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Philipe Souza Corrêa

Jogos como Recurso Terapêutico para a Funcionalidade dos Membros Superiores na Doença de Parkinson

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Jogos como Recurso Terapêutico para a Funcionalidade dos Membros Superiores na Doença de Parkinson

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Dedicatória

Àqueles que enfrentam a jornada do Parkinson com coragem e determinação. Sua força e resiliência nos ensinam diariamente o verdadeiro significado da superação.

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RESUMO

A presente tese é constituída por três estudos. **Artigo 1:** Uma revisão sistemática foi conduzida com o objetivo de quantificar e analisar o efeito de protocolos de terapia baseada em Realidade Virtual (RV) na destreza manual em indivíduos com doença de Parkinson (DP). A busca foi realizada nas bases de dados PubMed, EMBASE e PEDro até dezembro de 2020 e oito artigos foram incluídos na análise. Embora a maioria tenha demonstrado melhora na destreza manual, os artigos apresentaram alto risco de viés e baixa qualidade metodológica. Os resultados sugeriram que a terapia baseada em RV possui potencial e viabilidade como protocolo de reabilitação para destreza manual, porém os estudos analisados não abordaram os impactos relacionados às atividades de vida diária (AVD's) e à qualidade de vida (QV) na DP. **Artigo 2:** Teve como objetivo verificar os efeitos de uma intervenção nos membros superiores (MMSS) utilizando equipamento de RV não imersivo nas AVD's e na QV de indivíduos com DP, por meio de uma série de casos. Seis participantes foram avaliados por meio do miniexame do estado mental, da escala unificada de avaliação para a DP (UPDRS), do questionário sobre a doença de Parkinson (PDQ-39) e do *test d'évaluation des membres supérieurs de personnes âgées* (TEMPA). As intervenções tiveram duração de 27 minutos, duas vezes por semana, durante cinco semanas, utilizando o *Leap Motion Controller*. Observou-se melhora na força e resistência muscular, nas AVD's e na QV. Portanto, o protocolo baseado em RV aplicado nos MMSS foi eficaz para melhorar as variáveis analisadas, além de servir como piloto para o protocolo das atividades virtuais e referência para o cálculo amostral do estudo principal. **Artigo 3:** Este ensaio clínico randomizado teve como objetivo analisar e comparar os efeitos de jogos de RV não imersiva com jogos de tabuleiro na funcionalidade dos MMSS, AVD's e QV na DP. Vinte participantes, *Hoehn & Yahr* 2-3, foram divididos em dois grupos: jogos de RV não imersiva (n = 10) e jogos de tabuleiro (n = 10). As sessões tiveram duração de 30 minutos, duas vezes por semana, durante 8 semanas e os participantes foram avaliados quanto às AVD's (TEMPA e MDS-UPDRS-II), função motora geral (MDS-UPDRS-III), destreza manual através do *Box and Block Test* (BBT) e *Nine Hole Peg Test* (9HPT), além da qualidade de vida (PDQ-39). Os resultados mostraram que ambos os tratamentos foram eficazes, não havendo diferença significativa entre os grupos em relação as variáveis. Houve melhora nas AVD's, conforme evidenciado pela execução das tarefas do TEMPA e MDS-UPDRS-II. Além disso, a destreza manual apresentou resultados positivos no BBT e 9HPT, com os jogos de RV demonstrando melhora intragrupo e na comparação intergrupos. Ambos os grupos mostraram melhora na função motora e na qualidade de vida. Portanto, constatou-se que os jogos de RV não imersivos e os jogos de tabuleiro têm um grande potencial como protocolos de reabilitação para os MMSS, impactando diretamente nas AVD's e na QV de indivíduos com DP. O caráter desafiador e motivador dessas abordagens pode oferecer uma nova perspectiva de tratamento, especialmente nos estágios iniciais a moderados da doença.

Palavras-chave: Doença de Parkinson; Extremidade superior; Realidade virtual; Jogos e Brinquedos; Atividades Cotidianas; Qualidade de vida.

ABSTRACT

The present thesis consists of three studies. **Article 1:** A systematic review was conducted with the aim of quantifying and analyzing the effect of Virtual Reality (VR)-based therapy protocols on manual dexterity in individuals with Parkinson's disease (PD). The search was carried out in the PubMed, EMBASE, and PEDro databases up to December 2020 and eight studies were included in the analysis. Although most have shown improvement in manual dexterity, the articles presented a high risk of bias and low methodological quality. The results suggested that VR-based therapy has potential and feasibility as a rehabilitation protocol for manual dexterity, but the analyzed studies did not address aspects related to activities of daily living (ADLs) and quality of life (QoL) in PD. **Article 2:** The objective was to verify the effects of an Upper Limb (UL) intervention using non-immersive VR equipment on ADLs and QoL in individuals with PD through a case series. Six participants were assessed using the Mini-Mental State Examination, Unified Parkinson's Disease Rating Scale (UPDRS), Parkinson's Disease Questionnaire (PDQ-39) and the Test d'évaluation des membres supérieurs de personnes âgées (TEMPA). The interventions lasted 27 minutes, twice a week, for five weeks, utilizing the Leap Motion Controller. Improvement was observed in muscle strength, endurance, ADLs and QoL. Therefore, the VR-based protocol applied to UL was effective in improving the analyzed variables, serving as a pilot for virtual activities protocol and a reference for sample size calculation in the main study. **Article 3:** This randomized clinical trial aimed to analyze and compare the effects of non-immersive VR games with board games on UL functionality, ADLs and QoL in PD. Twenty participants, Hoehn & Yahr 2-3, were divided into two groups: non-immersive VR games (n = 10) and board games (n = 10). Sessions lasted 30 minutes, twice a week, for 8 weeks and participants were evaluated for ADLs (TEMPA and MDS-UPDRS-II), overall motor function (MDS-UPDRS-III), manual dexterity through the Box and Block Test (BBT) and Nine Hole Peg Test (9HPT), as well as QoL (PDQ-39). The results showed that both treatments were effective, with no significant difference between groups in terms of variables. Improvement in ADLs was evident from TEMPA and MDS-UPDRS-II task performance. Additionally, manual dexterity showed positive results in BBT and 9HPT, with VR games demonstrating intra-group and inter-group improvement. Both groups exhibited improvement in motor function and QoL. Thus, it was found that non-immersive VR games and board games have great potential as rehabilitation protocols for UL, directly impacting ADLs and QoL in individuals with PD. The challenging and motivating nature of these approaches offers a new perspective for treatment, especially in early to moderate stages of the disease.

Key words: Parkinson Disease; Upper Extremity; Virtual Reality; Play and Playthings; Activities of Daily Living; Quality of Life.

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LISTA DE ABREVIATURAS E SIGLAS

AVD	Atividade de vida diária
ADL	Activity of daily living
BBT	Box and Block Test
DP	Doença de Parkinson
UFCSPA	Federal University of Health Sciences of Porto Alegre
H&Y	Hoehn e Yahr
LMC	Leap Motion Controller
MMSS	Membros superiores
MoCA	Montreal Cognitive Assessment
9HPT	Nine Hole Peg Test
PD	Parkinson’s disease
PDQ-39	Parkinson's Disease Questionnaire
QoL	Quality of life
RV	Realidade virtual
SPSS	Statistical Package for the Social Sciences
TEMPA	Test d'Évaluation des Membres Supérieurs de Personnes Agées
UL	Upper limb
UPDRS	Unified Parkinson's Disease Rating Scale
USB	Universal Serial Bus
VR	Virtual reality

SUMÁRIO

1 CONTEXTUALIZAÇÃO

1.1 DOENÇA DE PARKINSON

Descrita inicialmente em 1817 pelo médico inglês James Parkinson (PARKINSON, 1969), a Doença de Parkinson (DP) é uma desordem degenerativa progressiva do sistema nervoso central caracterizada por sintomas motores de bradicinesia (lentificação dos movimentos), rigidez (aumento do tônus simétrico, tanto na extensão quanto na flexão do membro), instabilidade postural e tremor (habitualmente em repouso, porém pode ser cinético ou postural) (SONG et al., 2014; MAHALE; YADAV; PAL, 2015). O início da doença é insidioso, mas acredita-se que o surgimento seja advindo de fatores ambientais e genéticos, geralmente de maneira unilateral e com os seus sinais permanecendo assimétricos por algum tempo (SOUZA et al., 2011).

A principal causa da DP ainda não foi determinada, porém agentes viróticos, genéticos e tóxicos são apontados como responsáveis em pequenos subgrupos de indivíduos. A idade média de início é 60 anos e a duração média da doença, desde o diagnóstico até a morte, é de 15 anos, com uma taxa de mortalidade de 2 para 1, sendo os casos com início anterior aos 40 anos denominados como DP de início precoce (BARBOSA e SALLEM, 2005). Em todo o mundo, é a doença degenerativa mais frequente após a doença de Alzheimer, tendo uma incidência de novos casos que varia de 8 a 18 para cada 100.000 indivíduos ao ano (MAHALE; YADAV; PAL, 2015; YEH et al., 2016). São 17,4 casos em 100.000 pessoas por ano, entre 50 e 59 anos de idade, e 93,1 casos em 100.000 pessoas por ano, entre os 70 e 79 anos, com risco de desenvolvimento da doença em torno de 1,5% nessa faixa etária.

De acordo com PEREIRA et al. (2021), no Brasil apenas dois estudos determinaram a prevalência de parkinsonismo. No estudo de base populacional na cidade de Bambuí (estado de Minas Gerais), a prevalência foi de 3,3% para a DP entre os indivíduos com mais de 64 anos de idade (BARBOSA et al., 2006). Para outras síndromes parkinsonianas, apenas um estudo realizado no sudoeste do país fornece dados sobre indivíduos com mais de 75 anos e encontrou uma prevalência bruta de 10,7% de síndromes parkinsonianas nessa população (VALE et al., 2018).

A fisiopatologia da doença decorre da perda seletiva (lesões) de neurônios dopaminérgicos localizados na parte compacta da substância negra, que contém

o corpo celular dessas células nervosas, tendo uma consequência dupla sobre os neurônios efetores do putâmen (WICHMANN, 2019). Em indivíduos saudáveis, primeiramente, a dopamina é considerada excitatória na via direta para o globo pálido medial/substância negra parte reticular, devido à sua ação nos receptores D1 dos neurônios de projeção que contêm GABA/substância P/dinorfina. Em segundo lugar, a dopamina também é considerada um inibidor dos neurônios do putâmen através de uma via indireta, que contém GABA/encefalina, os quais projetam-se para o globo pálido lateral e atuam nos receptores D2 (SIMON; TANNER; BRUNDIN, 2020).

Em relação a sintomatologia, indivíduos com DP podem apresentar sintomas não motores como alterações cognitivas e psiquiátricas. Mudanças cognitivas em fases iniciais da doença, quando presentes, geralmente são discretas (distúrbios visuoespaciais) e sem repercussão significativa sobre o desempenho cognitivo. Entretanto, nas fases avançadas essas alterações podem se instalar de forma mais grave, configurando um quadro demencial em cerca de 15 a 20% dos casos (BARBOSA; SALLEM, 2005; TEIVE et al., 2016; XIA et al., 2023).

Quanto aos sintomas motores, de maneira individual ou combinada, podem causar alterações em diversas atividades do cotidiano. A bradicinesia, descrita pela lentidão e dificuldade em iniciar os movimentos, além da perda dos movimentos automáticos (PATIL et al., 2014), pode, ao longo da doença, tornar o indivíduo imóvel, cujas ações e expressões gestuais tendem a se mostrar reduzidas (FOLEY, 2018). A rigidez, também conhecida como hipertonia plástica, provoca um aumento do tônus muscular observado nos membros, tronco e pescoço. É evidenciado principalmente através da mobilização passiva ao nível do punho e do cotovelo, em que ocorre uma resistência aumentada ao movimento passivo denominada "cano de chumbo", que é igual em todas as direções e pode se apresentar de forma subclínica nas fases iniciais da DP, ou em “roda denteada”, quando um membro é deslocado passivamente e podem-se sentir, superpostos à rigidez, curtos períodos de liberação rítmicos e intermitentes (BARBOSA; SALLEM, 2005; XIA et al., 2023).

Já o tremor em repouso, de ritmo regular (4 a 5 ciclos/segundo), está presente nas extremidades e ocorre em aproximadamente 75% dos sujeitos, sendo uma das manifestações mais características da DP (PONT-SUNYER et

al., 2015). Ocorre de forma assimétrica e diminui ou desaparece com os movimentos voluntários, sendo exagerado pela fadiga, esforços de concentração intelectual e emoções, e desaparece durante o sono (ITO, 2014). Pode se manifestar nos membros inferiores, maxilar, lábios e língua, entretanto acaba tendo um impacto considerável nas funções dos membros inferiores e membros superiores (MMSS), mais precisamente em pés e mãos, respectivamente (PROUD et al., 2015).

1.2 DISTÚRBIOS DOS MEMBROS SUPERIORES NA DOENÇA DE PARKINSON

Os distúrbios dos movimentos dos membros superiores podem estar presentes em pessoas com DP a partir do diagnóstico, com deficiências como micrografia ou tremor em repouso, sendo frequentemente o primeiro sinal da doença. Dificuldades na manipulação de objetos com velocidade e destreza adequadas também são relatadas (DAHDAL et al., 2016). Desde o estágio inicial da doença, as alterações aparecem ocasionando prejuízos na velocidade e amplitude de movimento, causando perdas da função manual, de modo que implicam diretamente na redução das atividades de vida diária (AVD's) e consequentemente na qualidade de vida destes indivíduos, tornando-os mais dependentes (QUINN; BUSSE; DAL BELLO-HASS, 2013). À medida que a doença progride, os distúrbios podem levar a limitações no trabalho, recreação e tarefas diárias, como vestir-se e comer (PROUD et al., 2015).

A presença da rigidez juntamente com a bradicinesia e o tremor dificultam os movimentos complexos integradores ou repetidos (ABUSRAIR; ELSEKAILY; BOHLEGA, 2022). É observado, por exemplo, uma alteração na escrita, em que uma frase se inicia com letras bem formadas e que se deterioram progressivamente para uma letra cada vez menor e executada de forma lenta (PROUD et al., 2015). Ações como fazer a barba, escovar os dentes, pentear o cabelo, abotoar-se, aplicar maquiagem, vestir-se ou tocar instrumentos musicais se tornam extremamente difíceis com o avanço da doença (JANKOVIC; LANG, 2004).

A diminuição da força e aumento da dificuldade no controle do torque de digitação foram previamente relatados em pessoas com DP. Embora o déficit de força ainda seja debatido, esta foi identificada como um dos fatores contribuintes

para a bradicinesia, principalmente dos MMSS (BRYANT et al., 2018). Assim, foi verificado que o treinamento de força pode potencialmente transferir para melhoria, por exemplo, na micrografia, devido a um possível benefício quanto à bradicinesia. Esta hipótese foi sustentada pela descoberta de que este treinamento reduziu significativamente a bradicinesia e aumentou a força e a potência muscular em idosos com DP (NI et al., 2016).

A avaliação objetiva da disfunção motora da DP, bem como da extremidade superior, é importante para a seleção do tratamento a ser aplicado nesta condição neurológica (BANK et al., 2018). Instrumentos clínicos, como a Escala Unificada de Avaliação da Doença de Parkinson (MDS-UPDRS) e a escala de estadiamento motor de Hoehn e Yahr (H&Y), são ferramentas semiquantitativas usadas por neurologistas para avaliação, atribuindo uma pontuação de acordo com a gravidade da doença (CAVALLO et al., 2019).

Um componente importante da prática baseada em evidências é o uso de ferramentas de avaliação com fortes propriedades para quantificar a progressão da doença e os resultados do tratamento. No entanto, as diretrizes atuais para fisioterapia e terapia ocupacional na intervenção de pessoas com DP contêm poucas recomendações para auxiliar na seleção de ferramentas adequadas para mensuração da funcionalidade dos MMSS (KEUS et al., 2014; PROUD et al., 2015). Na sua maior parte, os testes avaliam atividades mais específicas, como a destreza manual fina, não abrangendo os MMSS de forma global. Algumas das ferramentas mais comumente utilizadas para avaliar a função dos MMSS são os testes dos Nove Pinos (*Nine Hole Peg Test*) e o da Caixa e Blocos (*Box and Block Test*), ambos indicados para avaliar a destreza manual do indivíduo (CORREA et al., 2016).

Recentemente, um estudo (DE FREITAS et al., 2017) aplicou e validou o *Test d'Évaluation des Membres Supérieurs de Personnes Agées* (TEMPA) na DP, o qual serve para avaliar as limitações dos MMSS. Trata-se de um instrumento padronizado que possui um manual de instruções, apresentando oito tarefas para serem realizadas, com testes unilaterais e bilaterais. As tarefas são semelhantes aos afazeres realizados nas AVD's, como abrir um pote e tirar uma colher cheia de café, destrancar uma fechadura, escrever em um envelope, entre outros (MICHAELSEN et al., 2008). Este teste tem origem canadense, e foi

traduzido e adaptado para o português em indivíduos com DP (DESROSIERS; HEBERT; DUTIL, 1993; DE FREITAS et al., 2017).

