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Belo Horizonte
Escola de Educação Física, Fisioterapia e Terapia Ocupacional da UFMG
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Dissertação apresentada ao Programa de Mestrado em Ciências da Reabilitação da Escola de Educação Física, Fisioterapia e Terapia Ocupacional da Universidade Federal de Minas Gerais como requisito parcial para a obtenção do título de Mestre em Ciências da Reabilitação.

Área de Concentração: Desempenho Funcional Humano
Linha de pesquisa: Desempenho cardiorrespiratório

Orientador: Prof. Dr. Marcelo Velloso
Coorientadora: Dra. Liliane Patrícia de Souza Mendes

Belo Horizonte
Escola de Educação Física, Fisioterapia e Terapia Ocupacional da UFMG
2022

M386r 2022

Martins, Thiago Henrique da Silva
Modificação do unsupported upper limb exercise test e avaliação de suas propriedades psicométricas em indivíduos com síndrome pós-covid-19. [manuscrito] / Thiago Henrique da Silva Martins – 2022.
78 f.: il.

Orientador: Marcelo Velloso
Coorientadora: Liliane Patrícia de Souza Mendes

Dissertação (mestrado) – Universidade Federal de Minas Gerais, Escola de Educação Física, Fisioterapia e Terapia Ocupacional.

Bibliografia: f. 65-67

1. Pulmões – doenças – Teses. 2. Reabilitação – Teses. 4. Membros superiores – Teses. 4. COVID-19 (Doenças) – Teses. I. Velloso. Marcelo. II. Mendes, Liliane Patrícia de Souza. III. Universidade Federal de Minas Gerais. Escola de Educação Física, Fisioterapia e Terapia Ocupacional. IV. Título.

CDU: 615.825

Ficha catalográfica elaborada pelo bibliotecário Danilo Francisco de Souza Lage, CRB 6: n° 3132, da Biblioteca da Escola de Educação Física, Fisioterapia e Terapia Ocupacional da UFMG.

UNIVERSIDADE FEDERAL DE MINAS GERAIS

PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS DA REABILITAÇÃO

FOLHA DE APROVAÇÃO

MODIFICAÇÃO DO UNSUPPORTED UPPER LIMB EXERCISE TEST E AVALIAÇÃO DE SUAS PROPRIEDADES PSICOMÉTRICAS EM INDIVÍDUOS COM SÍNDROME PÓS-COVID-19

THIAGO HENRIQUE DA SILVA MARTINS

Dissertação submetida à Banca Examinadora designada pelo Colegiado do Programa de Pós-Graduação em CIÊNCIAS DA REABILITAÇÃO, como requisito para obtenção do grau de Mestre em CIÊNCIAS DA REABILITAÇÃO, área de concentração DESEMPENHO FUNCIONAL HUMANO.

Aprovada em 25 de fevereiro de 2022, pela banca constituída pelos membros:

Marcelo Velloso:08688838836 Assinado de forma digital por Marcelo Velloso:08688838836 Dados: 2022.02.25 17:09:30 -03'00'

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Prof(a). Vanessa Pereira de Lima
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Belo Horizonte, 25 de fevereiro de 2022.

Dedico este trabalho a todos os pacientes do projeto Respirar. Obrigado por me ensinarem a ser grato por pequenos gestos, conversas, e por confiarem no papel da Fisioterapia no manejo da condição de saúde de cada um.

AGRADECIMENTOS

Diante deste trabalho, agradeço primeiramente aos meus pais, Dilma e Cléber por todo esforço e trabalho durante minha educação para que eu pudesse priorizar os estudos, independentemente das nossas dificuldades. Assim como à minha irmã Gabi que sempre entendeu minhas ausências diante os estudos. Fui o primeiro da família a concluir uma graduação, o primeiro a receber o título de mestre e sou feliz em dizer que devo isso a vocês. E agora serei exemplo à minha sobrinha Eloísa.

Ao Ricardo Rodrigues, agradeço por ser meu porto seguro, meu companheiro nessa jornada que é a vida, meu exemplo de profissional e pesquisador. Sem seu apoio eu tenho certeza que este mestrado não teria tido o mesmo brilho.

À Universidade Federal de Minas Gerais pela oportunidade de vivenciar o título de excelência e qualidade que a instituição carrega. Hoje finalizo este trabalho com a certeza de que pude aproveitar bastante o que o universo UFMG pôde me oferecer.

Ao professor Marcelo Velloso, meu orientador, por ter me escolhido e acolhido, por ter depositado toda sua confiança e por ter me apresentado a reabilitação pulmonar e o projeto Respirar. Você foi responsável por mudar minha visão a respeito de uma área da Fisioterapia que antes não era prioridade.

À Liliane Mendes, minha coorientadora, minha gratidão eterna. Hoje sou mais fisioterapeuta devido aos seus ensinamentos, aos puxões de orelha, e à formação clínica. Espero ser um dia metade da profissional e professora que você é.

À Bianca Carmona, minha outra coorientadora não oficial, toda minha gratidão ao seu companheirismo, ao apoio nos momentos em que parecia impossível realizar as tarefas, e por ser minha dupla infalível na reabilitação.

A todos os alunos que passaram pelo projeto respirar por toda paciência, pela troca e por toda ajuda durante o início do trabalho, principalmente à Isis Santos, Leticia

Ferreira, Marina Couto, Daniel Gibson, Guilherme Telles, Anna Pataro, Fernanda Rodrigues e Fernanda Soares.

Às professoras Raquel Rodrigues Britto e Danielle Aparecida Gomes Pereira, pela oportunidade na iniciação científica durante a graduação, no instituto Jenny de Andrade Faria. Por terem despertado em mim o interesse e paixão pela reabilitação. O acolhimento e troca com vocês foi essencial para que eu ingressasse no programa de pós-graduação.

Às colegas de mestrado, Bruna Gontijo, Jessica Loures, Graziele Tavares e Gabriela Nascimento, só tenho a agradecer pela caminhada até aqui. Pela troca, pelo apoio, pelas conversas e por sempre estarem disponíveis quando mais precisei.

A todos os meus amigos por torcerem por mim e por entenderem minhas ausências. Principalmente à Anamaria Lima, Vanderlei, Marina Almeida, Marina Melo, Taciane Mendes, Kezzia de Oliveira e Amanda Riani. Obrigado por me escutarem, por vibrarem e por tornar minha vida tão incrível.

Por fim, agradeço a todos aqueles que passaram por mim e contribuíram de alguma forma com minha formação e crescimento.

PREFÁCIO

Esta dissertação foi elaborada e estruturada de acordo com as normas do Programa de Pós-Graduação em Ciências da Reabilitação da Escola de Educação Física, Fisioterapia e Terapia Ocupacional da Universidade Federal de Minas Gerais (UFMG).

A primeira seção contém a introdução com a revisão da literatura sobre o tema, a justificativa, bem como os objetivos do estudo.

A segunda seção contém dois artigos científicos, produtos do estudo realizado, formatados segundo as normas do periódico *The Brazilian Journal of Physical Therapy* (BJPT) (ISSN: 1413-3555).

O primeiro artigo foi submetido para publicação e após as considerações da banca examinadora da presente dissertação, o segundo artigo será revisado e submetido para publicação, porém a publicação do segundo artigo depende a publicação do primeiro.

A terceira seção traz as considerações finais da dissertação referentes aos resultados encontrados no estudo e uma reflexão sobre a minha experiência durante o período de formação.

As demais seções contêm as referências bibliográficas, anexos e apêndices.

RESUMO

A síndrome pós-COVID-19, causada pelo vírus SARS-CoV-2, provoca uma reação sistêmica devido à cascata inflamatória induzida pela infecção e ao uso prolongado de corticosteroides, especialmente em indivíduos com passagem por unidades de terapia intensiva (UTI). Alguns sintomas são comumente observados na síndrome pós-COVID19, tais como a tosse seca, a dispneia, a fadiga, as dores articulares, além de outros relacionados ao acometimento sistêmico que afetam a capacidade funcional. Devido a isto, é recomendado que estes indivíduos sejam encaminhados a programas de reabilitação que atuem na funcionalidade, de forma individual, e após uma avaliação criteriosa da capacidade funcional. A avaliação da capacidade funcional é comumente realizada por testes de campo, porém, até o momento, dentro do nosso conhecimento, não foram validados testes que avaliam a funcionalidade dos membros superiores (MMSS) para indivíduos pós-COVID-19. O *Unsupported Upper Limb Exercise test* (UULEX) é um teste incremental destinado a avaliar a capacidade de exercício dos MMSS por meio do aumento da carga e da amplitude de movimento dos MMSS. No entanto, estudos têm demonstrado que os indivíduos avaliados pelo UULEX não alcançam níveis mais elevados e interrompem o teste precocemente devido à fadiga. Sendo assim, a modificação do teste parece ser uma boa estratégia para melhor investigar a capacidade de exercício de MMSS destes indivíduos. Ainda, em decorrência da pandemia e a necessidade de restrições e distanciamento social, o sistema de atendimento remoto e telemedicina ganharam maior destaque na área da saúde. Porém, também dentro do nosso conhecimento, os testes funcionais de membros superiores (MMSS) não foram amplamente estudados nessa modalidade de atendimento. Desta maneira, o artigo 1 apresenta um estudo metodológico sobre a modificação do UULEX e sua validação (UULEX-M). Sessenta e quatro indivíduos com síndrome pós-COVID-19 com média de idade de 61±14 anos realizaram o teste original e a versão modificada de forma presencial. Não foram observadas diferenças significativas para as variáveis fisiológicas e sintomas entre os testes ($p>0.05$), exceto para frequência cardíaca ao final do teste (4bpm; 0,9 a 7,42; $p=0.013$), porém não apresentou relevância clínica. Foi observado uma correlação forte entre os tempos dos testes (rho=0,872; $p<0,001$), apesar do menor tempo para a versão modificada (3,97min; 3,4 a 4,55; $p<0,001$). Também foi observado uma diferença significativa entre sexos, onde os homens apresentaram maior tempo de teste em relação as mulheres ($p<0,001$). Considerando a importância do distanciamento social neste momento de pandemia e a necessidade de maiores investigações a respeito da modalidade de atendimentos online, a validação da aplicação do teste de forma remota e a verificação da responsividade à um programa de telerreabilitação pulmonar foram abordadas no artigo 2. Recentemente uma revisão rápida mostrou a possibilidade de aplicação de testes funcionais, que avaliam somente MMII, de forma remota, mas com algumas ressalvas quanto a segurança e a impossibilidade de prescrição de exercícios com base nos testes. O artigo 2 desta dissertação avaliou 26 indivíduos com síndrome pós-COVID-19 e nenhuma diferença estatisticamente significante foi observada entre o teste modificado aplicado presencialmente e remotamente ($p>0,263$). Quanto a responsividade, um grupo de 44 indivíduos, participantes de um programa de telerreabilitação pulmonar de baixo custo que envolvia treinamento aeróbico e de resistência, padronizados, o teste modificado online foi capaz de identificar mudança no tempo de teste (3,77min; 2,43 a 5,11; $p<0,001$), na dispneia (-2,55; -3,51 a -1,59; $p<0,001$) e na percepção de esforço (-

1,18; -2,22 a -0,14; p=0,032), após oito semanas de intervenção com um tamanho de efeito muito grande (d de Cohen: 1,09) para o tempo de teste realizado. De forma geral, este estudo sugere que o UULEX-M é um bom teste para avaliar a capacidade de exercício de resistência dos membros superiores em indivíduos com síndrome pós-COVID-19 além de ser mais prático e demandar menos tempo e necessidade de material, sendo uma alternativa para uso na prática clínica em avaliações domiciliares, nos centros de reabilitação e hospitais.

