Control group practiced group training for impulsivity variables.	120 min	10 session (1 session per week)	Patients diagnosed with Borderline Disorder practicing group training to control impulsivity variables.	10 week
SCHOENBERG et al. (2014)	50	Adult patients diagnosed with ADHD (DSM-IV-TR) aged 18 to Disorder, (SCID-II and DIB-R)	Mindfulness-Based Cognitive Therapy Skills Training (DBT-M)	3 hours	12 session session per week)	People on the waiting list (n = 24) Disorder taking DBT Interpersonal Effectiveness Skills Training (DBT-IE)	12 week
ROUX et al. (2020)	44	Adolescent boys with behavioral disorders were recruited between 12 and 19 years of age in a specialized institution	Mindfulness-Based Program (MBP)	50 min	16 session (1 session per week)	Waiting list with usual treatment at the institution (psychotherapy, psychomotricity and speech therapy)	16 week

3.2 Pooled analysis of mindfulness study

The meta-analysis of effect sizes from eighteen mindfulness studies on the effects on impulsivity show a significant effect (g= -0,2; 95% CI, -0,38, -0,03; p= 0,02; figure 2). Furthermore, studies favored the use of mindfulness as a therapeutic alternative for impulsivity. This analysis revealed a low heterogeneity among the included studies (Q(7)= 15.37, p= 0,03; I2 = 0,00%; T2= 0,00; figure 2).

Figure 2. Overview and visualization of effect sizes in tDCS studies through statistical summary and forest plot



3.3 Intervention characteristics

All the studies used mindfulness techniques that involved the principles of non-judging, patience, acceptance and trust. Most of the articles used exercises like training for mindful breathing by means of popping bubbles, smelling the flowers, breathing through the stomach and counting during the process of breathing. Furthermore, another methodology is meditation training to achieve relaxation, that involves practicing yoga.

Another interventions used were family mindfulness-based intervention (AMIRI et al., 2022; SIEBELINK et al. 2022), mindfulness-based cognitive therapy (SCHOENBERG et al. 2014), meditación fluir (FRANCO et al. 2016), Mindfulness-based addiction therapy (DAVIS et al., 2019; SPEARS et al., 2017), Mindfulness-based stress reduction (KORPONAY et al., 2019; TARRASCH, 2018), Dialectical Behavior Therapy- Mindfulness skills training (SOLER et al., 2018) and mindfulness meditation training (ALQARNI; HAMMAD, 2021;

KIANI et al., 2016; RON-GRAJALES et al., 2021; ROUX et al., 2020; SALMOIRAGO-BLOTCHER et al., 2019; SANZ et al., 2021; SHEAD et al., 2016; SOLER et al., 2016;).

3.4 Intervention measurements

To assess the level of attention and impulsiveness, the following scales were applied: Six studies used the Barratt Impulsiveness Scale (ALQARNI; HAMMAD, 2021; KORPONAY et al., 2019; SALMOIRAGO-BLOTCHER et al., 2019; SHEAD et al., 2020; SOLER et al., 2016; SOLER et al., 2018), Three used UPPS-P (DAVIS et al., 2019; ROUX et al., 2020; VINCI et al., 2016), Two Conners' Parent Rating Scale (CPRS) (AMIRI et al., 2022; SIEBELINK et al., 2022), Conners' Continuous Performance Test (CPT) (KIANI et al., 2016; SCHOENBERG et al., 2014; SOLER et al., 2016; TARRASCH, 2018), Stroop Task (RON-GRAJALES et al., 2021; SANZ et al., 2021), and SPEARS et al. (2017) used PANAS scale, Perceived Stress and Withdrawal Symptoms.

The result most significantly practicing mindfulness and analyzed by BIS 11 was Alqarni & Hammad (2021) study, showing that is appropriate to use mindfulness training for impulsive students with learning disabilities as it has a strong impact on reducing attentional, motor, and non-planning impulsiveness for the group practicing only mindfulness. More studies are necessary to determine the effects of mindfulness training on impulsivity.

3.5 Subgroup characteristics

The characteristics of each study are detailed in Table 3. Of the studies that reported gender (n = 15), approximately 43.39% of participants were male (n = 594) and 56.61% were female (n = 775). The mean age of participants ranged from 9.5 to 48.6 in the intervention group with mindfulness-derived methods and, in the control group, ranging from 10.0 to 49.8. Only two studies did not provide information on the age of the participants (SPEARS et al., 2017; ALQARNI & HAMMAD, 2021). Of the studies reporting the ethnicity of participants (n = 5), approximately 63.04% were white/caucasian people (n = 546), 25.8% were black (n = 218), 8.54% were unknown (n = 74), 2.77% were mixed (n = 24) and 0.46% were Chinese/Asian (n = 4).

In addition, four studies reported the economic conditions of the participants, prevailing conditions of medium, low-middle, and low income, with annual income ranging from values less than $30,000 for some, average annual salary reaching $5500 for others, in

addition to unemployment for third parties. Five studies reported schooling. The overall mean age of participants' schooling ranged approximately across studies from 7.5 to 12.44 years, with 21 individuals in seventh grade, 9 in eighth grade, 25 having studied less than high school, 22 in high school, and 81 in university graduation. Regarding mental disorders and addictions, four studies reported participants with Attention Deficit Hyperactivity Disorder (ADHD) (SIEBELINK et al., 2022; SCHOENBERG et al., 2014; ROUX et al., 2020; KIANI et al., 2016), two studies reported participants with Borderline Personality Disorder (SOLER et al., 2016; SOLER et al., 2018) and three studies mentioned substance abuse (DAVIS et al., 2019; SPEARS et al., 2017; VINCI et al., 2016). Only four studies reported the use of medication by participants throughout the analyzed intervention, the main drugs used being SSRI, Benzodiazepines, Mood stabilizers, Antidepressants, and Antipsychotics.

Table 3. Subgroup characteristics

	DAVIS et al. (2019)	FRANCO et al. (2016)	KORPONAY et al. (2019)	VINCI et al. (2016)	SCHOENBERG et al. (2014)	SOLER et al. (2016)
Age (median)	25,3	15,85	C: 49,8 T: 48.6	20,13	T = 18 to 65 years.	T = 32.95 (average) C = 32.00
Gender						
Male	51	16	53	49	-	T = 2 / C = 1
Female	28	11	52	158	-	T = 17 / C = 24
Race						
White	73	-	94	177	-	-
Black	6	-	-	13	-	-
Brown	-	-	-	-	-	-
Chinese/ Asian	-	-	4	-	-	-
Mixed	-	-	4	-	-	-
Unknown/ other	-	-	3	27	-	-
Economic condition	Median yearly salary $5500	-	-	-		-
Schooling	Not in school: 70 C: 29 T: 41 Last grade completed: 11,9 2 year-college: 7 C: 5 T: 2	-	-	-	-	T = 12.44 (years of study) C = 11.41 (years of study)
Employment status (Parents)	-	-	-	-	-	-
Current ADHD medication	-	-	-	-	**n = 31**	T: SSRI (n = 15); Benzodiazepines: (n = 9); Mood stabilizers (n = 2); Antipsychotics (n = 8) C: SSRI (n = 14); Benzodiazepines: (n = 12); Mood stabilizers (n = 1); Antipsychotics (n = 9)
ADHD	-	-	-	-	n = 50	-
PTSD	Substance use	-	-	Alcohol	-	-
Addiction	-	-	-	-	-	-
Scale	UPPS-P Scale	Cohen's D	BIS-11	UPPS-P	CPT	BIS-11 and CPT-II

