UNIVERSIDADE ESTADUAL PAULISTA
"JÚLIO DE MESQUITA FILHO"
Campus de Presidente Prudente

Programa de Pós-Graduação em Ciências do Movimento

ASPECTOS QUALITATIVOS E REPERCUSSÕES CRÔNICAS DA INSERÇÃO DA TERAPIA BASEADA EM REALIDADE VIRTUAL EM PROGRAMA DE REABILITAÇÃO CARDÍACA CONVENCIONAL

Mayara Moura Alves da Cruz

Setembro - 2022

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Mayara Moura Alves da Cruz

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Presidente Prudente, 07 de outubro de 2022.

Dedicatória

Dedico esta tese àqueles que sempre estiveram ao meu lado, me amando, apoiando e incentivando meu crescimento, meu marido e minha família!

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No dia 25 de julho de 2020 fui afligida por uma angústia e ansiedade que me trouxeram repentinamente a sensação de “não vou conseguir!”. Então, no intuito de fazer com que aquele sentimento passasse, parei e vislumbrei o dia de hoje. Imaginei como seria e quem estaria aqui comigo e, em meio à minha imaginação, comecei a pensar nos meus agradecimentos. De início, já sabia que queria algo diferente e dado ao fato de que hoje é um dia muito especial para mim, acredito que posso fugir do convencional. Antes de tudo, gostaria de dizer que não sei se ensinei algo para alguém que está aqui hoje, mas eu sei que aprendi muito com cada um de vocês, e é a isso que sou grata! E é isso que quero destacar hoje aqui!

Com meus pais eu aprendi a confiar em Deus, descansar, não ficar ansiosa apenas viver o hoje, afinal, “basta cada dia o seu mal”. E se vocês perceberam um toque poético em minhas palavras, isso é graças a minha mãe, que tentou de todas as formas estimular o nosso gosto pela leitura, porém, confesso que não deu muito certo... por outro lado, as investidas do meu pai com a música foram mais proveitosas, não resultou em nenhum cantor profissional, mas nos viramos muito bem! Com meu irmão eu aprendi o que é amor à primeira vista! Quando o vi naquele refeitório do orfanato, quis correr, o abraçar e dizer “Você é meu irmão!”. Já com minha irmã eu descobri o que é ter uma amizade verdadeira e digna de melhor amiga! Nós brincamos, rimos, brigamos, nos desculpamos e cuidamos uma da outra. Confidencio aqui que as vezes sinto falta de quando estávamos só nos três (eu, Nathália e Thiago), mas ao mesmo tempo amo nós seis!

Com meu marido eu aprendi o que é o amor verdadeiro. E o amor verdadeiro é tranquilo, repleto de parceria, sem cobranças... onde existe doação mútua, e nisso meu marido é expert, confesso que tenho que aprender mais com ele. E pensando em todas essas qualidades do meu esposo... não posso esquecer de outras duas pessoas, afinal se ele é assim, alguma contribuição eles tiveram, não é mesmo Suzete e Alceu? Com meus sogros eu não só aprendi, mas eu vi a definição da palavra, bondade, pois nesses 5 anos de convivência eu os vi inúmeras vezes ajudando alguém, seja dando carona, levando ao médico, comprando um remédio, ou ajudando na mudança. São tantos atos de bondade e amor que não consigo descrever, entretanto, quero destacar que os admiro muito em vocês!

Agora que já falei de todos da minha família biológica, vou falar da minha outra família, meus amigos, que são a família que escolhemos e somos escolhidos. Minha família Unespiana, que embora eu não tenha passado pelo apadrinhamento, me sinto por ela adotada. Essa família é muito grande, composta por todos do laboratório de fisiologia do estresse, que em conjunto me ensinam a cada dia mais sobre ajudar o próximo, pois sempre que precisei alguém me ajudou, me ensinou, me apoiou! E assim, eu quero destacar algumas pessoas.

O meu querido orientador, o qual me ensinou o que é ser um mestre, e um bom mestre é aquele que além de apoiar e ensinar seus alunos, também os inspira a aprender e a pensarem por si mesmos. E isso é mais que comprovado quando olhamos os frutos que estão aqui presentes e os que não estão também. Obrigada chefe por ter me dado exemplo do professor que eu quero ser!

Já a Carol, minha dupla eterna, é aquela pessoa antenada e que me deixa a par das atualidades, com ela eu aprendi o que significa TBT, o que é um tirante e qual a blusa que se deve ir ao show do Harry Styles. Com a Maju aprendi a fazer análise simbólica, cálculo amostral, ANOVA... mas aprendi algo muito mais importante, aprendi como se faz para entrar no lab, afinal é só pegar a chave na guarita e entrar! Com o Felipe eu entendi o verdadeiro significado de proatividade, e todos hão de concordar comigo, afinal quem não tem o Felipe como co-autor de algum artigo?

Já a Luana, é alguém que me inspira a externar mais calma e paciência ao falar, mas isso é algo que infelizmente ainda não consegui aprender. A Laís foi a pessoa que me apresentou o laboratório, ela me mostrou onde ficava cada coisa, como utilizar cada equipamento e me ensinou estatística básica, então vocês podem imaginar como me senti importante no dia em que eu realizei a análise de qui- quadrado para ela. A Anne que além de admirá-la em tudo que faz, me ensinou que podemos ser pesquisadores de excelência e ter um tempo de diversão, que pode ser utilizado para jogar algo como... pokemon go.

Saindo agora dos meus amigos do laboratório, com a Paty aprendi que precisamos ter paciência, pois uma hora a resposta chega! E que não precisamos estar perto, nos falando sempre para sermos amigos. Já a Joany é uma espécie de enciclopédia misturada com o vade-mécum, praticamente tudo que eu não sei, não entendo muito bem... ela sabe e sempre me ajuda! Com a Andressa eu aprendi que não é o tempo que faz o tamanho de uma amizade.

Quero falar agora sobre duas pessoas que o estudo qualitativo me apresentou, a Prof.ª Marcia e a Isis, elas me ensinaram o que é uma pesquisa qualitativa de qualidade, e foram as minhas mentoras nesse novo e desafiador processo, cujo resultado vocês viram aqui hoje.

Quero falar também sobre a banca, a qual eu escolhi a dedo e são pessoas incríveis! A Rose me ensinou que para mantermos a jovialidade precisamos levar a vida de forma leve! Com a Mari aprendi que podemos fazer malabarismo com as facetas das nossas vidas, então podemos sim ser mãe de 3 e seguir com uma vida acadêmica, mesmo que seja complica do em alguns momentos. Já a Ray me ensinou que mesmo sendo bem-sucedida em uma profissão, podemos ir atrás de outra que toca mais fundo em nosso coração. E o Paulinho me ensinou que mesmo com os muitos afazeres do dia a dia é importante nos importarmos com os outros, e que independentemente de quem seja, somos todos iguais. Com o Prof. Vitor eu aprendi que a simplicidade pode ser a fórmula perfeita para o sucesso, afinal, ele mesmo com todo seu sucesso é uma pessoa tão simples de lidar.

Mudando agora um pouco a minha forma de escrita, quero agradecer diretamente aos participantes deste projeto. Muito obrigada a todos que se dispuseram a participar, sem vocês nada seria possível. O presente trabalho foi realizado com apoio da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Código de Financiamento 001

E por fim, eu quero falar Daquele que em hipótese nenhuma será o menos importante, Deus! Deus, é tão maravilhoso, pois preparou e cuidou de cada detalhe da minha vida. Obrigada senhor por todas as bênçãos que têm derramado em minha vida, o senhor que me capacitou para que eu conquistasse tudo o que conquistei até hoje. E muito obrigada Deus, por ter colocado em minha vida todas essas pessoas as quais eu citei aqui.

Antes de terminar, quero dizer que... mãe, aquela sua filha cujo um dia enquanto a senhora a via brincar, chorou ao pensar que nunca poderia pagar uma faculdade para ela estudar, não só se graduou, como se tornou mestre e hoje se torna doutora!

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Epígrafe

"Pois eu bem sei os planos que tenho a vosso respeito, diz o senhor; planos de paz, e não de mal, para vos dar o fim que desejais".

(Jeremias 29:11)

Resumo

Introdução: Apesar dos benefícios que os programas de reabilitação cardiovascular (RCV) podem promover, existem problemas quanto à sua aderência, a qual pode estar relacionada a diversos fatores, dentre eles, à motivação. Terapias alternativas podem refletir na motivação e promover aumento da aderência a RCV e, nesse contexto, a terapia baseada em realidade virtual (TRV) surge como uma opção. Entretanto, aspectos quantitativos e qualitativos da sua associação a RCV convencional ainda precisam ser investigadas. **Objetivo:** Analisar as repercussões hemodinâmicas e autonômicas crônicas da inserção da TRV em RCV convencional; analisar qualitativamente a percepção dos pacientes e dos fisioterapeutas frente a utilização da TRV. **Métodos:** O estudo foi conduzido com 26 pacientes (62,04 ± 12,22 anos) participam regularmente da RCV. As intervenções foram realizadas durante 12 semanas, nas quais os participantes realizaram 2 sessões semanais de RCV + 1 de TRV. As repercussões hemodinâmicas (pressão arterial, frequência cardíaca, frequência respiratória, saturação de oxigênio), autonômicas (índices lineares e não lineares) e percepção de esforço (escala de Borg) foram avaliadas. Foi realizado também uma avaliação qualitativa por meio de grupos focais com os pacientes e com os terapeutas. **Resultados:** Com exceção da aparente falta de significância clínica observada em Entropia de Shannon, componente de baixa frequência (LF) (nu) e componente de alta frequência (HF) (nu), a inserção da TRV um programa convencional não causou alterações significativas nas variáveis analisadas. Em relação a análise qualitativa, os pacientes demonstraram boa aceitação e satisfação do TRV, destacando benefícios físicos e psicossociais. Já os fisioterapeutas relataram vantagens do uso da TRV (Ex.: mudanças na rotina de tratamento tradicional) e problemas relacionados à segurança durante a execução da TRV (Ex.: configuração do dispositivo antes da sessão e controle da intensidade do esforço durante a sessão). **Conclusão:** A inserção da TRV foi capaz de manter as repercussões hemodinâmicas e autônomas crônicas causadas pela RCV convencional. Além disso, pacientes cardiopatas demonstraram satisfação com a inclusão da TRV no programa de RCV convencional, demonstrando que essa terapia tem potencial para ser uma nova abordagem nessa população, permitindo a diversificação do treinamento. Por fim, os fisioterapeutas reconhecem que a TRV pode ser associado à RCV para melhorar a adesão dos pacientes a esses programas.

Palavras-chave: terapia de exposição à realidade virtual, cardiopatias, fatores de risco de doenças cardiovasculares, exercício, sistema nervoso autonômico.

Abstract

Introduction: Despite the benefits that cardiovascular rehabilitation programs (CR) can promote, there are problems regarding their adherence, which may be related to several factors, among them, motivation. Alternative therapies may reflect on motivation and promote increased adherence to CR, in this context, virtual reality-based therapy (VRBT) emerges as an option. However, quantitative and qualitative aspects about VRBT association with conventional CR still need to be investigated. **Objective:** evaluate the chronic hemodynamic and autonomic repercussions of insertion of VRBT in traditional CR; qualitatively analyze the perceptions of patients and physiotherapists about VRBT. **Methods:** 26 patients (62.04 ± 12.22 years) who regularly participate in CR will participate in this study. Interventions will be carried out for 12 weeks, performed 2 weekly sessions of CR and 1 of VRBT. The chronic hemodynamic (blood pressure, heart rate, respiratory rate, oxygen saturation), autonomic (linear and non-linear indices) and perceived exertion (Borg scale) repercussions was assessment. A qualitative assessment through a focus group conducted with patients and another with therapists was performed. **Results:** Except for the apparent lack of clinical significance observed in Shannon Entropy, low frequency LF (nu), and high frequency HF (nu), the combination of VRBT as routine in a conventional program did not cause significant changes in the analyzed variables. Regarding the qualitative analysis, patients demonstrated good acceptance and satisfaction of VRBT. Physical and psychosocial benefits were highlighted. Physiotherapists reported some advantages of using this new therapy (e.g. VRBT changes to the traditional treatment routine) and problems related to safety during the execution of the VRBT (e.g. setting up the device before session and control of effort intensity during the session). **Conclusion:** combination of VRBT was able to maintain the chronic hemodynamic and autonomic repercussions caused by conventional CR. In addition, patients with cardiac conditions demonstrated satisfaction with the inclusion of VRBT in a conventional CRP, demonstrating that VRBT has the potential to be a new approach for this patient population, allowing training diversification. Finally, physiotherapists recognize that VRBT can be associated with CR to improve patients' adherence to these programs.