Palavras-chave: Membros superiores. Reabilitação. Teste UULEX.

ABSTRACT

The post-COVID-19 syndrome, caused by the SARS-CoV-2 virus, causes a systemic reaction due to the inflammatory cascade induced by the infection and the prolonged use of corticosteroids, especially in individuals passing through intensive care units (ICU). Some symptoms are commonly observed in the post-COVID19 syndrome, such as dry cough, dyspnea, fatigue, joint pain, in addition to others related to systemic involvement that affect functional capacity. Because of this, it is recommended that these individuals be referred to rehabilitation programs that act on functionality, individually, and after a careful assessment of their functional capacity. The assessment of functional capacity is commonly performed by field tests, however, to date, to the best of our knowledge, tests that assess upper limb functionality (MMSS) for post-COVID-19 individuals have not been validated. The Unsupported Upper Limb Exercise test (UULEX) is an incremental test designed to assess the exercise capacity of the upper limbs by increasing the load and range of motion of the upper limbs. However, studies have shown that subjects evaluated by UULEX do not reach higher levels and discontinue the test early due to fatigue. Therefore, the modification of the test seems to be a good strategy to better investigate the upper limb exercise capacity of these individuals. Also, as a result of the pandemic and the need for restrictions and social distancing, the remote care system and telemedicine gained greater prominence in the health area. However, to the best of our knowledge, upper limb functional tests (ULL) have not been widely studied in this type of care. In this way, article 1 presents a methodological study on the modification of the UULEX and its validation (UULEX-M). Sixty-four individuals with post-COVID-19 syndrome with a mean age of 61±14 years underwent the original test and the modified version in person. No significant differences were observed for the physiological variables and symptoms between the tests ($p>0.05$), except for heart rate at the end of the test (4bpm; 0.9 to 7.42; $p=0.013$), but it was not clinically relevant. A strong correlation was observed between the test times ($rho=0.872$; $p<0.001$), despite the shorter time for the modified version (3.97min; 3.4 to 4.55; $p<0.001$). There was also a significant difference between sexes, where men had a longer test time compared to women ($p<0.001$). Considering the importance of social distancing at this time of a pandemic and the need for further investigations regarding the modality of online care, the validation of the test application remotely and the verification of responsiveness to a pulmonary telerehabilitation program were addressed in article 2. Recently, a quick review showed the possibility of applying functional tests, which assess only the lower limbs, remotely, but with some reservations regarding safety and the impossibility of prescribing exercises based on the tests. Article 2 of this dissertation evaluated 26 individuals with post-COVID-19 syndrome and no statistically significant difference was observed between the modified test applied in person and remotely ($p>0.263$). As for responsiveness, a group of 44 individuals, participants of a low-cost pulmonary telerehabilitation program that involved aerobic and resistance training, standardized, the modified online test was able to identify a change in the test time (3.77min; 2, 43 to 5.11; $p<0.001$), dyspnea (-2.55; -3.51 to -1.59; $p<0.001$) and perceived exertion (-1.18; -2.22 to - 0.14; $p=0.032$), after eight weeks of intervention with a very large effect size (Cohen's d: 1.09) for the test time performed. Overall, this study suggests that the UULEX-M is a good test to assess the resistance exercise capacity of the upper limbs in individuals with post-COVID-19 syndrome, in addition to being more practical and requiring less time and

material, being an alternative for use in clinical practice in home assessments, in rehabilitation centers and hospitals.

Keywords: Upper limbs. Rehabilitation. UULEX test.

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LISTA DE ABREVIATURAS E SIGLAS

UTI - Unidade de Terapia Intensiva

UULEX - unsupported upper limb exercise test

UULEX - M - unsupported upper limb exercise test modificado or modified

ULL - upper limb functional tests

MMSS - Membros superiores

MMII - membros inferiores

TC6 - Teste de caminhada de seis minutos

6MWT - six-minute walk test

ESWT - Endurance shuttle walk test

DRC - doenças respiratórias crônicas

AVD - atividades de vida diária

DPOC - doença pulmonar obstrutiva crônica

COPD - chronic obstructive pulmonary disease

ADL – activities of daily living

AVD-glittre - teste de atividades de vida diária glittre

RPE - rate of perceived exertion

PFCS - Post COVID-19 Functional Scale

SD - Standard deviation

FEV1: forced expiratory volume in one second

FVC: forced vital capacity

FEV1/FVC: ratio between forced expiratory volume in one second and forced vital capacity

Bpm - batimentos por minuto

Kg - quilograma

BMI - body mass index

SUMÁRIO

1 INTRODUÇÃO

Após a infecção por SARS-COV-2 a presença e persistência, por mais de 4 semanas, de um ou mais sintomas como tosse seca, dispneia, fadiga, dores articulares, além de outros sintomas relacionados ao acometimento sistêmico, caracterizam a síndrome pós-COVID-19. (NALBANDIAN *et al.*, 2021; CARFI; BERNABEI; LANDI, 2020). O estado pró-inflamatório induzido pela COVID-19 e o uso prolongado de corticosteroides tem sido associados a alguns efeitos que podem levar à fraqueza muscular e manifestações no sistema musculoesquelético (HASAN *et al.*, 2021). Em casos mais graves, pode ser observada evolução para distúrbio restritivo compatível com fibrose pulmonar. Estudos prévios indicam que 47% desses indivíduos apresentam redução da capacidade de difusão pulmonar para monóxido de carbono e 25% redução da capacidade pulmonar total (CARFI; BERNABEI; LANDI, 2020; HASAN *et al.*, 2021; MO *et al.*, 2020).

As manifestações citadas acima, podem impactar a capacidade funcional desses indivíduos, como demonstrado em outras doenças respiratórias, tais como, doenças pulmonares intersticiais e doença pulmonar obstrutiva crônica (JANAUDIS-FERREIRA *et al.*, 2012, 2014, 2016; MO *et al.*, 2020). Esta redução da capacidade de exercício pode causar limitação nas atividades de vida diária e na participação, além de aumentar as chances de hospitalização e mortalidade, como ocorre em indivíduos com doenças respiratórias crônicas (ALISON *et al.*, 2017; ROCHESTER *et al.*, 2015; SPRUIT *et al.*, 2013). Seguindo os domínios da classificação internacional de funcionalidade (CIF) há garantia de melhor abordagem dos impactos na saúde do indivíduo (BUI *et al.*, 2017). Assim, boas ferramentas de avaliação devem ser utilizadas para observar deficiências, detectar limitações em atividades e identificar restrições em participação (BUI *et al.*, 2017; MENDES, LILIANE, 2019).

A avaliação da capacidade funcional pode ser realizada por meio de testes de campo validados e padronizados, como por exemplo o teste de caminhada de seis minutos (TC6') e o *Endurance shuttle walk test* (ESWT) (KOCKS *et al.*, 2011; REVILL *et al.*,

1999, 2010; SINGH *et al.*, 2014). O TC6' tem como desfecho principal a distância caminhada em seis minutos, ou seja, quanto maior a distância melhor a capacidade funcional. O teste tem velocidade autorregulada e é o mais utilizado na prática clínica devido à praticidade de aplicação e ao seu baixo custo. (RODRIGUES BRITTO; PEREIRA DE SOUSA, 2006; SINGH *et al.*, 2014). O ESWT, tem como desfecho o tempo em que o indivíduo se mantém caminhando em uma velocidade predeterminada por sinais sonoros. Esse teste é menos utilizado em nosso meio, mas apresenta boa sensibilidade para detectar os efeitos da reabilitação em indivíduos com doenças respiratórias crônicas (DRC) (EATON *et al.*, 2006; SINGH *et al.*, 1992, 2014). Tanto o TC6' quanto o ESWT avaliam a atividade de caminhada, e, portanto, apenas atividades de membros inferiores (MMII), não incluindo a avaliação de atividades com os membros superiores (MMSS) que são igualmente importantes para a realização das atividades de vida diárias (AVD), tais como pegar objetos em locais altos, estender roupas e pentear os cabelos (JANAUDIS-FERREIRA *et al.*, 2012, 2016). Nesse contexto, o teste *Glittre Activities of Daily Living* (Teste de AVD-Glittre) se propôs a suprir as limitações dos testes citados anteriormente por ser constituído de múltiplas tarefas que envolvem tanto MMII quanto MMSS (MENDES, LILIANE P.DE SOUZA *et al.*, 2020; SKUMLIEN *et al.*, 2006). Dentre as tarefas estão as atividades de sentar e levantar, subir e descer escadas e mover objetos em prateleiras com diferentes alturas. No entanto, esse teste inclui apenas uma atividade de MMSS e não avalia diretamente a capacidade de exercício dos MMSS (MENDES, LILIANE P.DE SOUZA *et al.*, 2020; SKUMLIEN *et al.*, 2006).

Como alternativa para avaliação de MMSS, alguns testes padronizados têm sido propostos para indivíduos com DRC tais como o teste de argolas de seis minutos e o *Unsupported Upper Limb Exercise Test* (UULEX) (JANAUDIS-FERREIRA *et al.*, 2012; LIMA *et al.*, 2018; MARQUES *et al.*, 2020; TAKAHASHI *et al.*, 2003). O UULEX avalia a capacidade máxima de exercício dos MMSS sem apoio por meio de movimentos repetitivos e sincronizados, utilizando os braços por longos períodos em diferentes alturas com aumento de peso e velocidade constante dada por um metrônomo à 30 batidas por minuto (JANAUDIS-FERREIRA et al., 2012b; LIMA et al., 2020a; TAKAHASHI et al., 2003a). O teste exige materiais específicos para ser realizado,

como um *banner*, onde estão dispostos os oito níveis do teste e barras plásticas com diferentes pesos. A carga inicial do teste é de 0,2Kg, e é alterado após o indivíduo atingir o nível 8 e, a partir daí, ocorrem variações de carga a cada minuto. O teste é interrompido quando o indivíduo relata fadiga muscular ou dispneia (JANAUDIS-FERREIRA et al., 2012a, 2013; MARQUES et al., 2020; TAKAHASHI et al., 2003b).