Desta forma, visto que os distúrbios de movimento dos MMSS são apenas levemente responsivos ao tratamento dopaminérgico, os indivíduos se beneficiarão de um acompanhamento regular com seus terapeutas no processo de avaliação e tratamento (CABRERA-MARTOS et al., 2018). Assim, quanto às abordagens das disfunções dos MMSS na DP, já existem na literatura alguns tratamentos específicos descritos. Entre elas, técnicas como musicoterapia (CÔRTE; LODOVICI NETO, 2009), as técnicas baseadas no treinamento de repetição em tarefa simples e dupla tarefa (TOMO et al., 2014), a terapia de movimento induzida por restrição do MMSS (LEE; LEE; HWANG, 2011), a terapia por espelho (BONASSI et al., 2016), a *técnica Lee Silverman Voice Treatment - BIG* para melhorar as amplitudes de movimento (FARLEY; KOSHLAND, 2005), entre outras, têm sido utilizadas visando a reabilitação e minimização das perdas motoras das extremidades superiores.

Novas modalidades de reabilitação indicam que jogos de realidade virtual (RV) e de tabuleiro estão começando a ser aceitos como ferramentas terapêuticas adjuvantes no tratamento de doenças neurológicas. A RV através de simulação em tempo real proporciona a oportunidade de realizar atividades repetitivas e recompensadoras (LUN et al., 2005; LAVER et al., 2015; YANG et al., 2016, CHING-TENG, 2019). Destaca-se por ser uma terapia tecnológica recomendada para a melhora do aprendizado de movimentos, pois através de um *feedback* visual o indivíduo é capaz de trabalhar tanto processos motores quanto cognitivos ao mesmo tempo (DOCKX et al., 2016). Da mesma forma, os jogos de tabuleiro além dos mesmos benefícios supracitados, possuem também a implicação do ambiente real em tarefas que exigem a manipulação, destreza e funcionalidade dos MMSS (TREHER, 2011). Assim, sendo real ou virtual, ambos podem proporcionar um ambiente desafiante e motivador aos indivíduos com DP, contribuindo para a restauração da funcionalidade dos MMSS.

1.3 JOGOS DE REALIDADE VIRTUAL E DE TABULEIRO NA DOENÇA DE PARKINSON

Dentro do contexto da fisioterapia, a tecnologia de RV é recomendada para aperfeiçoar a aprendizagem motora em um ambiente seguro e pode ser

uma alternativa valiosa para abordagens convencionais (KESHNER, 2004). Ao oferecer feedback aprimorado sobre o desempenho, possibilitando a prática repetitiva individualizada da função motora e estimulando simultaneamente os processos motores e cognitivos, a RV oferece oportunidades para aprender novas estratégias motoras e para reaprender habilidades motoras que foram perdidas como resultado de lesão ou doenças neurodegenerativas como a DP (GOBLE; CONE; FINGLE, 2014). Estudos pilotos iniciais utilizando delineamentos não controlados exploraram a eficácia das intervenções de RV na DP e sugeriram efeitos positivos na marcha, equilíbrio e função cognitiva após o treinamento (DOCKS et al., 2016).

Embasada em uma tecnologia avançada, a RV permite aos usuários se envolverem em ambientes simulados e interativos, proporcionando uma experiência sensorial rica de forma imersiva ou não-imersiva (KWON; PARK; KOH, 2023). O ambiente imersivo envolve o uso de dispositivos como óculos de RV e controles de movimento, criando a sensação de presença completa em um contexto virtual, permitindo aos usuários explorarem e interagirem com esse ambiente de forma natural e intuitiva (CAMPO-PRIETO; CANCELA-CARRAL; RODRÍGUEZ-FUENTES, 2023). Por outro lado, a realidade virtual não imersiva é experimentada por meio de dispositivos não imersivos, como computadores ou dispositivos móveis, onde os usuários ainda podem interagir com o ambiente virtual, mas a sensação de presença é menos intensa (NAVARRO-LOZANO et al., 2022). Ambas as abordagens têm suas vantagens e aplicações em diversos campos, como treinamento, educação, entretenimento e terapia, com o potencial de revolucionar a forma como interagimos com a tecnologia e o mundo ao nosso redor.

Novos dispositivos têm surgido no mercado, como o *Leap Motion Controller* (LMC), que se enquadra como um equipamento não-imersivo de RV capaz de registrar os movimentos das extremidades superiores do indivíduo sem a necessidade de colocação de sensores ou dispositivos no corpo. Com esse dispositivo, uma representação virtual dos MMSS pode ser gerada na tela de um computador, onde o usuário realiza movimentos de acordo com os exercícios propostos, como tocar e pegar objetos, ordenar figuras, tocar piano, entre outros (OÑA et al., 2018).

O LMC possibilita a captura e o rastreamento dos movimentos sutis da mão e dos dedos, controlando um ambiente virtual que requer a coordenação de todo o membro superior para a prática de tarefas virtuais (IOSA et al., 2015). Sua portabilidade e baixo custo tornam o tornam adequado para realização de exercícios em ambientes terapêuticos e domiciliares, com pouca necessidade de supervisão. Além disso, serve como uma ferramenta para fornecer feedback automático por meio da tela do computador, com base nos padrões de movimentos do complexo dedos-punho-mão (SMERAGLIUOLO et al, 2016). A repetição dessas tarefas, estimulada pelo LMC, aprimora o efeito de reabilitação, contribuindo para a (re)aprendizagem motora dos indivíduos ao melhorar aspectos de aquisição, retenção e transferência das atividades (OÑA et al., 2018).

Em estudos que utilizaram o LMC como ferramenta de RV não-imersiva para intervenção nos MMSS em indivíduos com DP, foi observada uma melhora nos resultados no *BBT* e *9HPT* (CIKAJLO et al., 2018; FERNÁNDEZ-GONZÁLEZ et al., 2019; ISERNIA et al., 2020; OÑA et al., 2018; SÁNCHEZ-HERRERA-BAEZA et al., 2020). Conforme verificado em recente revisão sistemática (LAHUDE et al., 2022) o uso desta abordagem teve o enfoque apenas na destreza manual, não abordando de forma específica a execução das AVD's como consequência dos benefícios observados. Grande parte dos resultados deveu-se ao fato da similaridade do jogo imposto com a tarefa exigida nos testes de destreza. Assim, observa-se que indivíduos com DP necessitam de uma maior especificidade no treinamento da tarefa, devido a uma redução da flexibilidade de aprendizado e uma diminuição da fase de automação do gesto motor, fatores que podem ser melhorados com o uso de *feedback* visual presentes na RV (FERNÁNDEZ-GONZÁLEZ et al., 2019).

Alguns estudos trazem que a qualidade de vida parece ser pouco influenciada pelo uso da RV em sujeitos com DP. VAN BEEK et al. (2019) constatou um benefícios apenas no subgrupo que apresentava uma baixa destreza manual no começo do tratamento (OXFORD GRICE et al., 2003). Este fato pode ter ocorrido devido a uma falta de mensuração do impacto funcional que a melhora das habilidades manuais proporciona aos indivíduos, diminuindo a autopercepção das alterações de qualidade de vida. Contudo, enquanto há revisões sistemáticas que apresentam um resultado positivo da RV em

indivíduos com DP neste desfecho (BARRY; GALNA; ROCHESTER, 2014; FREITAG et al., 2019), algumas ainda não apresentam um resultado conciso quanto ao seu real efeito na qualidade de vida (DOCKX et al., 2016; TRIEGAARDT et al., 2019).

De acordo com LAHUDE et al. (2022), as principais vantagens da terapia baseada em RV para a destreza manual foram a alta aderência aos protocolos propostos, capacidade de modulação a dificuldade do exercício e sua progressão, além de um maior *feedback* visual e auditivo gerado pelos equipamentos. Pode-se ainda ressaltar a possibilidade de alta variedade de exercícios, aumento do senso competitivo, baixo custo, além de nenhum efeito adverso relatado (CIKAJLO et al., 2018; FERNÁNDEZ-GONZÁLEZ et al., 2019; ISERNIA et al., 2020; OÑA et al., 2018; SÁNCHEZ-HERRERA-BAEZA et al., 2020)

Quanto aos jogos de tabuleiro, não existe na literatura nenhuma abordagem específica da sua utilização em indivíduos com DP. A aplicação terapêutica destes jogos tem sido amplamente explorada como uma abordagem eficaz para auxiliar no tratamento de diversas condições de saúde mental e cognitiva. Esses jogos proporcionam uma forma lúdica e envolvente de estimular habilidades cognitivas, sociais e emocionais, promovendo a interação social, o pensamento estratégico, a tomada de decisões e a resolução de problemas (RAMANI; SIEGLER, 2008).

Os jogos de tabuleiro são jogados em mesas e não requerem dispositivos eletrônicos, sendo assim chamados de "jogos desconectados". Em comparação com outros tipos de jogos, proporcionam aos indivíduos experiências concretas que aumentam as intenções de participação e estimulam o pensamento de ordem superior. Além de serem uma atividade de lazer, os jogos de tabuleiro também oferecem a oportunidade de aprender e sentir um senso de realização e empolgação (D'ASTOUS; GAGNON, 2007).

Em indivíduos com demência ou comprometimento cognitivo leve, os jogos de tabuleiro têm mostrado benefícios no aprimoramento da memória, da atenção e da capacidade de concentração (LAWRENCE et al., 2018). Além disso, têm sido utilizados como uma forma de terapia ocupacional em idosos, auxiliando na manutenção das habilidades cognitivas e reduzindo o declínio funcional (BIRKS et al., 2016). No contexto da saúde mental, são usados em

terapias de grupo para auxiliar no desenvolvimento de habilidades de comunicação, empatia e cooperação (BAVLY HANNA, 2022).

A utilização desses jogos podem ser uma ferramenta valiosa no tratamento de transtornos de ansiedade e depressão, proporcionando uma forma estruturada de enfrentar desafios e promovendo a sensação de conquista e autoestima (TOWNSEND et al., 2022). Além disso, também tem sido explorada em crianças com transtornos do espectro autista, contribuindo para o desenvolvimento das habilidades sociais, de comunicação e interação (RAMALHO; SARMENTO, 2019). Esta abordagem tem sido amplamente aplicada na educação e numerosos pesquisadores têm investigado tópicos relacionados, aos quais incluem motivação e desempenho (KLEIN E FREITAG, 1991; KLEIN, 1992), atitude e afeição (WILDE, 1994), e desenvolvimento cognitivo e compreensão do conhecimento (CALDWELL, 1998; RAMANI; SIEGLER, 2008).

TREHER (2011) considera que os jogos de tabuleiro são exercícios para a mente e para as mãos, sendo adequados para todas as idades e podendo tratar de qualquer assunto, sendo excelente método para combinar aquisição de conhecimento e experiência. Tendo um ambiente competitivo, mas não ameaçador, motiva os jogadores a se concentrarem nos jogos e aprimorar a aprendizagem. Assim, oferecem uma alternativa interessante e eficaz para complementar abordagens terapêuticas convencionais, trazendo benefícios para a saúde mental, cognitiva e emocional (RAMALHO; SARMENTO, 2019), podendo também ser um método eficaz para a reabilitação dos MMSS em indivíduos com DP.

Desta forma, estudos são necessários para apoiar o uso terapêutico da RV não-imersiva e jogos de tabuleiro no tratamento de distúrbios motores dos MMSS na DP. É frequente que um amplo repertório de limitações no desenvolvimento das atividades funcionais apareça, assim como restrições na realização das tarefas de vida diária ao longo da progressão da doença. Contudo, a reabilitação da função das extremidades superiores é extremamente desafiadora, no qual o tratamento através de jogos pode incluir métodos de aprendizado adaptando os níveis de dificuldade e a exigência dos exercícios com base no desempenho individual e o *feedback* de erros e acertos em determinadas tarefas (OÑA et al., 2018). Assim, as intervenções com exercícios

baseados em jogos de RV e de tabuleiro podem melhorar a adesão, estimulando os usuários a se exercitar de maneira personalizada, motivadora, lúdica e desafiadora podendo contribuir de maneira positiva para a reabilitação (DOCKS et al., 2016; CHING-TENG, 2019).

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2 OBJETIVOS

Artigo 1

Quantificar e analisar através artigos científicos o efeito de protocolos de terapia baseada em Realidade Virtual sobre a destreza manual de indivíduos com doença de Parkinson, a partir de uma revisão sistemática da literatura.

Artigo 2

Verificar os efeitos de uma intervenção em membros superiores com equipamento de realidade virtual não-imersivo nas atividades de vida diária e na qualidade de vida de indivíduos com doença de Parkinson, a partir de uma série de casos.

Artigo 3

A partir de um ensaio clínico randomizado, analisar e comparar os efeitos de jogos de realidade virtual não-imersiva com jogos de tabuleiro na funcionalidade dos membros superiores, atividades de vida diária e qualidade de vida de indivíduos com doença de Parkinson.

3 ARTIGO 1

THE IMPACT OF VIRTUAL REALITY ON MANUAL DEXTERITY OF PARKINSON'S DISEASE SUBJECTS: A SYSTEMATIC REVIEW

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REVIEW

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The impact of virtual reality on manual dexterity of Parkinson's disease subjects: a systematic review

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ABSTRACT

Purpose: To present the latest available evidence on the effects of a VR-based therapy on the manual dexterity of PD subjects.

Materials and methods: The search was conducted in PubMed, EMBASE, and PEDro databases. Were included in the systematic review Randomized Clinical Trials, Pilot and Feasibility studies published up to December 2020. The studies should include at least one of the following assessments: Box and Blocks Test, 9-Hole Peg Test; Purdue Pegboard Test. PEDro Scale was used to assess the methodological quality of the included studies.

Results: Eight studies were included in the review. Most studies have shown an improvement in outcomes for manual dexterity, but most of them presented a high risk of bias with low methodological quality. A high heterogeneity was observed in the protocols used for each study.

Conclusion: The results suggest that VR-based therapy has great potential and feasibility to be used as a manual dexterity rehabilitation protocol in PD subjects. However, these results must be interpreted carefully and studies with greater methodological rigor must be conducted.

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KEYWORDS
Virtual reality; Parkinson's disease; dexterity; exergame; assistive technology

➤ IMPLICATIONS FOR REHABILITATION

- Rehabilitation programs using virtual reality seem to have greater adherence to the user.
- Immersive virtual reality systems seem to do better in manual dexterity than non-immersive systems.
- It is plausible to use virtual reality systems in telerehabilitation for manual dexterity training in subjects with Parkinson's' Disease.
- The use of Virtual Reality by the therapist in a rehabilitation program allows him to modulate the exercises, enabling a wide variety of therapeutic options.

Introduction

Parkinson's disease (PD) is characterized as a complex neurological disorder, with motor symptoms that are mainly associated with the development of Lewy bodies and the loss of dopaminergic neurons in the substantia nigra [1]. The PD prevalence varies between 1–2 per 1000 inhabitants in the general population, and affects 1% of subjects over 60 years [2]. It is considered the second most prevalent neurodegenerative disease in the world [3].

Motor function is commonly affected and is represented by the classic symptoms of tremor, stiffness and bradykinesia [2]. There are also cognitive changes, depression, postural and gait pattern changes, and impairment of manual dexterity [4,5]. Dexterity can be defined as the skillful and controlled manipulation of a tool or object by the fingers [6]. Deficits in sensorimotor processes, including a reduction in movement speed, difficulty in executing sequential movements, and the loss of ability to synchronize and coordinate movements directly affects the manual dexterity [7]. There is also a reduction in the ability of interdigital individualization, resulting in greater difficulty in combining the movements of reach and handgrip [8]. The impact of PD on manual dexterity disturbs the performance of activities of daily living at different stages of the disease, which is an important clinical marker of the disease evolution [9].

The impairment of fine motor function is a prevalent symptom, making it difficult to perform simple activities such as leafing through pages, buttoning shirts, tying shoes, using smartphones, remote controls and keyboards [10]. Studies indicate that the cause of this symptom is less related to bradykinesia, tremor and stiffness, and more to limb–kinetic apraxia (LKA), described as an inability to perform a motor act in which it is not entirely caused by elementary motor deficits, such as weakness, sensory loss, ataxia or involuntary movements [11,12]. However, the evidence suggests that the dopaminergic pharmacological treatment, despite having a great impact on bradykinesia, still shows low performance in improving fine manual dexterity in PD [11].

Among the rehabilitation modalities for PD, virtual reality (VR) can be defined as the use of simulations created from hardware and software that allow the user to get involved with environments that mimic the real world [13]. VR stands out for being a technological therapy recommended for motor learning, because through visual feedback the individual is able to work on motor and cognitive processes at the same time, in a challenging and motivating environment [14]. In addition, an external observer

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can monitor and record the entire performance of the proposed task, analyzing its progress [15].

In recent years, VR has been investigated in post-stroke subjects [16], cerebral palsy [17] and PD [18], showing improvement in balance and gait when compared to conventional therapies only. Systematic review with meta-analysis showed that VR focused on motor control, balance, gait and strength is more effective than a conventional rehabilitation program for individuals with PD. The authors speculate that such results occurred due to the user's greater motivation towards the virtual environment [19]. Santos et al. [20] analyzed the effect of protocols using the Nintendo Wii device in addition to conventional therapy, and there were greater positive effects on balance and quality of life than when using conventional exercises. Triegaardt et al. [21] in his systematic review and meta-analysis including 1031 participants suggests that virtual reality can be used in the rehabilitation routine in subjects with PD, but the results are still conflicting and the impact of VR on manual dexterity in this population has not been fully clarified.

Thus, the objective of this systematic review was to quantify and analyze, through studies published in the scientific literature, the effect of VR-based therapy protocols on the manual dexterity of individuals with PD, in order to fill this gap in VR studies in neurological diseases and facilitate the therapist's clinical practice.