Key-words: virtual reality exposure therapy; cardiovascular diseases; heart disease risk factors; exercise; autonomic nervous system.

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Lista de abreviaturas e siglas

Lista de abreviaturas e siglas

ACE: angiotensin II converting enzyme

BMI: body mass index

BP: blood pressure

Ca^+: calcium

CR: cardiovascular rehabilitation

CRP: cardiovascular rehabilitation program

CVD: cardiovascular diseases

DBP: diastolic blood pressure

DCV: doenças cardiovasculares

DET determinismo ou determinism

DFA: Flutuações depuradas de tendências

f: frequência respiratória ou respiratory rate

FC: frequência cardíaca

$FC_{max::}$ frequência cardíaca máxima

HF: high frequency

HR: heart rate

HRR: heart rate reserve

HRV: heart rate variability

Kg: kilograms

LF: low frequency

m: meters

mmHg: millimeters of Mercury

ms: milliseconds

nu: normalized units

PAD: Pressão arterial diastólica

PAS: Pressão arterial sistólica

PR: *plot* de Recorrência

PSE: percepção subjetiva de esforço

RCT: randomized clinical trial

RCV: reabilitação cardiovascular

REC: recurrence rate

RPE: rating of perceived exertion

RMSSD: root-mean-square of differences between adjacent normal RR intervals in a time interval expressed in milliseconds

SBP: systolic blood pressure

SD: standard deviation

SDNN: standard deviation of all normal RR intervals expressed in milliseconds

SE: Shannon Entropy

SpO2: saturação de pulso de oxigênio ou oxygen pulse saturation

SPSS: Statistical Packages for Social Sciences

TRV: terapia baseada em realidade virtual

VFC: variabilidade da frequência cardíaca

VO2pico: Consumo de oxigênio pico

VRA: visual Recurrence Analyzes

VRBT: virtual reality-based therapy

0V: standard without variation

1V : standard with one variation

2LV: standard with 2 equal variations

2ULV: standard with 2 different variations

Lista de símbolos

Lista de símbolos

>: Maior que

<: Menor que

=: Igual

(): Parênteses

%: Porcentagem

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Sumário

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Apresentação

Este é um modelo alternativo de tese e contempla a pesquisa intitulada: **Aspectos qualitativos, repercussões hemodinâmicas e autonômicas crônicas da terapia baseada em realidade virtual em participantes da reabilitação cardiovascular**, realizada no Laboratório de Fisiologia do Estresse da Faculdade de Ciências e Tecnologia – FCT/UNESP.

Em concordância com as normas do modelo alternativo do Programa de Pós-Graduação em Ciências do Movimento da Faculdade de Ciências e Tecnologia da Universidade Estadual Paulista "Júlio de Mesquita Filho", a presente tese está dividida da seguinte forma:

✓ Introdução, contendo a contextualização do tema pesquisado;

✓ Artigo I: Cruz MMA, Laurino MJL, Christofaro DGD, Ghisi GLM, Vanderlei LCM. Long-term effects of virtual reality-based therapy in cardiovascular rehabilitation: a longitudinal study. Que está em processo de revisão no periódico: *Physiotherapy Theory and Practice* (normas para submissão no site: https://www.tandfonline.com/journals/iptp20).

✓ Artigo II: Cruz MMA, Silva IG, Ricci-Vitor AL, Silva JM, Franco MR, Vanderlei LCM. Perceptions and preferences of patients with cardiac conditions to the inclusion of virtual reality-based therapy with conventional cardiovascular rehabilitation: A qualitative study. Brazilian J Phys Ther. 2022;26(3):100419.

✓ Artigo III: Cruz MMA, Silva IG, Ghisi GLM, Vanzella LM, Ricci-Vitor AL, Gonzaga LA, Franco MR, Vanderlei LCM. Perceptions of physiotherapists about virtual reality using exergames in cardiovascular rehabilitation: a qualitative study. Que está em processo de revisão no periódico: *Games for Health Journal* (normas para submissão no site: https://www.liebertpub.com/loi/G4H).

✓ Conclusões, obtidas por meio da pesquisa realizada; e

✓ Referências, no formato recomendado pelo Comitê Internacional de Editores de Jornais Médicos (ICMJE – *Internacional Committe of Medical Journal Editours*), para apresentação das fontes utilizadas na redação da introdução.

Introdução

INTRODUÇÃO

Consideradas como a principal causa de morte do mundo, as doenças cardiovasculares (DCV) levam a óbito cerca de 17,9 milhões de pessoas por ano, e estima-se que em 2030, esse valor possa aumentar para 22,2 milhões de mortes[1]. Uma vez instaladas, esses doenças geram consequências no aspecto físico, socioeconômico e psicológico dos pacientes, que em conjunto promovem uma redução na qualidade de vida[2–4].

Em relação ao aspecto físico, além da diminuição da capacidade funcional, podem ser descritas a presença de dispneia, fadiga, angina e intolerância ao exercício físico, dentre outros[2,4]. Este último, é um dos principais sintomas relacionados às DCV, e que contribui para alterações neuro-humorais[5], desequilíbrio autonômico, o qual inclui aumento no tônus simpático e redução do tônus parassimpático, reduzindo assim a variabilidade da frequência cardíaca (VFC)[5], sendo esta um importante preditor de mortalidade[6].

Em relação ao aspecto socioeconômico, as DCV geram altos gastos econômicos ao sistema de saúde, devido sua alta taxa de morbidade e incapacidade laboral. Dados nacionais mostram que em 2015 foram gastos R$ 37,1 bilhões de reais com as DCV, dentre os quais podemos citar as despesas com internações, perda de produtividade e o aumento de aposentadorias precoces[3]. E no aspecto psicológico, essas doenças podem ocasionar a presença de ansiedade e depressão[7,8].

Diante do exposto, evidencia-se que o tratamento das DCV deve ser priorizado. Neste contexto, a reabilitação cardiovascular baseada em exercícios (RCV) surge como uma importante forma de terapia utilizada no tratamento e prevenção dessas doenças, visto que, estudos demonstram benefícios da prática regular de exercícios físicos na melhora da função cardiovascular, capacidade aeróbia, qualidade de vida e redução de até 30% da mortalidade em cardiopatas[9–11]. Além disso, a RCV promove ainda atenuação no aparecimento de angina em repouso, isquemia aos esforços, redução de fatores de risco, benefícios psicológicos e melhora na modulação autonômica [12–15].

Apesar dos benefícios que a RCV proporciona, existem problemas quanto à aderência dos pacientes ao tratamento[13,16,17]. Esta falta de engajamento pode estar relacionada a diversos fatores, tais como: falta de tempo, preocupações financeiras, baixa escolaridade, comorbidades, idade avançada e pouca motivação[18–20].

Neste contexto, objetivando estimular o engajamento por parte dos pacientes, e assim, aumentar a aderência a programas de RCV, iniciou-se uma busca por terapias alternativas, dentre elas, a terapia baseada em realidade virtual (TRV)[21]. A TRV é definida como o uso de sistemas de realidade virtual como forma de terapia, esses sistemas, podem ser do tipo imersivo, como os simuladores de voo e capacetes de realidade virtual; semi-imersivo, como os óculos de realidade virtual e não-imersivo, que como exemplo temos alguns jogos de computadores e videogames, que receberam a denominação de exergames, pois possibilitam a mistura entre exercício físico e jogos, fazendo assim, com que os videogames sejam utilizados também como uma modalidade de exercício físico[22].

Os exergames são aplicados por simulação de movimentos, e têm sido apontados como uma nova ferramenta que usa tecnologia para tratamentos fisioterapêuticos[23,24] e podem se destacar como uma opção para tratamento de cardiopatas, bem como o tratamento de portadores de fatores de risco para doenças cardíacas[25–27], apresentando vantagens, tais como maior variabilidade, ou seja mais opções em jogos que podem ser utilizados; adaptabilidade, ou seja, maior potencial para oferecer recursos que permitam ao paciente se adaptar mais facilmente; transparência para o armazenamento de dados; acesso remoto de dados online; economia no sentido de permitir que a TRV seja aplicada usando diferentes equipamentos o que pode facilitar o acesso, por exemplo, como o uso de smartphones, além de estimular a motivação[21,28].

Além das vantagens descritas acima, em cardiopatas a TRV por meio de simulação, ou seja, executada por reprodução de movimentos, proporcionou respostas hemodinâmicas agudas fisiológicas e semelhantes à RCV, mas com maior magnitude para frequência cardíaca (FC), frequência respiratória (f), percepção subjetiva de esforço (PSE) durante a sua execução e até cinco minutos após a interrupção da sessão. Além disso, a TRV promoveu intensidade suficiente para que o paciente atingisse sua FC de treinamento[26].

Já em relação a repercussões hemodinâmicas crônicas, Chuang et al.[25] observaram que um grupo que realizou exercício em ergômetro com a projeção de realidade virtual (projeção de imagens durante a realização do exercício físico em esteira ergométrica) obteve melhores respostas de FC_{max} e VO_{2pico}, maior pico de equivalente metabólico e limiar anaeróbio que o grupo convencional, o qual realizou o exercício apenas com o ergômetro, sugerindo também que a recuperação no fornecimento e utilização de oxigênio para pacientes revascularizados em TRV é superior àqueles que realizaram a RCV convencional. Este é um fato relevante, visto a importância das alterações que o exercício físico, principal instrumento da RCV, promove no sistema cardiovascular, permitindo assim que o organismo se adapte à sua realização[2].

Os estudos supracitados apresentam os efeitos da TRV utilizando simulação sobre as repercussões hemodinâmicas agudas e os efeitos da TRV por meio de projeção sobre as repercussões hemodinâmicas crônicas em indivíduos cardiopatas, porém, não foram encontrados estudos que mostram repercussões hemodinâmicas crônicas frente a inserção de uma sessão semanal da TRV por meio de simulação em um programa de RCV convencional, em pacientes com doenças cardiovasculares e/ou fatores de risco. Esse é um aspecto importante, pois tem aumentado a utilização de exergames, onde os pacientes realizam simulação de movimentos captadas por sensores de câmera e vídeo, em programas de RCV. Portanto, é importante investigar se a associação dessa nova terapia com a RCV convencional é efetiva ou não para manter ou aumentar os efeitos hemodinâmicos crônicos induzidos pela RCV convencional.

Ainda como efeitos hemodinâmicos crônicos, podemos incluir que é importante investigar como a inserção da TRV afeta a modulação autonômica, uma vez que a RCV promove benefícios sobre ela e o sistema nervoso autônomo é importante, visto que regula diversas funções hemodinâmicas do organismo e sofre modificações durante o exercício físico[29].

A avaliação do sistema nervoso autônomo pode ser realizada por meio da VFC, sendo esta, uma técnica não invasiva de avaliação da modulação autonômica cardíaca, a qual exprime as oscilações nos intervalos entre batimentos cardíacos consecutivos (iRR)[30]. Alterações nos padrões da VFC indicam comprometimento na saúde, em geral, alta VFC é encontrada em indivíduos saudáveis, onde os mecanismos autonômicos são eficientes enquanto baixa VFC é frequentemente observada em indivíduos com prejuízos no funcionamento fisiológico [31].

Para análise da VFC, podem ser utilizados métodos lineares no domínio do tempo e da frequência e métodos não-lineares que são baseados na teoria do caos [30,32]. A utilização de métodos não lineares para analisar a VFC vem crescendo, devido evidências de que os mecanismos da regulação cardiovascular se relacionam de modo não linear[33]. Tal método descreve as flutuações complexas de ritmo e é capaz de separar estruturas de comportamento não linear nas séries temporais de batimentos cardíacos de forma mais adequada que os métodos lineares [34]. Dentre os métodos não-lineares podemos citar: a análise de flutuações depuradas de tendências (DFA), o *plot* de Recorrência (PR) e a análise simbólica[32].

Além do que foi exposto até aqui, um estudo realizado pelo nosso grupo, que inseriu uma sessão de TRV ao programa de RCV convencional, com frequência de três vez por semana, observou aumento na aderência dos pacientes ao programa RCV[35], entretanto, a aderência voltou a valores próximos aos iniciais após doze semanas do fim do protocolo. O aumento da aderência não foi relacionado ao perfil, às barreiras, à motivação ou ao engajamento e entendemos que existem outros fatores que não puderam ser quantificados que podem ter sido responsáveis por esses resultados.

Assim, se faz importante uma investigação de aspectos qualitativos em relação a associação da TRV à RCV, objetivando aprofundar o conhecimento e obter novas perspectivas dessa nova intervenção[36]. O método mais utilizado de pesquisa qualitativa é a realização de entrevistas com grupos focais, que é capaz de compreender com mais detalhes a perspectiva humana[36,37], ou seja, não para investigar a modalidade terapêutica propriamente dita, mas buscando entender o significado desta modalidade para os pacientes, para os terapeutas, buscando entender suas características aplicadas em seus contextos de vida[38].