	SIEBELINK *et al.* (2022)	RON-GRAJALES *et al.* (2021)	SPEARS *et al.* (2017)	SALMOIRAGO-BLOTCHER et al. (2019)	ALQARNI & HAMMAD (2021)	AMIRI et al. (2022)
Age (median)	C= 11,4 T= 11	C= 19,45 T= 18,75	-	HE-MT School: 14,6 HE-AC School: 14,5	-	Mother's age: C: 35,14/ T: 37,05 Child's age: C: 10/ T: 9,5
Gender						
Male	C= 16 / T= 33	C= 29	185	22	-	-
Female	C= 15 / T= 16	-	226	31	-	-
Race						
White	-	-	170	32	-	-
Black	-	-	198	1	-	-
Brown	-	-	-	-	-	-
Chinese/ Asian	-	-	-	-	-	-
Mixed	-	-	-	10	-	-
Unknown/ other	-	-	44	10	-	-
Economic condition	lower-middle	-	annual income < $30.000	-	-	-
Schooling	-	C= 7,5 T= 8,2	-		-	-
Employment status (Parents)	Employed: T= 47 C= 41	-	-	-	-	-
Current ADHD medication	T = 45 C= 38	-	-	-	-	-
ADHD	All (n= 103)	-	-	-	-	All children (n= 24)
PTSD	-	-	-	-	-	-
Addiction	-	-	Smoking	-	-	-
Scale	CPRS	Stroop Task	PANAS scale/ Perceived Stress/ Withdrawal Symptoms	BIS-11	BIS-11	CPRS

	SOLER et al. (2018)	*ROUX et al. (2020)*	TARRASCH (2018)	KIANI et al. (2016)	SHEAD et al. (2020)	SANZ et al. (2021)
Age (median)	T = 30.51 C = 33.29	T = 12 to 19 years.	T = 9,6 to 10,7 years. C = 10.17 years	T= 13.17 average C = 13.42 average	T = 21.6 average	T = 18.75 C = 19.45
Gender						
Male	T = 2 e C = 5	-	T = 30 / C = 20	n = 0	-	n = 40
Female	T = 33 e C = 30	-	T = 28 / C = 23	n = 30	T = 53 (89,8%)	n = 0
Race						
White	-	-	-	-	-	-
Black	-	-	-	-	-	-
Brown	-	-	-	-	-	-
Chinese/ Asian	-	-	-	-	-	-
Mixed	-	-	-	-	-	-
Unknown/ other	-	-	-	-	-	-
Economic condition	T: student (n = 1), employed (n = 13), unemployed/sick leave (n = 21) C: student (n = 5), employed (n = 10), unemployed/sick leave (n = 20)	-	-	-	-	-
Schooling	T: Less than high school (n = 15), High school graduate (n = 11), University graduate (n = 9) C: Less than high school (n = 11), High school graduate (n = 11), University graduate (n = 13)	-	-	T = seventh grade (n = 10) eighth grade (n = 5) C = seventh grade (n = 11) eighth grade (n = 4)	university students (n = 59)	T = 8.2 C = 7.5
Employment status (Parents)		-	-	-	-	-
Current ADHD medication	T: Antidepressants (n = 29); Benzodiazepines (n = 22); Antipsychotics (n = 12) and Mood stabilizers (n = 12) C: Antidepressants (n = 28); Benzodiazepines (n = 18); Antipsychotics (n = 14) and Mood stabilizers (n = 9)	-	-	-	-	-
ADHD		n = 24 (54%)	-	n = 30	-	-
PTSD		-	-	-	-	-
Addiction		-	-	-	-	-
Scale	BIS-11	UPPS-P	CPT	CPT	BIS and MAAS	Stroop Task; Stop-Signal with Neutral Stimuli (Stop-It) and Stop Signal with Emotional Stimuli

3.6 Pooled analysis of all studies

A limitation of the studies was the comparison between mindfulness vs. placebo on BIS 11, observed that only one study used the comparison "mindfulness vs. placebo", the others studies compared mindfulness plus other intervention, ex. Attention control, versus the use of this intervention without mindfulness, creating the following data (SMD -1.48; 95% CI -2.87,

-0,09; p= 0.04; I2 93%; Figure 1). The figure 2 represents the forest plot of the study that used only mindfulness vs placebo. Results obtained of UPPS-P (SMD -0.28; 95% CI -0.78, 0.22; p= 0.28; I2 46%, figure 3). The comparison at Mindfulness vs. placebo on CPRS created the following data (SMD -1.02; 95% CI -2.94, 0.90; p= 0.30; I2 96%; Figure 4), and CPT (SMD -0.09; 95% CI -0.43, 0.26; p= 0.62; I2 0%; Figure 5).

Figure 1. Mindfulness analysis in BIS 11

Figure 1 Mindfulness analysis in BIS 11.

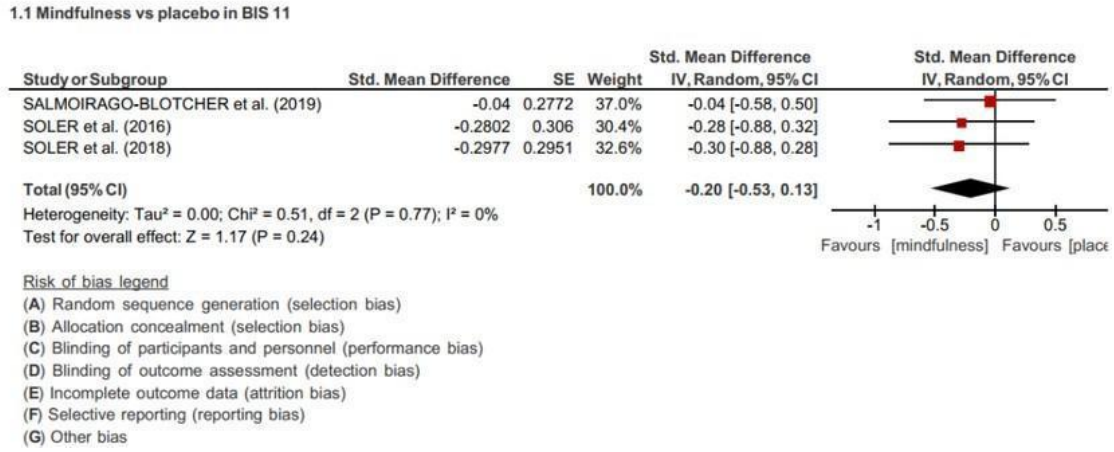


Figure 2. Mindfulness analysis in UPPS-P

Figure 2 Mindfulness analysis in UPPS-P.