O treinamento de MMSS tem sido recomendado como parte essencial dos programas de reabilitação pulmonar (ALISON *et al.*, 2017; BOLTON *et al.*, 2013; ROCHESTER *et al.*, 2015; SPRUIT *et al.*, 2013). Diversas propostas de treinamento de MMSS têm sido estudadas e aplicadas a indivíduos com DRC. Até o momento, sabe-se que um treinamento combinado de força e resistência para os MMSS tem gerado melhor resultado nessa população, porém exige uma avaliação específica para que seja corretamente prescrito (MCKEOUGH *et al.*, 2016).

A literatura mais recente, que aborda a população pós-COVID-19, recomenda que a reabilitação deva tratar os sintomas que o sujeito está apresentando e que estes devem ser identificados a partir de uma avaliação individualizada e ampla (BARKER-DAVIES *et al.*, 2020; CARFI; BERNABEI; LANDI, 2020). Em função da pandemia da COVID-19, a realização da reabilitação pulmonar nas modalidades de atendimento remoto, tais como o teleatendimento e o telemonitoramento tornaram-se realidade para controlar os sintomas, principalmente para a população de indivíduos com DRC, devido ao alto risco destes de contrair COVID -19. A oferta da reabilitação pulmonar fora dos ambientes tradicionais vem sendo estudada há algum tempo. Holland et al, mostraram que a reabilitação domiciliar para indivíduos com DPOC usando recursos mínimos é viável e produziu resultados semelhantes à reabilitação baseada em centros de reabilitação (HOLLAND *et al.*, 2017). Porém, a avaliação desses indivíduos era feita presencialmente. Em 2020, por conta da pandemia do COVID-19, HOLLAND *et al.* abordaram a importância da avaliação da capacidade funcional, concluindo que alguns testes são passíveis de serem realizados de forma remota, entretanto, nenhum teste específico para avaliar os MMSS foi citado.

1.1 JUSTIFICATIVA

Embora o UULEX seja um teste válido para avaliação dos MMSS, estudos prévios demonstram que os indivíduos com doença pulmonar obstrutiva crônica (DPOC) o realizam por pouco tempo e geralmente sem progredir o peso das barras, permanecendo na carga de 0,2Kg, e encerrando o teste devido à fadiga muscular (JANAUDIS-FERREIRA et al., 2011, 2012b; TAKAHASHI et al., 2003b). Este fato pode ser explicado pelo tempo de aquecimento e pela quantidade de níveis do UULEX, o que pode elevar os níveis de lactato sanguíneo e consequentemente, causar a fadiga precoce dos braços, antes iniciar a mudança da carga (PORTO *et al.*, 2009; VELLOSO *et al.*, 2003). Além disso, o uso concomitante da musculatura acessória da respiração e os movimentos dos MMSS contra a gravidade, aumentam a produção de ácido lático e levam o centro respiratório a aumentar a ventilação (DE SOUZA et al., 2010; VELLOSO et al., 2003). Ainda, a carga proposta no teste original (0,2Kg) não representa as tarefas realizadas durante as AVD, tais como carregar mantimentos, organizar armários, limpar a casa, entre outras. Devido aos fatores relatados, este estudo se propõe a modificar o teste UULEX a fim de alcançar resultados que mimetizem a realidade das AVD, e, portanto, se aproximem das limitações funcionais diárias do indivíduo, além de tornar o teste mais fácil de ser realizado, seja de forma presencial ou remota, em ambiente domiciliar, ambulatorial ou hospitalar.

1.2 OBJETIVOS

1.2.1 Objetivo primário

- Modificar o teste *Unsupported Upper Limb Exercise test* (UULEX).

1.2.2 Objetivos secundários

- Realizar a validação concorrente do *Unsupported Upper Limb Exercise test* modificado (UULEX-M) para indivíduos pós-COVID-19 e comparar resultados entre sexos.

- Validar o UULEX-M para ser realizado de forma remota.
- Avaliar a responsividade do UULEX-M à telerreabilitação pulmonar de baixo custo.

2 ARTIGO 1

A ser submetido para o periódico The Brazilian Journal of Physical Therapy:

MODIFIED UNSUPPORTED UPPER LIMB EXERCISE TEST (UULEX-M) TO ASSESS UPPER LIMB EXERCISE CAPACITY ON POST-COVID-19 SYNDROME.

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*A autoria deste artigo no momento da submissão deverá incluir os outros coautores que contribuíram de forma importante para o estudo, conforme critérios de autoria definidos pela revista.

HIGHLIGHTS

- UULEX-M is valid to assess UL exercise capacity in post-COVID-19 syndrome.
- The time for UULEX-M was significantly longer for males compared to women.
- UULEX-M is less complex and requires less time to be performed compared to UULEX.

2.1 ABSTRACT

Introduction: Due to the inflammatory cascade induced by SARS-CoV-2 and prolonged use of corticosteroids, especially in patients with intensive care units, some symptoms are commonly observed in the post-COVID19 syndrome such as dry cough, dyspnea, fatigue, joint pain, in addition to other symptoms related to systemic involvement. These symptoms are associated with functional declines and to date, to the best of our knowledge, tests that assess upper limb functionality (MMSS) for post-COVID-19 individuals have not been validated. The Unsupported Upper Limb Exercise test (UULEX) is an incremental test designed to assess upper limb exercise capacity. However, studies have shown that subjects with chronic obstructive pulmonary disease (COPD) evaluated by UULEX do not reach higher levels and discontinue the test early due to fatigue. Therefore, modification of the test may be reasonable.

Objective: To verify the concurrent validity of the modified UULEX test (UULEX-M) to assess the exercise capacity of the upper limbs of individuals with post-COVID-19 syndrome.

Methods: Subjects with post-COVID-19 syndrome had upper limb exercise capacity assessed in a single day, using the UULEX and UULEX-M tests in random order with 30-minute intervals between them, or until vital data returned to baseline values. The UULEX-M, proposes fixed load, without heating time and reduction of the number of levels. Subjects were classified for functionality according to the post-COVID-19 functional status scale. Data normality was verified by the Shapiro-Wilk test. Concurrent validity was analyzed by the correlation between time and physiological variables of the tests using the Pearson and Spearman correlation tests. For comparisons between the tests, the t-test and Wilcoxon were used.

Results: Sixty-four individuals were included, with a mean age of 61±14 years. Considering the total sample, the time on the UULEX-M, despite being shorter, showed a strong correlation with the UULEX ($r=0.872$; $p<0.001$) as well as the heart rate at the peak of the test ($r=0.774$; $p<0.001$). The correlation between tests was moderate for fatigue ($r=0.566$, $p<0.001$) and dyspnea ($r=0.605$, $p<0.001$). In the analysis between the sexes, a strong correlation was also observed between the tests for women (UULEX:6.32±3.42min and UULEX-M: 3.19±1.66min; $r=0.887$; $p<0.001$) and

moderate correlation for men, (UULEX: 9.71±3.12min and UULEX-M: 5±2.14min; r=0.744; p<0.001). Testing time for women was on average 36% shorter than for men.

Conclusion: In the present study, the UULEX-M proved to be valid for evaluating the upper limb exercise capacity in individuals with post-COVID-19 syndrome. The UULEX-M time was significant shorter and induced the same symptoms and physiological responses in both genders. UULEX-M is a good test to assess the upper limp exercise capacity in subjects with post-COVID-19 syndrome and are more practical and demands less time and material necessity, being an alternative in clinics and home assessments or even in hospitals.

Keywords: COVID-19, Validation Study, Upper Extremity.

2.2 INTRODUCTION

The proinflammatory state induced by COVID-19 and the prolonged corticosteroid use have been associated with some effects that can lead muscle weakness and other impacts on the musculoskeletal system[1]. In more severe cases, evolution to a restrictive disorder compatible with pulmonary fibrosis has already been observed[1–3]. After SARS-CoV-2 infection the presence and persistence of some symptoms such as muscle fatigue and weakness, dyspnea, pain, cognitive impairment, sleep disturbances, and others characterize the post-COVID-19 syndrome,.[2] These injuries and symptoms can impact the functional capacity and increase the chances of hospitalization and mortality as demonstrated in other diseases such as interstitial lung disease and chronic obstructive pulmonary disease[3–7]. Therefore, it is reasonable to evaluate the functional capacity in post-COVID-19 syndrome.[8–10].

The assessment of functional capacity is carried out through validated and standardized field tests. The most common used is the six-minute walk test (6MWT). Until the present, some studies have reported significantly changes in distance on 6MWT in individuals with post-COVID-19 syndrome[11,12]. However, the test only assesses the activity of walking, not including the assessment of activities with upper limbs that reflect activity daily living (ADL) such as picking up objects in high places, hanging clothes out on the clothesline and take down the laundry, and combing hair[4,6]. As an alternative for upper limb assessment, some standards tests have been proposed such as the six-minute pegboard ring test and the unsupported upper limb exercise test (UULEX) [4,13–15].

The UULEX aims to assess peak upper limb exercise capacity without arms support[13]. The test evaluates individual's ability to perform repetitive and synchronized movements, using the arms for long periods at different heights with increased weight and constant speed[4,13,16]. The test needs a specific material to be performed like the board, plastic bars with different loads, and a metronome. The initial load is 0.2Kg, being changed after the individual reaches level 8 and then from there, the change will take place every minute with load increments, being limited by symptoms, such as muscle fatigue and dyspnea[4,13–15].

Although UULEX is a valid test for evaluating upper limbs, studies with participants with chronic respiratory diseases, showed that they remain a short time performing UULEX. In addition, the participants remained in 0.2Kg load and ended the test due the rate of perceived exertion[4,13,17]. This could be explained by the warm-up time and numbers of levels in UULEX that can induce increases in blood lactate levels and an early arm fatigue before changed the load (DE SOUZA *et al.*, 2010; VELLOSO *et al.*, 2003). Besides that, the concomitant use of accessory muscles of respiration and the movements of the upper limbs against gravity, increase lactic acid production and induce the respiratory center to increase ventilation[7,18,19]. In order to achieve results that better reflect the upper limb functionality and turn the test easily to be performed at home, ambulatory or hospital environment; this study has as a proposal to modify the UULEX test.