Meneghini et al[39], realizaram um estudo qualitativo com adultos e idosos, no qual após 12 semanas do término do protocolo com exergames esportivos (Xbox 360 Kinect Sportstm) foi realizado um grupo focal em que os participantes relataram benefícios psicológicos tais como melhora na autoestima, na concentração, no humor, e até mesmo no raciocínio e memória. Além disso, benefícios físicos também foram apontados, tais como melhora na agilidade e benefícios na interação social devido a troca de experiências e a criação de laços de amizade. Os autores acreditam que essa percepção de benefícios com a prática de exergames pode aumentar a motivação dos participantes e assim, facilitar a adesão ao exercício físico.

Ramos et al[40], avaliaram quantitativamente e qualitativamente a influência da TRV por meio do Wii Fit na melhora de equilíbrio em portadores de Parkinson, e observaram que apesar de não haver diferença estatística entre a TRV e a terapia convencional sobre esse desfecho, de forma qualitativa os pacientes em sua maioria demonstraram preferência pela TRV e relataram que se sentiram mais motivados em realizá-la associada a terapia convencional.

Diante dos estudos mostrados acima, entendemos como importante compreender a percepção do paciente frente à TRV, entender como ela afeta a motivação e engajamento, visto que, esses aspectos influenciam a aderência por parte dos pacientes aos programas de RCV, e poderia auxiliar na elaboração de soluções do desafiador problema de baixa adesão à terapia convencional. Além disso, também é relevante conhecer a percepção do terapeuta frente a aplicação da TRV, identificando as barreiras e os facilitadores para sua utilização, uma vez que a identificação de tais fatores pode auxiliar em adaptações necessárias e na disseminação dessa nova modalidade de terapia. Sendo assim, acreditamos que essa análise qualitativa irá expandir os conhecimentos a respeito dessa nova terapia e sua implantação em um programa de RCV na visão do paciente e do terapeuta.

Tomados em conjunto, o texto apresentado acima aponta para algumas lacunas na literatura: Quais as repercussões hemodinâmicas crônicas da associação da TRV por meio de simulação ao programa de RCV? Quais as repercussões autonômicas crônicas da associação da TRV por meio de simulação ao programa de RCV? Quais as percepções dos pacientes com a associação da TRV à RCV, considerando seu aspecto qualitativo? Quais as percepções dos terapeutas com a associação da TRV à RCV, considerando seu aspecto qualitativo?

Assim, este estudo tem por objetivo avaliar as repercussões hemodinâmicas crônicas da inserção da TRV na RCV na frequência de uma vez por semana por meio da FC, pressão arterial sistólica (PAS) e diastólica (PAD), f, saturação de pulso de oxigênio (SpO_2), PSE, além de investigar as repercussões autonômicas, utilizando métodos lineares e não lineares da VFC em participantes de um programa de RCV. Adicionalmente, este estudo tem por objetivo analisar qualitativamente a percepção dos pacientes e dos fisioterapeutas frente a utilização da TRV, bem como sua associação à RCV.

Nossa hipótese é de que a associação da TRV à RCV pode promover ganhos ou pelo menos manter os benefícios crônicos obtidos pelo PRC em relação aos dados hemodinâmicos e autonômicos. Em relação aos aspectos qualitativos, acreditamos que a inserção da TRV vai ser bem recebida pelos pacientes e terapeutas.

Para cumprir com os objetivos propostos, foram elaborados três artigos científicos, que serão apresentados na íntegra. O primeiro deles intitulado: **"*Long-term effects of virtual reality-based therapy in cardiovascular rehabilitation: a longitudinal study*"**, teve por objetivo analisar os efeitos a longo prazo da combinação da TRV com a RCV na fase III. Os resultados deste estudo permitem concluir que a combinação da TRV com RCV convencional foi associada à manutenção dos efeitos a longo prazo nos desfechos hemodinâmicos e autonômicos, sugerindo que essa terapia pode ser utilizada como uma nova modalidade de tratamento combinado com sessões de RCV convencionais.

O segundo artigo intitulado: **"*Perceptions and preferences of patients with cardiac conditions to the inclusion of virtual reality-based therapy with conventional cardiovascular rehabilitation: A qualitative study*"**, teve por objetivo analisar qualitativamente as percepções e preferências dos pacientes em relação à inclusão da TRV ao programa de RCV convencional, além de entender como a TRV afeta a adesão do paciente a esse programa. Os resultados deste estudo permitiram concluir que houve satisfação com a terapia proposta e seus elementos foram bem aceitos por alguns pacientes. Mas a maioria dos pacientes relatou que não houve influência do TRV na motivação e adesão ao programa de RCV, justificando que sua adesão à prática de exercício físico está ligada à conscientização de sua importância.

O terceiro artigo intitulado: **"*Perceptions of physiotherapists about virtual reality using exergames in cardiovascular rehabilitation: a qualitative study*"**, teve como objetivo investigar a percepção de fisioterapeutas sobre a utilização da TRV por meio de exergames na RCV. Os resultados deste estudo nos permitiram concluir que os fisioterapeutas que utilizam a TRV dentro do programa de RCV perceberam benefícios, incluindo o aumento da adesão ao RC. Os fisioterapeutas também apontaram o perfil dos pacientes como uma influência ao medo em realizar a TRV, assim como influência também a satisfação e aceitação dessa terapia. Além disso, os fisioterapeutas recomendaram que para a utilização da TRV deve se levar em consideração a capacidade de automonitoramento dos sintomas, ausência de restrições de movimento e preferências pessoais dos pacientes, além da realização de uma sessão de adaptação antes de iniciar a TRV para que se entenda as necessidades e preferências dos pacientes.

Artigo 1

Long-term effects of virtual reality-based therapy in cardiovascular rehabilitation: a longitudinal study

ABSTRACT

Background: In Cardiovascular Rehabilitation (CR), patient adherence to the maintenance phase is a major challenge. Virtual reality-based therapy (VRBT) promotes acute hemodynamic and autonomic repercussions similar to conventional rehabilitation and can increase patient adherence to the program. However, it is unknown whether the combination of VRBT to a conventional CR manages to maintain or even improve clinical and autonomic variables in long term. **Objective:** To analyze whether VRBT combination in a conventional CR can maintain or improve clinical and autonomic variables in cardiac patients in the maintenance phase of these programs. **Methods:** Twenty-six volunteers (62.04 ± 12.22 years) were evaluated, who underwent an initial assessment and two other assessments (in the sixth and 12th week) of the following outcomes: systolic and diastolic blood pressure, respiratory rate, pulse saturation of oxygen, heart rate, perceived exertion, and cardiac autonomic modulation, using linear and non-linear heart rate variability methods. **Results:** Except for the apparent lack of clinical significance observed in ES, LF (nu), and HF (nu), the combination of VRBT as routine in a conventional program did not cause significant changes in the analyzed variables. **Conclusion:** combination of VRBT was able to maintain the chronic hemodynamic and autonomic repercussions caused by conventional CR.

Keywords: cardiac rehabilitation; virtual reality exposure therapy; autonomic nervous system; exercise; cardiovascular diseases.

INTRODUCTION

Cardiac rehabilitation (CR) is a well established secondary prevention intervention for cardiovascular diseases (CVD) (Carvalho et al, 2020). However, high drop-out rates and low adherence to the program are reported worldwide (Benzer et al, 2017; Wieczorrek et al, 2016), especially during phase III of the program, with more independent exercises and self-monitoring. The aim of phase III, also called "maintenance phase", is to maintain the physical fitness and consolidate lifestyle changes through a multidisciplinary approach, including exercise, patient education and stress management (Sainz L, 2021). Research has shown that the use of alternative therapies in phase III CR can improve the adherence to the program, including the use of virtual reality-based therapy (VRBT). In a study by Cruz et al. (2021), weekly VRBT sessions associated to CR resulted in an increase of 8% in program adherence.

An important aspect regarding the use of alternative therapies in CR is their effectiveness to promote acute and long-term positive modifications, and if the effect is similar to the one observed in the conventional CR. In this sense, is already reported that one session of VRBT promotes acute modifications on autonomic modulation (Silva et al, 2020), hemodynamic variables (heart rate [HR] and blood pressure [BP]), and rating of perceived exertion (RPE) (Cruz et al, 2020), similar to what is observed in CR. Also, the VRBT has chronic positive effects on clinical and physical variables in CR patients, such as improvements in cognitive function and quality of life. (Jaarsma et al, 2015; Chuang, Sung, Chang, and Wang, 2006).

It is worth highlighting that HR, BP, and RPE are important tools used to control exercise intensity in CR, and exceeding the prescribed values for these variables may expose the patient to higher risk for cardiac events. As the autonomic nervous system regulates several hemodynamic functions of the organism and undergoes modifications during physical exercise, its investigation is important (Vanderlei et al, 2009). However, it is not known what is the effect of the combination of VRBT in CR to maintain or even improve autonomic variables.

In this context, this study aimed to analyze the long-term effects the combination of VRBT in phase III of CR. It was hypothesize that VRBT use would lead to maintainance in clinical and autonomic repercussions, thus confirming that it could be an alternative and effective option for CR.

METHODS

Design

This longitudinal study included patients from the Cardiology Division of the Center for Physical Therapy and Rehabilitation Studies and Treatment of the São Paulo State University (UNESP), Faculty of Sciences and Technology, Presidente Prudente, São Paulo, Brazil. Participants completed 12 weeks of CR associated with VRBT, with assessments carried out at baseline (pre-CR+VRBT), mid-point (6 weeks), and at CR discharge (12 weeks). The study was conducted in accordance to the standards required by the Declaration of Helsinki and approved by the Ethics Committee of FCT/UNESP (approval number CAAE 29742920.9.0000.5402). All participants provided written informed consent.

Participants

The inclusion criteria included the following: I. patients who were referred to CR by their cardiologist with a diagnosis of heart disease (e.g. ischemic heart disease and heart failure) or at least one cardiovascular risk factor (e.g. diabetes, hypertension, dyslipidemia), considering those defined by the American College of Sports Medicine (2010); II. Have attended the regular CR programming for at least three months, to avoid the acute modifications promoted by the exercise; III. With age ≥ 18 years old. The exclusion criteria were the following: I. Patients who presented conditions that could interfere in the practice of exercise during VRBT, such as balance disorders (e.g. labyrinthitis and vestibular neuritis), musculoskeletal diseases (e.g. knee arthrosis), and/or acute signs or symptoms (e.g. angina, fatigue);II. Patients with atrial fibrillation, once the RR intervals recording used to analyze the autonomic modulation is directly influenced by this arrhythmia (Catai et al, 2016); and III. Individuals who refused to participate in the study. Those who dropped out at any stage of the study, or those who presented errors greater than 5% on the continuous HR record were excluded from the analysis.

Study Procedures and data collection

Participants completed 3 assessments: baseline (pre-CR), mid-point (6 weeks), and at CR discharge (12 weeks). The baseline assessment included clinical characteristics and measures of clinical and autonomic variables. The mid-point and the CR discharge assessment included clinical and autonomic. Patients were instructed not to consume stimulant substances (e.g. coffee, tea, chocolate, soda, and alcoholic beverages) during a 24 hours period before the assessments.

Data collection of clinical and autonomic variables were performed at rest in the 1st, 18th and 36th session. The rest period was performed for 10 minutes in the lying position before the training session. All clinical variables, that include the RPE and hemodynamic variables - BP, HR, respiratory rate (RR), oxygen pulse saturation (SpO2), - were collected at the 5th minute of rest. As to the autonomic modulation, HR was captured beat-by-beat by a heart rate monitor (Polar RS800, Polar Electro, Kempele, Finland) (Gamelin, Berthoin and Bosquet, 2006) throughout the initial rest period. For the heart rate variability (HRV) analysis, the epoch ranging from the 5th to the 10th minute was considered (Vanderlei et al, 2009).

Intervention

The CR+ VRBT sessions were carried out in an environment with controlled temperature between 21 ºC and 24ºC and relative air humidity between 40% and 60%. The intervention was 12 weeks long, with a frequency of three sessions a week and 36 sessions in total. Of these, two sessions were CR and one was VRBT. Each session consisted of three phases as followed: warm-up (15 minutes), exercise (30 minutes), and recovery phase (5 minutes), with an average duration of 60 minutes. Both the warm-up and the exercise phases were specific for each therapeutic modality session, CR or VRBT. The recovery phase was the same for both sessions, on which patients laid down on mattresses and performed stretching exercises associated with diaphragmatic breathing (Carvalho et al, 2020).