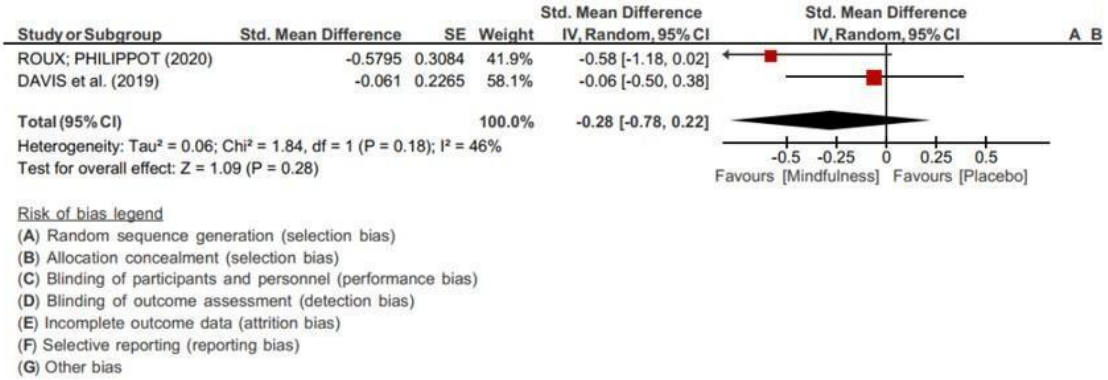


Figure 3. Mindfulness analysis in CPRS

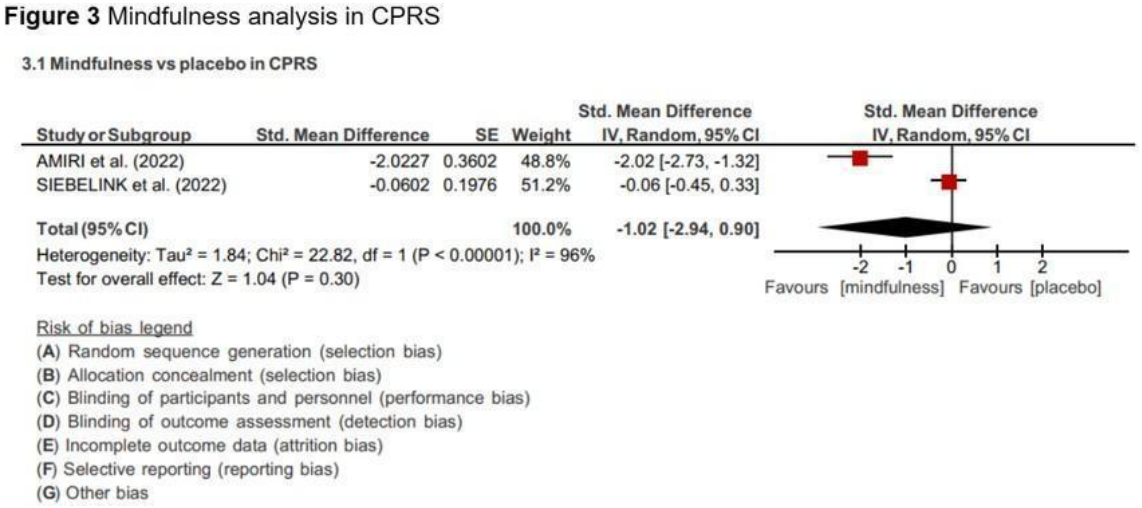
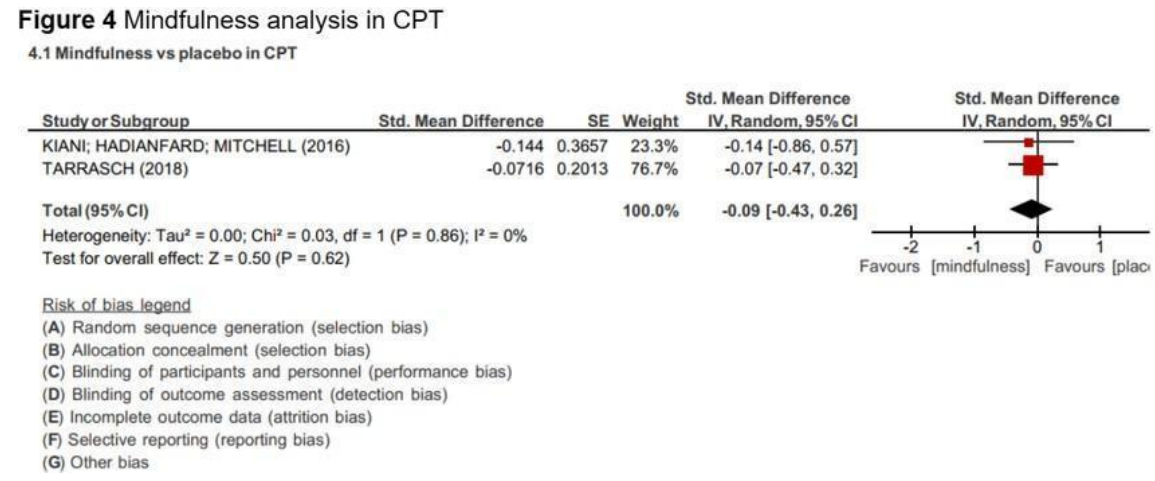


Figure 4. Mindfulness analysis in CPT



We request data on the other articles selected for review and which were not included in the forest plot, but no response was received from the authors.

4. Discussion

Overall, 18 RCTs and 1571 patients were eligible for inclusion in this systematic review and meta-analysis. The need of comparison groups and trials comparing intervention strategies made limitations, but with consistent results and impressions. There are few studies having many different strategies of mindfulness, with different amounts of sessions, and strategies to measure different domains of impulsivity. So there is too much heterogeneity in few studies to have confidence to say if it is really useful to control or to improve any

impulsivity domain.

However, impulsivity considering mindfulness has many applications and varied practices commonly including a change in lifestyle, but fills the inclusion criteria since it has exercises like training for mindful breathing by means of popping bubbles, smelling the flowers, breathing through the stomach and counting during the process of breathing. A median of 8 to 16 weeks showed a low result using mindfulness on impulsivity comparing mindfulness and other intervention, for example Dialectical Behavior Therapy.

The literature on the use of mindfulness-based interventions on impulsivity is very limited and it is practically impossible to make a broad comparison between the results of the present study and other studies. In spite of this, our findings demonstrating the effectiveness of mindfulness-based intervention in reducing impulsivity are in agreement with many of the existing studies (DELAZAR et al., 2022; SCHMIEDELER, 2015).

The authors chose in the meta-analysis not to compare some articles included in the review as long as they use other methodologies to assess impulsivity, making it difficult to compare them to the studies overall. Furthermore, some studies used a different way to approach their statistical analysis, making it difficult to adjust to the standard of comparison. However, all studies agree that mindfulness is a potential alternative form of long-term treatment.

The forest plot of studies using BIS 11 to compare impulsivity pre test and post test show a large standard deviation and a low effectiveness of mindfulness because all of studies used different control groups that were using interventions to compare with mindfulness. The study of Alqarni & Hammad (2021) compared mindfulness and none intervention, so had a large standard deviation than the others studies represented in figure 1. This study show that is appropriate to use mindfulness training for impulsive students with learning disabilities as it has a strong impact on reducing attentional, motor, and non-planning impulsiveness for the group practicing mindfulness.