Materials and methods

The study was registered in the International Register of Systematic Reviews (PROSPERO) and can be consulted through the link: https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=210881. This systematic review follows the recommendations of the PRISMA Checklist.

Search strategies

The search was conducted in the following databases: PubMed, Physiotherapy Evidence Database (PEDro), and EMBASE. The search terms used were "Parkinson's Disease" (Mesh term) combined with "Virtual Reality Exposure Therapy" (Mesh term), "Exergame", "Serious Gaming", "User-computer Interface". The complete search strategy can be found in Appendices. In order to increase the sensitivity of the search, we did not include terms related to our outcome of interest. Two independent researchers conducted the search.

Eligibility criteria

This review included randomized clinical trials, pilot and feasibility studies with or without a control group; investigating people diagnosed with Parkinson's disease at any degree of the Hoehn and Yahr scale (grades I–V) without restriction of age, sex, or duration of disease; who used at least one of the following tools to assess manual dexterity as a primary or secondary outcome: 9 Hole Peg Test, Pegboard Test or Box and Block Test. The included studies showed no restrictions on the type of virtual reality implemented (immersive or not) or duration of the treatment protocol; When present, the comparison group was done with conventional physical therapy, placebo or between two types of virtual reality; studies published in Portuguese or English. Unpublished articles (preprint) or with incomplete data were excluded.

Outcome measures

The primary outcome, fine and gross manual dexterity, was measured by the 9-Hole Peg Test (9HPT), Purdue Pegboard Test (PPT) and Box and Blocks Test (BBT). The secondary outcomes were motor function, assessed by the Movement Disorders Society Unified Parkinson's Disease Rating Scale – Part III (MDS-UPDRS-III); Quality of life, assessed by Parkinson's Disease Questionnaire (PDQ-39) and Short Form Health Survey (SF-12); and Customer Satisfaction and Usability, assessed by Client Satisfaction Questionnaire-8 (CSQ-8), System Usability Scale (SUS), and Pittsburgh Rehabilitation Participation Scale (PRPS).

Data extraction and quality assessment

Two independent reviewers performed the screening of articles through the titles and abstracts. A checklist for the inclusion and exclusion criteria was used for each study. Studies that did not meet the criteria were excluded. The full reading of potential studies was performed in a second review by at least two reviewers independently. Disagreements regarding the study's eligibility were later discussed among the reviewers. When it was not possible to reach consensus, a third reviewer was requested. Studies eligible for inclusion in the review were assessed using the PEDro scale for methodological quality [22]. The 6-point cutoff was adopted to consider a high quality or low quality article. From the studies selected from the eligibility criteria, the following data were extracted: Methodological design, number of subjects, comparison groups (if any), intervention protocol and outcome results. The searches were carried out between 26 October and 20 December 2020. Through the search strategies, a total of 684 articles were registered. After exclusions based on the title of the article and exclusions of duplicates, 49 articles remained for complete analysis. A total of 41 articles were excluded based on the eligibility criteria. Eight articles were included in the final review. The results flowchart can be seen in Figure 1.

Results

Eight articles were added to the review with a sample of 132 patients. The sample consisted mainly of men (M: 87/F: 45) aged between 56 and 79 years.

The most used tool to measure manual dexterity was the Box and Blocks Test, applied in 7 studies [23–28]. Three studies used the Nine-Hole Peg Test [27–29] and the Purdue Pegboard Test [23,26,30]. Only 2 studies used these tools in isolation [24,25], the remaining used a combination of 2 tools. Among the secondary outcomes proposed by this review, 5 studies used User Satisfaction Questionnaires [23,25,26,29,30]; 3 studies used the PDQ-39 [27–29]; 3 studies used UPDRS-III [25,27,29]. The device most often used for the Virtual Reality protocol was the Leap Motion Controller [23–26,29,30] in an isolated or combined manner (Oculus Rift or Kinect). Only 3 studies had a Control group [24,26,28], consisting mainly of conventional physiotherapy (strength, balance, stretching and proprioception exercises) (Table 1).

Six studies used instruments to measure adherence and usability of VR-based therapy: CSQ-8 [23,26], SUS [24,29], PRPS [29], and specific questionnaires designed by the researchers [25,30]. Four studies measured the quality of life of the volunteers: PDQ-39 [27–29] and SF-12 [24]. Three studies quantified the motor function of the upper limb using UPDRS-III [25,27,29] (Table 2).

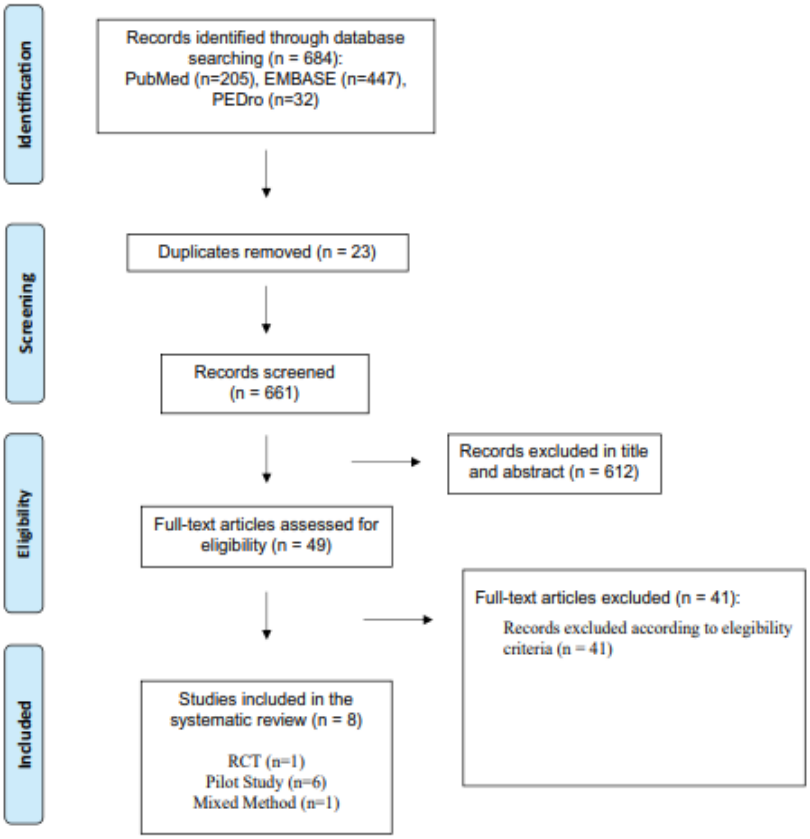

Figure 1. Studies included in the Systematic Review, according to the PRISMA Checklist (2009) criteria: Identification, Screening, Eligibility, and Included Studies.

The PEDro methodological quality assessment (Table 3) found articles ranging from a score of 4–10. A total of 5 articles were considered of low methodological quality (<6), while 3 articles were classified as having good methodological quality.

Discussion

Our aim was to analyze, through different protocols, the impact of VR-based therapy on manual dexterity of PD subjects, in order to elucidate and systematize the different results found in the scientific literature. Some systematic reviews were published using VR in PD for different outcomes [14,18,21,31–33], predominantly the gait and balance outcomes analyzed; no publication focused on the analysis of manual dexterity in this population. For the standardization of primary results, we chose studies that used only BBT [34] to assess gross manual dexterity or the 9-HPT [35] and/or PPT [36] to the fine manual dexterity.

The results found for the main outcome were highly heterogeneous, probably due to a mix of protocols adopted for the articles. The small sample and the lack of a comparison group adopted in most studies can also interfere with the outcomes. An improvement in BBT and 9HPT results was observed in the post-treatment in studies that mainly used the Leap Motion Controller (LMC) as a VR tool [23,24,26,27,30]. Most of these results are due to the fact that the game is similar to the task required in dexterity tests. Individuals with PD need greater specificity in training the task, due to a reduction in learning flexibility and a decrease in the automation phase of the motor gesture, factors that can be improved with the use of visual feedback present in VR [37]. A treatment focussed on specific tasks must be essential to improve the function of the upper limb in these individuals [38].

Rehabilitation protocols using VR varied across studies. Most studies included in this review used an average of 30-min sessions each [23,25,26,29,30] with frequency ranging from two [29,30] to three sessions per week [23,25,27] with a minimum of 8 sessions [29] and a maximum of 60 sessions total [24]. Although review addressing the use of VR in PD in different outcomes still do not show a consensus regarding time, frequency and volume of rehabilitation protocols adopted [14,18,21], we can observe that a greater volume of sessions totals seems to have a positive influence on manual dexterity when compared to a smaller volume in this population.

We must emphasize that the frequent use of LMC in the studies is due to the fact that it is a portable device, low cost, and easy to use [39]. In addition, it allows to capture the movements of the upper limb with great precision, having a better accuracy than equipment such as the Kinect [40]. Furthermore, it is possible to use it concurrently with *Head-Mounted displays*, device used as glasses on which the image is projected onto your lens [41], for a more immersive and pleasurable experience [23,25]. Due to its small size, the LMC is also plausible for home use [24]. Other studies have already pointed out the effectiveness of the device for other neurological conditions, with a positive result on the function of the upper limb [42].

Table 1. Summary of studies included in the systematic review.

Author	Subjects	VR	Comparator	Assessment Tools	Protocol	Features
Baeza et al. [23]	– 6 DP subjects (M:5) – Age: 74.50 ± 4.72 – Disease duration: NA – H&Y: II-IV	LMC + Oculus Rift II.	NA	BBT; PPT; Jamar Dynamometer; ARAT; CSQ-8 Outcomes measured before and after treatment and after a 1-month follow-up.	30 min session, 3 times a week for 6 weeks. Total of 18 sessions.	BBT score increases in the post-treatment for the most affected limb vs. pre-treatment. PPT improved for both limbs in the pre–post-treatment and in the pre-follow-up.
Isernia et al. [24]	– 31 DP subjects (M:17) IG:11 / CG:20 – Age: IG: 65.55 ± 9.06 CG: 67.55 ± 9.33 – Disease duration: NA – H&Y: I-II	LMC + Kinect (HEAD program).	Conventional Physiotherapy	BBT; BBS; 10MWT; 2MWT; MoCA; RBMT-3; SF-12; PANAS. Outcomes measured pre-treatment (T0), after 1 month of use in the clinic (T1), after 3 months of home use (T2) and 3 months after the end of the home protocol (T3).	45 min session for 12 weeks. Total of 60 sessions.	Improvement of BBT in T1 vs. T0 in both limbs. A significant difference was noticed in the IG in T2 vs. T1 when compared to the CG in BBT for the non-dominant limb. There were no differences between groups at follow-up (T3).

Author	Subjects	VR	Comparator	Assessment tools	Protocol	Features
Van Beek et al. [29]	– 10 PD subjects (M:7) – Age: 65.40 ± 7.01 – Disease duration: 8.50 ± 4.38 years – H&Y: II-IV	LMC	NA	9HPT; PDQ-39; DextQ-24; UPDRS-III; SUS; PRPS; Adherence scores and participants' opinions.	30 min sessions, 2 times a week for 4 weeks. Total of 8 sessions.	No significant differences in the pre- and post-treatment for the following outcomes: 9HPT, DextQ-24 and UPDRS-III.
Cikajlo et al. [25]	– 20 PD subjects (M:9) G1:10 / G2:10 – Age: G1: 71.3 ± 8.4 G2:67.6 ± 7.6 – Disease duration: 7.1 years – H&Y: II-III	LMC. +Oculus Rift CV1.	Participants were randomized into 2 groups: semi-immersive VR (G1) and immersive VR (G2)	BBT; UPDRS; Motivation questionnaire; Kinematic Analysis of the Upper Limb.	30 min session for 3 weeks. Total of 10 sessions.	Both groups increased their BBT scores in the pre–post treatment, but no significant difference was found between groups. A reduction in the UPDRS score was found in both groups after treatment.

Author	Subjects	VR	Comparator	Assessment tools	Protocol	Features
Fernández-González et al. [26]	– 23 PD subjects (M:11) IG:12 / CG:11 – Age: IG: 65.77 ± 7.67 CG: 67.36 ± 12.12 – Disease duration: NA – H&Y: II-IV	LMC	Conventional Physiotherapy	BBT; PPT; Jamar Handgrip; CSQ-8.	30 min session for 6 weeks. Total of 12 sessions.	Significant improvement in all post-treatment outcomes in the IG, except for BBT in the least affected limb. Significant increase only for PPT of the most affected limb in the CG. Analysis between groups showed a significant increase in the IG for PPT for the most affected member and "Assembly" when compared to the CG.
Onã et al. [30]	– 5 PD subjects (M:3) – Mean age: 56,6 – Disease duration:NA – H&Y: II-IV	LMC	NA	BBT; PPT; Jamar Handgrip; User Experience Questionnaire.	30 min session, 2 times a week for 6 weeks. Total of 12 sessions.	Increased BBT score for all post-treatment participants. Increased overall PPT score for the most affected limb.

Author	Subjects	VR	Comparator	Assessment tools	Protocol	Features
Cikajlo et al. [27]	– 28 PD subjects (M:12) – Age: 68 ± 7 – Disease duration: 6 ± 4 years – H&Y: II-III	Kinect V2.	NA	BBT; 9HPT; UPDRS-III	40–60 min a session for 2–3 weeks. Total of 10 sessions	Increase in pre–post values in the 9HPT and BBT tests. However, only the BBT showed a statistically significant increase. All participants showed an increase in the final score of the game (10th session) when compared to the first session
Allen et al. [28]	– 36 PD subjects: (M:23) IG: 19/ CG:19 – Age: IG: 67.5 ± 7.3 CG: 68.4 ± 8.5 – Disease duration: IG 7.9 ± 3.9 CG 8.7 ± 6.1 – H&Y: NA	Exergame developed by the authors	Control group (no intervention)	BBT; 9HPT; Coin Rotation Task and Manual ability Measures-36 questionnaire	3 weeks Total of 12 sessions.	There were no significant differences in the BBT, 9HPT, and Coin Rotation Task tests within or between groups

M, Male; H&Y, Hoehn & Yahr; NA, non-applicable; BBT, Box and Blocks Test; 9HPT, Nine-hole Peg Test; UPDRS, Unified Parkinson's Disease Rating Scale; LMC, Leap Motion Controller; PDQ-39, Parkinson Disease Questionnaire-39; DextQ-24, Dexterity Questionnaire-24; SUS, System Usability Scale; PRPS, Pittsburgh Rehabilitation Participation Scale; ARAT, Action Research Arm Test; CSQ-8, Client Satisfaction Questionnaire-8; 10MWT, Ten Meter Walk Test; 2MWT, Two Minute Walk Test; MoCA, Montreal Cognitive Assessment; RBMT-3, Rivermead Behavioral Memory Test-Third Edition; SF-12, Short Form Health Survey; PANAS, Positive Affect and Negative Affect Schedule.

Motor function and quality of life quantified by UPDRS-III and PDQ-39 respectively presented conflicting results. Cikajlo in 2019 [25] reported a lower score of UPDRS-III in both studied groups (immersive VR/semi-immersive VR) after treatment and Cikajlo in 2018 [27] quantified a better post-treatment score with the use of the Kinect device. However, these results were not found by Van Beek [29], which used the Leap Motion Controller device in isolation. Among the diversity adopted between the protocols, we must highlight the shorter treatment time imposed by Van Beek [29] and its possible impact on this outcome. The quality of life seems to be little influenced by the use of VR in subjects with PD. While Allen [28] observed a better score on the PDQ-39 in both groups (control and intervention), Van Beek [29] found an improvement in the score only in the subgroup that had low dexterity at the beginning of treatment [43]. These inconclusive results corroborate the current literature; while there are systematic reviews that show a positive impact of VR on PD subjects [31,44], some still do not have a concise result [14,32].

Among the satisfaction questionnaires used at the end of the protocol, Baeza [23] and Fernandéz-González [26] applied the CSQ-8. Both studies obtained a high degree of satisfaction with average scores of 29.3 and 29.6, respectively. We also report VR functionality to improve mood [24] and motivation [29], crucial factor for PD treatment, since 40–50% of this population may suffer from depressive symptoms at some stage of the disease, directly impacting in physical and cognitive decline, in addition to increasing the risk of mortality [45]. In general, the studies reported a good rate of adherence to the protocol and feasibility of use for the population studied, these factors become of great importance due to the subject's need to engage in long-term treatment at the same time as the activity becomes something pleasurable and plausible to be carried out [4].

The main advantages of VR-based therapy for manual dexterity analyzed in this review were: High adherence to the proposed protocols; Ability to modulate the difficulty of the exercise and its progression; Great visual and auditory feedback generated by the equipment. We can also emphasize the possibility of high exercise variability; Increased user's competitive sense; Low cost; Ability to use through Telerehabilitation; Ease of recording treatment progress, plus no adverse effects reported. Among the barriers observed for the use of this therapy are: Fatigue; Increased tension; Feeling of frustration when obtaining a low score in the Game; Fear of using VR; Great interference of parkinsonian tremor for the realization of the Game.

The limitations of the studies included in this review were the low number of randomized clinical trials, low sample size, absence of a comparison group, and great heterogeneity of treatment protocols used. In addition, only individuals without cognitive decline were included in the studies, and these results cannot be generalized to the entire population of PD.