In both sessions, the exercise intensity was the same and based on CR guidelines, which, except for clinical and/or physical limitations, was prescribed between 40-70% heart rate reserve (HRR) for patients with CVD and 60%-80% HRR for those with cardiovascular risk factors (Podlog et al, 2015). In addition, for intensity control, the Borg scale was also used (Borg, 1982). During the session, the target intensity monitored by the Borg scale was between 12 and 16 (Mezzani et al, 2013).

CR Sessions

CR sessions were conducted by physiotherapists. The warm-up phase consisted of stretching, upper and lower limb exercises, and combined exercises, aiming to perform muscular and cardiorespiratory warm-up, to achieve greater metabolic efficiency, in addition to providing a period for adjusting HR and blood pressure. The conditioning phase consisted of aerobic exercises on a treadmill and a cycle ergometer, with loads individually adjusted to keep the effort within the pre-established intensity, as previously described (Carvalho et al, 2020).

Virtual reality-based sessions

To perform the VRBT sessions, two virtual reality games were selected based on the studies by Leutwyler, Hubbard, Vinogradov and Dowling (2012) and Sampaio, Subramaniam, Arena and Bhatt (2016). The game “Just Dance 2015” was used in the warm-up phase, in which the patient followed routines according to the songs selected from a pilot protocol to progressively increase the HR and thus ensure the safety of the session in the same way as in CR sessions. The songs used in this phase (total duration of 15 minutes) were the following: Only You (And You Alone)- Love Letter; Don't Worry Be Happy- The Bench Men; Ain't No Mountain High Enough- Marvin Gaye and Tammi Terrell; Macarena- Los Del Río; Happy- Pharrell Williams. The exercise phase was performed with the game "Shape Up", in which patients performed the exercise proposed by the personal trainer of the game. Each game lasted 5 minutes, and as 6 games were played, a total of 30 minutes was dedicated to this phase.

Both games were projected on a wall by a projector (Epson Power Life, H309A, China) from the console (Xbox One KinectTM, Microsoft, Redmond, WA). These games generated simulations of virtual environments, on which the participants interacted using their own movements captured through motion capture sensors by camera or video. In addition, during the period to excharge games (around 30 seconds), patients were instructed by a therapist to perform exercises to minimize the period of inactivity.

Outcomes

Systolic blood pressure (SBP), diastolic blood pressure (DBP), RR, SapO2, HR, RPE, and cardiac autonomic modulation, using linear and non-linear methods of heart rate variability (HRV) were assessed at baseline, mid-point and CR discharge.

SBP and DBP were indirectly assessed using a stethoscope (Littmann, Saint Paul, USA) and aneroid sphygmomanometer (Welch Allyn-Tycos, New York, USA) on the patient's left arm (Barroso et al, 2020). The f was measured by counting the respiratory incursions for one minute without the patient noticing the process, to prevent changes in the usual characteristics of breathing (Irwin and Tecklin, 2003). HR was assessed using a previously validated heart rate monitor (Polar RS800, Polar Electro, Kempele, Finland) (Gamelin, Berthoin and Bosquet, 2006).

RPE was assessed using the Borg scale (Borg, 1982). Finally, SpO2 was verified using a pulse oximeter (Mindray PM-50 Pulse Oximeter, China) (Nunes and Terzi, 1999).

For HRV analysis, the HR was recorded beat-by-beat by the Polar RS800CX heart rate monitor (Polar Electro, Kempele, Finland) with a sampling rate of 1000Hz. From this record, researchers selected the section between the 5th and 10th minute of rest, with at least 256 intervals between consecutive heartbeats (RR intervals) for analysis (Vanderlei et al, 2009). After recording, the series of RR intervals was digitally filtered by the Polar Pro Trainer - Version 5.0 software (Polar Electro, Kempele, Finland) using a moderate filter, which was complemented by manual filtering performed in the Excel software (Microsoft Excel - 2010 version, United States) to eliminate premature ectopic beats and artifacts. Only series with more than 95% of sinus beats were included in this study (Vanderlei et al, 2009).

For analysis of linear indices in the time domain, the rMSSD (root-mean-square of differences between adjacent normal RR intervals in a time interval expressed in milliseconds) and SDNN (standard deviation of all normal RR intervals expressed in milliseconds) were considered. In the frequency domain, the analysis was performed by spectral components of low (LF -0.04–0.15 Hz) and high (HF- = 0.15–0.40 Hz) frequency, in normalized units (nu). The spectral analysis was calculated using the Fast-Fourier transform algorithm (Vanderlei et al, 2009). Kubios software (Biosignal Analysis and Medical Image Group, Department of Physics, University of Kuopio, Finland) was used for this analysis.

Regarding non-linear indices, the quantitative analysis of the recurrence plot was used, based on the recurrence rate [REC] and determinism [DET] (Baptista, 2011). The recurrence plot calculation was performed using the Visual Recurrence Analyzes (VRA) software version 4.9 (Eugene Kononov, Springfield, MA, USA). In addition, the analysis of Detrended Fluctuation Analysis (DFA) was also used, performed by the software available on PhysioNet (http://www.physionet.org/) (Vuksanovic and Gal, 2005). The Poincaré plot was performed using the Kubios software (Biosignal Analysis and Medical Image Group, Department of Physics, University of Kuopio, Finland). Finally, Shannon Entropy [SE] (Porta et al, 2001) was also used, which was calculated by the Symbolic Analysis fast version – version 4.0 software (Universita' degli Studi di Milano, Italy, 2005).

Sample size calculation

The sample size was calculated by GPower® software version 3.1.9.7 using the results obtained in a pilot study. For this calculation, the values of the rMSSD index were used, considering a mean difference of 3.0 ms and a standard deviation of 5.51, with an alpha risk of 5% and a beta risk of 80%. Results indicated that a sample size of 24 would be sufficient.

Statistical analysis

Data analysis was performed blindly. First, descriptive statistics were computed to describe participants' sociodemographic and clinical characteristics. Continuous variables are presented as mean ± standard deviation (SD), median, minimum and maximum, and discrete variables are presented as number (percentage) unless otherwise stated.

To analyze the clinical and autonomic data, homogeneity was initially assessed using the Mauchly sphericity test and, if the assumed sphericity was violated, the Greenhouse-Geisser correction was considered. To investigate change between assessments, the analysis of variance for repeated measures was applied. The Bonferroni post-test or the Friedmann test followed by the Dunn post-test were also used. Effect size analysis was calculated from Eta-squared, on which 0.01 = small effect size; 0.06 = moderate effect size; 0.14 = large effect size . Statistical significance of 5% was considered. All analysis was completed using IBM SPSS Statistics version 22.0 software (SPSS Inc.; Chicago, IL, USA).

RESULTS

The distribution of patients during the stages of the study and consequent sample loss are shown in Figure 1.

“Insert Figure 1”

“Insert Table 1”

The characteristics of the population are shown in Table 1. In addition to Table 1, out of the 26 patients evaluated, 61.54% (n = 16) are considered elderly (age greater than or equal to 60 years) (WHO, 2018). Regarding BMI, 11.54% (n = 3) were classified as normal or eutrophic, 61.54% (n = 16) as overweight, 7.69% (n = 2) as obese I and 19.23% (n = 5) as obese II (WHO, 1995).

Table 2 shows the comparison of clinical and autonomic data between the baseline, mid-point, and at CR discharge. Lower values for Shannon entropy were observed in the 12th week compared to the first week one (p=0.037), as well as lower values in LF nu (p=0.035) and HF nu (p=0.026) were observed between the first and sixth week.

DISCUSSION

This is the first study to assess whether the combination of VRBT in phase III CR maintenance of CR effects clinical and autonomic effects. Results showed that the use of VRBT did not cause major changes in these variables, except for the apparent lack of clinical significance observed in ES, LF (nu), and HF (nu).

There is a great deal of evidence for the CR benefits, such as improved physical performance and symptom-free exercise capacity observed in stable patients (Bellmann et al, 2020). Moreover, prolonged physical exercise reduces resting BP and HR. There is a reduction in mortality on cardiac patients that increase activity and continue leading active lifestyles.

Therefore, maintaining the practice of physical exercise is important for these patients, as they maintain the effects obtained (Magalhães et al, 2013), as was observed in our study.

Concerning hemodynamic data, the values of the analyzed variables are within normal limits (Badawy, Nguyen, Clark and Halm, 2017; Barroso et al, 2020; Jubran, 2015; Lau, Watson and Ping, 2016) in the three assessments, with no significant difference. These results suggest that the addition of a session of VRBT to the CR programming contributed to the maintainance of the hemodynamic benefits induced by CR. Since VRBT is an option that can increase program adherence (Cruz et al, 2021), its combination with CR sessions in the maintenance phase seems to be potentially advantageous.

As the autonomic modulation, for the non-linear indices, the ES showed a significant decrease in the comparison between the CR discharge and baseline. These low values represent regular temporal series, that is, lower autonomic nervous system complexity (Godoy, 2016) in these individuals after 12 weeks of VRBT+CR. Lower autonomic nervous system complexity is associated with a worst prognosis, which is observed in heart disease patients. Despite this decrease, the values found are within those observed in other studies with heart disease (Acharya et al, 2014; Kunz et al, 2011). Furthermore, despite not having shown significance, it is worth emphasizing the values observed in the total DFA, alpha 1 and alpha 2: they are values close to one, which expresses a fractal system usually found in healthy young subjects. Usually the total DFA, alpha 1 and alpha 2 are lower than one for individuals with cardiac diseases (Acharya, Lim and Joseph, 2002), so having higher values indicate a good health condition.

Regarding the linear indices of HRV, a reduction in parasympathetic modulation was observed after 6 weeks of combination of VRBT, indicated by a decrease in HF (nu) values in the mid-point assessment when compared to the baseline. However, at the 12-week point assessment there was an increase in these values to values close to the baseline ones. In addition, an increase in global autonomic activity was observed in the mid-poinmt assessment, indicated by a significant increase in LF (nu)on week 6 (Vanderlei et al, 2009), which remained higher than the baseline values in week 12, but without significance. It is important to highlight that, although we strictly follow all precautions for the collection and analysis of HRV indices (Catai et al, 2020), several external factors could indirectly influence HRV, such as, weather conditions, job-related parameters and noises (Sammito and Böckelmann, 2016). In relation to weather, heat reduces HRV due to increases sympathetic nervous system activity. There seems to have a connection between the shift work and the decrease in HRV, as lower HRV was observed in people who work in night shifts over many years, because of the chronodisruption. Finally, noise exposure increases sympathetic nervous system activity, causing a decrease in HRV. These are external factors that may have influenced the results obtained in the sixth week.

It is important to emphasize that throughout the experimental protocol of this study, there was no increase in load in either of the two training modalities, therefore, an improvement in the clinical or autonomic parameters was not expected. but a maintenance the benefits already achieved (Carvalho et al, 2020).

In general, the results obtained in this study indicate that the combination of one weekly session of VRBT within a CR program was able to maintain the values of clinical and autonomic variables caused by conventional therapy. This is an important fact because, due to the chronic character of CVD and the fact that treatments usually last for long periods of time, thus adherence is a major problem, as demonstrated in the study by Wieczorrek et al.(2016), where after 12 months of treatment only 48 % of patients were still attending CR. Thus, VRBT is shown as an alternative and safe therapy for CR, and due to its fun component, it can lead to better adherence to CR sessions. In addition, results from our study showed that VRBT could maintain the benefits obtained in CR, such as improved aerobic fitness and autonomic modulation(Besnier et al, 2017; Lazzeroni et al, 2017; Saavedra, Romero, Roa and Rodríguez-núnez, 2018).

While the present study provides preliminary evidence of the effectiveness of the combination of VRBT in CR, caution is needed when interpreting these results. First, this was not a randomized study, so no causal conclusions can be drawn. Also, there was no long-term follow-up after the intervention to establish whether benefits are sustained beyond the 12-week point. Secound, it is unknown how generalizable this intervention and the effects would be to other CR programs in Brazil, as well as among patients attending other CR models around the world. Finally, the use of VRBT is limited to a group of stable patients, so it is unknown how this therapy would perform in other groups. Having a control group, blinding and multiple assessments, and including other CR models and outcomes should serve as the basis for future research.

CONCLUSION

The combination of VRBT in CR was associated with maintenance of long-term effects in hemodynamic and autonomic outcomes, suggesting that this therapy could be used as a new treatment modality combined with CR sessions.