The primary aim of this study was to evaluate concurrent validity of UULEX-M with UULEX[13] in participants with post-COVID-19 syndrome. The secondary aims were to compare the difference between genders in test time, physiological responses, and symptoms during the tests.

2.3 MATERIAL AND METHODS

2.3.1 Participants and study design

This was a methodological study. Participants were recruited from referrals to an outpatient pulmonary rehabilitation program at Federal University of Minas Gerais, Belo Horizonte, Brazil. Participants were included in the study if they had a diagnosis of post-COVID-19 syndrome which is characterized by the presence and persistence for more than 4 weeks of one or more symptoms such as fatigue, muscle weakness, dyspnea, pain, sleep disturbances, balance deficit, cognitive impairment, anxiety and depression. In addition to being stable over the past month with medication optimized and no exacerbation symptoms. Participants were excluded if were using oxygen supplementation, if they presented concomitant cardiovascular, pulmonary, orthopedic, or neurological conditions that could impair exercise performance, and

those who did not understand the test commands. Participants would also be excluded if they were already enrolled in a pulmonary rehabilitation program. Written informed consent was obtained from all participants. This study was approved by Ethics Committees from UFMG/Brazil (CAAE:35867320.3.0000.5149).

2.3.2 Measures

2.3.2.1 Unsupported Upper Limb Exercise Test (UULEX)

This test was developed by Takahashi et al (2003). It is an upper limb incremental exercise test used to assess peak arm exercise capacity. The test consists of a panel 119 cm high by 84 cm wide and five 84 cm plastic bars weighing 0.2 kg; 0.5kg; 1.0kg; 1.5kg, and 2.0kg. Each level comprising a colored strip 8 cm wide, 5 cm apart (Figure 1). The participant in seated position is instructed to raise the 0.2kg plastic bar with both hands at a constant cadence of 30 beats per minute, paced by the sound signal of a metronome[13,20]. Participants were also instructed to move the upper limbs from the pelvic girdle to the first level of the panel, positioned at the knees level, and this movement was performed for two minutes as a warm-up. Then, every minute, participants were guided to reach a higher level of the panel. When they reached the eighth level of the panel, the 0.2 kg bar was replaced, every minute, by the 0.5 kg, then by 1.0 kg, 1.5 kg, and 2.0 kg until reaching the maximum performance or until feel any symptoms that limited the continuity of the test such as fatigue or dyspnea. The test was also stopped if the participant was unable to follow the metronome's beep or remained at the corresponding level/height. Two verbal feedbacks were allowed so that the participant could correct the posture, limb height or speed. The primary outcome is the time to perform the test.

Please insert Figure 1 here

2.3.2.2 Modified Unsupported Upper Limb Exercise Test (UULEX-M)

UULEX-M was developed and conducted with the same concepts as the original UULEX. The modifications consist, in general, in the reduction of the number of levels,

removal of the warm-up time, and increase of the load. Five levels were considered corresponding to different anatomic references of participant's body at different heights. Level one refers to lap height (Figure 2.1), level two to above navel height (Figure 2.2), level three to shoulders height (Figure 2.3), level four to nose height (Figure 2.4), and level five to above the head height (Figure 2.5). To perform the test each participant was instructed to use an object with 1 kg (35,27oz). Subjects had to move upper limbs from pelvic girdle (Figure 2.I) to test level and go back to the pelvic girdle continuously throughout the test and at all levels. The movement was performed by 60 seconds and change to the upper level, always starting from pelvic girdle level and returning. Individuals also must be instructed to reach the highest level. When final level was reached, participant had to keep it until reaching their maximum performance or until symptoms limit them (e.g., dyspnea or muscles fatigue). Just like the original UULEX test, two verbal feedbacks were allowed so the participant can correct the posture, limb height: or speed. Upper limb support in the lap was not allowed. The examiners registered the time taken by the subject to complete the test, which represents the upper limbs endurance capacity, in other words, longer time means better results.

Before the UULEX-M starts, it is necessary to guarantee that the participant can hear the beep metronome, in a 30 beats per minute as on original UULEX and take measurements of vital data and rate of perceived exertion (RPE). It is important to instruct the participants as follows:

"The aim of this test is to move your arms carrying an object with 1kg as long as possible, at different heights, and without support your limbs. The heights correspond to points on your body that are the lap, above the navel, shoulder, face, and above the head. You will start the test in the lap level, beginning in the pelvic girdle going forward at lap level and then go back to the pelvic girdle. Now I am going to show you and please do it with me."

The examiner must verify whether the participant is able to identify heights based on body points and it is recommended to repeat the movements with the participant before starting the test (see below):

"You need to keep the moves following the metronome beep. The time between two beeps corresponds to a complete movement. When I ask you to change the level, please keep going back to your hip. You will just change the height when go forward. When you achieve the level above the head, keep moving until you cannot take it anymore. You have two chances to correct the height or synchronize the movement with the beep. The test will end when you are unable to maintain constant movement in synchrony with the beep or when you experience any limiting symptoms. REMEMBER that the aim of the test is to move your arms AS LONG AS POSSIBLE. The test starts in three, two, one, GO!"

Please insert Figure 2 here

2.3.3 Other measures

The modified Borg scale was used to measure the symptoms of dyspnea and RPE at rest and during each minute of the UULEX-M. It is a valid and reliable scale graduated from 0 to 10 corresponding to the progressive increase in the participants perceived exertion level, with 0 being no effort and 10 maximum effort [21].

In order to characterize the sample, the spirometer (Spirobank II - MIR) was used to perform pulmonary function test following the standards recommended by the American Thoracic Society [22]. Reference values established by Pereira et al., (2007) were used for sample characterization. The Jamar dynamometer (North Coast Medical) was used to measure handgrip strength in kilograms. Participant was positioned seated in a chair without arms support with the spine erects, the knees flexed at 90º, the shoulder in adduction and neutral rotation, the elbow flexed to 90º, forearm in half pronation, and wrist in a neutral position for a slight extension. The tested upper limb was placed suspended, and the hand placed on the dynamometer, being supported by the examiner. Three measurements were performed in both upper limbs, with a rest time of 60 seconds between measurements. The mean of the measurements of each upper limbs were calculated separately and used for sample characterization [23].

The Post COVID-19 Functional Scale (PCFS) [24], was used to classify the participants' functionality, based on the history and report of the participant who presents post-COVID-19 syndrome diagnosis. Participants were ranked in "no functional limitations", "negligible functional limitations", "mild functional limitations", "moderate functional limitations", and "severe functional limitations". This scale considers the ability to carry out activities in the home environment, symptoms of pain, anxiety and depression, and self-management of activities [24].

2.3.4 Procedures

Participants attended for one data collection session. Demographic data such as height, weight, and age were recorded. After that, spirometry and handgrip strength tests were performed, and participants completed PCFS. The participants then performed one UULEX and one UULEX-M, in random order. The order of the tests was randomized in blocks by a computer program (https://www.random.org/). During both tests, peripheral oxygen saturation (SpO2) and pulse rate were continuously monitored (MD300CF3 Dellamed, China). Dyspnea and rate of perceived exertion (RPE) were assessed before and immediately at the end of each test using the modified 0-10 Scale [21]. Participants rested 30 minutes between tests or until all parameters returned to the baseline levels. The time to complete the tests were recorded as the test outcomes.

2.3.4.1 Sample size

The sample size calculation was based on a pilot study and was calculated on equivalence between UULEX and UULEX-M tests. Equivalence of SpO2 and heart rate, were chosen as the physiological variables of equivalence and the standard deviations (SD) of these measurements in the first ten participants of the study (2% for SpO2, 7 beats per minute for HR, and 2.07min for the time) were used in the calculation of sample size. A power of 0.90, an alpha of 5% and an equivalence limit of 3% for SpO_2[25], 14 beats per for heart rate[13] and 2.33 for time[13] were considered. The calculation determined a sample size of 36 participants for time, 20 for SpO_2 and 12 for HR.

2.3.4.2 Data Analysis

Data are presented as mean and standard deviation, unless otherwise stated and the normality was verified by the Shapiro-Wilk test. The comparisons between genders for demographic, spirometric, PCFS classification, handgrip strength, and clinical variables were performed by Student *t* test, according to the characteristic and/or variable distribution. Comparisons between UULEX and UULEX-M tests times and physiological responses were performed by *t*-tests or Wilcoxon, according to data normality. To verify the relationship between UULEX and UULEX-M tests, and handgrip force the Pearson or Spearman correlation coefficient were used, according to data normality. The strength of the correlations was defined as < 0.20 as minimal or absent, from 0.25 to 0.50 as weak, from 0.50 to 0.75 as moderate, and from 0.75 to 1.0 as strong [26]. The level of significance was set at 5%. The Statistical Package for the Social Sciences (SPSS) v19.0 (Chicago, IL, USA) was used for analyses.

2.4 RESULTS

2.4.1 Participant characteristics

From seventy-two selected participants, sixty-four were recruited, and eight participants were excluded due to orthopedic conditions that limited tests performance. Table 1 presents demographic, anthropometrics, spirometric, and clinical participants data. Men and women were similar for demographic and anthropometrics characteristics. About 36% of the total sample met functional classification 2 (mild functional limitations) in PCFS scale. Participants achieved more than 75% of predicted handgrip force. Women presented lower values to handgrip force and worse functional classification compared to men.

2.4.2 Comparisons and relationship between UULEX and UULEX-M

Table 2 shows the results for both tests. The time for the UULEX-M was significantly shorter than UULEX for the total group and for males and females. Considering the total sample, more than half of individuals (53%) reached level 7 or more on UULEX,

which is close to shoulder level and above. Almost 80% of the sample remained at 0.2Kg and 11% reached the load of 2kg. Fifty-two percent of males reached level 7 or above, 68% remained in the load of 0.2Kg, and 18% achieved the load of 2Kg. On the other hand, 73% of females reached level five or lower and 93% remained in the load of 0.2Kg.

In the UULEX-M, considering the total sample, 50% of participants were between levels four and five (above shoulder level) and 20% in level three (shoulder level). In addition, 71% of males remained above level four while 73% of females remained under this level. The load for UULEX-M was constant (1kg).