Conclusion

VR-based therapy for manual dexterity in PD subjects is gaining notoriety in recent years due to the low cost and popularization of commercial motion capture devices. We conclude that this is a therapy that is feasible to be used for training manual dexterity in subjects with PD. However, the literature still lacks well conducted studies for this outcome. Caution is recommended when interpreting the results obtained due to the wide variety of protocols adopted. Further studies should be conducted for this purpose, including randomized controlled trials and a larger sample population to investigate real effectiveness of the treatment.

Table 2. Results of secondary outcomes.

Author	Results
Baeza et al. [23]	High degree of satisfaction with treatment in all participants measured by the CSQ-8.
Isernia et al. [24]	Higher adherence rate in the ClinicHEAD group when compared to HomeHEAD, and good usability rate in both groups measured by SUS. Increased quality of life and mood in T1 vs. T0 measured by SF-12 and PANAS, respectively.
Van Beek et al. [29]	High adherence rate and increased motivation rate as measured by PRPS. No difference in the UPDRS-III score. Improvements in the score for the "low dexterity" subgroup in PDQ-39. 70% of the participants reported a good usability of the system through SUS.
Cikajlo et al. [25]	Increased interest rate in both groups over the course of treatment. The group that used immersive VR reported a greater perceived effort. The non-immersive RV group reported a lower pressure / tension in the treatment measured by IMI. UPDRS-III score decreased in both post-treatment groups.
Fernández-González et al. [26]	High degree of satisfaction in both groups measured by the CSQ-8.
Oňa et al. [30]	Application of a user experience questionnaire demonstrated the best scores in the "Utility" and "Gameplay" category.
Cikajlo et al. [27]	PDQ-39 measured only in the pre-treatment reported greater problems with mobility, body discomfort and emotional well-being. Improvement in the UPDRS-III score after treatment.
Allen et al. [28]	Drop in the PDQ-39 score in both post-treatment groups.

CSQ-8, Client Satisfaction Questionnaire-8; SUS, System Usability Scale; SF-12, Short Form Health Survey; PANAS, Positive Affect and Negative Affect Schedule; PRPS, Pittsburgh Rehabilitation Participation Scale; UPDRS-III, Unified Parkinson's Disease Rating Scale; PDQ-39, Parkinson's Disease Questionnaire.

Table 3. Pedro score.

Author	1	2	3	4	5	6	7	8	9	10	11	Total
1 Baeza et al. [23]	✓	X	X	X	X	X	✓	✓	✓	X	✓	5
2 Isernia et al. [24]	✓	X	X	X	X	X	✓	✓	✓	✓	✓	9
3 Van Beek et al. [29]	✓	X	X	X	X	X	X	✓	✓	✓	✓	5
4 Cikajlo et al. [25]	✓	✓	X	X	X	X	X	X	✓	✓	✓	5
5 Gonzalez et al. [26]	✓	✓	X	✓	X	X	X	✓	✓	✓	✓	7
6 Oňa et al. [30]	✓	X	X	X	X	X	X	✓	✓	X	X	3
7 Cikajlo et al. [27]	✓	X	X	X	X	X	X	✓	✓	X	✓	4
8 Allen et al. [28]	✓	✓	✓	✓	X	X	✓	✓	✓	✓	✓	9

1. Eligibility criteria; 2. Random distribution of subjects in each group; 3. Secret allocation of subjects; 4. Similar groups in relation to the most important prognosis; 5. Blind participation of subjects; 6. Blind participation of therapists; 7. Blind examiners; 8. At least one key result obtained in more than 85% of the subjects; 9. The subjects received treatment or control condition; 10. Intergroup statistics; 11. Presence of precision and variability measures.

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Author contributions

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Appendices

Search strategy

Patient (#1):

[Idiopathic Parkinson's Disease] OR [Lewy Body Parkinson's Disease] OR [Parkinson's Disease, Idiopathic] OR [Parkinson's Disease, Lewy Body] OR [Parkinson Disease, Idiopathic] OR [Parkinson's Disease] OR [Idiopathic Parkinson Disease] OR [Lewy Body Parkinson Disease] OR [Primary Parkinsonism] OR [Parkinsonism, Primary] OR [Paralysis Agitans]

Intervention (#2):

[Virtual Reality Immersion Therapy] OR [Virtual Reality Therapy] OR [Reality Therapies, Virtual] OR [Reality Therapy, Virtual] OR [Therapies, Virtual Reality] OR [Therapy, Virtual Reality] OR [Virtual Reality Therapies] OR [VR] OR [Exergame] OR [Serious gaming] OR [User-computer interface]

Type of study (#3):

(randomised controlled trial [pt] OR controlled clinical trial [pt] OR randomised controlled trials [mh] OR random allocation [mh] OR double-blind method [mh] OR single-blind method [mh] OR clinical trial [pt] OR clinical trials [mh] OR ("clinical trial"[tw]) OR ((singl[tw] OR doubl*[tw] OR trebl*[tw] OR tripl*[tw]) AND (mask*[tw] OR blind*[tw])) OR ("latin square"[tw]) OR placebos [mh] OR placebo*[tw] OR random*[tw] OR research design [mh: noexp] OR comparative study [mh] OR evaluation studies [mh] OR follow-up studies [mh] OR prospective studies [mh] OR crossover studies [mh] OR control*[tw] OR prospectiv*[tw] OR volunteer*[tw]) NOT (animal [mh] NOT human [mh]) OR (Pilot Project) OR (Project, Pilot) OR (Projects, Pilot) OR (Pilot Study) OR (Pilot Studies) OR (Studies, Pilot) OR (Study, Pilot) OR (Feasibility Study) OR (Studies, Feasibility) OR (Study, Feasibility)*

Search #1 AND #2 AND #3.

4 ARTIGO 2

VIRTUAL REALITY AS AN INTERVENTION TOOL FOR UPPER LIMBS IN PARKINSON'S DISEASE: A CASE SERIES

(Publicado no periódico Fisioterapia e Pesquisa – *Qualis B1, Fator de Impacto 0.280*)

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ORIGINAL RESEARCH

Virtual reality as an intervention tool for upper limbs in Parkinson's disease: a case series

Realidade virtual como ferramenta de intervenção para os membros superiores na doença de Parkinson: série de casos

Realidad virtual como herramienta de intervención para los miembros superiores en la enfermedad de Parkinson: una serie de casos

Jênifer Aline Cemim[1], Philipe Souza Corrêa[2], Bruna dos Santos Pereira[3], Jesuély Spieckert de Souza[4], Fernanda Cechetti[5]

ABSTRACT | Parkinson's disease (PD) is a neurodegenerative disorder in which dopaminergic loss occurs in the basal nuclei region. One major complaint associated with PD is upper extremity motor deficits (UE), frequently reported in difficulties to perform activities of daily living (ADL), which may negatively affect quality of life. In recent years new technologies have emerged to assist the UE rehabilitation process in PD, such as virtual reality. Therefore, this study sought to verify the effects of an intervention in the UE with semi-immersive virtual reality equipment on ADLs and quality of life of individuals with PD. Six individuals with PD were selected for intervention, and evaluated by the Mini Mental State Examination, the Hoehn & Yahr Scale, the Unified Parkinson's Disease Rating Scale (UPDRS), the Parkinson's Disease Questionnaire (PDQ-39) and the *test d'évaluation des membres supérieurs de personnes âgées* (TEMPA). The interventions lasted 27 minutes per session, twice per week, for 5 weeks, using the *Leap Motion Controller*. Individuals showed improvement in muscle strength, muscle endurance, ADLs, and quality of life, all statistically significant. In conclusion, the protocol based on virtual reality applied to the upper limbs effectively improved the activities of daily living and quality of life in individuals with PD.

Keywords | Parkinson's Disease; Upper Extremity; Virtual Reality.

RESUMO | A doença de Parkinson (DP) é uma desordem neurodegenerativa na qual ocorre a perda dopaminérgica na região dos núcleos da base. Uma das principais queixas associadas à DP são os déficits motores dos membros superiores (MMSS) frequentemente relatados em dificuldades para realizar as atividades de vida diária (AVDs), podendo interferir negativamente na qualidade de vida. Nos últimos anos novas tecnologias surgiram para auxiliar no processo de reabilitação dos MMSS na DP, sendo a realidade virtual uma delas. Portanto, este estudo teve como objetivo verificar os efeitos de uma intervenção nos MMSS com equipamento de realidade virtual semi-imersiva nas AVDs e na qualidade de vida de indivíduos com DP. Foram selecionados seis indivíduos com DP para intervenção, avaliados por meio do miniexame do estado mental, da escala de Hoehn e Yahr, da escala unificada de avaliação para a DP (UPDRS), do questionário sobre a doença de Parkinson (PDQ-39) e do *test d'évaluation des membres supérieurs de personnes âgées* (Tempa). Seis sujeitos foram submetidos à intervenção com duração de 27 minutos por sessão, duas vezes na semana, por cinco semanas, utilizando o *Leap Motion Controller*. Obteve-se melhora na força muscular, na resistência muscular, nas AVDs e na qualidade de vida, todos com significância estatística. Dessa forma, verificou-se que

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o protocolo baseado em realidade virtual aplicada nos MMSS foi eficaz para melhorar as AVDs e a qualidade de vida dos indivíduos com DP deste estudo.
Descritores | Doença de Parkinson; Extremidade Superior; Realidade Virtual.

RESUMEN | La enfermedad de Parkinson (EP) es un trastorno neurodegenerativo con pérdidas dopaminenérgicas en la región de núcleos basales. Una de las principales quejas asociadas a la EP son los déficits motores de los miembros superiores (MMSS), que muchas veces resultan en dificultades de realizar las actividades de la vida diaria (AVD), lo que impacta negativamente la calidad de vida. En los últimos años surgieron nuevas tecnologías para ayudar en el proceso de rehabilitación de los MMSS en la EP, y una de ellas es la realidad virtual. Por lo tanto, este estudio tuvo como objetivo comprobar los efectos de una intervención en los MMSS utilizando un equipo de realidad virtual semiinmersivo en las AVD y en la calidad de vida de individuos con EP. Se seleccionaron a seis individuos con EP para la intervención, que fueron sometidos a evaluación por el Miniexamen del Estado Mental, la Escala de Hoehn y Yahr, la Escala Unificada de Evaluación de la Enfermedad de Parkinson (UPDRS), el Cuestionario de la Enfermedad de Parkinson (PDQ-39) y el *test d'évaluation des membres supérieurs de personnes âgées* (Tempa). Seis sujetos se sometieron a una intervención de 27 minutos por sesión, dos veces por semana, durante cinco semanas, utilizando el *Leap Motion Controller*. Hubo una mejora en la fuerza muscular, en la resistencia muscular, en las AVD y en la calidad de vida, todos con significación estadística. Así se constató que el protocolo basado en realidad virtual aplicado a los MMSS fue eficaz en la mejora de las AVD y en la calidad de vida de los individuos con EP de este estudio.
Palabras clave | Enfermedad de Parkinson; Extremidad Superior; Realidad Virtual.

INTRODUCTION

Parkinson's disease (PD) is characterized by a slow progression, being the second most frequent neurodegenerative disease worldwide, behind only Alzheimer's disease[1]. Parkinson's disease results from the decrease in the production of idiopathic dopamine, but there are some studies that indicate a possible interaction with genetic and environmental factors. The disease prevalence increases with age, usually affecting individuals aged over 60 years and, rarely, people aged over 40 years[2]. In Brazil, there are approximately 220,000 patients with PD, figure that may double by 2030. Such data are worrisome due to the high incidence of hospitalizations, in addition to the need for medication and care for the rest of life[3].

One of the main complaints of those affected by PD are motor deficits of the upper limbs (ULs), often associated with difficulties in daily tasks such as tying shoelaces, buttoning buttons, typing on keyboards, among others. Since the initial stage of the disease, these changes appear, causing losses in speed and range of motion, with losses in manual function that directly reduce activities of daily living (ADLs) and, consequently, in the quality of life of these individuals, making them more dependent[4]. As the disease progresses, changes in upper limbs will increasingly limiting work, recreation, and ADLs[3,4].

According to the European Physiotherapy Guideline for Parkinson's Disease[5], there are no specifically effective techniques for the rehabilitation of upper limbs in PD, requiring further investigations on beneficial therapies. Among some treatments, techniques such as music therapy[6], based on repetition training in simple and double task[7], movement therapy induced by upper limbs restriction[8], mirror therapy[4], Lee Silverman voice treatment – BIG method to improve the range of motion[9], have been used to rehabilitate and to minimize motor losses in the upper limbs[5].

However, in recent years, new technologies have emerged to assist in the rehabilitation process of subjects with PD, with virtual reality (VR)[10] being one of them. VR treats balance, gait, upper limb and lower limb deficits in different populations, such as older adults, in post-stroke sequelae, in multiple sclerosis and in PD. The techniques that use VR propose an interaction between the patient and a computer system, which creates a virtual environment. Sucha environment can stimulate motor learning via repetition, feedback, and motivation to achieve the expected results[11]. Furthermore, as VR involves cognitive and motor skills stimulation, it can contribute to greater independence in ADLs when compared to training based only on motor exercises. The intervention by VR is promising in the application of upper limbs motor movements[12].

One of the tools used for the rehabilitation of upper limbs is the Leap Motion Controller (LMC)[13], which allows for the creation of a control interface for hand and finger movements, requiring no manual contact or touch with the equipment[14]. There are also other types of instruments that use VR, such as the Kinect[15] and Nintendo Wii exergames, the latter has a motion sensor called the Wiimote and a platform called the Wii Balance Board[16]. However, LMC seems to offer more precise movements as well as more detailed information on hand and finger location, speed and angles of movement[17]. Likewise, this tool is interesting for rehabilitation and can be adapted according to the needs of each individual, promoting a more playful and fun interaction through various movements of the upper limbs that can be performed in several games[18].

Due to the portability and low cost of the sensor, LMC is appropriate for exercises in therapeutic and home environments without extensive supervision. The current literature shows relevant results regarding the use of LMC in the rehabilitation of upper limbs in other pathologies, evaluating gross motor function and manual dexterity, as in stroke[19-21], cerebral palsy[22], Duchenne muscular dystrophy[23], and post-burn rehabilitation[24]. However, only one pilot study with five participants described the use of LMC with a focus on improving dexterity and unilateral and bilateral manual coordination in PD[25]. Thus, this study aimed to verify the effects of an intervention in upper limbs with immersive virtual reality equipment in ADLs and in the quality of life of individuals with Parkinson's disease.

METHODOLOGY

This is a case series with convenience and non-probabilistic sampling, which evaluated and intervened via virtual reality in six individuals with PD. As inclusion criteria, participants should have the understanding of the games on the first day of familiarization and be able to perform the tests. Individuals who had brain pacemaker implantation, who had recent lesions or limitations in the function of upper limbs due to another diagnosis were excluded from the study.

Procedures and evaluations

Two weekly meetings lasting 27 minutes per session were held in the individuals' home environment over five weeks, totaling 10 interventions. Pre- and post-treatment evaluations were performed in the 1st and 10th interventions. The Mini Mental State Examination (MMSE)[26] was used to assess cognitive function encompassing the following domains: temporal orientation, spatial orientation, immediate and recall memory, calculus, language-naming, repetition, comprehension, writing, and drawing copy. This is not a diagnostic tool, but it helps to determine which functions should be investigated. The test procedure is given by a score, in order to assign the individuals' schooling level; thus, the higher the score, the lower the cognitive deficit. Then, the classification of the motor staging of PD was performed by the Hoehn and Yahr scale[27]. Based on this tool, the individual is classified into one of five stages based mainly on signs and symptoms to assess the disability level. Individuals classified in the scale from one to three are in the stages of mild to moderate disability, while those with stages four and five, severe disability.

After this procedure, the unified scale of evaluation for Parkinson's disease (UPDRS) was applied – part III (motor examination), items from 20 to 25, in which resting tremor, postural or kinetic tremor of hands, rigidity, quick finger tapping (thumb and index fingers) with the greatest possible amplitude, opening and closing the hands with fast and wide movements, and, finally, rapid movements of pronation and supination of hands. Recently, a study[28] evaluated and compared the original version (UPDRS) and the updated version (MDS-UPDRS) and found high reliability for the use of these items specifically for the evaluation of upper limbs.

Subsequently, the Parkinson's Disease Questionnaire (PDQ-39)[29] was applied, consisting of 39 questions covering the themes mobility, activities of daily living, emotional well-being, social support, body discomfort, stigma, cognition, and communication. In this questionnaire, the individuals identify how often they found themselves in the situations mentioned in the last 30 days. The options are never (zero points), rarely (one point), sometimes (two points), often (three points) and always (four points). From 0 to 100, the lowest score corresponds to the highest quality of life.

Finally, the *test d'*évaluation *des membrer supérieurs de personnes* âgées (TEMPA)[30] was applied, an instrument that assesses the degree of disability of the upper limbs. It presents a manual on how to administer it, the necessary measures to make the box and where to dispose of the specific material of each task. The materials required for

the test are: 100g coffee pot, 1,000mL water jar, coffee spoon, cup, water cup, medicine jar and 10 placebo capsules, white envelopes, seal, pencil, playing cards, coins (R$1, R$0.50, R$0.25, and R$0.10), small glass jar (7cm diameter and 5cm high), small objects (toothpick, nut, safety pin, 2.5cm diameter button and nail), piece of non-slip material and sheets for recording the scores[29]. Figure 1 illustrates the box and materials required to perform the test.