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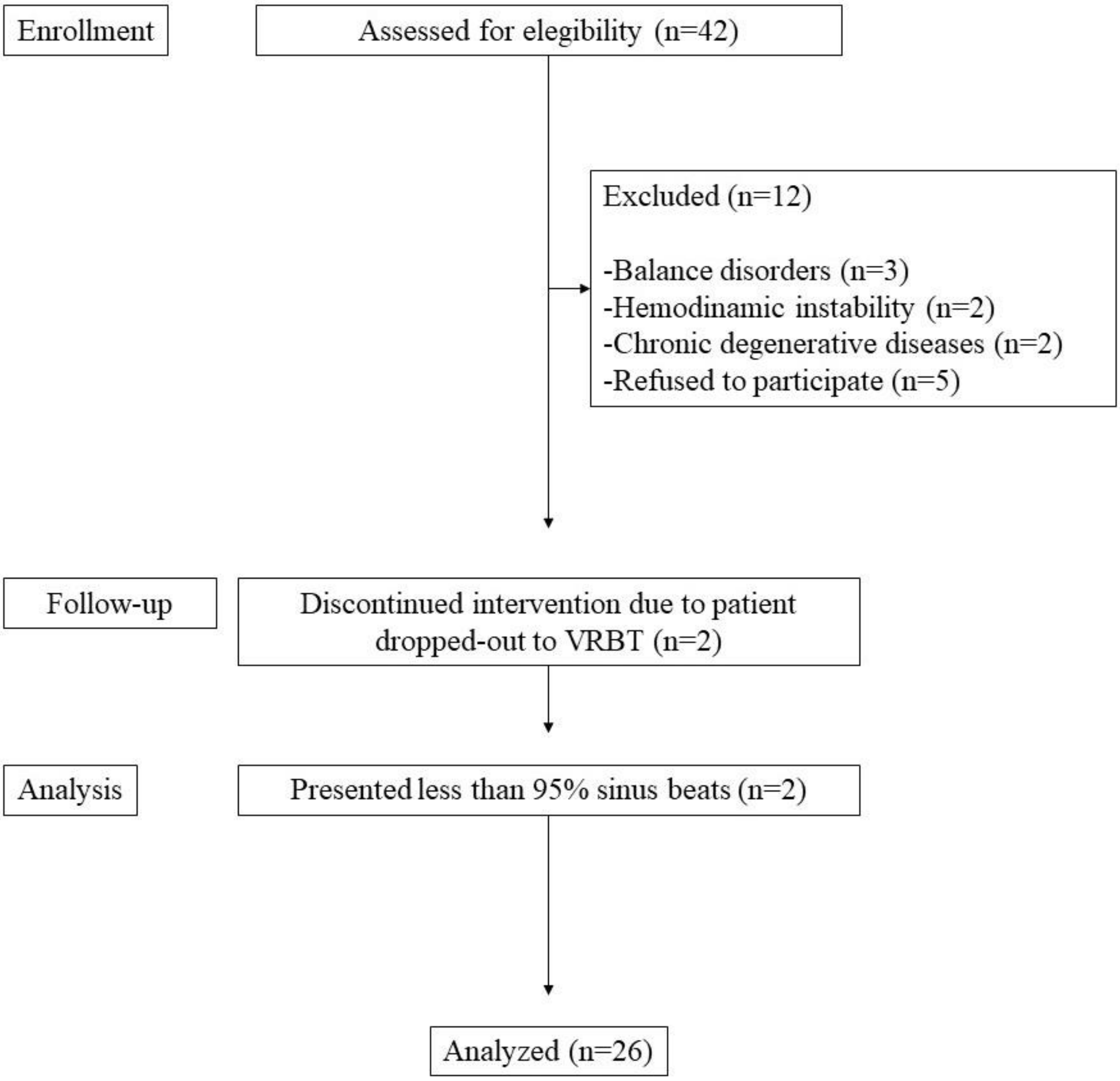

Figure 1. Flow diagram

Table 1. Patients' characteristics

Characteristics	(n=26)
Age, years (mean±SD)	62.04±12.22
BMI, kg/m² (mean±SD)	29.26±4.69
Sex, %(n)	
Men	50.00% (n=13)
Women	50.00% (n=13)
Clinical diagnosis, %(n)	
Cardiovascular diseases	**69.23% (n=18)**
Ischemic heart disease	72.22% (n=13)
Heart failure	22.22% (n=4)
Interatrial communication	5.56% (n=1)
Risk factors, %(n)	**33.33% (n=8)**
Arterial hypertension	62.50% (n=5)
Low cardiorespiratory fitness	37.50% (n=3)
Medications, %(n)	
Aldosterone antagonist	7.69% (n=2)
Antiplatelet agent	61.54% (n=16)
Antiarrhythmic	7.69% (n=2)
Coronary vasodilator	11.54% (n=3)
Beta blocker	65.38% (n=17)
Blockers of Ca^{+}	11.54% (n=3)
Diuretic	34.62% (n=9)
ACE II inhibitors	69.23% (n=18)
Statins	57.69% (n=15)
Hypoglycemic	26.92% (n=7)
Vasodilator	7.69% (n=2)

Legend: BMI: body mass index; kg: kilograms; m: meters; Ca+: calcium; ACEII: angiotensin II converting enzyme; SD: standard deviation. The results are expressed as mean and standard deviation, or as a percentage and absolute number.

Table 2. Comparison of hemodynamic and autonomic data between the baseline, mid-point and post-CR assessments

Variables	1st Week	6th Week	12th Week	Eta- Squared	Effect size
SBP (mmHg)	116.54±9.77	123.08±10.87	117.77±11.09	0.197	High
DBP (mmHg)	71.92±8.01	73.08±9.28	73.85±11.69	0.055	Low
HR (bpm)	69.42±9.39	66.50±8.34	66.92±7.94	0.117	Moderate
RR (bpm)	17.58±3.76	17.23±3.39	16.92±4.17	0.039	Low
SpO_2 (%)	96.12±1.68	96.23±1.86	96.46±1.24	0.035	Low
RPE	6.35±1.23	6.31±1.12	6.00±0.00	0.175	High
DFA total	0.973±0.15	1.025±0.14	1.002±0.19	0.136	Moderate
ALFA1	0.944±0.27	0.981±0.27	0.972±0.24	0.037	Low
ALFA 2	0.939±0.16	1.000±0.16	0.968±0.21	0.125	Moderate
REC (%)	34.94±9.59	37.24±8.86	36.37±10.37	0.108	Moderate
DET (%)	97.97±1.77	98.34±1.37	98.24±1.61	0.090	Moderate
SE	3.658±0.41	3.497±0.40	3.443±0.45*	0.295	High
0V (%)	24.307±13.83	27.983±15.31	30.049±17.16	0.171	High
1V (%)	46.510±5.99	45.251±6.82	43.547±6.62	0.118	Moderate
2LV (%)	8.324±4.49	6.896±4.07	7.269±5.91	0.122	Moderate
2ULV (%)	20.859±11.77	19.870±11.39	18.968±11.98	0.035	Low
RMSSD (ms)	20.372±13.41	22.778±18.12	19.188±10.57	0.089	Moderate
SDNN (ms)	27.428±12.14	34.488±16.23	30.554±13.94	0.147	High
LF (nu)	54.924±20.79	63.93±16.14*	59.254±17.62	0.246	High
HF (nu)	45.072±20.79	36.03±16.10*	40.708±17.61	0.115	Moderate
LF/HF	1.935±1.75	2.440±1.76	2.087±1.58	0.113	Moderate
SD1 (ms)	13.384±8.37	16.123±12.83	13.604±7.48	0.087	Low
SD2 (ms)	34.056±13.78	45.419±20.47	40.454±19.40	0.215	High
SD1/SD2	0.394±0.18	0.360±0.17	0.365±0.18	0.046	Low

Legend: SBP: systolic blood pressure; DBP: diastolic blood pressure; mmHg: millimeters of Mercury; HR: Heart rate; bpm: beats per minute; RR: respiratory rate; bpm: breaths per minute; SpO2: peripheral oxygen saturation; %: percentage; RPE: rating of perceived exertion; DFA: Detrended fluctuation analysis; REC: recurrence rate; DET: determinism; SE: Shannon entropy; 0V: standard without variation; 1V = standard with one variation, 2LV: standard with 2 equal variations; 2ULV: standard with 2 different variations; RMSSD: root-mean square of differences between adjacent normal RR intervals in a time interval expressed; SDNN: standard deviation of all normal RR intervals; LF: low frequency; nu: normalized unit, ms: milliseconds; HF: high frequency *Difference in comparison with the 1st week (Post Bonferroni test; $p<0.05$).

Artigo 2

Perceptions and preferences of patients with cardiac conditions to the inclusion of virtual reality-based therapy with conventional cardiovascular rehabilitation: A qualitative study

ABSTRACT

Background: Virtual reality-based therapy (VRBT) has been recently used in rehabilitation programs, as it can improve patient's adherence to treatment. However, patients' acceptance of VRBT has been scarcely investigated. **Objective:** To qualitatively analyze the perceptions and preferences of patients about the inclusion of VRBT to a conventional cardiovascular rehabilitation program (CRP). **Methods:** Fifteen patients from a randomized clinical trial participated in focus groups for qualitative assessment. **Results:** Patients demonstrated good acceptance and satisfaction of VRBT. Physical and psychosocial benefits were highlighted, and patients reported the perception of higher exercise intensity in VRBT then when doing conventional training. In addition, the frequency of VRBT (once a week), associated with conventional treatment was reported as satisfactory. Cognitive aspects that influenced participation to the new approach were also raised by study participants. **Conclusion:** Patients with cardiac conditions demonstrated satisfaction with the inclusion of VRBT in a conventional CRP, demonstrating that VRBT has the potential to be a new approach for this patient population, allowing training diversification. Benefits perceived by patients include physical, mental, and social aspects.

Keywords: cardiac rehabilitation, physiotherapy, qualitative research, treatment adherence and compliance, virtual reality exposure therapy.

INTRODUCTION

Virtual reality-based therapy (VRBT) has been identified as a new tool for physical therapy treatments.[1,2] Advantages of using this tool include, the variety of games that can be used for therapeutic purposes, the potential for offering resources that allow patients to adapt more easily, transparency for data storage, and remote access of online data. Another advantage is that VRBT can be applied using different equipment, such as smartphones,[3] which can facilitate accessibility.

The literature shows that VRBT increases motivation,[3] which is essential in the treatment of individuals with cardiac conditions, because lack of motivation is related to low adherence to treatment.[4-7] Studies have demonstrated that VRBT application in individuals with cardiovascular diseases (CVD) is a therapy with potential to increase functional capacity in patients with heart failure,[8] and may promote acute physiological hemodynamic and autonomic responses similar to those obtained in a conventional cardiovascular rehabilitation program (CRP).[9,10]

A previous study conducted by our research group[11] showed that the inclusion of VRBT sessions to conventional CRP increased patient's adherence to the first sessions of treatment. To improve knowledge about the inclusion of VRBT with a conventional CRP, and obtain new perspectives from patients regarding this treatment combination, the present study aimed to qualitatively analyze the perceptions and preferences of patients regarding the inclusion of VRBT to a conventional CRP, and understand how VRBT affects patient's adherence to CRP. This information can allow the development of strategies with higher adherence levels.

METHODS

Participants from this study were part of a randomized clinical trial (RCT) that evaluated two physical training groups.[9] One group performed only conventional CRP (three sessions of conventional CRP in a week) and the other group performed VRBT associated with conventional CRP (one session of VRBT and two sessions of conventional CRP in a week) for 12 weeks. In the CRP session, the warm-up consisted of stretches and exercises for the upper limbs, lower limbs, and both combined. The exercise training phase consisted of exercises performed on a treadmill. In the VRBT session, the warm-up was performed using "Just Dance 2015" game, in which patients reproduced choreography in a previously defined sequence. The exercise training phase was performed through "Shape Up" exercise games following a virtual therapist. The group that performed VRBT sessions included with conventional CRP training were invited to participate in this qualitative study. During VRBT, the exercise intensity was the same as used in the conventional CRP (40-70% HRR for patients with CVD and 60%-80% HRR for those with cardiovascular risk factors). The training protocol has been published in detail previously.[9]

At the end of the clinical trial, all 27 patients were invited to participate in focus groups to collect qualitative data. Fifteen patients opted to participate in this study and, after being informed about the studies' procedures and objectives, signed the informed consent form. The qualitative study was approved by the Research Ethics Committee of Universidade Estadual Paulista (UNESP), Presidente Prudente, SP, Brazil (n° CAAE: 29742920.9.0000.5402).

The focus group meetings were performed with 3 to 7 participants, had an average duration of 60 minutes, and were conducted by a female moderator, a PhD student, with previous experience in qualitative research and cardiovascular rehabilitation, who had no previous contact with the participants. A second researcher, who also had no previous contact with study participants, participated in the interview to take notes. To conduct the focus group, the moderator used an interview script, previously developed, containing the open-ended questions listed in Table 1.

Table1. Script of questions used in the focus group with patients.