UULEX-M provoked the same physiological responses and symptoms to the UULEX, except for HR, that was significantly higher for UULEX when considering total sample. The time for the tests was 35% and 36% shorter for UULEX and UULEX-M, respectively in women compared to men. In general, score for RPE arms were higher than for dyspnea. At the end of the UULEX, 70% of the sample scored seven or more the RPE of arms while scores for dyspnea at seven or more were obtained by 13% of participants. About UULEX-M, 64% of the sample scored seven or more the RPE or arms while 13% rated dyspnea as score seven. None participant scored dyspnea as more than seven in UULEX-M.

The UULEX time was moderately correlated with the UULEX-M for males and strongly correlated for females and total sample. In addition, most of the physiological variables were moderately to strongly correlated, except for diastolic blood pressure (DBP) mmHg in women (Table 3). The correlation between test times and handgrip force for the total sample was weak (UULEX: rho=0.385; p=0.003; UULEX-M: rho=0.429; p=0.001). The correlation between test times and functional classification was moderate (UULEX: rho = -0.729; $p<0.001$; UULEX-M: rho= -0.662; $p<0.001$).

2.5 DISCUSSION

To our knowledge, this is the first study dedicated to investigating the upper limb exercise capacity in post-COVID-19 individuals. Results from this study confirm that: 1) UULEX-M is valid to assess the upper limbs exercise capacity; 2) UULEX-M provoked the same physiological responses and symptoms as UULEX, except for HR. 3) the time to perform UULEX-M was significantly shorter than UULEX for total group and for males and females. 4) Men performed the tests for longer compared to women.

The initial load of 0.2 kg proposed by the original test is compatible with some activities of daily living such as brushing teeth, combing hair, and the final load of 2kg is compatible with other heavier activities such as carrying groceries, moving and placing heavy objects on shelves and cupboards, and others. However, Takahashi et al. 2003, have previously demonstrated that participants performed 7.95 ± 2 min on UULEX, and stopped the test with a load of 0.2Kg. Due the characteristics of the original test as perform a warm-up time before and load progression slowly may explain these findings. These procedures can be a limiting fact to evaluate activities of daily living (ADLs). In the UULEX-M, do not exist warm-up time and the 1kg load is five times greater than the initial load of the original test what can be more suitable to simulate the real ADLs. Thus, even if the load does not change, it is possible to assess a greater load that better represents ADLs that use more weights and effort. At the same time when the load was not changed in UULEX-M as in mean results of UULEX studies, the endurance characteristic could also be maintained. Accordingly, moderate to strong correlations between tests found in this study could be justifiable.

Similar arms RPE and dyspnea scores were observed by Takahashi et al for subjects with COPD during the elaboration of the UULEX test[13]. Our results show that the main reason for interrupt both tests was arms exertion. These findings are an indication that despite the differences in tests protocols, the participants equally reached peak exercise capacity. UULEX-M was performed in a shorter time and the test provoked similar physiological responses and symptoms compared to UULEX, except for heart rate. However, the difference observed for HR was only four beats per minute, therefore, despite statistically different, the difference was not clinically significant. This

modification seems to be interesting since, upper limb function was equally evaluated in a shorter time and with a greater load.

Lima et al. found that men remained 6% more time performing the test compared to women (11.99 ± 1.9min; 12.89 ± 2.15 min; respectively, p=0.03)[16]. Our study also observed differences in test times between genders since both the UULEX time and UULEX-M were 35% and 36% longer for males, respectively. It is known that men had better values for body composition as lower percentage of body fat and higher percentage of muscle mass than women, especially in upper-body. Moreover, men had better aerobic and anaerobic energy production.[16,32,33]. These findings may explain the longer times achieved by males on both tests compared to females. The handgrip force assessment can be used to check upper limb strength as this measure has a great correlation with functionality and muscle strength[34,35]. However, in our study the correlation between handgrip and the time of the test was weak. Since the tests may include endurance and strength capacity assessment, the weak correlation was expected in handgrip strength. Unfortunately, this study did not assess handgrip endurance.

The UULEX needs specific material to be performed like the board and sticks with different loads. This fact may impact its clinical applicability despite its good reproducibility and reliability. Considering UULEX-M, it is known that among its main characteristics is the ease of application, since the panel is not necessary for the orientation of the anatomical levels of the individuals, and the load is easily achieved with objects within the environment itself such as milk cartons and water bottles. This fact facilitates the implementation of this tool in many different clinical contexts, as it allows its use at any level of health care, including places where resources are scarce.

Due to pandemic COVID-19 and social isolation during the research this article presents some limitations that should be addressed in a new study, such as test-retest reliability assessment and direct measurement of ventilatory and metabolic responses. Still, UULEX-M was not correlated with specific questionnaires about participation and activity life. Although PCFS was applied, it was not used for this purpose.

2.6 CONCLUSION

UULEX-M showed excellent correlation results with the original UULEX version. The UULEX-M time was significantly shorter and induced the same physiological responses and symptoms in total sample and in both genders. This study suggests that the UULEX-M is a good test to assess the upper limp exercise capacity in subjects with post-COVID-19 syndrome, it is more practical, and it demands less time and resources, being an alternative in clinics and home assessments or even in hospitals. More studies with different population will be needed.

Acknowledgements

The authors are grateful to the UFMG pulmonary ambulatory health professional group, in the name of Dr Carolina Coimbra Marinho. Also grateful to the physiotherapy undergraduate students.

Funding:

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001; by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and; by Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG).

Competing interests: The authors have no conflicts of interest to disclose.

Figure 1 Volunteer performing UULEX

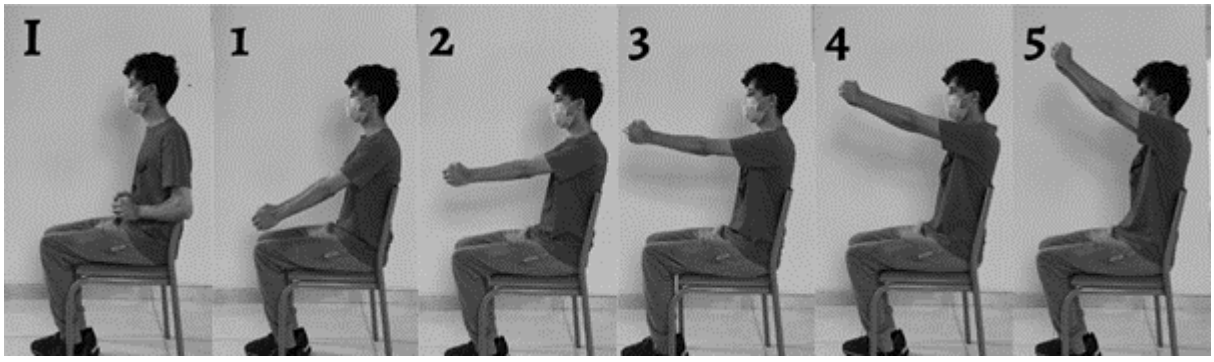

Figure 2 - UULEX-M test

I represent Initial point (pelvic girdle); 1 means level one (lap height); 2 means level two (above navel height); 3 means level three (shoulders height), 4 means level four (nose height) and 5 means level five (above the head height).

Table 1 – Characteristics of study participants (n=64)

Characteristic	All n=64	Men n=34	Women n=30	Men vs Women p-value
Age, *years*	61.11 (14.42)	62.26 (15.47)	59.71 (13.17)	0.562
BMI, *Kg/m²*	31.08 (8.17)	29.45 (6.09)	32.77 (9.7)	0.119
FEV_1, % pred	82.79 (16.27)	81.41 (17.71)	84.26 (14.74)	0.509
FVC, % pred	84.26 (14.36)	85.05 (16.01)	83.4 (12.58)	0.666
FEV_1/FVC	0.78 (0.1)	0.75 (0.11)	0.81 (0,09)	0.024
Handgrip force, *kg*	28.61 (10.33)	34.73 (8.42)	22.28 (8.11)	>0.001
Handgrip force, % pred	78.62 (33.86)	76.42 (38.68)	80.82 (28.76)	0.618
Functional Classification (PCFS) (%)				
0 - No limitations functional limitations	10 (15.6)	9 (26.5)	1 (3.3)	>0.001
1 - Insignificant functional limitations	16 (25)	12 (35.3)	4 (13.3)	
2 - Mild functional limitations	23 (35.9)	11 (32.4)	12 (40)	
3 - Moderate functional limitations	8 (12.5)	2 (5.9)	6 (20)	
4 - Severe functional limitations	7 (10.9)	-	7 (23.3)	

Data presented as mean (SD). Functional classification is presented as number of participants (%) according to Post COVID-19 Functional Scale (PCFS). BMI: body mass index; FEV_1: forced expiratory volume in one second; FVC: forced vital capacity; FEV_1/FVC: ratio between forced expiratory volume in one second and forced vital capacity; pred: predicted

Table 2 - Comparison between UULEX tests

	UULEX *Takahashi, 2003* Mean (SD)				UULEX-M Mean (SD)				UULEX – UULEX-M Mean difference (95% CI)		
	Total	**Men**	**Women**	**Men vs Women**	**Total**	**Men**	**Women**	**Men vs Women**	**Total**	**Men**	**Women**
Time, *min*	8.12 (3.66)	9.71 (3.12)	6.32 (3.42)	3.38 (1.74 to 5.02) *	4.15 (2.12)	5 (2.14)	3.19 (1.66)	1.81 (0.85 to 2.78) *	3.97 (3.4 to 4.55) *	4.71 (3.92 to 5.49) *	3.13 (2.35 to 3.92) *
Test Level	5 (4-8)	7 (4.75 - 8)	4 (1.5 - 6)	3 (1.18-3.61) *	4 (2-5)	4 (3-5)	2 (1-4)	2 (0.76-2.16) *	-	-	-
Load, Kg	0.2 (0.2-0.2)	0.2 (0.2 – 1.125)	0.2 (0.2-0.2)	0.35 (0.68-0.63) *	-	-	-	-	-	-	-
SpO_2, %	95 (2.47)	95 (2.18)	95 (2.8)	0.01 (-1.23 to 1.26)	96 (2.07)	96 (1.76)	96 (2.4)	0.01 (-1.03 to 1.06)	-0.23 (-0.7 to 0.23)	-0.24 (-0.82 to 0.,35)	2 (-1.02 to 0.56)
HR, bpm	100 (17.55)	102 (19.67)	97 (14.59)	5 (-3.41 to 14.09)	96 (15.74)	97 (15.38)	94 (16.2)	4 (-4.42 to 11.37)	4 (0.9 to 7.42) *	5(-0.35 to 10.41)	3 (-0.514 to 6.85)
SBP, mmHg	137 (19.25)	139 (20.32)	135 (18.14)	3.2 (-6.48 to 12.88)	135 (19.6)	136 (21.45)	134 (17.52)	3 (-7.06 to 12.67)	2 (-2.23 to 5.98)	2 (-4.36 to 8.47)	2 (-3.62 to 6.96)
DBP, mmHg	78 (8.57)	78 (9.89)	77 (6.92)	0.96 (-3.36 to 5.28)	77 (8.3)	77 (9.76)	77 (6.4)	-0.57 (-4.75 to 3.62)	0.81 (-1.16 to 2.79)	1.53 (-1.12 to 4.18)	0 (-3.1 to 3.1)
Dyspnea,	4 (3–5.75)	4 (3-5)	3 (2-6)	0.28 (-0.73 to 1.29)	3.5 (2–5)	4 (2-5)	3 (2-5)	0.49 (-0.55 to 1.54)	0.45 (-0.02 to 0.93) *	0.35 (-0.24 to 0.95)	0.57 (-0.23 to 1.36)
RPE, Arms	7 (5–8)	7 (2-5)	7 (4.75-8.25)	0.23 (-0.83 to 1.28)	7 (6–8)	7 (6-8)	7 (5-8)	0.53 (-0.41 to 1.47)	-0.09 (-0.51 to 0.32)	-0.24 (-0.8 to 0.33)	0,07 (-0,58 to 0,71)