In addition, the study by Amiri et al. (2022) showed that mindfulness-based parenting approach is a good strategy by reducing impulsivity in patients with ADHD as it helps to regulate children’s behavior by teaching the techniques for parents to apply with their children at home and can reduce the stress of being a parent. However, the study by Siebelink et al. (2022) show that family mindfulness-based intervention was not more effective than care-as-usual only in reducing mean parent-rated child self-control deficits at group level, but

this intervention had added value in terms of the proportion of children who reliably improved. However, beneficial effects on ADHD symptoms were found for teacher-rated self-control deficits.

The studies comparing mindfulness on impulsivity using Continuous Performance Task scale (CPT) show that mindfulness is a good option for students with elevated ADHD symptoms compared to non intervention (KIANI; HADIANFARD; MITCHELL, 2016). The study of Tarrasch (2018) does not demonstrate a high rate of effectiveness of mindfulness on impulsivity due to the conditions under which the study was applied to the experimental group, which functioned as a workshop in a noisy environment.

The studies that used UPPS-P to evaluate mindfulness efficacy provide support indicating that mindfulness may inhibit impulsive decision-making most effectively during time of heigh- tened emotional distress, demonstrated by positive and negative urgency. There is difference on forest plot compared by UPPS-P because the participants are different, one group is ADHD students (ROUX; PHILIPPOT, 2020) and the other one are students that are treating substance use disorder (DAVIS et al., 2019), so the mindfulness response were better on ADHD group than that one.

Although studies using mindfulness are in the early stages, there is a potential benefit of this practice for the physical and mental health of students and the impulsive population. Most studies showed mindfulness to a population of people with an impulsive component, so when comparing conventional treatment isolated vs. conventional treatment and mindfulness, these patients had a good result on impulsivity. Therefore, there is a need for further studies on mindfulness as a therapeutic alternative for impulsivity, and to conduct analyses over a longer period of time.

5. Conclusion

A considerable part of the studies available in the current scientific literature associating the subject of mindfulness and the different types of mindfulness-based interventions demonstrate that there is great potential in the use of these techniques for different scenarios, from support to the treatment of pathologies based on a trait of impulsivity like ADHD and Borderline Personality Disorder, to compulsive overeating and violent behavior. The findings of this systematic review and meta-analysis corroborate this perspective, in which methods based on mindfulness work to reduce the components of

impulsivity, characterizing themselves as a potential alternative and complementary model for treatment and behavioral change in the long term. Mainly because it is a tool with a low implementation cost and is scalable. However, due to a series of methodological limitations in the study designs and divergences in the program implementation model, it is still not possible to conclude definitively about the real effectiveness of Mindfulness in reducing impulsivity.

Thus, new studies are indispensable to replicate the observed findings in a more standardized way and with a more robust sample space, structuring from the number of sessions and their frequency, a more homogeneous selection of participants, the choice of practice active by the control group, a method of quantification and supervision of activities carried out at home, as well as the use of more objective analysis tools than self-report, aiming at a better understanding of the relationship between the various variables involved in the theme. These are fundamental measures to carry out a more honest and accurate interpretation, validating whether there is a linear and proportional correlation between the elements then discussed.

6. References

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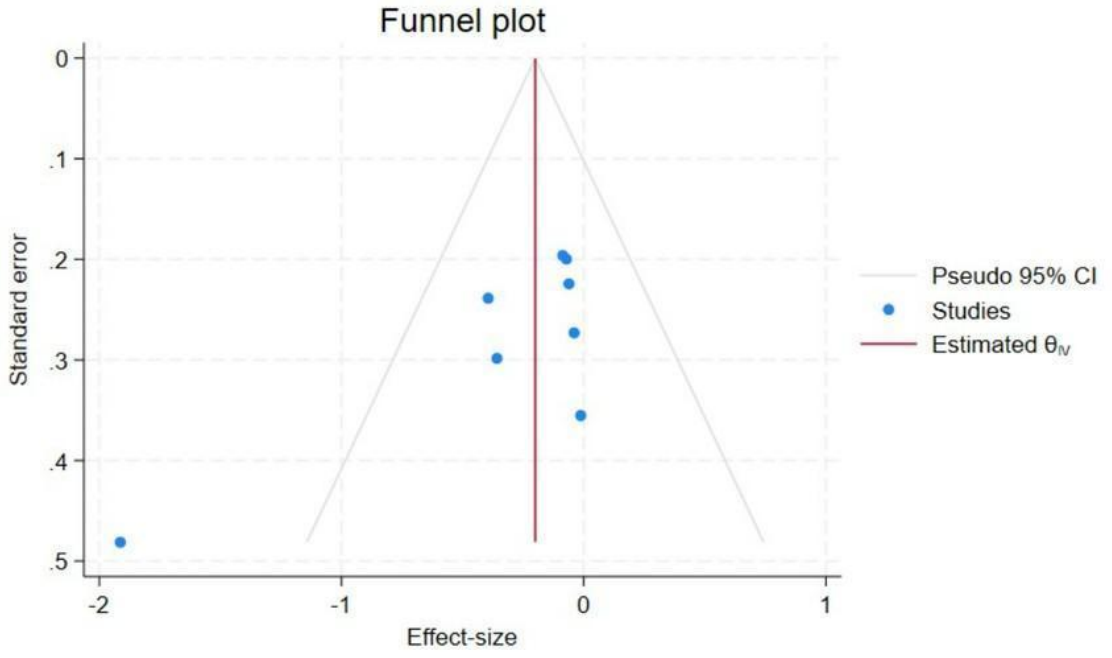
7. Supplementary Figures

Figura 5. Supplementary figure 1



4.3 Estudo 3 - *"Effects of yoga on impulsivity in patients with and without mental*

disorders: a systematic review and meta-analysis of randomized clinical trials"

1. Introduction

Impulsivity is an inter-individual characteristic with an impact on many psychiatric disorders, such as some personality disorders, eating disorders, substance use disorders, and self-injurious behavior. Individuals who express more impulsivity traits are more likely to have accidents, have addiction-related disorders, and worse coping under stressful conditions (PAUTRAT et al., 2022). In conditions of substance use, impulsivity affects the course of treatment and may be related to a lack of forethought and negative urgency, leading to a poor response to psychotherapy. However, in the case of a decrease in two impulsivity traits, negative urgency and novelty seeking appear to decrease slightly, having a small favorable impact without treatment (HERSHBERGER; UM; CYDERS 2017).

The practice of Yoga has a probable millennial origin and was built on a complex set of mind-body and philosophical elements that involves mindful practice of physical postures, breathing techniques, meditations, relaxation techniques and certain lifestyle principles, essentially aiming to offer man a path of living the existence with purpose and fullness. As it constitutes a system of multifactorial practices, throughout history several modalities have been created to improve its execution. In general, they are all based on the following pillars: breathing technique and development of self-awareness; posture training including stretching exercises and specific postures (asana); body relaxation activities and meditative practices focused on cognitive control and attention in the present. In western cultures, postures, self-awareness, and meditation are taught more often, leaving behind part of the ethical and moral code related to philosophy (KHANNA; GREESON, 2013). Sessions can be carried out following two main strands: long-term and low-frequency practices or short-term and high-intensity practices. An example of the second strand is the Vipassana program in which individuals practice yoga (in the form of disciplined mindful attention to the physical sensations, in a steady pose) for 10 days, spending an average of 11 hours a day.