1. Did you enjoy having one video game session and two sessions of exercise on the treadmill in the same week?
2. Would you associate video game sessions with the cardiac rehabilitation program?
3. In the games, did you feel represented by the drawings? Would you prefer to see a design with another biotype (older, heavier)? Or the character does not matter?
4. Did you like to see your image in the video game? Did you prefer to be represented by a drawing (be it of similar sex, age, unreal, different character)? Or the character does not matter?
5. Did you like the scenarios used in games with nature, imaginary scenarios like the moon, in imaginary times (as in the dinosaur era)? Or would you rather be seen in a clinic setting? Or the scenario does not matter?
6. Did you prefer games that you should look at and reproduce the movements or those in which the teacher demonstrated the exercises? Did you like both? Didn't like any?
7. Did you like the chosen songs? Would you preferer another style of music? Would you prefer music in your language? Or it does not matter?
8. Did you enjoy interacting with imaginary objects (watermelon, snowball, stepping on the carpet) in the game?
9. Did you notice the feedback messages on the screen, such as timing, the scale for changing games? Liked?
10. Did you like the awards at the end? Why? Do you think they stimulated competition with your partner?
11. Do you prefer to perform the treatment in pairs or in groups? Why?
12. Did participating in video game sessions encourage you not to miss sessions?
13. Did you avoid missing more on video game days than on conventional rehabilitation days?
14. If it were made available to you, would you do it on vacation, holidays, or when sessions are suspended? If not, why?
15. After orientation, would you have a VRBT session at your home? Why?
16. What did you like most about the video game? Why?
17. What did you like least about the video game? Why?
18. What would you change about the treatment you were offered? Why?
19. Do you think you have improved with the video game?
20. Would you recommend this new therapy (video game) to another patient?
21. Did you like the video game treatment? If so, why?
22. Did the video game motivate you to exercise? If so, why?
23. Would you replace participating in the cardiac rehabilitation program with video game sessions?
24. Did you ever feel forced to participate in video game therapy?
25. Did you feel safe during video game therapy?
26. Is there anything else you would like to say?

The focus group meetings were conducted in a university study laboratory, where the clinical trial was conducted. The meetings were audio-recorded using a recording device (OLYMPUS / VN-8100PC, Tokyo, Japan) and transcribed verbatim. During the focus group meetings, data were collected up to the theoretical saturation point, that is, until the moment when no new information was obtained.[12,13]

Analysis of qualitative data

After the verbatim transcriptions of the statements obtained in the focus group meetings, analyses for identification and classification into categories were performed by three independent researchers. The analysis was developed by categorization, organization, and compaction of the data. Thus, a content analysis was performed, which consists of the description of phenomena, allowing the researcher to understand the data by refining the words into smaller categories related to the content.[13] Therefore, it is possible to reduce the number of words in fewer categories, aiming at providing new knowledge for new actions.[13]

Finally, the researchers performed a triangulation, which consisted of a discussion about the differences in the results, to reach a consensus. Subsequently, the results were forwarded to 10% of the participants to confirm whether the results were consistent with the focus groups, and whether they really reflected participants' views and perspectives.

RESULTS

The sample characterization is presented in Table 2.

Table 2. Patients'charactheristics.

Characterization	(n=15)
Age (years)	60.80±14.51
BMI (kg/m²)	28.73±4.23
Sex	
Men	27% (n=4)
Woman	73% (n=11)
Ethnic background	
White	73% (n=11)
Black	20% (n=3)
Other	7% (n=1)
Time of treatment in CR program (months)	84.53± 61.41
Clinical diagnosis Cardiovascular diseases	**53% (n=8)**
Ischemic heart disease	50% (n=4)
Heart failure	38% (n=3)
Atrial septal defect	13% (n=1)
Risk factors	**47% (n=7)**
Arterial hypertension	57% (n=4)
Low cardiorespiratory fitness	43% (n=3)
Drugs in use	
Aldosterone antagonist	7% (n=1)
Antiplatelet agent	40% (n=6)
Antiarrhythmic	7% (n=1)
Coronary vasodilator	20% (n=3)
Beta blocker	60% (n=9)
Diuretic	13% (n=2)
ACE inhibitors	60% (n=9)
Statins	40% (n=6)
Hypoglycemic	20% (n=3)
Vasodilator	7% (n=1)

Legend: ACE, angiotensin II converting enzyme; BMI, body mass index; Ca+, calcium. The results are expressed as mean and standard deviation, or as a percentage and absolute number.

A qualitative analysis identified the following three themes: 1) “VRBT Features that influence patients' motivation and adherence”; 2) “Patient profile”; and 3) “VRBT home viability”.

Theme 1- VRBT Features that influence patients' motivation and adherence

In general, patients reported the perception of higher exercise intensity during VRBT then during conventional training, and the importance of a familiarization period with the new therapy. In addition, the frequency of VRBT (once a week), associated with conventional treatment was reported as satisfactory. The patients did not reach a consensus regarding the accomplishment of the VRBT in pairs or in groups, some patients reported that the pair activity provides better game / patient interaction and other patients reported that group activity could increase the fun of the therapy. The games used are commercial games, with prizes at the end of the games, which generated competition during the therapy, which provided greater stimulus when performing the exercises. On the other hand, the disappointment of loss in the game was mentioned by some patients. Game components, such as characters, scenarios, music, interaction with imaginary objects, and feedback messages were aspects that drew patients` attention. In general, patients were satisfied with the VRBT and enjoyed the variety of approaches used in the program. In addition, patients reported physical, mental, and social benefits provided by VRBT. However, most patients believe that VRBT did not influence adherence and motivation. Only one patient reported greater adherence to treatment due to VRBT, and two other patients reported that they felt more motivated to perform the VRBT sessions.

- *“I would associate. Because I loved it, that's exactly what she said, because we work hard too.” (Subject 7, woman, 72 years old)*

- *“Ah, I think it was good for me, right? I even got better, because I could even follow the exercises correctly, except in the first days, but then I thought it was good.” (Subject 9, woman, 80 years old)*

- *"So, look why it happened, there were two of us, so there was a little competitiveness. I think it's good for us ... because you are looking to improve yourself." (Subject 7, woman, 72 years old)*

- *"When you are winning, you are happy, but when you lose you get a little upset ..." (Subject 1, woman, 46 years old)*

- *"I think our image was really cool! (in-game image feedback) ... I think even to be correcting posture, seeing the sequence of exercises." (Subject 3, male, 47 years old)*

- *"The award, she valued what we were able to do best." (Awards) (Subject 3, male, 47 years old)*

- *"Was good. Mainly because I have been participating for 10 years, you know, and I found something different, like, it left that routine, you know, from exercise and everything." (Subject 5, woman, 39 years old)*

- *"It improved agility, because it works more the head, more the body, more everything." (Subject 7, woman, 72 years old)*

- *"I would definitely recommend ... mainly to people over 50, 60 years old, I think so ... Because ... for example, because of the mind." (Subject 8, woman, 64 years old)*

- *"For me, yes ... I keep doing it at home ... I stopped physical therapy and I keep doing it by application." (Subject 13, woman, 30 years old)*

Theme 2- Patient profile

This theme encompasses information related to individual characteristics that can influence VRBT practice. Patients reported that advanced age and lower cognitive and functional capacity are factors that limit the performance of the proposed exercises. As a suggestion, they suggested that a homogeneous selection of participants would be interesting, as people with the same functional level would present better VRBT performance as a group.

- *"A little because of my age, mine, my structure, I can't take much effort." (Subject 10, woman, 79 years old)*

- *"It is in pairs I think it would be more interesting if you put two people on the same level of physical conditions, right?" (Subject 15, woman, 57 years old)*

Theme 3 - VRBT home viability

VRBT was considered to be a potential home therapy, without face-to-face supervision of therapists, after receiving previous guidance. On the other hand, some patients reported that they would face problems in performing this therapy at home, due to the need for commitment required, and safety concerns. Finally, some patients reported that the viability depends on intrinsic capacity of self-knowledge.

- *"Today we have the experience. Just like the question you already asked, "Would you do it at home?", Today with experience, but within the limits of each one." (Subject 3, male, 47 years old)*

- *"Yes, but all this in my case, with limitations! Likewise, I still have cardiac problems that I feel bad with excess. So, everyone knowing their limit to perform at home alone, has to be careful." (Subject 3, male, 47 years old)*

- *"You are safe (presence of the therapist in the VRBT), you are not left with that insecurity, "oh something will happen"." (Subject 7, woman, 72 years old)*

DISCUSSION

In general, the inclusion of VRBT to a CRP demonstrated good acceptance by patients, who reported physical and psychosocial benefits gained with the therapy. In addition, elements related to the intensity and frequency of carrying out the VRBT were identified, as well as the physical and cognitive aspects of the individuals who influence the conduct of this therapy.

The satisfaction and perception of benefits regarding physical, mental, and social aspects, reported by patients, corroborate the findings of a study developed by Meneghini et al,[14] where, adults and elderly, submitted to a training protocol with sports exergames (Xbox 360 Kinect Sportstm) reported psychological benefits, such as improved self-esteem, concentration, mood, and even reasoning and memory, in addition to improvements in agility and benefits in social interaction, resulting from the exchange of experiences and the creation of friendships. The perception of physical, mental, and social benefits found in our study, may explain the fact that patients mention VRBT to other individuals with CVD.

Regarding motivation, most patients reported that there was no VRBT influence on motivation and adherence to the CRP. Patients justify this aspect, as they state that previous awareness of the regular physical activity importance for patients with cardiac conditions is clear to them. In fact, the literature points out that the influence of beliefs prior to CRP, related to the benefits that physical training provides to patients with cardiac conditions, directly influences these individuals' adherence to physical exercise.[15] Thus, we believe that this finding justifies the fact that most patients reported that their adherence to the practice of physical exercise is linked to awareness of its importance. In addition, the playful characteristic of this type of therapy provided motivation for two patients, which also meets the findings of previous studies.[16,17]

Patients with cardiac conditions report a perception of higher intensity in the VRBT program.[9] In a previous study, a greater magnitude of RPE ($p < 0.01$) during the execution of VRBT and until 5 minutes of recovery was observed. Additionally, 74% ($n = 20$) of patients reached their heart rate reserve during the intervention and 33% ($n = 9$) exceeded heart rate reserve. However, this higher perception of exercise intensity, was related by some patients to difficulties in following the proposed exercises, highlighting the need for a period of familiarization to increase patient performance.

Patients also reported that the best way to perform the VRBT is in association with conventional therapy, as conducted in the present study. Patients stated that both therapies are important for physical well-being. There was no consensus regarding preferences to conduct the therapy in pairs or in groups, however, some patients reported that VRBT conducted in pairs helps to maintain the focus on therapy, improving game-patient interaction, while other patients reported that VRBT conducted in a group could increase the fun of the therapy and, consequently, the motivation.

It is important to note that the games used in this study are commercial games that have been adapted to the routine implemented for VRBT. These games promote the stimulus of competition among the participants with prizes at the end of the games and, in some cases, this competition provided a greater stimulus when performing the exercises.

Previous studies have shown that competition between patients stimulates motivation and improves individual's physical performance,[18,19] however, this stimulus also depends on personal characteristics, and thus, in some cases, demotivation from this competition may occur.[20] However, this fact was not observed in the present study.

Regarding the components of the games, such as characters, scenarios, music, interaction with imaginary objects, and feedback messages, patients showed contentment and satisfaction, the visualization of their own image on the game screen was a factor that helped in performing the exercise properly and enabled patient-game interaction by promoting greater stimulation.

The possibility of viewing the patient's image in real time allows the correction of postures and movements during the VRBT, which facilitates the correct execution of the exercises and the achievement of satisfactory results in terms of injury prevention due to the incorrect execution of exercises.[21] The availability of greater diversification of music and games and translation into the source language, were characteristics of the games cited as aspects that needs improvement.

Factors such as advanced age, lower cognitive capacity, and lower functional capacity seem to make it difficult to perform the exercises proposed during the VRBT sessions. It is known that during the aging process there are physical and cognitive changes, which can negatively influence the practice of physical activity in general,[22,23] which may explain why these complaints came from some of the patients. These factors influence the conduct of VRBT, considering that this type of therapy contains combined and more complex exercises than conventional therapies.[9]

In addition, the patients also stated that people with the same functional level would perform better in VRBT when conducted in pairs, so the homogeneous selection of the participants should be an aspect to be considered in future programs.

The VRBT advantages, related to data access and cost-benefit, associated with beneficial effects and safety,[10] allow to consider its use as a potential home therapy without supervision. However, most patients believe that it would be possible if there was a previous period of familiarization. However, difficulties with adherence and concerns about the safety of VRBT without supervision, such as the fear of exceeding physical limits were presented as limiting factors for home therapy.