*Data are present at mean and standard deviation (SD) except for Test Level, Load, Dyspnea and RPE, median (1º-3ºinterquartil). The level of significance was set at 5%. *: Significant difference between tests. Definition of abbreviations: SpO_2: Peripheral Oxygen Saturation; HR: heart rate; min: minutes; SBP: systolic blood pressure; DBP: diastolic blood pressure; RPE: rate of perceived exertion. Values for SpO_2, HR, SBP and DBP, Dyspnea, and RPE Arms are from the end of test.*

Table 3 - relationship UULEX tests

		UULEX-M *Spearman's rho* (p-value)		
		Total	**Female**	**Male**
UULEX *Takahashi, 2003*	Time, *min*	rho = 0.872; p<0.001	rho = 0.899; p<0,001	rho = 0.744; p<0.001
	SpO_2, %	rho = 0.635; p<0.001	rho = 0.556; p=0.001	rho = 0.703; p<0.001
	HR, bpm	rho = 0.774; p<0.001	rho = 0.888; p=<0.001	rho = 0.652; p<0.001
	SBP, mmHg	rho = 0.704; p<0.001	rho = 0.739; p=<0.001	rho = 0.688; p<0.001
	DBP, mmHg	rho = 0.475; p<0.001	rho = 0.211; p=0.263	rho = 0.655; p<0.001
	Dyspnea, *Modified Borg Scale (0-10)*	rho = 0.566; p<0.001	rho = 0.516; p=0.003	rho = 0.602; p<0.001
	RPE, Arms	rho = 0.605; p<0.001	rho = 0.711; p<0.001	rho = 0.466; p=0.005

The level of significance was set at 5%. Definition of abbreviations: SpO_2: Oxygen saturation; HR: heart rate; min: minutes; SBP: systolic blood pressure; DBP: diastolic blood pressure; RPE: rate of perceived exertion. Values for Dyspnea, RPE Arms are from the end of test.

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3 ARTIGO 2

A ser submetido para o periódico The Brazilian Journal of Physical Therapy:

UULEX-M PERFORMED REMOTELY IN INDIVIDUALS WITH POST-COVID-19 SYNDROME: CONCURRENT VALIDITY AND RESPONSIVENESS TO A TELEREHABILITATION PROGRAM WITH MINIMAL RESOURCES

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HIGHLIGHTS

- The remote version is feasible and valid to assess arms exercise capacity.
- UULEX-M online is responsive to change after pulmonary rehabilitation program.
- To our knowledge this is the first study to use a totally remote upper limbs test.

3.1 ABSTRACT

Introduction: The post-COVID-19 syndrome, caused by the SARS-CoV-2 virus, causes symptoms that affect functional capacity, such as muscle fatigue and dyspnea on exertion. The assessment of functional capacity is commonly carried out by field tests, however, with the restrictions and social distance due to the new coronavirus pandemic, the health assistances were adapted to the remote form. To the best of our knowledge, upper limb functional tests (MMSS) have not been widely studied for individuals with post-COVID-19 syndrome, in this type of care. Therefore, the online UULEX-M was developed from the modification of the Unsupported Upper Limb Exercise Test (UULEX), in order to allow the evaluation of the upper limb function remotely.

Objective: To evaluate the psychometric properties as the validity and responsiveness of the online UULEX-M test and the upper limb function of individuals with post-COVID-19 syndrome in a pulmonary telerehabilitation program (PTP).

Methods: Individuals with post-COVID-19 syndrome were evaluated in person and remotely, using the UULEX-M. Another group of individuals performed the test before and after pulmonary telerehabilitation. The PTP consisted of 8 weeks of aerobic training and resistance training, in addition to lung re-expansion and bronchial hygiene techniques, as well as an educational intervention for self-management of health. Data normality was verified by the Shapiro-Wilk test. Concurrent validity was analyzed through the correlation between time, subjective perception of dyspnea (Borg) and upper limb fatigue between tests using Pearson and Spearman correlation. To analyze the responsiveness of the online test to the PTP, the statistical tests t-test and Wilcoxon were used, and the effect size by the d-Cohen index.

Results: For concurrent validation, 26 individuals with a mean age of 54.46±14.87 years were evaluated. 42.3% had insignificant functional limitations. The correlation between test time was strong (UULEX-M: 4.6±2.95 min and online UULEX-M: 4.46±3.03 min; $r=0.943$; $p<0.001$). The same was observed when analyzing the correlation separated by sex. For the analysis of responsiveness, 44 individuals with a mean age of 49.34±14.58 years were evaluated. 27.3% had severe functional limitations. Subjects increased test time after PTP by an average of 3.77 minutes (4.59 vs 8.37; $p<0.001$) with large effect size (d-Cohen=1.09).

Conclusion: UULEX-M applied remotely shows excellent correlation results with the UULEX-M in present. The UULEX-M it is responsive to a rehabilitation program with a standardized endurance upper limb training. The UULEX-M online is excellent and feasible to evaluate individuals that is far away to the rehabilitation centers.

Descriptors: Rehabilitation, Upper extremity, COVID-19.

3.2 INTRODUCTION

The COVID-19, caused by SARS-CoV-2 virus infection, leads to functional declines in parallel with muscle weakness, drop in peripheral oxygen saturation, and dyspnea[1]. Recent studies have shown that after hospital discharge post-COVID-19 patients have high rates of fibrosis-like lung abnormalities, where 47% of individuals had impaired lung-diffusing capacity for carbon monoxide and 25% had reduced total lung capacity[2]. These changes directly reflect on the functional capacity of these individuals. The most recent literature for post-COVID-19 population recommend rehabilitation in order to treat these symptoms[1,3], however, no upper limb approach is reported.

In the emergence of COVID-19 pandemic, the pulmonary rehabilitation programs had to adopt modalities of remote care such as telehealth to still controlling symptoms of people with chronic respiratory diseases, who were part of the group of risk for COVID-19. Holland et al, showed that a home-based pulmonary rehabilitation for chronic obstructive pulmonary disease (COPD) using minimal resources was feasible and produced similar results as center-based pulmonary rehabilitation[4]. However, the trial did not evaluate a completely remote program, including meetings to perform the assessments and maintenance of training load. The assessment of functional capacity is necessary, and some tests can be performed remotely[5], however, to our knowledge, tests to assess the functional capacity of upper limbs remotely have not yet been proposed.

The upper limb training has been recommended as a pulmonary rehabilitation element[6–9]. Some modalities of training for upper limbs have been addressed for people with chronic respiratory disease[10]. To date, it is known that a combined strength and endurance upper limb training obtains better results in this population[10]. A modified upper limb exercise test (UULEX-M) has been proposed as an alternative to assess endurance upper limb exercise capacity in individuals with post-COVID-19 due to the facility of its application. Thus, this test may be used to evaluate remotely people that are far away from center-base pulmonary rehabilitation.

The primary aim of this study was to evaluate concurrent validity of UULEX-M performed remotely and in person in people with post-COVID-19 syndrome. The

secondary aim was to evaluate the responsiveness of the UULEX-M to an eight-week pulmonary telerehabilitation program with minimal resources.

3.3 METHODS

3.3.1 Study design and participants

This was a methodological study with procedures divided into two main sections: 1) concurrent validity of remote UULEX-M; and 2) responsiveness. This study was approved by Ethics Committees from UFMG/Brazil (CAAE:35867320.3.0000.5149). Participants were included in the study if they had a diagnosis of post-COVID-19 syndrome which is characterized by the presence and persistence of one or more symptoms such as fatigue, muscle weakness, dyspnea, pain, sleep disturbances, balance deficit, cognitive impairment, anxiety and depression. In addition to being stable over the past month with medication optimized and no exacerbation symptoms. Participants were excluded if were using oxygen supplementation, if they presented concomitant cardiovascular, orthopedic, or neurological conditions that could impair exercise performance, and those who did not understand the test commands. Written informed consent was obtained from all participants.

3.3.2 Measures

3.3.2.1 Modified Unsupported Upper Limb Exercise Test (UULEX-M)

The modified test emerged as an alternative to assess the upper limb exercise capacity and was validated to individuals with post-COVID-19 syndrome. UULEX-M uses five anatomical references that consists of lap height, above navel height, shoulders height, nose height, and above the head height. In order to perform the test each participant was instructed to use an object with approximately 1 kg (35,27oz). Subjects must move upper limbs from pelvic girdle to first test level and go back to the pelvic girdle. The speed is controlled by a metronome at 30 beats per minute. The movement is performed for 60 seconds and then, changed to the upper level -always starting from pelvic girdle level and returning. Individuals were instructed to reach the highest level. When final level was reached, participants had to maintain it until reaching their

maximum performance or until have been limited by symptoms (e.g., dyspnea or muscles fatigue). Two verbal feedbacks are allowed so participants can correct the posture, limb height, or speed. Upper limb support in the lap is not allowed. The examiner registers the time taken to complete the test and this outcome represents the endurance capacity of upper limbs, that is, longer time means better results.

In the remotely modality, participants were instructed to place their mobile devices or computers at a position that examiners could view them from the side, seated in a chair with a backrest, and with feet fully rested on the floor. The examiner assured that could see the participants' entire body on the screen. The sound signal from metronome application was played by the examiner. Considering that this test was performed at participants home, the load should be easily obtainable by participants such as a milk carton, 1L water bottles.