Figure 1. TEMPA Box

The test consists of performing tasks with the upper limbs, such as: (1) opening a pot and removing a spoonful of coffee; (2) unlocking a lock, picking up and opening a container of pills; (3) writing in an envelope and sticking a postage stamp; (4) shuffling and distributing playing cards; and the unilateral ones: (1) reaching and moving a pot; (2) lifting a jar and pouring water into a cup; (3) handling coins; and (4) picking up and moving some objects.

This test was translated into and adapted for Brazilian Portuguese, in addition to being validated for adults with PD. Each task should be timed from the moment the individual removes their hand from the cradle as soon as they finish the task[31]. Tasks are assessed in different ways. First by the speed of execution, and the time should be recorded and then the functional quotation, which refers to the autonomy to perform each task, should be evaluated. Then, the analysis of the tasks must be carried out, which characterizes and quantifies the difficulties faced by the examined individual, being composed of five items: active range of motion, force of execution of the movement, precision of the broad movements, grips and precision of the fine movements. All items are evaluated by a scale score. To complete the assessment, handgrip strength and relative isometric muscle endurance should be measured using a handgrip dynamometer and a stopwatch.

Intervention

Firstly, the patient was trained with the Leap Motion Controller instrument for five minutes for a presentation and interaction of virtual immersion. From the second meeting, the protocol was done in eight sessions: in the first game, lasting seven minutes; in the second and third game lasting six minutes each; and the last game lasting eight minutes, totaling 27 minutes of interaction with games. Between the games, a rest of about two minutes was adopted. The games were chosen in order to relate the movements performed with common tasks performed in the ADLs, and can be found at the Leap Motion website.

The LMC is a device with a Universal Serial Bus (USB) device capable of tracking hands and fingers via VR with high precision and performance[18]. Due to its small size, it is necessary to connect the USB device to the computer and place your hands above the LMC. The instrument has three infrared light emitters and two cameras that receive these lights. Regarding size and weight, it has respectively 8.0×3.0×1.2cm and 45g. As for the precision of the movements, it is the only device that allows interaction with objects of small thickness, from 0.01mm[32]. Figure 2a shows the device with VR interaction.

Participants were seated in a comfortable chair, without forearm support, with elbows flexed at 90°, in front of a table with the computer screen positioned horizontally to the eyes. The first game was the Playground, with three moments: first, hands must be placed under the LMC for calibration; then participants must take the squares and fit into the "bodies" that will appear, ending with the removal of petals from a flower (Figure 2b). Another game used was Takt – Rhythm, which involves hitting the notes where they appear in the space. This game has a score and is divided into difficulty-based levels (Figure 2c). The next game used was Vitrun Air, which consists of dragging a "sphere" along an obstacle course, from which the individual must dodge the obstacles until the end of each level (Figure 2d). Finally, the game Joca – The Handglider was played, which consists of moving a "plane" in order to get as many coins as possible, also dodging obstacles. The score count was restarted if collision occurred (Figure 2e).

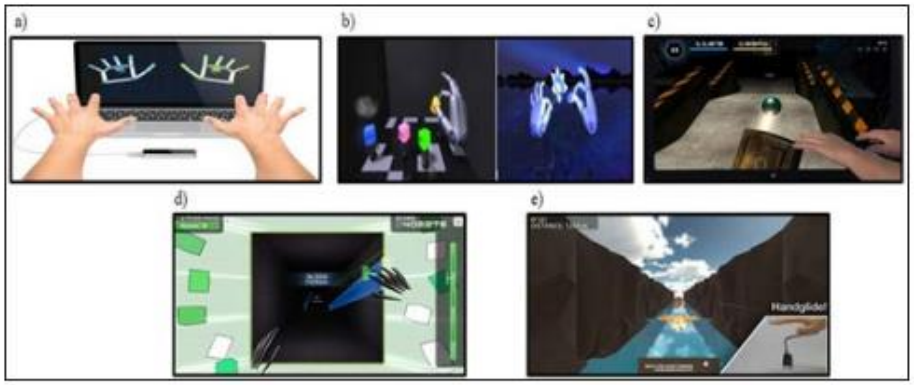

Figure 2. (a) Leap Motion Controller; (b) Playground; (c) Takt – Rhythm; (d) Vitrun Air; (e) Joca – The Handglider

At the last meeting, a satisfaction questionnaire with questions regarding the intervention, considering that most patients had never had contact with a laptop computer. The answers were objective and divided into questions, for example: "Did you feel pain at any time of therapy?", and the patient should mark among the options "a lot," "more or less," or "little."

Statistical analysis

Data were recorded in an Excel database and subsequently analyzed using the Statistical Package for the Social Sciences (SPSS) version 13.0.

In the descriptive analysis of continuous variables, the mean and standard deviation or median (interquartile range) were used. For the categorical variables, the data were expressed in n (% of all cases). The significance level adopted for all tests was 5% (α=0.05). To verify the means before and after the physical therapeutic care, paired t-test for parametric data and the Wilcoxon test for non-parametric data were used.

RESULTS

Among the six participants, two were women and four were men, with a mean age of 70.83 years. As shown in Table 1, participants were positioned from stages two to four on the Hoehn and Yahr scale.

Table 1. Sample demographics

Individual	Age	Gender	H&Y
1	59	W	2
2	76	W	3
3	47	M	3
4	72	M	2
5	86	M	2
6	85	M	4
Average	70.83	-	2.66

H&Y: Hoehn and Yahr scale; M: man; W: woman.

In the MMSE, we did not found statistically significant improvement in cognitive status, comparing pre- and post-intervention values. However, in the PDQ-39 the results showed a significant improvement in the individuals' quality of life. In the UPDRS-III scale (items 20–25), subjects showed no post-intervention improvement (Table 2).

Table 2. Comparison of pre- and post-intervention means and medians

Characteristic	Pre	Post	p
MMSE	23.333 (5.46)	25.333 (5.78)	0.08
PDQ-39	51.38 (26.85)	44.86 (22.29)	0.05*
UPDRS-III (items 20-25)			
ResTre	1.66 (1.36)	1.50 (1.04)	0.36
PostKinTre	2.00 (1.67)	1.83 (1.47)	0.36
Rig	1.50 (1.37)	1.50 (1.37)	-
FinTap	2.00 (1.00-3.00)	1.00 (1.00-3.00)	0.08
HanMov	1.00 (1.00-3.00)	1.00 (0-3.00)	0.15
ProSupM	1.66 (0.81)	1.33 (1.03)	0.17

Data on mean (standard deviation) or median (minimum and maximum). MMSE: Mini Mental State Examination; PDQ-39: questionnaire on Parkinson's disease; UPDRS-III: Unified Scale of Evaluation for Parkinson's Disease – motor examination; ResTre: resting tremor; PostKinTre: postural or kinetic tremor of hands; Rig: rigidity; FinTap: continuously finger tapping; HanMov: hand movements; ProSupM: pronation and supination movements of hands.

*: significant value in the pre- and post-intervention comparison.

Regarding TEMPA, the total result (functional quotation) showed a statistically significant improvement in questions related to ADLs (Table 3).

By analyzing each item corresponding to the tasks performed via the speed of execution, we could also observe a significant improvement in the items "pick up and move a pot – right hand," "lift a jar and pour water into a cup – right hand," "lift a jar and pour water into a cup– left hand," "handle coins – right hand," and "pick up and move small objects – right hand." Moreover, we observed significant positive outcomes in the hand grip strength of the right hand, as well as an improvement in post-intervention isometric resistance, in both hands (Table 3).

Table 3. Comparison of the means and medians of the pre- and post-intervention of TEMPA

Characteristic	Pre	Post	p
TEMPA	-25.83 (12.41)	-22.83 (12.84)	0.03*
PTP-D (sec)	4.77 (3.68-21.22)	3.70 (3.06-10.63)	0.02*
PTP-E (sec)	5.51 (3.25-16.43)	4.07 (2.68-10.20)	0.07*
APTCCC-B (seg)	21.45 (8.38)	19.57 (11.27)	0.32*
PJSA-D (sec)	18.31 (16.10-42.44)	13.82 (9.39-26.41)	0.02*
PJSA-E (sec)	18.85 (14.71-50.99)	14.43 (10.54-36.78)	0.02*
DFARCP-B (sec)	30.52 (27.12)	34.61 (10.75)	0.71*
EECS-B (sec)	40.15 (23.74)	45.39 (17.87)	0.74*
EDCJ-B (sec)	31.26 (22.76)	41.13 (15.89)	0.44*
MM-D (sec)	24.40 (12.37)	19.36 (10.16)	0.01*
MM-E (sec)	23.25 (11.15)	20.21 (5.42)	0.43*
PMPO-D (sec)	23.97 (13.53-38.07)	13.19 (9.72-35.47)	0.02*
PMPO-E (sec)	24.25 (10.72)	23.15 (13.61)	0.85*
Handgrip strength			
Right (kg)	20.97 (9.54)	28.45 (11.64)	0.02*
Left (kg)	21.11 (8.63)	25.59 (10.95)	0.08*
Isometric endurance			
Right (sec)	21.08 (13.84-62.4)	36.81 (24.66-72.45)	0.04*
Left (sec)	26.31 (17.49)	37.39 (21.53)	0.01*

Data on average (standard deviation) or median (minimum and maximum). Tempa: test d'évaluation des membres supérieurs de personnes âgées; PTP-D: pick up and move a pot – right hand; PTP-E: pick up and move a pot – left hand; APTCCC-B: open a jar and take out a spoonful of coffee – bilateral; PJSA-D: lift a jar and pour water into a cup – right hand; PJSA-E: lift a jar and pour water into a cup – left hand; DFARCP-B: unlock a lock and open a container of pills – bilateral; EECS-B: write in an envelope and stick a postage stamp – bilateral; EDCJ-B: shuffle and distribute playing cards – bilateral; MM-D: handle coins – right hand; MM-E: handle coins – left hand; PMPO-D: lift and move small objects – right hand; PMPO-E: lift and move small objects – lefthand.

*: significant value in the pre- and post-intervention comparison.

Regarding the satisfaction questionnaire applied (Table 4), we observed that all participants reported the games as "fun" and "interesting." Considering the difficulty imposed by some games, the individuals answered that the physical therapist support was essential. Some subjects reported that after playing the games, they felt tired or in pain, but nothing that prevented them from performing the intervention.

Table 4. Virtual Reality Satisfaction Questionnaire

No.	Question	IND 1	IND 2	IND 3	IND 4	IND 5	IND 6
1	Are video game sessions fun?	2	2	2	2	2	2
2	Were the games interesting to you?	1	2	2	2	2	2
3	Do games meet a real need?	2	2	2	1	2	2

(continues)

Table 4. Continuation

No.	Question	IND 1	IND 2	IND 3	IND 4	IND 5	IND 6
4	Would you keep using the games if you could?	2	2	2	1	2	2
5	Would you use the games at home?	1	2	2	0	2	2
6	Were the games clear to play and easy to understand?	2	1	1	1	1	0
7	Were you able to play without the support of the physical therapist?	1	1	1	1	0	0
8	If you did receive support, was the physical therapist's support important?	2	2	2	2	2	2
9	Was the game model adequate?	2	2	2	2	2	1
10	Are the elements used in therapy sessions adequate (laptop computer, leap motion)?	2	2	2	2	2	2
11	Were you able to perform all games successfully?	2	1	2	2	1	0
12	Were one-handed exercises simple to perform?	1	1	2	1	1	0
13	Were the exercises with both hands simple to perform?	1	1	1	2	1	0
14	Did the games require much effort?	1	1	2	0	2	2
15	In general, is the level of difficulty of the games adequate?	2	2	2	2	2	1
16	Did you feel tired after playing the games?	0	2	1	0	1	2
17	Did you feel pain at any point in therapy?	0	2	1	0	0	2

IND: individual; "0": little; "1": more or less; "2": much.

DISCUSSION

Based on this study objective, to verify the effects of an intervention in upper limbs with semi-immersive virtual reality device in ADLs and in the quality of life of individuals with Parkinson's disease, in both TEMPA and PDQ-39 tests, individuals with PD improved after intervention. These findings corroborate the study by Tomo et al.[7], who analyzed the effects of training four tasks (wearing a coat, combing hair, answering the phone, and taking a glass to the mouth). In this study, the groups were divided into simple and double task over five one-hour long training sessions and 15 minutes for each task, in which improvement was observed in the box and block test[33]. Alike, our research tasks were similar to the mentioned study, as they intended to improve the functionality of the upper limbs and were similar to the performed ADLs.

Motor limitations related to ADLs—such as mobility and communication—negatively affect quality of life, causing depression and leading to little interaction and participation in the social life of individuals with PD[33]. The study by Fontoura et al.[34] conducted an intervention with conventional physical therapy and VR, using the Microsoft Kinect X-Box console to perform the Kinect Adventures games, which consists of several adventures and sports, and Kinect Dance, which involves dancing, through a motion sensor that tracks the entire body. The intervention involved the performance of movements of the upper limbs with different amplitudes, lasting 30 minutes, for five weeks. The authors observed quality of life improvements, similar to the study by Santana et al.[35], which evaluated the effects of VR on the quality of life of patients with PD, also using the PDQ-39 as an investigation tool.

In the study by Oña et al.[25], an intervention was performed via VR with LMC in a protocol with six games, two sessions of 30 minutes per week, for six weeks, with five patients, observing an improvement in muscle strength, especially in the hand not affected by PD. Furthermore, they also observed that, despite the participants accepting the intervention, they had difficulties executing some exercises. This study showed an improvement in muscle strength and endurance, the latter possibly due to the fact that the participants remained for 27 minutes with elevated upper limbs, contracting muscles such as deltoid, supraspinatus, infraspinatus, round pronator, wrist and finger flexors, among others. According to the questionnaire applied at the end of the study, the interventions were satisfactory, fun, and interesting; however some participants experienced difficulties in performing some movements in the proposed games, sometimes requiring the therapist assistance.

Although some studies indicate that the interaction with VR can become exhaustive and cause fatigue after 20 minutes, the results of this intervention show good

potential even in short- and medium-training sessions[24,25]. In the study by Soares et al.[36], the sessions lasted 30 minutes and improved the execution time of the box and block test [33]. Similarly, Wang et al.[37] with 45-minutes long sessions, found possible beneficial results in the recovery of the functioning of the upper limbs in subjects who suffered a subacute vascular accident. In the study by Iosa et al.[20] with sessions of 30 minutes, good results were also found in the recovery of manual skills, assessed via the 9-hole peg test[38] after the LMC intervention. Thus, our research is in line with the aforementioned studies regarding the protocol used—27 minutes per session—since the individuals did not present fatigue or pain that made the intervention impossible, making it possible to perform all games without dropping out during the protocol.

In the study by Santana et al.[35], they observed functional gains in all aspects of UPDRS-III after intervention with VR and functional exercises for upper limbs, lower limbs and balance, in groups that underwent game therapy. Pompeu et al.[39], who conducted a comparative research between groups of individuals with PD who underwent game therapy and balance exercises, showed improvement in motor functioning after the intervention in both groups. In this study, we did not verify significant improvement in the UPDRS-III scale (items 20–25), which is possibly related to the therapy targeting only wide movements of the upper limbs, as well as the small number of participants.

VR presents motor and cognitive demands, in which some specific skills are trained and compromised by Parkinson's disease. The games reflect important elements for motor learning, such as repetition, motivation and feedback, and enhance cognitive use due to the visual and auditory cues provided by the games[40]. Based on our outcomes, even observing the engagement and a better performance in the games during the intervention, no significant improvements were obtained in the MMSE score, which might be explained by the intervention period, stages of the disease from mild to moderate and small sample size. Finally, games can improve attention and concentration by repeating movements and, consequently, stimulate motor learning.

Our outcomes are significant, achieving the proposed objective, showing that the use of the LMC device can be an effective method for rehabilitation in Parkinson's disease. However, there were some limitations in relation to the small sample size, the heterogeneity of the patients and the low number of sessions. Therefore, we suggest to carry out further studies with VR via the Leap Motion Controller to consolidate this intervention tool, with a greater number of sessions, a more homogeneous sample, and more participants.

CONCLUSION

The intervention protocol based on VR was effective in improving the functioning of the upper limbs, thus contributing to ADLs and the quality of life of individuals with PD in this study. Notably, all games improved performance during the intervention and, based on the satisfaction questionnaire, we observed a good acceptance of the proposed protocol. Thus, the semi-immersive virtual reality with the use of the Leap Motion Controller device seems to be an effective proposal for rehabilitation of the upper extremities in Parkinson's disease.

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5 ARTIGO 3

VIRTUAL AND BOARD GAMES AS THERAPEUTIC RESOURCES FOR UPPER LIMB FUNCTIONALITY IN PARKINSON'S DISEASE: A RANDOMIZED CLINICAL TRIAL

(Formatado conforme normas do periódico Disability and Rehabilitation: Assistive Technology – *Qualis A2, Fator de Impacto 2.290*)

Abstract

Purpose: To analyze and compare the effects of non-immersive virtual reality (VR) games with board games on the functionality of upper limbs, activities of daily living (ADLs), and quality of life (QoL) in individuals with Parkinson's disease (PD).
Materials and Methods: Twenty PD subjects, classified as Hoehn & Yahr 2-3, were randomly divided into non-immersive VR games (n=10) and board games (n=10), with median ages of 67 and 69 years, respectively. They engaged in 30 minutes of gameplay, twice a week for 8 weeks. Outcomes were measured using the following assessments: ADLs (TEMPA test), manual dexterity assessed by the Box and Block Test (BBT) and Nine Hole Peg Test (9HPT), UPDRS parts II and III, QoL (PDQ-39), and cognitive screening using the Montreal Cognitive Assessment (MoCA).
Results: Both groups showed improvements in execution time with the right hand, manual endurance of the left hand, and functional scoring of the test. In the BBT, improvement was observed in both groups, but without any intergroup differences. Positive results were observed in the 9HPT for the right hand, while only the VR games group showed improvement in the execution of the task with the left hand, performing better compared to the board games group. Additionally, both groups showed improvement in UPDRS parts II and III, and PDQ-39. The MoCA test did not show any changes in either of the groups.
Conclusion: VR and board games demonstrate significant potential as rehabilitation protocols for upper limbs, directly impacting ADLs and QoL in PD individuals.