As a suggestion for the implementation of home VRBT without supervision, the assessment of viability considering the individual's ability to know their limitations is an important aspect, which was presented by some participants. It is known that this aspect is recommended for performing phase four of a CRP, that is, stable patients with the ability to assimilate self-monitoring of training are eligible to perform this phase,[24] therefore, we assume that it is possible to conduct this VRBT at home.

As a limitation of this study, some of the patients who participated in the previous study did not participate in the focus group. All patients were invited, but 12 of them did not participate, with 11 giving a justification: moving to another city (n = 2), illness (n = 3), work (n = 4), and personal problems (n = 2).

CONCLUSION

Given the above, we can say there was satisfaction with the proposed therapy and its elements were well accepted by some patients. But most patients reported that there was no VRBT influence on motivation and adherence to the CRP, justifying that their adherence to the practice of physical exercise is linked to awareness of its importance.

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Artigo 3

Perceptions of physiotherapists about virtual reality using exergames in cardiovascular rehabilitation: a qualitative study

Short running title: Physiotherapist's perception of virtual reality

ABSTRACT

Background: Cardiovascular rehabilitation (CR) is an outpatient model of secondary preventive care. Despite its benefits, CR is greatly under-utilized. **Objective:** This study aimed to investigate perceptions of physiotherapists about virtual reality-based therapy (VRBT) using exergames in CR. **Methods:** A qualitative research methodology using focus groups was employed to evaluate the perceptions of 5 physiotherapists who carried out a clinical trial that investigated the association of VRBT with traditional training in CR. **Results:** Physiotherapists reported some advantages of using this new therapy (e.g. VRBT changes to the traditional treatment routine) and problems related to safety during the execution of the VRBT (e.g. setting up the device before session and control of effort intensity during the session). In addition, they provided suggestions for improving games for cardiac patients, including feedback on the games screen and the possibility of including hemodynamic parameters in therapy. **Conclusion:** Physiotherapists recognize that VRBT can be associated with CR to improve patients' adherence to these programs.

Key words: cardiac rehabilitation, virtual reality exposure therapy, treatment adherence and compliance, physiotherapist, qualitative research.

INTRODUCTION

Cardiac rehabilitation (CR) is considered one of the most clinically and cost effective therapeutic interventions in cardiovascular disease (CVD) management, significantly reducing both morbidity and mortality.[1–3] Traditional CR involves delivery of structured exercise, education, and risk reduction largely by non-physician health workers, such as physiotherapists, in an outpatient setting.[4] Robust evidence demonstrates CR is cost-effective.[5] Despite its benefits, CR is grossly under-developed and under-used. It is estimated only 14% of patients access CR in middle-income countries.[6] In Brazil, there is only one CR spot for every 99 ischemic heart disease patient.[7]

Virtual reality-based therapy (VRBT)[8] is a computerized hardware and software system that generates simulations of real or imaginary environments with which participants can interact at different levels using their own movements. This therapy provides to patients diversity of games (i.e. several game options), adaptability to different co-morbidities, transparency for data storage, access to data remotely, and the most important is the improvement in patients' motivation which stimulates adherence. [9–11] Effectiveness of VRBT has been confirmed in patients with coronary artery disease, heart failure, coronary revascularization, and arterial hypertension[12,13]. VRBT is a feasible and safe complementary treatment to traditional CR, that promote physical and psychosocial benefits, such as improvement in functional performance, higher energy levels quality of life, reducing symptomatology and depression[12].

Research has shown that when VRBT is used in cardiovascular patients, there are similar benefits than those obtained in traditional CR, promoting an intensity sufficient for patients to reach their cardiac frequency reserve.[14] In this context, exergames – a type of VRBT – is a good alternative to increase the level of physical activity, as they are video-games that promote players' physical movements with strength, balance, and flexibility activities. VRBT using exergames may promote physical activity, enhance motivation and increase adherence in CR,[12] thus demonstrating its viability to use in these programs.

However, the use of a new technology, such as VRBT, can create challenges to patients and the healthcare team, such as the lack of knowledge and skills.[15] In addition, cost and setting up of the VR devices, and more importantly, maintenance are aspects that could also create barriers to VRBT use and must be considered before implementation in CR. Therefore, the aim of this study was to investigate perceptions of physiotherapists (who delivered care for individuals with CVD attending a conventional CR in association to VRBT) about virtual reality using exergames in CR using a qualitative research approach.

MATERIALS AND METHODS

This was a narrative research using a qualitative approach to examine the perception of physiotherapists about virtual reality using exergames in CR as part of a randomized controlled trial that investigated the use of VRBT in CR (Clinical Trial Registration: NCT03377582). The study was conducted at the Cardiology Division Center for Physical Therapy and Rehabilitation Studies and Treatment of the São Paulo State University (UNESP) in Presidente Prudente, São Paulo, Brazil.

The RCT protocol is published elsewhere.[14] In summary, the 12-week intervention included 3 CR weekly sessions: one of VRBT and two of traditional CR. All sessions were supervised by physiotherapists, who assisted two patients per session, 27 in total. Both sessions had 3 phases: warm-up (15 minutes), activity (30 minutes), and relaxation (5 minutes). In the VRBT session, the warm-up phase was performed by the game *Just Dance* and the activity phase by the game *Shape Up*. In the CR sessions, the warm-up was performed through upper limbs, lower limbs, and combined exercises and the activity phase was performed on a treadmill. The relaxation phase was performed with the patient lying on a mat, performing breathing exercises and stretching in both types of sessions. When the data collection for the trial finished, all 5 physiotherapists who conducted the exercise training were invited to participate in a focus group to share their perceptions about the use of VRBT in CR. The qualitative study was approved by the Research Ethics Committee of FCT / UNESP (nº CAAE: 29742920.9.0000.5402).

Qualitative data was collected from a 50-minute focus group session by a female moderator (I.G.S.), PhD student with previous experience in qualitative research and CR, who had no previous contact with participants. A semi-structured focus group interview guide (Table 1) was used to facilitate this session. The focus group guide was designed based on expert knowledge, past focus group scripts and existing literature.[13,16,17] Field notes were compiled and summarized by a second researcher (L.G.), who also had no previous contact with the physiotherapists participating in the study. During this focus group, data were collected up to the theoretical saturation point, that is, until the moment when no new information was obtained.[18,19]

“Insert table 1”

Data Analysis

Focus group sessions were digitally audio-recorded and transcribed verbatim by the research team. A thematic content analysis was used to identify, clarify, analyze and report themes evolving from the focus groups.[20] Transcripts were reviewed independently by three research team members (M.M.A.C.; I.G.S.; A.L.R.) and initial systematic coding and categorization of transcripts was conducted through repeated readings and line-by-line analysis by two independent coders. Finally, triangulation was applied to the data.[21] Subsequently, the results were shared to available participants to confirm whether the results were in accordance with their views and perceptions. In the end, trustworthiness criteria was reached by team consensus of all qualitative data extracted.[22] Anonymity and participant confidentiality was ensured using pseudonym initials.

RESULTS

Our population was composed of 5 participants (i.e. 5 physiotherapists) and all agreed to be part of this research. Five themes were identified to describe the perceptions of these professionals regarding the use of VRBT in CR. Figure 1 illustrates the key themes extracted. Citations are described in Table 2.

"Insert Figure 1"

Theme 1: Barriers to implementation of VRBT in CR

This theme shows information related to barriers identified by physiotherapists before and during VRBT sessions. Physiotherapists perceived those patients were insecure to undergo a new therapeutic modality. In addition, they reported technical difficulties with the VRBT equipment as the main barrier, specifically related to setting up the device before session, turning off all equipment after session, and control of effort intensity during the session. The competitiveness among patients was also cited by physiotherapists as a barrier to use of VRBT in CR.

Theme 2: Physiotherapist's perception of the patient during VRBT sessions

Physiotherapist's perception of patients during VRBT was also one of the themes extracted. Physiotherapists reported that patients had a greater rating of perceived exertion and satisfaction during VRBT compared to traditional CR exercise sessions. Overall, patients were happy and satisfied with a new modality of therapy that could make them be active during sessions in a fun way.

Theme 3: Advantages of VRBT use in CR

Physiotherapists perceived many advantages of VRBT use in CR, including the possibility of patients to exercise at home, the opportunity to have different ways to exercise during the CR programming, and the influence the modality had on patients' adherence to CR sessions. In addition, physiotherapists demonstrated satisfaction with the cost-benefit of VRBT and reported they identified similar physiological effects of VRBT compared to traditional CR.

Theme 4*: *Safety of VRBT in the CR setting

Safety of VRBT in the CR setting was often mentioned by physiotherapists, who identify the importance of establishing an eligibility criteria for the CR patients that would be referred to VRBT. In addition, the need for monitoring during VRBT in an outpatient setting, supervised or unsupervised at home was warrantied, and clinical staff should be trained to better use this new type of therapy.

Theme 5: Improvements for VRBT use in CR

Physiotherapists suggested improvements for VRBT use in CR, including having a specific VRBT game development for cardiac patients. They also suggested having information sessions about the therapy, so patients could learn and familiarize more with VRBT. In addition, a test session could be included as part of the training where levels of difficulty could be determined (to have a better progression of training intensity), and patients' preferences for games could be identified. The possibility of different scenarios, languages, hemodynamic parameters' feedback to check signs and symptoms and intensity control were also suggested.

"Insert table 2"

DISCUSSION

In this qualitative study, physiotherapists who carried out a clinical trial using VRBT were invited to share their perceptions about the use of this therapy as part of CR programming. Our results showed that physiotherapists identify VRBS as an opportunity for patients to exercise in different ways during sessions, which could directly impact their motivation and adherence to the program. They also reported patients were happy and satisfied with a new modality of therapy that could make them be active during sessions in a fun way. However, few barriers were also identified and included setting up the device before session, turning off all equipment after session, and control of effort intensity during the session. Safety was also mentioned and different suggestions proposed for improvements, including clinical staff training on VRBT use and having an information session with patients to teach them about this technology and also understand their preferences.

Barriers to VRBT were identified by physiotherapists before, after and during the session. Barriers before VRBT were related to patients' fear of undergoing a new therapeutic modality, a sensation that may have been influenced by the age of patients. CR participants are usually 65 years old or older[4] and may not be have technology literacy to deal with VRBT. Therefore, the suggestion by physiotherapists to have information sessions could be key to implementation of VRBT in CR, as the clinical team could teach patients about VRBT and understand their preferences. Although physiotherapists reported patient’s fear, they also mentioned that after the initial fear patients were satisfied with VRBT. This perception corroborate with those described by Cruz et al,[16] who observed that patients with cardiac conditions demonstrated satisfaction with the inclusion of VRBT in a traditional CR.

During the VRBT sessions, physiotherapists perceived barriers related to technical difficulties and logistics of preparing the space to sessions. Since not all patients will be taking VRBT sessions, it is important for rehabilitation programs to have a specific location and adequate infrastructure for VRBT use. A place where the device can be previously assembled and with enough space to carry out wide movements without blockage would be ideal, but we understand this is not the reality of many CR programs. A feasibility study assessing the use of VRBT in public and private rehabilitation centers is warrantied to understand if this therapy could be implemented in different settings and spaces across the nation.

The fact of the games used were not specific for cardiac patients was reported as a barrier due the difficulties in controlling exercise intensity. Therefore, physiotherapists suggested the development of games specific to this population. Considering intensity control, the literature suggests that heart rate (mainly measured by heart rate reserve; HRR),[20] The Borg scale,[23] and instruments used to measure exercise intensity should be used during VRBT sessions.[22] In our study, the exercise intensity was controlled by HRR and the Borg scale. However, due to VRBT characteristics, the load adjustment was possible only when using dumbbells and shin guards, which makes it difficult to control the intensity.

Moreover, competitiveness among patients generated by the games was also perceived as a barrier. The competition encouraged some patients to perform the exercise in an intensity higher than prescribed as they aimed for a better game score. This important aspect must be controlled by the clinical team using VRBT to make sure quality of exercise is not overlooked by game scores. In that way physiotherapists suggested to set common goals for all participants: as patients were exercising in pairs, they should be seen as a team and not opponents.

Information related to physiotherapists' perception during the VRBT sessions was also collected. Physiotherapists observed a greater perception of patients' exertion during VRBT, which corroborates with a previous study,[14] that may be related to movements complexity. Despite this, they reported patients' satisfaction with the new therapy, which in some cases appeared to be related to patients' profile. Women and younger patients, who had previously contact with VRBT, showed greater enthusiasm. Gender and age are factors that influence motivation to exercise in general,[24] and studies have shown younger adults are more willing to try a new intervention approach,[25] which is aligned with our findings.