Despite the methodological limitations in currently available scientific literature, several clinical trials and meta-analyses demonstrate clinical utility of yoga as a complementary intervention to conventional treatments, whether pharmacological or non-pharmacological. Sustained practice of yoga can generate a series of benefits for individuals' quality of life, improve their physical fitness (FIELD, 2011) and also their

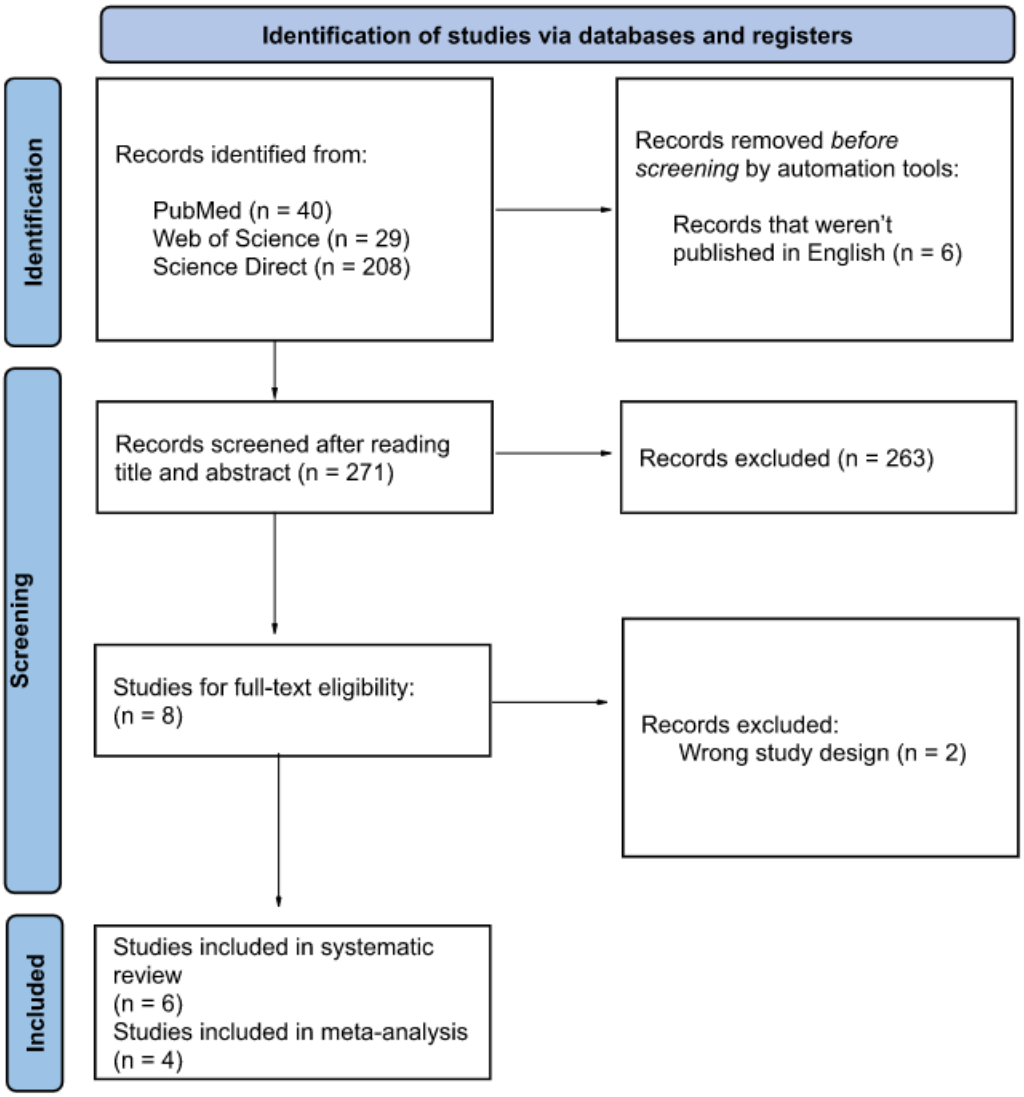
emotional state (HARTFIEL et al., 2011; MOADEL et al., 2007). The use of objective scientific tools such as electroencephalogram (EEG) in studies allowed the demonstration of possible physiological changes due to yoga in the body. A study demonstrated that there was a reduction in oxygen consumption following a yoga-based relaxation technique (TELLES & DESIRAJU, 1991). Similarly, another study demonstrated regulation of brain activity following yoga (HOFFMANN, 1999). Understanding the relationship between yoga activity and brain functioning, especially related to cognition, is of great importance for clinical conditions associated with impulsivity. A specific work demonstrated that as compared to control group (yoga naive subjects), yoga practitioners showed greater activation of ventrolateral prefrontal cortices (vlPFC) during stroop task. vlPFC is associated with a better executive-dependent capacity and ability to reduce emotional interference during competing cognitive demands (FROELIGER et al., 2012).

These emerging scientific evidences, along with absence of significant reports on the possible adverse effects (BALASUBRAMANIAM et al., 2013), and its low cost of implementation make yoga a potentially useful adjunct treatment in conditions involving impulse control issues (HU et al., 2015; ZHAO et al., 2017). Thus, current systematic review aimed at investigating the potential effects of yoga as an adjunct intervention in conditions involving impulse control issues, such as attention deficit hyperactivity disorder (ADHD), borderline personality disorder, bipolar affective disorder, and substance use disorders.

2. Material and Methods

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Statement (PRISMA, 2021). The review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO, registration number (CRD42023389088).

Figure 1. Screening of the articles following the PRISMA Flowchart



2.1 Eligibility criteria

Inclusion in this systematic review was restricted to studies that met all the following eligibility criteria: (1) randomized trials or non-randomized cohorts; (2) those in patients with impulsivity (ADHD with impulsivity and Non-ADHD; borderline disorder; bipolar disorder; medication users; tabagists; addiction) doing yoga; (3) those with control group (placebo or waitlist); and (4) those reporting any of the outcomes of interest (improvement of impulsivity with objective and subjective scales). Exclusion criteria was based on (1) studies without a control group.

2.2 Search strategy

We systematically searched PubMed, Scopus, and Science Direct in January 2023 using the following search strategy: *(impulsivity OR impulsive behaviors OR impulsivities)*

AND yoga. The search was restricted to articles published in English and the period of publication was not delimited.

2.3 Data extraction

Two authors (MO and JL) independently assessed the articles for inclusion and in case of disagreement, a third evaluator deliberated. This process was executed through Rayyan.ai - Intelligent Systematic Review. After the triage phase, both authors (MO and JL) independently extracted the data after predefined search criteria and quality assessment.

2.4 Quality assessment

Quality assessment of RCTs was performed with Cochrane's tool for assessing bias in randomized trials (ROB-2) where in studies are scored as high, low, or some concerns of bias in 5 domains: randomization process, deviations from intended interventions, missing outcome data, measurement of the outcomes, and reporting, as shown in table 1 (COCHRANE, 2011). Publication bias was investigated by funnel-plot analysis of point estimates according to study weights and by Egger's regression test.