Keywords: Parkinson Disease; Upper Extremity; Activities of Daily Living; Virtual Reality; Play and Playthings

Implications for Rehabilitation

- Rehabilitation programs using virtual reality and board games seem to have greater adherence, in addition to provide a challenging and motivating role to the user.

- The use of virtual reality in a rehabilitation program allows the modulation of exercises, enabling a wide variety of therapeutic options.

- Providing different treatment modalities, especially through board games, for the rehabilitation of upper limbs, facilitating the execution of daily activities in Parkinson's disease.

INTRODUCTION

Parkinson's disease (PD) is a chronic neurodegenerative disease of the central nervous system, characterized by the progressive loss of dopamine-producing cells in the substantia nigra, leading to both motor and non-motor symptoms, including impairment of upper limb (UL) [1]. The disease affects approximately 10 million individuals worldwide, with an annual increase of nearly 60,000 new cases [2]. The burden of motor symptoms and the impairment of some activities of daily living (ADLs), such as eating, hygiene and dressing, related to changes in functional mobility, have been identified as one of the main predictors of quality of life (QoL) in this disease [3].

Since the early stages of PD, changes occur causing impairments in speed and range of motion, resulting in manual function losses, directly affecting the reduction of ADLs and, consequently, the QoL for these individuals making them more dependent [4]. As the disease progresses, UL disturbances can lead to limitations in work, recreation, daily tasks [5] and the presence of rigidity, along with bradykinesia and tremor, hinders complex integrated or repetitive movements [6].

For example, a change is observed in handwriting, where a sentence begins with well-formed letters and progressively deteriorates into smaller and slower letters [5]. Actions such as shaving, brushing teeth, combing hair, buttoning, applying makeup, dressing or playing musical instruments become extremely difficult [7]. Thus, despite clear evidence of deficits in UL motor control and dexterity in PD, significantly impacting ADLs [8], most rehabilitation research and clinical practice primarily focus on gait and postural balance-related issues [9]. Therefore, considering that upper extremity motor disturbances are only slightly responsive to dopaminergic treatment, regular therapist monitoring in the rehabilitation process can bring numerous benefits to individuals with PD [10].

Among the modalities for treating UL disturbances in PD, non-immersive virtual reality (VR) games, defined as the use of simulations created from hardware and software that allow the user to engage with environments mimicking the real world [11], stand out as a technological therapy recommended for improving movement learning. Through visual feedback, the individual can work on both motor and cognitive processes simultaneously in a challenging and

motivating environment [12]. Additionally, an external observer can monitor and record the user's performance in the proposed task, analyzing its progress in the activity [13]. However, despite recent systematic review evidence of VR's effects on manual dexterity [14], little is known about the effects of this modality on aspects related to ADLs and the impact on the QoL of individuals with PD.

On the other hand, board games, with evidence of improvement in cognition, fine motor skills and coordination in institutionalized elderly individuals [15], may be another resource for treating UL disturbances in PD. These games are played on tables and do not require electronic devices, hence referred to as "offline games". Compared to other types of games, they offer players concrete experiences that increase intention in participation, stimulate thinking and conflict resolution. Besides being a leisure activity, board games also offer players the opportunity to learn and experience a sense of achievement and satisfaction [16].

Therefore, the impact of arms dysfunctions in PD demands increased research efforts to explore possibilities for treating these impairments. Thus, the objective of this study was to analyze and compare the effects of non-immersive virtual reality games and board games on the functionality of upper limbs, activities of daily living and quality of life of individuals with Parkinson’s disease.

METHODOLOGY

This study consisted of a single-blind, randomized controlled clinical trial conducted in the subject’s home. It received ethical approval from the Federal University of Health Sciences of Porto Alegre (UFCSPA - no: 3.715.577) and was registered on Clinicaltrials.gov (IDNCT04796246). Before inclusion in the study, participants were properly informed about the study's objectives and course and received written information, providing consent to participate.

The protocol followed the standards established by the Declaration of Helsinki for experiments with human subjects. Individuals were recruited through telephone contact from a pre-existing list provided by the researchers. Participants diagnosed with PD, aged above 18 years, who were able to perform the tests and demonstrated an understanding of the games on the first day of familiarization were selected.

Individuals with deep brain stimulation and those with recent upper extremity (UE) injuries were excluded from the study.

Procedures and evaluations

Clinical and sociodemographic characteristics were collected at the beginning of the study to describe the sample. These measures included age, gender, laterality and disease staging. All data were collected by an independent researcher who was unaware of the patient allocation group at the beginning and after the intervention program.

The Test d'Évaluation des Membres Supérieurs de Personnes Agées (TEMPA) [17] was used to assess the degree of UL disability. The Brazilian version of the instrument consists of 8 standardized tasks that simulate ADLs, with 4 bilateral and 4 unilateral tasks. The functional tasks are as follows: (1) picking up and carrying a pot (unilateral); (2) opening a pot and taking a full coffee spoon (bilateral); (3) picking up a jar and pouring water into a glass (unilateral); (4) unlocking a lock and opening a container with pills (bilateral); (5) writing on an envelope and sticking a stamp on it (bilateral); (6) shuffling and dealing cards (bilateral); (7) picking up coins (unilateral); and (8) picking up and moving small objects (unilateral). The scores obtained in TEMPA were based on execution speed measured in tenths of a second, the degree of functionality and task analyses.

The degree of functionality refers to individual autonomy in each task, graded according to a 4-level scale: 0 - the task was successfully completed without hesitation or difficulty; 1 - some difficulty or hesitation in completing the task; 2 - the task was partially executed or some steps were performed with significant difficulty, possibly requiring task modification or assistance from the evaluator; and 3 - could not complete the task, even with assistance provided. Task analysis quantifies the difficulty encountered by the subject, according to 5 items related to sensorimotor skills of the UL: strength, range of motion, precision of broad movements, grip and precision of fine movements.

When the subject obtains a score of -2 at the functional level, the execution speed is not listed. The value of the total functional grading represents the sum of right unilateral tasks (0 to -12), left unilateral tasks (0 to -12), and bilateral tasks (0 to -12), potentially ranging from 0 to -36. Similarly, the same summary is done for the other 5 dimensions of functional analysis tasks. Considering that the precision of fine movement is not rated for tasks 1 and 3, and strength is not rated

for tasks 5 to 8, the task analysis dimension can range from 0 to -150. The total score represents the sum of functional and task analysis grading, totaling -186. Although the original scale proposes a negative score, with 0 indicating no disability and negative values indicating greater disability, the values were used independently of the sign in the statistical analysis. Thus, for this study, higher values correspond to greater disability. To complete the assessment, handgrip strength (average of the 3 measurements of maximum strength performed alternately on each limb) and relative isometric muscle endurance (time of grip above half of the average maximum strength) should be measured using a handgrip dynamometer and a stopwatch [18].

The Box and Block Test (BBT) was used to measure unilateral manual dexterity and consists of moving as many cubes as possible from one compartment to another in a wooden box, one by one, in one minute [19]. The Nine-Hole Peg Hole Test (9HPT), used to assess unilateral manual dexterity, consists of nine pegs and a board with nine holes, in which the individual is instructed to pick up one peg at a time and insert it into the holes contained in the board and then remove the pegs and return them to the original location. The time to complete the task is timed by the researcher [20].

The updated Unified Parkinson's Disease Rating Scale (UPDRS) encompasses Part I, Mentation, Behavior and Mood; Part II, Activities of Daily Living; Part III, Motor; Part IV, Complications. Only Part II was applied, designed to be a self-report questionnaire, but it can be reviewed by the investigator to ensure clear and complete completion, and Part III, in which instructions for the evaluator to provide or demonstrate tasks to the individual and is filled out by the evaluator. A higher score corresponds to a worse state [21]. The Hoehn & Yahr staging scale (H&Y) classify the motor stage of PD according to mainly symptoms. Subjects classified between one and three are in mild to moderate disability stages, while those in stages four and five are considered severely disabled [22].

Quality of life was assessed through the 39-item Parkinson's Disease Questionnaire (PDQ-39), consisting of 39 questions divided into 8 subscales (mobility, ADL, emotional well-being, stigma, social support, cognition, communication and bodily discomfort). The total score is given by the sum of all items and is then transformed into a range of 0 to 100 [23]. A lower value

corresponds to a better perception of the subject's QoL. Finally, the Montreal Cognitive Assessment (MoCA) for cognitive screening measures eight cognitive domains (short-term memory, visuospatial skills, executive function, attention, concentration, and working memory, language, orientation in time and space) that are scored within a range of 0 to 30 points (higher scores indicate better function) [24].

The primary outcome measure was activities of daily living (TEMPA test), and the secondary outcomes were manual dexterity (BBT and 9HPT); motor and daily life aspects (UPDRS parts III and II); grip strength and manual grip endurance (handgrip dynamometry); and quality of life (PDQ-39).

Participants were instructed to follow their normal medication and physical activity schedule without initiating any new exercise or medication program during the study. The pre- and post-tests occurred one hour after patients took their usual PD medications (the "on" state) to minimize motor fluctuations and variability of motor symptoms, administered by a blinded assessor.

Interventions

After the initial assessment (pre-test), participants were randomly assigned to a non-immersive virtual reality game-based therapy (VR games group) or a board game-based therapy (board games group). A single physiotherapist conducted the sessions with each participant individually for each group over 8 weeks. The 30-minute sessions were conducted twice a week on non-consecutive days, totaling 16 interventions. Each game had a total time of 6 minutes when performed with both arms concurrently (bilateral). When performed unilaterally, the total time was divided into 3 minutes per limb, totaling the same 6 minutes.

Participants from both groups were seated in a comfortable chair without forearm support, with their elbows flexed at 90 degrees, in front of a table. The VR games group used the Leap Motion Controller (LMC), a Universal Serial Bus (USB) device capable of detecting hand and finger movements through a non-immersive VR with high precision and performance, connected to a laptop computer [25]. The games used were "Playground," "Project Takt," "Virtrum Air," and "Joca - The Handglider", extracted from the website *gallery.leapmotion.com*.

The board games group used the games "Cai-não-Cai," "Genius®," "Disco-Bol," and "Futebol de Pinos". The description of all games is provided in Table 1.

----- INSERT TABLE 1 HERE -----

Statistical Analysis

The data were recorded in an Excel database and subsequently analyzed using Statistical Package for the Social Sciences (SPSS) version 20.0. The sample size was calculated after collecting data from 5 individuals per group. The difference between two means with independent groups was used for descriptive analysis, considering the main outcome of the study (TEMPA - Functional Score), with a minimum detectable difference of 5 points for a 5% alpha value and 20% beta value [26], resulting in 8 participants per intervention group.

The Shapiro-Wilk normality test indicated that the data had a non-parametric distribution. Continuous variables were described as median (minimum-maximum), while categorical variables were presented as absolute and relative frequency (n, %). The comparison of frequencies between groups (categorical variables) was performed using the chi-square test with adjusted residual analysis.

To compare medians before and after interventions, Wilcoxon test (within groups) and Mann-Whitney test (between groups) were used. A significance level of $p \leq 0.05$ was adopted and Cohen's effect size "r" was described for significant values ($r=z/\sqrt{n}$; 0.2-0.5: small effect, 0.5-0.8: moderate effect, 0.8 or more: large effect) [27].

RESULTS

Flowchart and Sample Characteristics

The study included a total of 20 participants, who were randomized into two distinct groups: the VR games group, consisting of 10 participants, and the board games group, also with 10 participants. To ensure concealed allocation, the eligibility of study subjects was determined based on inclusion criteria established by a blinded assessor who was not involved in the randomization process. The study design and distribution of individuals among the groups can be visualized in figure 1.

----- INSERT FIGURE 1 HERE -----

The analysis of the sample characterization data did not show any significant differences in any of the comparisons between the groups. The sample consisted of a total of 20 participants, with 10 in each group. The age range varied from 47 to 81 years, with medians of 67 and 69 years in the VR games group and board games group, respectively. Of the participants, 13 were male, and 7 were female.

Regarding the distribution of PD subtypes, each group showed an equal proportion. In terms of the most affected side by the disease, 11 individuals had the left side compromised, with 5 in the VR games group and 6 in the board games group. Additionally, the majority of participants were right-handed, with 9 individuals in the VR games group and 10 in the board games group. Regarding the motor staging, subjects ranged between stages 2 and 3 on the Hoehn and Yahr scale (Table 2).

----- INSERT TABLE 2 HERE -----

Activities of Daily Living, Manual Dexterity, Motor Examination, and Quality of Life

The results of the interventions before and after 16 sessions for both groups were compiled in Tables 3 and 4. Analyzing the TEMPA test data, no significant differences were found in the comparisons between the two groups in any of its domains. However, both the VR games group and the board games group showed improvements in execution time with the right hand, manual endurance of the left hand and functional scoring of the test. Additionally, the board games group also demonstrated improvements in bilateral execution time, manual endurance and manual strength of the right hand. The other variables did not show changes in the groups.

Concerning the results of the BBT, improvement was observed in both groups, but with no significant differences in the comparisons within the groups. In the 9HPT, both groups showed improvement in execution with the right hand, and only the VR games group showed positive values in execution with the left hand, surpassing the board games group in this aspect.

In the UPDRS - part II (Activities of Daily Living) analysis, both groups showed improvement in the total score. No significant differences were found in the comparison between groups. Regarding part III (Motor) of the UPDRS, only VR games group obtained a higher total score, showing more effectiveness in the comparison between the groups in this aspect.

Regarding the participants' quality of life, assessed by PDQ-39, both groups showed improvement in the total score and the emotional well-being item. However, the VR games group had isolated positive results in items related to activities of daily living and stigma. On the other hand, only in the board games group there was an improvement in mobility and communication items, showing superior results when compared to the VR games group in these aspects. The remaining analyses, including the MoCA test, did not show significant changes in either group.

----- INSERT TABLE 3 AND 4 HERE -----

DISCUSSION

Our study aimed to compare the effects of non-immersive virtual reality games with board games on upper limb functionality, activities of daily living and quality of life in individuals with PD, finding a significant improvement in these variables within each group. However, no significant differences were found in the comparison between the groups. This demonstrates that regardless of the method used, the proposal of specific and challenging activities for upper limbs dysfunctions can lead to significant modifications in the daily functions PD individuals.

In a study conducted by Proud et al. [5], it was highlighted that, among various tests, the BBT and 9HPT were considered useful tools to assess the level of arms activity in PD. However, these measures focus solely on the fine motor skills of individuals. This raised a subsequent question [18] about the "clinical utility of evaluating limitations in arms activities with tests or tasks that do not represent these individuals' ADLs and do not include the actual handling of objects?" In this context, the TEMPA test was developed as a tool that presents sequential tasks, including quantitative parameters (evaluation of execution speed) and qualitative parameters (functional scoring and task analysis) to detect upper limbs deficiencies [17].

By using this instrument specifically designed to evaluate UL motor function, as well as the ability to perform ADLs and functional independence [28], it became possible to infer, based on the improvement in quantitative and qualitative analysis evidenced by the TEMPA test in this study, that virtual and conventional game therapies are effective in improving ADL performance in PD. This finding reinforces the relevance of these therapeutic approaches in treating PD subjects, providing significant gains in UL functionality and, consequently, in the performance of daily activities.

Considering the relevance of games in rehabilitation and the restoration of arms functionality, the challenging role they impose on individuals with PD is noteworthy. While conventional therapies follow predetermined series and repetitions by the therapist, games bring tasks with goals to be achieved, stages to overcome and the possibility of facing opponents, either virtual or real. A recent study [15] highlighted that playing board games is an excellent opportunity for social interaction for the elderly in long-term care facilities, as these adults often lack social stimuli. In the present study, it was also evidenced that both the "social support" item and "communication" item, evaluated by the PDQ-39, had superior results in individuals undergoing this intervention. Additionally, virtual games can stimulate neural plasticity and motor reorganization in humans, activating mirror neurons in areas related to cortical, subcortical and cerebellar motor control through the visualization of body parts projected on the screen. Active therapy with virtual games also reduces the boredom of the rehabilitation process, increasing participant motivation, providing direct feedback and allowing dual-task training [29].

Manual dexterity is an impactful factor for tasks performed with the UL and can be influenced by cognitive factors such as attention, planning and working memory [30]. Therefore, interventions aiming improving cognitive function may indirectly benefit manual function in individuals with PD. A study conducted by Leung [31] showed that cognitive stimulation through computerized game-based interventions improves fine motor skills compared to control groups receiving other forms of intervention, such as balance training and speech therapies. Although our results did not show specific changes in cognition evaluated by the MoCA test, positive effects were observed in fine motor skills assessed by the BBT and 9HPT in both groups. This suggests that specific approaches for UL,

combined with challenges imposed by games, have the potential to produce benefits in the fine coordination of PD individuals.