Using VRBT in CR could be fun for patients and make them be more engaged in CR sessions. VRBT is fun and has a variety of scenarios; these aspects allow changes to the traditional treatment routine and may positively influence patients' adherence to CR, as reported in previous studies.[26,27] Overall, physiotherapists demonstrated satisfaction with VRBT and perceived the therapy as cost-effective (although no analysis of cost-effectiveness of VRBT has been done, which could serve as the basis of future research in the area). Physiotherapists pointed to the possibility of seeing more than one patient with the same equipment per session, which would reduce costs. While VRBT in phase four of a CR (i.e.home-based) is an option,[28] physiotherapists emphasized the need for patient training on where and how to use this therapy.

In addition, VRBT has physiological effects similar to traditional CR,[13,14] especially in relation to *stimuli* of physical and mental abilities, which corroborates with findings from previous studies.[12] That cite the fact that adults and the elderly after 12 weeks of training with games sports (Xbox 360 Kinect Sportst) report psychological benefits such as improved self-esteem, concentration, mood, reasoning and memory, in addition to improved agility and benefits in social interaction.[16,29]

The use of VRBT by cardiac patients, both supervised and unsupervised, must be performed safely;[12] for this, physiotherapists identify the importance of establishing a eligibility criteria for the CR patients that would be referred to VRBT, such as the ability to self-monitor symptoms, and the absence of co-morbidities and diseases that interfere with balance. It is important to note that during supervised sessions of VRBT, considering the difficulty in controlling the intensity of this therapy, the physiotherapist must pay attention to patients at all times, guiding them as the exercise progresses in relation to the load and execution of the movements.

The progress of exercise prescription during traditional CR is reported by CR guidelines[28,30] as related the patient's degree of cardiovascular risk, the individual exercise prescription and adequate monitoring. In unsupervised sessions, this is even more important and the ability to self-monitor symptoms is key for progression and adherence.[28,31] These recommendations are in agreement with what was perceived by physiotherapists in this study and should be followed for use of VRBT in CR.

Physiotherapists suggested changed to improve the experience of cardiac patients while using VRBT. These suggestions were the following: creation of a specific VRBT game development for cardiac patients, having information sessions about the therapy prior to start, and having a test session. People exercise differently and have different preferences. VRBT gives physiotherapists the opportunity to exercise patients using different modalities of the games, which can motivate and entertain at the same time. But it is important first to understand what patients want. Listening to patient preferences and taking steps to accommodate them can enhance treatment experiences and improve treatment outcomes.[32] It should, therefore, become part of ordinary clinical practice using VRBT.

With regard to better monitoring patients in both supervised and unsupervised CR sessions, suggestions were made regarding the possibility of including hemodynamic parameters in therapy, such as HRR, which would facilitate the control of training intensity, in addition to adding feedbacks on the games screen, which could inform patients about their HRR and help monitoring signs and symptoms.

Limitation, Clinical Implications and Future Directions

Caution is warranted in interpreting the findings of this study. Firstly, generalizability of findings is limited for several reasons. This study was completed in only one center in Brazil; therefore, it is unknown how generalizable the findings may be for CR programs in other settings or countries. In addition, although we did include all 5 physiotherapists that were part of the clinical trial training, there were only one focus groups, thus limiting the generalizability of the results. Despite this sample size is considered adequate for qualitative studies[33]. Previous qualitative studies also performed qualitative analysis with small sample sizes. [34–36] Finally, further investigations into the perceptions of use of VRBT in home-based CR is warranted.

Although more research is needed, physiotherapists in this study perceived VRBT as an acceptable therapy in CR and the advantages identified overcame the barriers. Physiotherapists suggested many ways to improve this therapy and believe that, for eligible patients, VRBT could benefit patients that are in phase four of CR. Since CR is under-used worldwide, finding fun ways to adhere patients to programs is always a challenge and based on the perceptions of physiotherapists from this study, VRBT could be one of the solutions for this program. On this note, cost and setting up of the VR devices, and more importantly, maintenance are very important aspects that must be considered before using VR technology in CR and other settings.[37]

CONCLUSION

The present study shows that physiotherapists using VRBT as part of CR programming perceived benefits with this therapy, including an increase in the adherence to CR. Physiotherapists also perceived that patients' profile influence fear of VRBT use, as well as satisfaction and acceptance with this therapy. The recommendation for VRBT use should take into consideration ability to self-monitoring symptoms, no movement restrictions and preferences. Having an information session prior to starting VRBT sessions to understand patients' needs and preferences is suggested and warrantied.

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Table 1. Script of questions used in the focal group for qualitative assessment.

1. Did you find any difficult in using VRBT? If yes, which ones?
2. Are there any advantages to using VRBT? If yes, which ones?
3. Are there any disadvantages to using VRBT? If yes, which ones?
4. Are there any short or long-term advantages in associating VRBT with traditional CR? If yes, which ones?
5. Are there any short-term or long-term disadvantages in associating VRBT with traditional CR? If yes, which ones?
6. During the performance of the protocols, what was your perception regarding the patients' feeling about the association of the two therapeutic modalities?
7. Considering the characteristic of each therapeutic modality, do you think their association is feasible in clinical practice? Why?
8. Considering the cost-benefit of each therapeutic modality, do you think their association is feasible in clinical practice?
9. Do you believe that VRBT provides to patients an intensity similar to CR, making they achieve the HRR? If not, do you believe that this can be made possible in some way?
10. In VRBT, did the patients perform the movements correctly? If not, do you believe that this can be made possible in some way?
11. Do you believe that patients can safely perform VRBT at home? Why?
12. Do you think that VRBT is suitable for the patient? If not, what would you change about it to make it more suitable for patients?
13. Do you think that VRBT influences patient adherence? Why? If not, do you believe that this can be made possible in some way?
14. What are the potential advantages of VRBT over CR, which could complement traditional sessions?
15. Do you believe that if the games were created specifically for cardiac patients, it would be positive? Why?
16. Did you find that the games offer complex or fast movements for the patient?
17. What precautions do you think you should take to apply VRBT?
18. Do you think the patients liked the settings and characters that represented them? Would you change anything?
19. Did you like the feedback messages? What would you change or add?
20. Is there anything else you would like to say?

Table 2. Participant's Citations

Thematic Category	Participant Remarks
Theme 1: Barriers to implementation of VRBT in CR	- *"For me, I think the biggest difficulty was convincing the patient to participate, start the therapy. Once they started, most of them liked it. So, for me, the difficulty was really convincing them to start ... many were already older, they didn't have contact with video games, so they didn't know what to expect from the therapy". (Subject 1, woman,25 years old).* - *"I think another difficulty is the equipment, the logistics of setting up the session, preparing the structure ... because as the room is for multiple use, you know, so we needed to set up and disassemble every time I had the session. So, it's the video game, projector, Kinect, stereo, light." (Subject 4, woman,21 years old)* - *"I say again about the intensity, right, because whether you want or not when you perform VRBT, then there is the exchange of games, so if you are at a certain intensity, when you have the exchange of games you can even ask the patient to try to maintain a stationary march or something else, but like it or not, it does not have the same constancy that it would have in traditional therapy, because you set the speed on the treadmill and you work out with that speed from beginning to end. Now there is a much greater oscillation, right." (Subject 3, male,23 years old).*
Theme 2: Physiotherapist's perception of the patient during VRBT sessions	- *"I think that their perception of exertion was a little higher, mainly due to the complexity of the movements, so sometimes they could not reproduce the movements themselves as they were requested by the games, they did it the way they could. But then, as they couldn't keep up, they had a greater sense of tiredness, because of that." (Subject 4, woman,21 years old)* - *"And I see a lot of correlation with the patients' age, younger patients, they tend to adhere better and like it more. Because I think it is already a platform that they have more contact, they already know, they have used it, different from much older patients, who had no contact with this type of equipment." (Subject 4, woman,21 years old)* - *"The most excited people, it's women, generally women, they tried harder, tried harder to do the same as they were seeing." (Subject 5, woman,21 years old).*
Theme 3: Advantages of VRBT use in CR	- *"Phase 4 of cardiovascular rehabilitation as well. It would be a way to encourage them to practice physical exercise at home. I think it is one of the intentions that virtual reality has been emerging in recent times." (Subject 3 male,23 years old).* - *...so, in addition, you have to take into account what the reality of that patient at home is, if he is able to have the equipment, right, because walking the patient can really go out and do it, he does not depend on any logistics. However, for VRBT it is necessary." (Subject 4, woman,21 years old).* - *"I think the routine changes a little, you know. Some reported that getting out of the routine from the traditional CR was good. This is also an advantage, changing the environment a little." (Subject 2, male,25 years old).*

	- *"Yes, because in "Shape up" (exercise game) there is that moment when, for example, they have to break the watermelon, they have to hit the ice, so there were phases in which time was short, so it stimulated a little of their agility, speed, but they were exercises that they liked, that had feedback ..." (Subject 4, woman,21 years old).* - *"Thinking that at least two patients can perform virtual reality in the same time and the price of a video game compared to two treadmills is much lower, right." (Subject 4, woman,21 years old).* - *"I think the most interesting part of virtual reality is the functionality part of it, so ... you can work the whole body. From motor coordination to broader movements ... there is the playful part that holds the attention, but I say again of the broader movement, you know, many times we do not develop some type of exercises that virtual reality includes." (Subject 3, male,23 years old).*
Theme 4: Safety of VRBT in the CR setting	- *"It depends on the patient. If they have that awareness of being able to self-monitor, it is a patient already going to phase 4, that we have a notion that he will be able to maintain his physiological state, right, and will avoid signs and symptoms. So it depends on whether he can identify these components so that he does not take any risks during the session that he will perform at home." (Subject 1, woman,25 years old).* - *"... as the intensity, at least in the beginning, it was higher in VRBT, they were able to reach (the heart rate reserve), which would be good. But when the patient is already working inside the reserve, I need to be careful that they do not exceed the limit ...When an episode happened in this sense, it was more verbal feedback. Ask them to slow down, do a little more slowly, control, pay more attention to the game to play." (Subject 4, woman,21 years old)* - *"The verbal feedback, from the physiotherapists to the patient, or even you perform a little for them to facilitate the vision, especially at the beginning, I believe it is important for them... (Subject 3, male,23 years old)*
Theme 5: Improvements for VRBT use in CR	- *"Yeah, at different levels of difficulty, right, it would be a dream, right." (Subject 3, male,23 years old).* - *"If you do a familiarization session, of training, for you to teach properly, but with the game ..." (Subject 5, woman,21 years old).* - *"As it is a game, you could adapt it, "Oh, Do you want to train more traditional or dance models today?". So, in traditional way they would do stretches, just like we perform in traditional CR, with normal warm-up. And in dance we would use the movements as the guy is talking, with a slower pace..." (Subject 1, woman, 25 years old).* - *"Functional games, because even "Shape up" was not a category that we used, but ... it has some functional games, for example, of you catching and hitting a target, catching a virtual ball and hitting inside the basket, kick to the goal." (Subject 4, woman,21 years old).* - *"Sensors that provide feedback, for example, of the heart rate on the screen itself, so that sometimes they would not even need a polar and oximeter, because some games provide this. So, the patient is already seeing the frequency in real time, he manages to graduate the level of intensity that*

	he has to do for example." (Subject 4, woman,21 years old) - *"And if there were guidelines in the game itself: "Is everything okay?", "How do you feel?", Then says: "Are you feeling symptoms? Chest pain? Cramp? Muscle pain? Fatigue?", "decrease the intensity"." (Subject 3, male,23 years old)*

Figure.1 Analyzed themes.

Conclusões

Conclui-se, a partir dos achados que:

I. A combinação da TRV com RCV convencional foi associada à manutenção dos efeitos a longo prazo nos desfechos hemodinâmicos e autonômicos, sugerindo que essa terapia pode ser utilizada como uma nova modalidade de tratamento combinado com sessões de RCV convencionais.

II. Houve satisfação com a terapia proposta e seus elementos foram bem aceitos por alguns pacientes. Mas a maioria dos pacientes relatou que não houve influência do TRV na motivação e adesão ao programa de RCV, justificando que sua adesão à prática de exercício físico está ligada à conscientização de sua importância.

III. Os fisioterapeutas que utilizam a TRV dentro do programa de RCV perceberam benefícios, incluindo o aumento da adesão ao RC. Os fisioterapeutas também apontaram o perfil dos pacientes como uma influência ao medo em realizar a TRV, assim como influência também a satisfação e aceitação dessa terapia. Além disso, os fisioterapeutas recomendaram que para a utilização da TRV deve se levar em consideração a capacidade de automonitoramento dos sintomas, ausência de restrições de movimento e preferências pessoais dos pacientes. A realização de uma sessão de adaptação antes de iniciar as sessões da TRV para que se possa entender as necessidades e preferências dos pacientes também é sugerida.

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