2.5 Statistical analysis

This systematic review and meta-analysis adhered to the guidelines set forth by the Cochrane Collaboration and followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (MOHER et al., 2009). Standardized mean differences, represented by Hedges' g, were utilized to extract data from individual studies for continuous outcomes. The effect size was determined using unbiased Hedges' g with 95% confidence intervals (CIs) to assess different measurements of impulsivity. Heterogeneity was assessed using the Cochran Q test and I^2 statistics, considering P values <0.10 and I^2 values $>25\%$ as indicators of significant heterogeneity. To account for the anticipated high heterogeneity, a DerSimonian and Laird random-effects model was employed for all outcomes.

Review Manager 5.3 (Cochrane Centre, The Cochrane Collaboration, Denmark) and Stata BE (version 18.0, StataCorp, College Station, TX, USA) were used for statistical analysis (Cochrane Training, 2023; Stata, 2019).

3. Results

3.1 Description of studies

After the screening process, six studies met the inclusion criteria. The study

characteristics are summarized in Table 2. There were 549 participants across the results, with 36.4% overall female; only one study engaged exclusively male participants. Only one study had a randomized crossover design (JENSEN; KENNY, 2014). Two studies used groups of children diagnosed with ADHD (COHEN et al., 2018; BUTZER et al., 2017); two studies analyzed prison population (BILDERBECK et al., 2013; KEREKES et al., 2017); one study selected groups of meditators expertises (BARROS-LOSCERTALES et al., 2021) and one study analyzed a population of 8 to 13 year old boys (JENSEN; KENNY, 2014). The control group ranged from waitlist, non-meditators, cooperative activities and physical education among the studies.

Table 1. Characteristics of the selected studies

	KEREKES 2017	BARROS-LOSCERTALES 2021	JENSEN & KENNY 2014	COHEN 2018	BUTZER 2017	BILDERBECK 2013
Nº of patients	152	46	19	23	209	100
Population	Prison population	Meditators expertises	8-13 years boys	Children diagnosed with ADHD	Children with 4 or more attention-deficit hyperactivity disorder (ADHD) symptoms	Prison population
Intervention	Combination of asanas (yoga postures), breathing exercises, deep relaxation, and meditation	To achieve the state of mental silence or thoughtless awareness, where thoughts are either suppressed or substantially reduced	Respiratory, postural, relaxation and concentration trainings	Yoga protocol themes according to instructions in a yoga DVD	Kripalu Yoga	Hatha yoga postures and stretches plus relaxation
Session time	90 min	84 minutes	60 minutes	30 minutes	45 min	120 minutes
Nº of sessions	10	-	20	12	32	10
Control group	Waitlist	Non-meditators	Cooperative activities	Waitlist	physical education-as-usual	Prisioners without experience on meditation
Median follow-up	10 weeks	-	20 weeks	6 weeks	6 months	10 weeks

3.2 Intervention characteristics

All the studies used yoga techniques that involved respiratory training, postures and relaxation (KEREKES et al., 2017; BARROS-LOSCERTALES et al., 2021; COHEN et al., 2018; BUTZER et al., 2017; JENSEN; KENNY, 2014; BILDERBECK et al., 2013). Hatha yoga was used by one study (BILDERBACK et al., 2013) and one study tested the program Kripalu Yoga (BUTZER et al., 2017). All the yoga sessions had more than 30 minutes of duration; and all of the studies but one had more than 10 sessions (BARROS-LOSCERTALES et al., 2021). Two studies had a 10 week median follow-up; one study didn't mention it (BARROS-LOSCERTALES et al., 2021).

3.3 Intervention measurements

To assess the level of attention and impulsiveness, the following scales were applied: The Barratt Impulsiveness Scale (BARROS-LOSCERTALES et al., 2021; BILDERBECK et al., 2013), The UPPS-P Impulsive Behavior scale (BUTZER et al., 2017), ADHD Rating Scale-IV (COHEN et al., 2018), Conners' Continuous Performance Test II[a] (KEREKES; FIELDING; APELQVIST, 2017) and Conners' Parent Rating Scale–Revised:Long (JENSEN; KENNY, 2004).

Conners' CPT II is a computerized test that measures attention, impulsivity and vigilance. After 10 weeks of yoga, The Conners' CPT II identified that the yoga group had significantly fewer errors of commissions (Incorrect responses to non-targets), increased hit reaction time (Response Speed) and better detectability compared to the control group (KEREKES; FIELDING; APELQVIST, 2017). Furthermore, participants in the yoga group demonstrated improved performance in a cognitive-behavioral task compared to the control group (BILDERBECK et al., 2013).

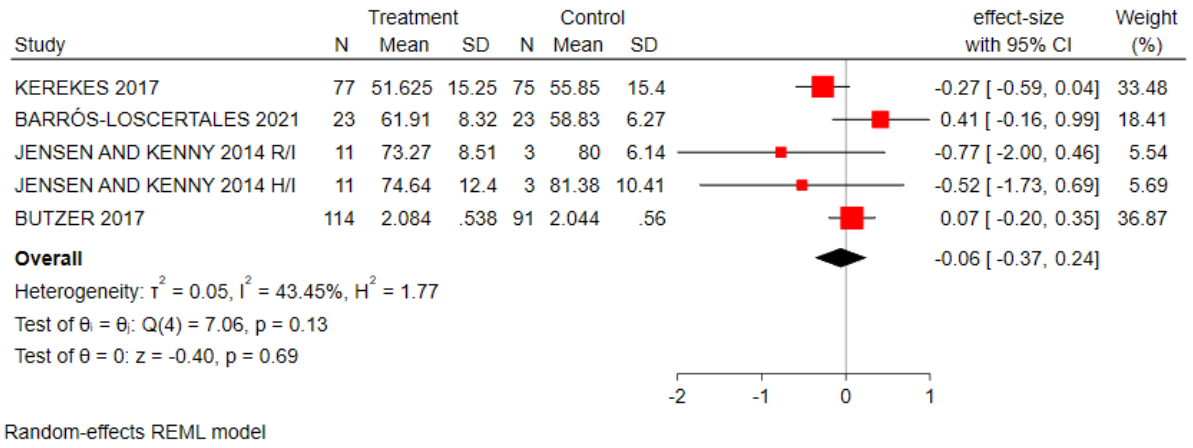
BUTZER et al. (2017) used the UPPS-P to predict the results of the relation between yoga and impulsivity. About negative urgency, positive urgency and sensation seeking, males reported significantly higher levels than females. Post analyzing the lack of premeditation, females in the yoga group reported a significant increase between one week pre-intervention and one week post-intervention, the a significant decrease from one week post-intervention and 6 months post-intervention, though males in yoga group did not report significant changes in lack of premeditation. Conversely, females in a control group reported a significant increase in lack of premeditation between one week post-intervention and one year post-intervention, though males in the control group did not report significant changes in lack of premeditation.

The Sahaja Yoga meditation showed an increased self-control score in the BIS-11 compared to the control participants, with a total BIS-11 score of meditators equal 61.91 and control group 58.83 (BARRÓS-LOSCERTALES et al., 2021).