Although the scientific literature on the specific use of board games in PD is limited, there are studies that highlight the general benefits of this modality for cognition, fine motor skills and social interaction. Chen [32] analyzed the effects of board games on the elderly, addressing improvements in cognition and reduced risk of cognitive decline. Although not exclusively focused on Parkinson's disease, the mentioned study provides evidence of the potential of this intervention to stimulate cognition and functionality in individuals. Additionally, Joddrell [33] investigated the use of board games and video games as a form of treatment for older adults, highlighting the therapeutic benefits of improving fine motor skills, cognition and social interaction in the elderly. Also, Noda [34] showed that, as a tool, board games can be expected to enhance knowledge comprehension, increase interpersonal interactions and motivate participants.

On the other hand, the study by Hindle [35], although focusing on cognitive rehabilitation in people with dementia associated with PD, emphasizes the importance of structured and goal-oriented activities, such as board games, to improve cognitive function and quality of life. Based on this, the present study demonstrated significant improvements in cognitive and functional skills in subjects who participated in board game-based interventions. Thus, it was possible to demonstrate an innovative and potentially positive therapeutic modality for UL functionality in PD.

A recent systematic review developed by our research group showed that VR-based therapy has great potential and feasibility to be used as a rehabilitation protocol for fine and gross manual dexterity in PD individuals. In this study, six out of eight analyzed studies used the Leap Motion Controller device for treatment [14]. Fernandez [36] identified that the LMC system and the designed serious games can be a viable rehabilitation tool for improving coordination, movement speed, and fine dexterity of UL in PD. Additionally, the feasibility of the tool for therapeutic execution in clinical and home environments was verified, ruling out possible adverse effects of computer screen use [37]. These results highlight that the use of virtual games through the LMC device represents a new therapeutic possibility for PD treatment, with the potential to increase arms functionality and have a direct impact on the ADLs of these individuals.

Harrison [38] revealed, based on their analysis of the UPDRS - part II scale in a cohort of 888 individuals, a robust correlation between ADL sub-scores and disease duration. This finding suggests that this measure could potentially serve as a superior marker of disease progression compared to the signs and symptoms assessed in other sections of the UPDRS, such as motor examination in part III. Paz [39] also observed that manual grip strength held predictive value for motor impairment in individuals experiencing freezing of gait. The recognition of VR and board games benefits for ADLs, assessed by the UPDRS - part II, along with the functional performance observed in the TEMPA test, has the potential to exert a direct impact on disease progression. Furthermore, the direct influence on overall quality of life as indicated by the PDQ-39 total score and the ADL subitem, specifically within the VR game group, is noteworthy. This could have significant implications for disease progress and the absence of changes in this subitem within the board game group may be due to lack of alterations prior to treatment.

Muscular rigidity and bradykinesia can impair the performance of simple tasks such as dressing, buttoning, zipping up, putting clothes over the head and tying shoelaces. Additionally, impaired dexterity can lead to spills, difficulties in cutting food and delays in eating, which can result in nutritional problems and even a decrease in the pleasure of eating [40]. This can result in frustration and delays in the execution of these basic activities, which can also hinder the use of cutlery, such as holding and properly manipulating food [41]. Thus, the improvement in the execution of ADLs and the reported quality of life, based on the proposed protocols, highlights the importance of treatment focused on the specificity of UL tasks, which, together with the impact on the daily life and well-being of individuals with PD, restore their independence and functionality to some extent.

An important point to highlight is that, except for the body discomfort and cognition items of the PDQ-39 questionnaire, all others (ADLs, mobility, well-being, stigma, social support, and communication) showed positive results in one or both interventions. A recent study [42] showed that factors related to loneliness and greater isolation in PD were associated, among other factors, with greater limitation in ADLs, lower palmar grip strength, more physical inactivity, higher frequency of pain and lower quality of life. It was also shown that PD involves

several social symptoms, such as difficulties in producing facial expressions and speech, which can have negative social consequences and greatly impact the QoL [43]. Thus, in the present research, a positive impact of direct interaction between the therapist and the individual was observed for issues related not only to ADLs and mobility but also to well-being, stigma, social support, and communication. Therefore, the role of the rehabilitator in approaches that provide moments of contact, interaction and communication is of fundamental importance, as well as therapies that encompass these aspects, promoting greater potential in PD rehabilitation.

Limitations of our study are the sample restriction regarding motor staging (Hoehn & Yahr 2-3), harm the power of the study to generalize prevents the generalization of results to more advanced cases of PD. Additionally, it is relevant to consider the feasibility of proposing the same board games in the virtual environment to enable a more specific comparison of the approach, despite the positive results presented here. Electromyographic analysis of specific muscle activation in different approaches may broaden the discussion about other factors influencing the improvement of UL. Therefore, possibilities are open for future studies that can elucidate other impacts of game use in the treatment of UL in PD.

CONCLUSION

The use of games for the treatment of arms functionality in Parkinson's disease represents an important rehabilitation tool, especially in the early to moderate stages of the disease. The ease of use, non-invasive nature, and, most importantly, the challenging environment proposed, whether in a virtual setting using the LMC or in a real setting using board games, allows for stimulating the functions of the upper limbs affected by the disease beyond what is usual.

Thus, the continuous development of methods with diverse approaches becomes crucial, aiming to improve activities of daily living and quality of life for individuals at all stages of Parkinson's disease. The design of new strategies and approaches that adapt to individual needs is essential, promoting a holistic and comprehensive intervention to better face the challenges imposed by PD.

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FIGURES AND TABLES

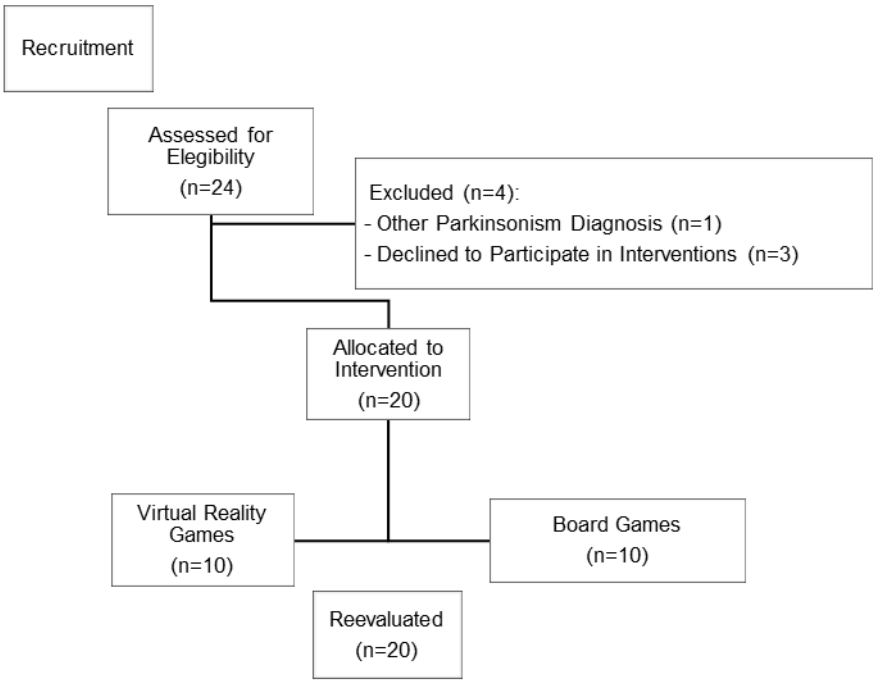

Figure 1: Flowchart

Table 1: Description of Games

Groups	Games	Description	
Virtual Reality Games (n=10)	**"Playground"** 	To pick up the squares and fit them into the "robots" that will appear, using pinch movements (thumb and index finger). Finally, all the petals of a flower must be removed.	Uni lateral
	"Project Takt" 	Touch the musical space that appears according to the rhythm of the music, performing wrist flexion/extension movements with slightly bent elbows. Divided by levels of difficulty, increasing as the interventions progress.	Bi lateral
	"Vitrun Air" 	Drag a "sphere" through a course that will present obstacles, taking care not to collide or fall into them. Perform elbow flexion/extension movements with the hand in a pronated position. The game features a time limit to advance to the next stage.	Uni lateral
	"Joca – The Handglider" 	Maneuver an "airplane" to collect as many coins as possible and be careful not to collide with obstacles. Movements involve pronation/supination of the hand and flexion/extension of the shoulder.	Uni lateral
Board Games (n=10)	**"Cai-Não-Cai"** 	Remove the highest number of sticks without letting the balls fall. Interaction with thin sticks, using pinch movements (thumb and index finger).	Uni lateral
	"Genius®" 	Tap on the sequence of colors proposed by the equipment itself with memorization and quick response, performing elbow and wrist flexion/extension movements.	Bi lateral
	"Futebol de Pinos" 	Simulate a soccer game, using the sticks to drive the ball to the opponent's goal with just one touch. Bilateral movements of wrist flexion/extension and pinch.	Uni lateral
	"Disco-Bol" 	Hit the disc towards the opposite goal to score a goal and prevent the opponent from scoring in your own goal. The movements involve elbow and wrist flexion and extension in a pronated position.	Uni lateral

Unilateral, one upper limb; Bilateral, two upper limbs.

Table 2: Sample Characterization

	Virtual Reality Games (n=10)	Board Games (n=10)	p
Age (years)	67 (47-81)	69 (63-72)	0,448
Gender			
Female	3 (30)	4 (40)	0,639
Male	7 (70)	6 (60)	
Laterality			
Left	5 (50)	6 (60)	0,653
Right	5 (50)	4 (40)	
Dominant Hand			
Left	1 (10)	0 (0)	0,305
Right	9 (90)	10 (100)	
Hoehn & Yahr			
2	4 (40)	6 (60)	0,371
3	6 (60)	4 (40)	

Continuous variable expressed as median (minimum-maximum). Categorical variables expressed as n (%). "p" value obtained for continuous variable through the Mann-Whitney test and categorical variables through the chi-square test with adjusted residue analysis. Laterality, side of symptom onset.

Table 3: Results of pre - and post - intervention clinical tests.

	Virtual Reality Games (n=10)				Board Games (n=10)				
	PRE	POST	p[a]	r[b]	PRÉ	POST	p[a]	r[b]	pΔ[c]
TEMPA									
Unilateral R (s)	46,6 (37,6-59,8)	40,6 (27,9-53,5)	0,022*	0,726	45,6 (33,0-82,7)	42,9 (30,9-49,3)	0,012*	0,792	
Δ (s)	-7,5 (-27,5-3,5)				-6,2 (-33,3-0,5)				0,762
Unilateral L (s)	47,0 (32,1-65,7)	45,1(27,0-69,8)	0,202	-	46,8 (26,7-76,0)	44,1 (29,4-46,1)	0,168	-	
Δ (s)	-3,4 (-21,8-15,4)				-2,4 (-29,9-2,6)				0,494
Bilateral (s)	97,0 (83,9-182,7)	109,0 (81,1-142,6)	0,284	-	115,9 (72,3-139,6)	99,7 (63,3-131,7)	0,012*	0,791	
Δ (s)	-9,6 (-40,0-24,0)				-9,6 (-22,1-1,4)				0,880
Total Time (s)	204,9 (167,0-291,8)	194,4 (136,1-239,8)	0,074	-	217,7 (132,2-298,4)	187,9 (126,3-227,3)	0,005*	0,888	
Δ (s)	-13,5 (-52,4-18,4)				-26,8 (-71,1- -2,6)				0,705
Endurance R (s)	43,0 (16,0-64,0)	55,6 (6,9-72,4)	0,074	-	45,8 (20,7-55,2)	66,4 (47,3-120,1)	0,028*	0,694	
Δ (s)	7,7 (-9,7-37,1)				27,1 (-3,8-64,8)				0,449
Endurance L (s)	53,5 (11,8-59,1)	60,6 (6,6-108,7)	0,012*	0,790	37,4 (19,9-63,3)	72,6 (28,1-100,3)	0,005*	0,888	
Δ (s)	13,3 (-5,2-57,4)				12,0 (0,0-80,0)				0,130
Strength R (kg)	25,2 (16,8-40,0)	25,3 (20,1-44,1)	0,444	-	18,8 (14,2-20,7)	22,4 (17,2-38,5)	0,036*	0,662	
Δ (kg)	2,9 (-14,7-15,1)				3,5 (-3,3-17,7)				0,545
Strength L (kg)	26,3 (17,9-36,8)	24,1 (17,6-35,5)	0,386	-	18,0 (8,1-28,0)	18,8 (9,3-42,0)	0,332	-	
Δ (kg)	-0,2 (-14,5-11,0)				1,1 (-3,3-13,9)				0,325
Functional Assessment	20,0 (17,0-24,0)	17,0 (12,0-23,0)	0,017*	0,775	16,5 (14,0-22,0)	14,0 (12,0-22,0)	0,038*	0,655	
Δ	-3,0 (-7,0-0,0)				-2,0 (-2,0-0,0)				0,268
BBT									
BBT D	27,0 (21,0-37,0)	30,0 (25,0-44,0)	0,012*	0,799	30,0 (23,0-35,0)	33,5 (21,0-47,0)	0,033*	0,675	
Δ	3,0 (0,0-14,0)				4,5 (-3,0-16,0)				0,733
BBT E	30,5 (21,0-36,0)	35,0 (26,0-42,0)	0,005*	0,890	28,5 (21,0-40,0)	32,0 (28,0-48,0)	0,009*	0,825	
Δ	5,0 (1,0-10,0)				6,0 (-1,0-13,0)				0,879
9HPT									
9HPT D (s)	28,3 (20,1-80,6)	25,4 (18,2-62,0)	0,007*	0,855	31,9 (26,2-45,6)	31,3 (23,5-36,8)	0,097	-	
Δ (s)	-3,3 (-18,0-0,9)				-2,6 (-9,9-2,1)				0,650
9HPT E (s)	29,6 (21,7-65,3)	26,4 (18,1-52,0)	0,028*	0,694	35,6 (25,6-40,4)	34,9 (25,6-44,3)	0,779	-	
Δ (s)	-4,5 (-13,2-6,1)				0,9 (-6,8-6,9)				0,015*

Data presented as median (minimum-maximum). p[a], intragroup analysis (Wilcoxon). r[b], effect size. pΔ[c] intergroup variation comparison (Mann-Whitney). TEMPA, *Test d'Évaluation des Membres Supérieurs de Personnes Âgées*. R, right. L, left. s, seconds. kg, kilograms. BBT, *Box and Block.* 9HPT, *Nine-Hole Peg Test*. *Significant data (p ≤ 0.05).

Table 4: Results of pre- and post-intervention questionnaires

	Virtual Reality Games (n=10)				Board Games (n=10)				
	PRE	POST	p[a]	r[b]	PRÉ	POST	p[a]	r[b]	pΔ[c]
UPDRS									
II Total	12,0 (2,0-29,0)	10,5 (2,0-25,0)	0,011*	0,808	15,5 (12,0-20,0)	10,5 (9,0-15,0)	0,005*	0,895	
Δ	-3,0 (-12,0-0,0)				-5,0 (-7,0- -2,0)				0,092
III Total	18,0 (7,0-26,0)	14,0 (6,0-19,0)	0,031*	0,682	15,0 (9,0-19,0)	15,0 (9,0-17,0)	0,334	-	
Δ	-4,0 (-13,0-4,0)				0,0 (-2,0-2,0)				0,039*
PDQ-39									
Mobility	37,5 (2,5-67,5)	17,5 (7,5-77,5)	0,382	-	65 (20,0-72,5)	17,5 (15,0-77,5)	0,034*	0,669	
Δ	-1,2 (-30,0-10)				-16,2 (-50,0-10)				0,181
ADL	41,6 (0,0-100)	29,1 (0,0-83,3)	0,027*	0,698	27,0 (0,0-50,0)	27,0 (0,0-58,3)	0,864	-	
Δ	-4,1 (-50,0-0,0)				-4,1 (-8,3-16,6)				0,509
Emotional well-being	45,8 (8,3-75,0)	20,8 (0,0-50,0)	0,011*	0,809	58,3 (4,1-75,0)	20,8 (0,0-45,8)	0,036*	0,664	
Δ	-8,3 (-29,1-0,0)				-16,6 (-45,8-4,1)				0,703
Stigma	50,0 (0,0-68,7)	31,2 (0,0-43,7)	0,035*	0,668	12,5 (0,0-60,0)	12,5 (0,0-31,2)	0,480	-	
Δ	-12,2 (-28,7-6,2)				0,0 (-28,7-6,2)				0,213
Social support	0,0 (0,0-50,0)	0,0 (0,0-50,0)	1,000	-	8,3 (0,0-50,0)	0,0 (0,0-50,0)	0,158	-	
Δ	0,0 (-8,3-41,6)				-8,3 (-33,3-41,6)				0,134
Cognition	25,0 (6,2-62,5)	25,0 (0,0-62,5)	1,000	-	25 (0,0-33,3)	21,8 (0,0-43,7)	0,339	-	
Δ	0,0 (-37,5-18,7)				-1,0 (-6,2-18,7)				0,697
Communication	25,0 (8,3-66,6)	25,0 (8,3-66,6)	1,000	-	16,6 (0,0-41,6)	14,1 (0,0-41,6)	0,044*	0,578	
Δ	0,0 (-25,0-33,3)				-8,3 (-16,6-0,0)				0,010*
Bodily discomfort	33,3 (8,3-50,0)	33,3 (11,1-50,0)	0,952	-	29,1 (16,6-75,0)	29,1 (0,0-91,6)	0,351	-	
Δ	1,3 (-25,0-25,0)				-8,3 (-16,6-16,6)				0,470
Total	36,8 (6,4-80,7)	28,2 (5,7-68,5)	0,049*	0,597	35,8 (8,9-42,9)	19,5 (4,4-41,0)	0,012*	0,793	
Δ	-2,2 (-15,8-1,9)				-8,0 (-23,7-0,6)				0,197
MoCA									
Total	24,0 (18,0-29,0)	26,0 (16,0-29,0)	0,605	-	23,0 (19,0-29,0)	23,0 (20,0-30,0)	0,070	-	
Δ	0,5 (-2,0-5,0)				0,5 (0,0-4,0)				0,716

Data presented as median (minimum-maximum). p[a], intragroup analysis (Wilcoxon). r[b], effect size. pΔ[c] intergroup variation comparison (Mann-Whitney). UPDRS: Unified Parkinson's Disease Rating Scale. Part II, Activities of Daily Living. Part III, Motor. PDQ-39, Parkinson's Disease Questionnaire (scoring). MoCA, Montreal Cognitive Assessment. *Significant data ($p \leq 0.05$).