3.3.3 Other measures

In order to characterize samples, pulmonary function was evaluated using spirometry values (Spirobank II - MIR) as recommended by the American Thoracic Society[11]. Reference values established by Pereira et al., (2007) were used for sample characterization. The Post COVID-19 Functional Scale (PCFS) was used to classify individuals' levels of functioning[12]. PCFS considers the ability to carry out activities in home environment, pain symptoms, anxiety and depression, and self-management of activities. This scale was filled based on history and reports of the individuals with post-COVID-19 syndrome. Considering this scale, functioning was classified by the researchers as "no limitations functional limitations", "insignificant functional limitations", "mild functional limitations", "moderate functional limitations" and "severe functional limitations".

Physiological variables such as heart rate, peripheral oxygen saturation, and blood pressure could not always be measured at the remote meetings because not all participants had the appropriate equipment. The modified Borg scale were used to measure the symptoms of dyspnea and rate of perceived exertion (RPE) at rest and during each minute of the test. This scale is a valid and reliable scale graduated from 0 to 10 corresponding to the progressive increase in the individual's perceived exertion

level, with 0 representing no effort and 10 maximum effort[13]. Such scale was used as an alternative to safely accompany the subjects during the online meetings.

3.3.4 Procedures

3.3.4.1 Concurrent validity of remote UULEX-M

In order to analyze concurrent validity of UULEX-M performed remotely, firstly participants attended in one data collection session in person where demographic data such as height, weight and age were collected. During this session participants performed spirometry and completed the PCFS. Participants then performed one UULEX-M. During the test, dyspnea and rate of perceived exertion (RPE) were assessed before and immediately at the end of each test using the modified 0-10 Scale[13]. Then, an online assessment for admission to pulmonary telerehabilitation was performed, where the UULEX-M remotely was applied.

3.3.4.2 Responsiveness

To evaluate the responsiveness of the UULEX-M to a telerehabilitation pulmonary program, participants attended an eight-week pulmonary telerehabilitation program twice a week. The assessments were performed before and at the end of the program. During assessments, dyspnea and RPE were assessed before and immediately at the end of each test using the modified 0-10 Scale[13]. Heart rate and peripheral oxygen saturation was monitored in participants who had their own equipment, but data were not registered. The sessions consisted of 30 to 40 minutes of endurance exercises (e.g., walking, stationary cycling, dance), 4 to 10 minutes of upper limb strength and endurance exercises, and 10 minutes of strength lower limb exercises comprising at least eight muscles.

Upper limb endurance exercises followed a protocol settled by the rehabilitation program team. The protocol (Figure1) used the UULEX-M as the basis and it was progressed according to participants' tolerance.

Please insert Figure 1 here

3.3.4.3 Sample size

The sample size calculation was based on a pilot study and was calculated on equivalence between UULEX and UULEX-M tests. Equivalence of dyspnea and RPE arms were chosen as the variables of equivalence and the standard deviations (SD) of these measurements in the first ten participants of the study. A power of 0.90, an alpha of 5% and an equivalence limit of 1.565 to dyspnea and 1.429 to RPE arms were considered. The calculation determined a sample size of 23 participants for dyspnea and RPE arms.

3.3.4.4 Data Analysis

Data are presented as mean and standard deviation, unless stated otherwise. The normality of distribution was verified with the Shapiro-wilk test. To compare the differences between tests Student paired t test or Wilcoxon were performed and to verify the relationship between UULEX-M performed remotely and in person. In order to assess the agreement of test times, the Intraclass Correlation Coefficient ICC (2,1) was used. Values below 0.74 represent moderate to poor reliability, between 0.75 and 0.89 report good reliability and values above 0.90, excellent[15]. The Pearson or Spearman correlation coefficient were used, according to data normality. The strength of the correlations was defined as < 0.20 as minimal or absent, from 0.25 to 0.50 as weak, from 0.50 to 0.75 as moderate, and from 0.75 to 1.0 as strong[15]. To analyze responsiveness, Student paired t test or Wilcoxon were performed (depending on data normality). Effect size was estimated as Cohen's d: d < 0.19 as insignificant, d ≥ 0.20 small, d ≥ 0.50 medium, d ≥ 0.80 large and d ≥ 1.30 as very large[16]. The level of significance was set at 5%. The Statistical Package for the Social Sciences (SPSS) v19.0 (Chicago, IL, USA) was used for analyses.

3.4 RESULTS

3.4.1 Participant characteristics

Table 1 presents demographic, anthropometrics, spirometric, and clinical participants data. Men and women were similar for demographic and anthropometrics characteristics. Most study participants were classified as functional classification 1 (negligible functional limitations) or functional classification 2 (mild functional limitations) on the PCFS scale.

To concurrent validity, from thirty-three selected participants, twenty-six were recruited and seven were excluded due to orthopedic conditions that limited test execution and for does not have a device to perform video calls. To responsiveness, from one hundred and eighty-six participants on telerehabilitation, forty-four subjects were recruited. One hundred and forty-two participants were excluded from this group due does not have post-COVID-19 diagnosis or to orthopedic and other health conditions that limited the test.

Please insert Table 1 here

3.4.2 Concurrent validity

Table 2 shows the results for UULEX-M test performed remotely and in person. There was no statistical difference between test times performed remotely and in person. There was no variation between the test levels in the different modalities. Approximately 42% of the sample reached level five. UULEX-M online provoked same dyspnea and RPE responses to the test performed in person. About 77% of the individuals scored seven or more the RPE of arms while 19% rated dyspnea as score seven in UULEX-M in present. Similar scores were observed remotely. Seventy percent of the individuals rated seven or more the RPE of arms and 11% scored seven or more to dyspnea. Strong correlations were observed between tests for time and levels, while for dyspnea and RPE correlations were weak and moderate, respectively. In general, arms RPE scores were higher than dyspnea RPE scores at the end of the

tests. The ICC for time in minutes for UULEX-M in present and remotely was ICC= 0.985 (IC 95% 0.967 to 0.993; p < 0.001).

Please insert Table 2 here

3.4.3 Responsiveness to pulmonary telerehabilitation program

After eight weeks, there were significant improvements in the UULEX-M time and scores of RPE for arms and dyspnea at the end of the test. According to Cohen's criteria, the effect size was large to UULEX-M time and scores of dyspnea, while the effect size for arms RPE was small (Table 3).

Please insert Table 3 here

3.5 DISCUSSION

To our knowledge, this is the first study dedicated to study an upper limb exercise capacity test performed remotely in post-COVID-19 individuals. Results from this study confirm that: 1) UULEX-M performed remotely is valid to assess the upper limbs exercise capacity; 2) UULEX-M performed remotely is responsive to change following a pulmonary telerehabilitation program with minimal resources.

The validity of the UULEX-M has been previously demonstrated through comparisons to the UULEX original version (study 1), which showed moderate to strong correlations between the test times (rho=0.872, p<0.001) and heart rates (rho=0.774, p<0.001), SpO_2 (rho = 0.635, p<0.001), dyspnea (rho = 0.566, p<0.001), and arm RPE (rho = 0.605, p<0.001) at the peak of the tests. The modified test elicited the same physiological responses and symptoms as the original version, with RPE being the main reason for discontinuation of the test.

The UULEX-M is simple and easy to apply. However, applying a remote test implies being subject to variations that may impair test performance, such as internet connection, material differences and non-understanding of the test. Despite that, our study does not show statistically differences and found an excellent concordance by

ICC between the application in person and in remotely way. Lima *et* al, 2018, with healthy adults showed a good reliability for UULEX with ICC= 0.85 (IC 95% 0.73 to 0.91; $p < 0.001$). As the UULEX is an incremental test, the authors attributed the results to the fact that the individual needed to perform the best performance on the test[24]. Although the UULEX-M does not have the characteristic of an incremental test, there is still the need for the patient to perform as long as possible.

Differences of 0.54 score to dyspnea perception and 0.08 to RPE arms were seen among versions. These differences were not statistically significant. However, it led to a weak correlation between online and in person version in RPE arms. The differences of how modified Borg scale was presented in both versions might explain such results. In the remote test version, the Borg scale were presented and verbally described only in the beginning of the test, and participants had to remember the scale and be able to grade their dyspnea symptoms, after the test. In contrast, the Borg scale was printed and fixed in front of the participants during the presential version, which may have led to more accurate scores for dyspnea symptoms in the face-to-face environment. Another factor that may contribute to a weak correlation is the difference between the loaded objects used in the test. During the test remote, individuals are instructed to use a 1kg object (example: 1L milk carton, a grocery bag, a water bottle), which are different from the dumbbell used in person. Thus, the shape of the object also may influence the score for RPE arms.

Our study demonstrated that individuals increase 82% of test time in the UULEX-M with a very large effect size, after eight weeks of pulmonary telerehabilitation. This reinforces that such test is responsive to change, as also stated by Janaudis-Ferreira et al 2011, 2013, that found out differences of 15.3% after six weeks in the UULEX test[21,22]. This present study indicates that a pulmonary telerehabilitation with a standardized upper limb training might be capable to increase the endurance arm capacity, as well as dyspnea and arms RPE in post-COVID-19 population. Future studies might be able to investigate the effects of interventions in patients post-COVID-19 using the UULEX test.

Despite the existence of field tests capable of being applied remotely, to date there is no knowledge of a remote test that addresses the upper limb and that allows it to be

used for training prescription[5]. Thus, this study contributes with a feasible modified test to be applicable in a pulmonary telerehabilitation program. A limitation of this study is that the UULEX-M was not correlate with direct measures of metabolic and ventilatory responses due the social isolation; and there was no randomization of the order of the tests during the validation of the remote and face-to-face test. It is suggested for future, more studies to investigate qualitative outcomes and the relationship with UULEX-M.

3.6 CONCLUSION

UULEX-M applied remotely shows excellent correlation results with the UULEX-M in present. The UULEX-M it is responsive to a telerehabilitation program with minimal resources. This study suggests that the UULEX-M still being a good test to assess the upper limp exercise capacity in present or remotely modality and it is feasible to evaluate individuals that is far away to the rehabilitation centers.

Acknowledgements

The authors are grateful to the UFMG pulmonary ambulatory health professional group, in the name of Dr. Carolina Coimbra Marinho. Also grateful to the physiotherapy undergraduate students.

Funding:

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001; by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and; by Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG).

Competing interests: The authors have no conflicts of interest to disclose.