3.4 Pooled analysis of the studies

The meta-analysis of effect sizes from four studies on the effects of yoga on impulsivity didn't show a significant effect ($g = -0.06$; 95% CI, -0.37–0.24; $p = 0.69$; figure 2). The analysis also didn't show a significant heterogeneity among the included studies ($Q(4) = 7.06$, $p = 0.13$; $I^2 = 43.45\%$; $T^2 = 0.05$; Figure 2). It is important to mention that BILDERBECK et al. (2013) and COHEN et al. (2018) were not included in the statistical analysis because of the lack of data available.

Figure 2. Statistical analysis of the selected studies



3.5 Subgroup characteristics

Characteristics of each study are detailed in table 3. Of the studies that reported gender (n= 6), approximately 63,57% (n= 349) of the participants were male and 36,43% (n= 200) were female. The median participants' mean age ranged from 10.63 to 46.5 on the yoga group, and 9.35 to 46.9 on the control group. One study did not report ethnicity (KEREKES et al., 2017). In the remaining studies, 271 participants were white/caucasian, 27 black participants, 70 chinese/Asian descendent participants, 21 mixed participants and 5 unknown. Furthermore, two studies reported economic conditions, prevailing low-middle and low income conditions.

Three studies reported schooling. Participants' mean schooling age ranged from 3 to 12. About mental disorders, two studies reported participants with Attention Deficit Hyperactivity Disorder (ADHD) (COHEN et al., 2018; JENSEN; KENNY, 2004) and didn't report post trauma stress disorder or addiction.

Figure 3. Baseline subgroup characteristics

	KEREKES 2017	BARRÓS-LOSCERTALES 2021	JENSEN & KENNY 2014	COHEN 2018	BUTZER 2017	BILDERBECK 2013
Age (mean)	I = 36.4 C = 34.9	I = 46.5 C = 46.9	I = 10.63 C = 9.35	I = 52 ±7 C = 46±10	12.64	37.38
Gender						
Male	133	12	19	15	77	93
Female	19	34	0	8	132	7
Race						
White	-	46 (white Caucasian)	18	10	117	80
Black	-	-	-	9	9	9
Brown	-	-	-	-	-	-
Chinese/ Asian	-	-	1	1	61	7
Mixed	-	-	-	2	16	3
Unknown	-	-	-	1	4	-
Economic condition	-	-	Low-middle	-	The 2013–2014 graduation rate at this school was 98.9 %, and 34.5 % of students were considered low income	-
Schooling	-	3.78 (yoga group) 4.04 (control group)	-	First year (n= 14) Second year (n= 3) Third year (n= 3) Fourth year (n= 2)	Grades 7 through 12	-
ADHD	-	-	All (n= 19)	2	-	-
PTSD	-	-	-	-	-	-
Addiction	-	-	-	-	-	-

I = intervention group
C = control group

3.6 Quality assessment

The funnel plot (supplementary figure 1) and the Egger's test (beta1= -2.88.; SE of beta1= 2.376; t= -1.21, P>|t| = 0.3490) did not show statistical significant evidence of publication bias. However, the quality of evidence regarding the effects of tDCS on impulsivity was graded as high as considerate downgrading criteria were present.

Table 2. Quality assessment of the studies using ROB-2

Study	Bias from randomization process	Bias due to deviations from intended interventions	Bias due to missing outcome data	Bias in measurement of the outcomes	Bias in selection of the reported result	Overall risk of bias
KEREKES et al 2017	Low	Some concerns	Low	High	Low	Some concerns
JENSEN; KENNY, 2014	Some concerns	Low	High	Some concerns	Some concerns	High
COHEN et al 2018	Low	Low	High	Some concerns	Low	Some concerns
BARRÓS-LOS CERTALES et al 2021	Low	Some concerns	Low	Low	Some concerns	Low
BUTZER et al 2017	High	Some concerns	Low	Some concerns	Some concerns	Some concerns
BILDERBECK et al 2013	Low	Some concerns	Low	Some concerns	Some concerns	Some concerns

4. Discussion

The review protocol included only RCTs, the need of comparison groups and trials comparing intervention strategies made a revision process restrictive, but with consistent results and impressions. There are few studies having many different strategies of Yoga, with different amounts of sessions, and strategies to measure different domains of impulsivity. So there is too much heterogeneity in few studies to have confidence to say if it is really useful to control or to improve any impulsivity domain. Also, we found no statistical significance on yoga to improve impulsivity.

Considering Yoga has many applications and varied practices commonly including a change in lifestyle, but fills the inclusion criteria since it has respiratory training, postures and relaxation, it might not be related to changes in daily life since the individuals were evaluated after 10-32 sessions. Findings on impulsivity should be better identified in longer-term studies in which those observed not only practice yoga but also implement its philosophy in their lives. Few weekly hours of meditation and breath exercises, the expected effects should be heterogeneous.

Anyway, Yoga as a holistic therapy using varied practices aiming to relax the body, control breath and calm down the mind might result in enhanced health. Yoga as an ability to turn the mind to a sustained attention to an object avoiding distractions might be the most interesting to reach good results for impulsivity control. The principles and values might be compatible with an individual's improvement in impulsivity. Yoga as an expression of integrative medicine allows a practice of a personalized medicine, a safe environment, a cost-effective treatment and a non-maleficent practice (VARAMBALLY et al., 2021).

It is noteworthy that impulsivity has been prone to confusion and ambiguity in both terminology and conceptual understanding. Impulsivity is not a singular trait but rather a multifaceted characteristic influenced by different psychological and neural mechanisms. Impulsive behavior can be associated with heightened motivation as well as reduced motivation (referred to as 'apathy'). It can reflect an inadequate information processing or a failure to regulate responses. The Barratt Impulsiveness Scale 11 (BIS-11) captures this heterogeneity through three different dimensions: motor (action without thinking), cognitive (quick cognitive decision-making), and non-planning (decrease in orientation towards future) (DALLEY; ROBBINS, 2017; PATTON; STANFORD; BARRATT, 1995). However, only one

of the studies selected in our meta-analysis used BIS-11 as a measurement of impulsivity (BARRÓS-LOSCERTALES et al., 2021).

The Conners' CPT II used by BILDERBECK et al. (2013) can provide valuable insights into impulsivity, however, it has some important disadvantages, such as limited assessment scope, lack of contextual factors, reliance on self-report measures and interpretation challenges. Interpreting the results of the CPT II requires expertise and knowledge of the test's psychometric properties. Misinterpretation of scores or failure to consider individual differences can lead to inaccurate assessments of impulsivity (MIRANDA et al., 2007; RICCIO et al., 2002).

BUTZER et al. (2017) was the only study that used the UPPS-P Impulsive Behavior scale, a 59 item self report scale which is a revised version of the original UPPS created by WHITESIDE and LYNAM (2001). It reveals five distinct facets of impulsivity. These facets include sensation seeking, which reflects a tendency to seek novel and thrilling experiences; lack of premeditation, which involves a disregard for the consequences of actions; lack of perseverance, which relates to difficulty in maintaining focus on long, boring, or challenging tasks; negative urgency, which entails impulsive actions during intense negative moods; and positive urgency, which involves impulsive actions during intense positive moods (CYDERS et al., 2014; DUGRÉ et al., 2019).