6 CONCLUSÃO GERAL

Com base no artigo 1, torna-se evidente que a condução de uma revisão sistemática sobre o emprego da realidade virtual nos membros superiores na DP foi de extrema relevância para a fundamentação desta tese. Isso se deve às implicações clínicas e terapêuticas que essa tecnologia pode oferecer a indivíduos nessa condição. Diversos pontos ressaltam a importância desse estudo, em que, primeiramente, possibilitou a compilação de todas as pesquisas pertinentes sobre o uso da RV na reabilitação dos MMSS, consolidando, assim, as evidências disponíveis. Além disso, propiciou uma análise abrangente dos resultados obtidos em diversos estudos focados na DP.

Foi possível identificar os protocolos específicos de intervenção com RV que mostraram melhores, permitindo a escolha da abordagem mais viável e promissora para aplicação no estudo principal. E o mais importante, ao se identificar as lacunas na pesquisa existente e as áreas que necessitavam de uma maior investigação, determinou-se uma exploração mais ampla no que diz respeito as atividades de vida diária e a qualidade de vida na DP, a partir de uma abordagem específica dos membros superiores.

Quanto ao artigo 2, a sua abordagem possibilitou uma avaliação inicial da viabilidade, segurança e potenciais benefícios do protocolo desenvolvido com base na RV não imersiva. A prática clínica real revelou-se por meio desse estudo, englobando aspectos como a aceitação do tratamento pelos participantes, a facilidade de uso da tecnologia e a sua integração à rotina terapêutica. Embora a ausência de um grupo de controle para comparação direta tenha limitações, foi possível identificar tendências e mudanças nos sintomas e funcionalidade dos MMSS, indicando benefícios potenciais na força e resistência muscular, bem como nas AVD’s e na qualidade de vida dos indivíduos envolvidos. Os resultados obtidos geraram hipóteses e orientaram pesquisas futuras, contribuindo, assim, para o refinamento de abordagens terapêuticas eficazes e adequadas aplicadas posteriormente.

Em relação ao último estudo, pode-se concluir que os jogos virtuais e de tabuleiro demonstraram um impacto positivo na reabilitação dos membros superiores na doença de Parkinson. Essas abordagens terapêuticas inovadoras oferecem uma maneira lúdica e envolvente de trabalhar a coordenação motora,

a destreza e a força dos braços e mãos, aspectos importantes para melhorar a funcionalidade e a qualidade de vida desses Indivíduos.

A partir deste estudo, emergiram aspectos de suma importância por meio das abordagens empregadas em ambos os grupos. Quanto a coordenação motora, verifica-se que os jogos exigem movimentos precisos e coordenados das mãos, como apontar, agarrar, soltar, girar ou deslizar. Esses movimentos ajudam a estimular os circuitos neurais responsáveis pela motricidade fina, que muitas vezes são afetados na DP. Também, os jogos exigiram manipulação de peças ou controles virtuais que desafiaram a destreza manual dos indivíduos com Parkinson, aumentando o estímulo à manipulação. Assim, o seu aprimoramento se mostra essencial para a realização de tarefas cotidianas, como, por exemplo, pegar objetos pequenos, abotoar roupas ou utilizar utensílios de cozinha.

Em relação ao incremento da força e resistência muscular, alguns jogos virtuais e de tabuleiro podem envolver ações que demandam força nos MMSS, como mantê-los suspensos contra a gravidade, mover peças ou segurar objetos com resistência. Essas atividades podem ajudar a fortalecer e a aumentar a resistência da musculatura da extremidade superior, contribuindo para a prevenção de complicações secundárias.

A natureza interativa e divertida dos jogos virtuais e de tabuleiro pode aumentar a motivação e o engajamento dos indivíduos durante a reabilitação. A abordagem lúdica pode ajudar a reduzir o estresse associado à terapia e incentivar a participação ativa, além de proporcionar o desafio de atingir os objetivos propostos por cada jogo. Os terapeutas podem adaptar as atividades de acordo com as necessidades específicas de cada sujeito, garantindo uma abordagem individualizada e progressiva.

É importante mencionar que os jogos virtuais e de tabuleiro não devem substituir completamente as terapias tradicionais de reabilitação, mas sim complementá-las. A abordagem ideal é a combinação de diferentes técnicas terapêuticas para alcançar resultados mais abrangentes. Além disso, a utilização dessas ferramentas deve ser supervisionada por profissionais de saúde especializados, como fisioterapeutas, terapeutas ocupacionais, fonoaudiólogos, psicólogos, que podem avaliar o progresso dos sujeitos e fazer ajustes nas estratégias de reabilitação, conforme necessário.

Desta forma, os jogos virtuais e de tabuleiro representam uma abordagem promissora e eficaz para melhorar a reabilitação dos membros superiores na doença de Parkinson. Ao proporcionar estímulos específicos e um ambiente de aprendizado lúdico, essas ferramentas podem ajudar na manutenção ou na recuperação da funcionalidade e da independência nas atividades de vida diária.

Assim, é considerável ressaltar que outros aspectos pertinentes aos MMSS serão investigados em futuras pesquisas. Isso inclui a comparação da utilização dos mesmos jogos tanto em ambientes reais quanto virtuais, visando analisar os movimentos solicitados pelo mesmo desafio. Além disso, a estratificação dos subgrupos da doença será considerada para um aprofundamento no entendimento do impacto que poderão potencialmente exercer na funcionalidade dos indivíduos com Doença de Parkinson.

6 IMPACTOS DO TRABALHO

Os estudos realizados apresentaram resultados de considerável relevância, com repercussões significativas em várias esferas. Inicialmente, os resultados da revisão puderam contribuir para o corpo de conhecimento científico, orientando pesquisadores a tomarem decisões informadas sobre a incorporação da RV nos planos de tratamento. A partir dos demais estudos, verificou-se que tanto os jogos virtuais quanto os de tabuleiro emergem como abordagens inovadoras e holísticas para a reabilitação dos membros superiores na doença de Parkinson, evidenciando impactos altamente positivos em múltiplas áreas.

No ambiente clínico, percebe-se aspectos positivos, por exemplo, na coordenação motora fina e grossa, ajudando a recuperar a destreza e habilidades motoras afetadas pela doença. Os jogos também se mostraram eficazes no estímulo à força e resistência muscular dos MMSS, com efeitos preventivos em relação à perda de massa muscular e à fraqueza. Adicionalmente, essas intervenções demonstraram melhorias substanciais na funcionalidade da extremidade superior, com implicações diretas nas AVD’s e, por conseguinte, na qualidade de vida das pessoas afetadas pela DP.

Além disso, os jogos podem ser utilizados em sessões terapêuticas em grupo, proporcionando oportunidades para que os indivíduos se conectem, compartilhem experiências e desenvolvam relacionamentos sociais. A participação em atividades lúdicas pode ajudar a reduzir o isolamento social muitas vezes vivenciado na DP, promovendo um senso de pertencimento e comunidade. Os jogos virtuais e de tabuleiro podem ser implementados como parte de programas de reabilitação mais amplos e, quando comparados a abordagens tradicionais, podem ser mais acessíveis economicamente.

A utilização dessas ferramentas inovadoras pode resultar em tratamentos mais eficazes e eficientes, reduzindo a necessidade de procedimentos médicos ou reabilitação intensiva a longo prazo. O avanço da tecnologia possibilita o desenvolvimento de jogos virtuais mais sofisticados e personalizados, adequados às necessidades específicas de cada indivíduo, assim como o uso de dispositivos de RV permite uma experiência imersiva ou não-imersiva, aumentando a motivação e o engajamento durante as sessões de reabilitação.

Já os jogos de tabuleiro tradicionais e digitais são parte da cultura e das tradições sociais, tornando-se uma abordagem de reabilitação mais familiar e culturalmente aceita para indivíduos com Parkinson. Essas atividades lúdicas podem ser adaptadas para diferentes contextos culturais, tornando-as mais inclusivas e relevantes para diversas populações.

A utilização destes jogos na reabilitação oferece uma oportunidade para os indivíduos aprenderem e desenvolverem habilidades motoras e cognitivas enquanto se divertem. Os profissionais de saúde podem utilizar essas ferramentas como recursos educacionais para conscientizar os sujeitos e seus familiares sobre a importância da reabilitação e dos cuidados contínuos na DP. Dessa forma, os jogos virtuais e de tabuleiro têm impactos significativos em diferentes aspectos da reabilitação dos MMSS. Essas abordagens inovadoras não apenas melhoram a funcionalidade física, mas também proporcionam benefícios sociais, econômicos, tecnológicos, culturais e educacionais, tornando-se uma importante aliada na promoção da qualidade de vida desses indivíduos.

ANEXOS

Parecer do Comitê de Ética em Pesquisa da Universidade Federal de Ciências da Saúde de Porto Alegre

UNIVERSIDADE FEDERAL DE CIÊNCIAS DA SAÚDE DE PORTO ALEGRE

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: LEAP MOTION CONTROLLER NA FUNCIONALIDADE DOS MEMBROS SUPERIORES NA DOENÇA DE PARKINSON: UM ENSAIO CLÍNICO RANDOMIZADO

Pesquisador: Fernanda Cechetti

Área Temática:

Versão: 4

CAAE: 24443019.7.0000.5345

Instituição Proponente: Universidade Federal de Ciências da Saúde de Porto Alegre

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 3.981.990

Apresentação do Projeto:

Introdução: Doença de Parkinson (DP) é uma desordem degenerativa devido à perda progressiva da dopamina nos núcleos da base, caracterizada por sintomas motores de bradicinesia, rigidez, instabilidade postural e tremor. Como uma das consequências está o acometimento da extremidade superior que pode impactar diretamente nas atividades de vida diária (AVD's) e na qualidade de vida dos indivíduos. Dentre os tratamentos para os membros superiores (MMSS) a realidade virtual tem surgido como uma opção de baixo custo para a realização atividades interativas e recompensadoras. Objetivo: Verificar os efeitos do Leap Motion Controller (LMC) na funcionalidade dos MMSS em indivíduos com doença de Parkinson. Metodologia: Trata-se de um ensaio clínico randomizado, no qual os avaliadores serão alheios aos grupos experimentais (simples-cego). Os sujeitos com DP serão aleatorizados em dois grupos: grupo intervenção, o qual receberá um tratamento com jogos de realidade virtual através do dispositivo LMC; e grupo controle, que irá receber um tratamento de fisioterapia convencional baseado nos jogos realizados pelo grupo intervenção. Ambos os tratamentos serão voltados para tarefas amplas e finas dos MMSS, em um protocolo com 4 atividades e duração de 27 minutos, 2 vezes na semana, por oito semanas. Os dois grupos serão avaliados em três momentos: antes da intervenção, imediatamente após as 8 semanas e 60 dias após o término das intervenções. Os mesmos serão analisados quanto as AVD's, por meio do teste TEMPA e parte II da avaliação unificada da
DP (MDS-UPDRS); avaliação motora (parte III) da MDS-UPDRS e estadiamento motor da DP (Hoehn

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& Yahr); destreza manual pelo teste da Caixa e Blocos (Box and Block test) e através do teste dos Nove Pinos (Nine Hole Peg test); cognição pela avaliação cognitiva Montreal (MoCA); e a qualidade de vida por meio do questionário sobre a DP (PDQ-39). Espera-se com este estudo mostrar que o tratamento com o dispositivo LMC possui efeitos positivos sobre a funcionalidade dos MMSS de indivíduos com DP.

Objetivo da Pesquisa:

Objetivo Primário:

Verificar os efeitos de um protocolo de intervenção com Leap Motion Controller na funcionalidade dos membros superiores, em indivíduos com doença de Parkinson.

Objetivo Secundário:

Avaliar a intervenção com realidade virtual sobre:

- Os aspectos motores da vida diária, por meio do teste TEMPA e da MDS-UPDRS (parte II);
- A avaliação motora, através do domínio específico da MDS-UPDRS (parte III);
- A força e resistência muscular, através do dinamômetro de preensão palmar (teste TEMPA).
- A destreza manual, pelo teste da Caixa e Blocos (Box and Block test) e do teste dos Nove Pinos (Nine Hole Peg test).
- Os aspectos cognitivos pela Avaliação Cognitiva Montreal (MoCA);
- A qualidade de vida, através do Questionário da Doença de Parkinson (PDQ-39).

Avaliação dos Riscos e Benefícios:

Riscos:

Todo projeto de pesquisa envolve riscos aos envolvidos. Neste caso, pode-se considerar como possível risco o aparecimento de vertigem e náuseas pelos jogos, além de dor e fadiga tanto visual como nos membros superiores. Mas, cabe ressaltar que os pesquisadores envolvidos proporcionarão assistência total caso os mesmos venham a aparecer. No TCLE consta detalhamento como segue: "Os riscos e/ou desconfortos que podem advir da presente pesquisa são: dor e cansaço nos braços, devido o tempo necessário para manter eles em movimento, bem como tonturas, pelo tempo de execução dos jogos. Caso ocorra algum dos desconfortos ou fatos acima descritos, para minimizá-los tomaremos como providência: realizar uma ou mais pausas necessárias durante o atendimento, e caso necessário encerramos o atendimento naquele dia. Para serem evitados esses desconfortos, será sempre bem explicado que o participante pode solicitar a pausa em qualquer momento, assim como interromper as atividades daquele dia ou até mesmo não realizar mais o tratamento. ".

Benefícios:

Os pesquisadores esperam diversos benefícios aos envolvidos, como por exemplo:

- melhora dos aspectos motores da vida diária, da força e resistência muscular, destreza manual, aspectos cognitivos, impactando diretamente na qualidade de vida.

Comentários e Considerações sobre a Pesquisa:

A pesquisa possui relevância acadêmica e social pois busca utilizar um dispositivo de realidade virtual,denominado "Leap Motion Controller" em comparação ao método tradicional, na melhoria da qualidade de vida de indivíduos com Doença de Parkinson.

Considerações sobre os Termos de apresentação obrigatória:

Todos os termos de apresentação obrigatória foram apresentados.

Recomendações:

Para iniciar a coleta de dados, a pesquisadora responsável (ou membro de pesquisa autorizado pela mesma) deverá retirar o TCLE original (documento aprovado deverá ser encaminhado sem os grifos em vermelho), assinado pela coordenadora do CEP UFCSPA, na secretaria.

Recomenda-se que;

1) quando um documento for atualizado, em alguma informação, atualizar a data do mesmo. Por exemplo, o termo de entrega de relatório, foi atualizado em 01/04/2020, na PB, porém o mesmo segue com data de 22/10/2019;

2)Identificar os documentos anexados à PB de forma inequívoca. Por exemplo, o Termo de entrega de relatório foi anexado à PB com nome (Anexo 5) e no projeto, há um anexo 5, mas refere-se a "QUESTIONÁRIO SOBRE A DOENÇA DE PARKINSON (PDQ-39)".

Conclusões ou Pendências e Lista de Inadequações:

Nada a constar.

Considerações Finais a critério do CEP:

De acordo com o parecer do Relator.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1451862.pdf	01/04/2020 15:13:21		Aceito
Outros	anexo5.doc	01/04/2020 15:12:08	Fernanda Cechetti	Aceito
Projeto Detalhado / Brochura Investigador	Projetoreformulado.docx	01/04/2020 15:08:56	Fernanda Cechetti	Aceito
Outros	CartaResposta3.docx	01/04/2020 15:08:06	Fernanda Cechetti	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLEreformulado.docx	01/04/2020 15:07:46	Fernanda Cechetti	Aceito
Outros	ANEXO1.doc	28/10/2019 20:25:26	Fernanda Cechetti	Aceito
Outros	CurriculoArthurLahude.pdf	25/10/2019 14:46:40	Fernanda Cechetti	Aceito
Outros	CurriculophilipeCorrea.pdf	25/10/2019 14:46:18	Fernanda Cechetti	Aceito
Outros	CurriculoFernandaCechetti.pdf	25/10/2019 14:42:58	Fernanda Cechetti	Aceito
Folha de Rosto	FolhadeRosto.pdf	25/10/2019 14:36:04	Fernanda Cechetti	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

PORTO ALEGRE, 20 de Abril de 2020

Assinado por:
Fernanda Bordignon Nunes
(Coordenador(a))