JENSEN and KENNY (2014) used the long version of The Conners' Parent Rating Scale – Revised (CPRS-R: long), which is the parent form of the Conners' Rating Scales – Revised (CRS-R) (PATANELLA et al., 2011). It is a parent-report measure that assesses children's problem behaviors, particularly symptoms of ADH) and related disorders (including oppositional defiant disorder and conduct disorder). However, the CPRS-R has some disadvantages when used to assess impulsivity. One of them is that it relies on the parent's subjective report of their child's behavior, which may not always be accurate (CONNERS et al., 1998). Another disadvantage is that it does not have formal reliability and validity scales (GURLEY et al., 2011). Instead, the manual recommends that the mental health professional using the CPRS-R examine the protocol for random responding by assessing for an overabundance of one particular answer and zigzag patterns (HURST et al., 2013).

The Conners' Continuous Performance Test-II (CONNERS, 2000), used by KEREKES et al. (2017), is a visual assessment tool designed to evaluate attention and measure the response inhibition component of executive control. Its purpose is to provide a reliable and

objective measure for the assessment of conditions such as ADHD and other neurological disorders. By utilizing this test, clinicians aim to incorporate standardized and objective evaluations into their diagnostic processes, enhancing the accuracy of assessments for these conditions. It also is a widely used measure of attention and impulsivity. However, only a minimal amount is known about its reliability. Findings indicated that the CCPT-II had strong internal consistency, adequate test-retest reliability for commission errors and response time, poor test-retest reliability for omission errors, and practice effects for omission and commission errors. The CCPT-II was largely unrelated to the BRIEF-A, Stroop Color and Word Test, and the STPI (PAGÁN et al., 2022; SHAKED et al., 2019).

To our knowledge, this is the meta-analysis of the effects of yoga sessions on impulsivity, however, our study has some important limitations. Firstly, the limited number of available studies and the high heterogeneity among them present challenges in drawing definitive conclusions. The diverse strategies of yoga, varying session durations, and different measures of impulsivity across studies contribute to the overall heterogeneity. Consequently, caution is warranted in interpreting the results due to the potential influence of these factors. The evaluation of individuals after a relatively short duration of yoga practice may not capture the full potential effects, and longer-term studies are needed to assess sustained impacts. Moreover, the measurement tools employed in the included studies have their own limitations, such as limited scope, reliance on self-report measures, and challenges in interpretation. Lastly, the conceptual understanding of impulsivity itself is multifaceted, leading to ambiguity and variability in its assessment across different studies.

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5 DISCUSSÃO

Nosso estudo tem um importante papel de evidenciar o que temos de evidência científica atualmente sobre a utilização das técnicas de Yoga, Mindfulness e Neuromodulação não invasiva no tratamento da impulsividade em pessoas com ou sem algum transtorno psiquiátrico. A evidência usando metanálise confere maior robustez à evidência científica ao fazer uma análise estatística com os dados encontrados.

Os três estudos expostos no tópico anterior foram desafiadores na padronização das definições das intervenções investigadas e nas técnicas utilizadas. Nos critérios de inclusão de artigos em cada um dos estudos isso foi evidenciado e, somente os artigos que partiram dos critérios de inclusão foram avaliados na análise. A heterogeneidade de definição e de forma de medir a impulsividade é uma das maiores dificuldades na confecção desta tese.

As técnicas de Yoga e de Mindfulness foram consideradas bastante promissoras na melhora da impulsividade. Por serem técnicas efetivas, escaláveis, de fácil implantação e baixo custo, podem ser adotadas como medidas terapêuticas e até mesmo de saúde pública. Essas técnicas já são aplicadas terapeuticamente em vários contextos e sua efetividade no tratamento da impulsividade foi evidenciada em vários testes psicométricos e escalas.

Uma grande limitação dos artigos que investigaram Yoga e Mindfulness foi que as intervenções feitas foram de curto prazo, não tendo um acompanhamento longitudinal dos pacientes. Isso acaba por excluir um importante fator que poderia diminuir ainda mais o fator impulsivo dos investigados que é a mudança do estilo de vida (YOSHIHARA et al., 2011).

A evidência para implementação das técnicas de Estimulação Transcraniana por Corrente Contínua (ETCC) e a Estimulação Magnética Transcraniana (EMT) no tratamento da impulsividade são insuficientes. Apenas um estudo que utilizou ETCC em uma população deprimida verificou benefício com a técnica. Mesmo que tenha havido muita heterogeneidade entre os parâmetros de estimulação, grupos de pessoas analisadas, números e periodicidade das sessões e tamanho de amostra, os estudos, de modo geral, não mostraram benefícios no uso dessas técnicas para melhora do comportamento impulsivo.

Devemos ser cuidadosos sobre qualquer generalização, ainda não é possível concluir de forma definitiva sobre a real eficácia das técnicas de Yoga, Mindfulness e Neuromodulação não Invasiva na redução da impulsividade. Assim, novos estudos são indispensáveis para

replicar os achados observados de forma mais padronizada e com um espaço amostral mais robusto; estruturando os estudos a partir do número de sessões, sua frequência, uma seleção mais homogênea dos participantes, a escolha da prática ativa pelo grupo controle, método de quantificação e supervisão das atividades realizadas no domicílio, bem como a padronização de ferramentas de análise da impulsividade, visando uma melhor compreensão da relação entre as diversas variáveis envolvidas no tema. Estas medidas são fundamentais para realizar uma interpretação mais honesta e precisa, validando se existe uma correlação linear e proporcional entre os elementos então discutidos.

6 CONCLUSÃO

Com base nos objetivos da tese e nos resultados dos três artigos realizados conclui-se que:

1) As técnicas de Yoga e Mindfulness são promissoras no tratamento de pacientes impulsivos
2) As técnicas de Estimulação Transcraniana por Corrente Contínua (ETCC) e Estimulação Magnética Transcraniana (EMT) não apresentaram evidências de auxílio no tratamento da impulsividade.
3) Houve muita variação entre os estudos dos parâmetros de estimulação utilizados de ETCC e EMT, não sendo possível, portanto, estabelecer algum padrão do que deve ou não deve ser feito nas intervenções.
4) Há muita variação nos estudos sobre a definição de Yoga e suas aplicações. O que foi padronizado neste estudo é que são técnicas de respiração e desenvolvimento do autoconhecimento; treinamento postural incluindo exercícios de alongamento e posturas específicas (asana); atividades de relaxamento corporal e práticas meditativas focadas no controle cognitivo e atenção no presente.
5) Há muita divergência entre as definições de Mindfulness e suas aplicações. A definição padronizada neste estudo foi que Mindfulness é a habilidade que utiliza do foco no momento presente para aumentar o autocontrole e integrar de forma harmônica os

conteúdos das emoções com uma postura racional.

6) Embora existam muitas pesquisas utilizando as técnicas estudadas, a falta de padronização e os desenhos de estudos escolhidos dificultam a inclusão dos artigos nas análises por não ser possível comparar os parâmetros da pesquisa.
7) Devido ao baixo número de artigos, ainda não é possível criar protocolos ou padrões de estímulos a serem realizados para melhoria da impulsividade. É importante que mais pesquisas sejam feitas para que essa padronização possa ser estabelecida e que parâmetros de intervenção clínica possam ser criados.

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