Week	*Time in each level*	*Load*
1	48 seconds	500g – (e.g. Water bottle (500mL))
2	1 minute	500g
3	1 minute and 24 seconds	500g
4	1 minute and 24 seconds (levels 1 to 4) 2 minutes and 36 seconds (level 5)	500g
5	1 minute and 30 seconds (levels 1 to 4) 4 minutes (level 5)	500g
6	2 minutes	1Kg (e.g Water bottle, food packaging)
7	1 minute and 30 seconds (levels 1 to 4) 4 minutes (level 5)	1Kg
8	1 minute (levels 1 to 4) 6 minutes (level 5)	1Kg

Figure 1 – Endurance Upper Limb training protocol flow

Table 1 – Characteristics of UULEX-M remotely validation study participants

	Concurrent Validity	**Responsiveness**
Characteristic	n=26	n=44
Age, years (SD)	55 (15)	49 (15)
BMI, *Kg/m²*(SD)	33.02 (7)	-
FEV_1, % pred	83.16 (14.46)	-
FVC, % pred	83.16 (14.46)	-
FEV_1/FVC	.81 (.06)	-
Functional Classification (PCFS) (%)		
0 - No functional limitations	-	2 (4.5)
1 - Insignificant functional limitations	11 (42.3)	9 (20.5)
2 - Mild functional limitations	8 (30.8)	11 (25)
3 - Moderate functional limitations	3 (11.5)	10 (22.7)
4 - Severe functional limitations	4 (15.4)	12 (27.3)

Data presented as mean (SD) to age and Level (%) to functional classification according to Post COVID-19 Functional Scale (PCFS). BMI: body mass index; FEV_1: forced expiratory volume in one second; FVC: forced vital capacity; FEV_1/FVC: ratio between forced expiratory volume in one second and forced vital capacity; pred: predicted. Responsiveness sample did not performed assessment in present, so pulmonary function was not measured.

Table 2 - Comparison e relationship between UULEX-M tests (n=26)

	UULEX-M *In person* Mean (SD)	**UULEX-M *remotely* Mean (SD)**	**UULEX-M *In person* vs UULEX-M *remotely***	**Spearman's rho**
Time, *min*	4.60 (2.95)	4.46 (3.03)	0.14 (-0.15 to 0.44)	rho = 0.971; p<0.001
Level	4 (2-5)	3.5 (2-5)	0.77 (-0.12 to 0.27)	rho = 0.963 p<0.001
Dyspnea, *Borg modified*	4.5 (2-6)	5 (3-6)	-0.54 (-1.4 to 0.36)	rho = 0.582; p=0.002
RPE, Arms	8 (6.75-9)	7 (6-8.25)	0.08 (-0.73 to 0.88)	rho = 0.498; p=0.010

*Data are present at mean and standard deviation (SD) to test time and median (1°-3° interquartile) for level, Dyspnea and RPE. The level of significance was set at 5%. *Significant difference between tests RPE: rate of perceived exertion. Values for Dyspnea and RPE Arms are from the end of test.*

Table 3 – Responsiveness for UULEX-M after 8 weeks of pulmonary telerehabilitation (n=44)

	Baseline Mean (SD)	**Week 8 Mean (SD)**	**Week 8 - Baseline Mean difference (95% CI)**	***P***	**Cohen's d**
Time, *min*	4.59 (2.03)	8.37 (4.46)	3.77 (2.43 to 5.11) *	<0.001	1.09
Dyspnea, *Borg modified*	6 (4.25-8)	3 (1-5)	-2.55 (-3.51 to -1.59) *	<0.001	0.966
RPE, Arms	8 (5-9)	5 (4-9.75)	- 1.18 (-2.22 to -0.14) *	0.032	0.425

*The level of significance was set at 5%. *significant difference between tests*
RPE: rate of perceived exertion. Values for Dyspnea, RPE Arms are from the end of test: median (1º-3ºinterquartil).

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4 CONSIDERAÇÕES FINAIS

Este estudo teve como objetivo modificar o *Unsupported Upper Limb Exercise Test (UULEX),* desenvolvido para avaliar a capacidade pico de exercício dos MMSS, e avaliar as propriedades psicométricas desta modificação. O UULEX-M (versão modificada) apresenta excelentes resultados de correlação com a versão original do UULEX. O tempo de UULEX-M foi significativamente menor e induziu os mesmos sintomas e respostas fisiológicas em ambos os sexos. Apesar da existência de testes de campo passíveis de serem aplicados remotamente, até o momento não havia um teste remoto que abordasse os MMSS e que permitisse sua utilização para prescrição de treinamento. O UULEX-M aplicado remotamente apresentou excelentes resultados de correlação com o UULEX-M aplicado presencialmente. Também foi possível concluir que o UULEX-M aplicado remotamente é responsivo a um programa de reabilitação com treinamento padronizado de resistência para os MMSS.

Este estudo sugere que o UULEX-M é um teste excelente para avaliar a capacidade de exercício dos MMSS em indivíduos com síndrome pós-COVID-19 e é mais prático e demanda menos tempo e necessidade de material específico, sendo uma boa escolha em clínicas e avaliações domiciliares (presencial ou remotamente) ou mesmo em hospitais. Isto por que a versão modificada necessita apenas de um objeto com 1Kg (35,27oz) e uma cadeira.

Uma limitação deste estudo é que o UULEX-M não foi correlacionado com questionários sobre participação e qualidade de vida. Além disso, devido à pandemia da COVID-19 e ao isolamento social, não foram feitos mais testes, bem como medida direta das respostas metabólicas e ventilatórias. Sugere-se para futuros estudos que investiguem os resultados qualitativos e a relação com o UULEX-M.

Este estudo é fruto do trabalho duro e da dedicação que um o programa de pós-graduação exige, principalmente quando associado a um período tão atípico como está sendo esse da pandemia da COVID-19. Como pesquisador, pude aprender mais sobre o que constitui uma boa evidência científica, a qualidade do processo de pesquisa e a importância da ciência na prática clínica. Pude aplicar tudo isso durante o período que atuei no “Projeto Respirar" de reabilitação pulmonar do departamento de Fisioterapia da UFMG, do qual sou grato por ter feito parte.

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ANEXOS

APROVAÇÃO COMITÊ DE ÉTICA

UNIVERSIDADE FEDERAL DE MINAS GERAIS

PARECER CONSUBSTANCIADO DO CEP

DADOS DA EMENDA

Título da Pesquisa: MODIFICAÇÃO DO UNSUPPORTED UPPER LIMB EXERCISE TEST E AVALIAÇÃO DE SUAS PROPRIEDADES PSICOMÉTRICAS EM INDIVÍDUOS COM DOENÇAS RESPIRATÓRIAS CRÔNICAS E PÓS COVID-19

Pesquisador: Marcelo Velloso

Área Temática:

Versão: 5

CAAE: 35867320.3.0000.5149

Instituição Proponente: Escola de Educação Física, Fisioterapia e Terapia Ocupacional

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 5.064.416

Apresentação do Projeto:

Projeto cujo objetivo principal é Modificar o UULEX, e realizar a validação concorrente e validade de face do Unsupported Upper Limb Exercise test modificado de 30 segundos (UULEX-M30), 60 segundos (UULEX-M60), e Unsupported Upper Limb Exercise test – Teleavaliação (UULEX-T) para indivíduos com DRC e/ou pós COVID-19.

Nesta emenda, os pesquisadores adaptaram alguns testes de forma que possam ser realizados por vídeo-consulta. O protocolo deixa claro que, em casos de aplicação dos testes por vídeo, há necessidade de acompanhamento de uma terceira pessoa por risco de queda.

Segundo os pesquisadores:

A capacidade funcional é realizada através de avaliações que utilizam testes de campo validados e padronizados para determinadas populações. Alguns testes são usados há bastante tempo na pratica clínica, como o teste de caminhada de seis minutos (TC6') e outros, apesar de não tão conhecidos, vem sendo bastante estudado como o endurance shuttle walking test (ESWT). Embora o TC6' e o ESWT possuírem relevância clínica, estes avaliam apenas a caminhada, e não incluem a

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avaliação de atividades com membros superiores (MMSS) que reflitam em AVD, como pegar objetos em locais altos, estender roupas e pentear os cabelos. Para a avaliação da capacidade funcional através unicamente dos MMSS, um teste disponível é o Unsupported Upper Limb Exercise Test (UULEX). Criado em 2003 por Takahashi et al, o UULEX avalia o pico da capacidade de exercício de MMSS sem realização de apoio do membro durante a atividade, e tem como parâmetro a capacidade do indivíduo em realizar movimentos, repetitivos e sincronizados, utilizando os braços por longos períodos em diferentes alturas com incremento de peso e velocidade constante. Apesar do UULEX ser um teste válido para avaliação da capacidade de exercício de MMSS dos pacientes com DPOC, ele apresenta um protocolo de execução que induz à algumas alterações fisiológicas que podem provocar limitações que influenciam no desempenho do indivíduo e na avaliação da sua capacidade funcional. Este estudo visa avaliar essas mudanças fisiológicas e a adaptação do teste para uma versão que informe melhor a capacidade funcional do indivíduo com doenças respiratórias crônicas e/ou pós-COVID-19.

Para maiores detalhes, ver parecer 4.532.846 de 9 de fevereiro de 2021.

Objetivo da Pesquisa:
Inalterados, conforme parecer 4.532.846 de 9 de fevereiro de 2021.

Avaliação dos Riscos e Benefícios:
Inalterados, conforme parecer 4.532.846 de 9 de fevereiro de 2021.

Salienta-se que alguns testes implicam em risco de queda para a população alvo (idosos possivelmente frágeis) e que há necessidade de acompanhamento presencial do teste por uma terceira pessoa em caso de aplicação remota do teste.

Comentários e Considerações sobre a Pesquisa:
O projeto tem mérito científico e é importante para melhoria das avaliações fisioterápicas, incluindo no tratamento de sequelas da covid-19.

Nessa emenda, os pesquisadores adaptam algumas avaliações e testes para o modo por vídeo e para realização domiciliar. O projeto foi colocado em diligência para que os pesquisadores fizessem ajustes explicando a necessidade de um acompanhante (familiar ou cuidador) que esteja

presente na televisita e para adição do risco de queda em alguns exercícios.

Os pesquisadores fizeram as adaptações pertinentes no TCLE.

Considerações sobre os Termos de apresentação obrigatória:
Foram apresentados

Carta de encaminhamento
Carta resposta às diligências - adequada
Projeto completo revisado - adequado
TCLE revisado – Adequado

Demais documentos não analisados. Ver parecer 4.532.846 de 9 de fevereiro de 2021.

Conclusões ou Pendências e Lista de Inadequações:
Somos favoráveis pela aprovação da emenda.

Considerações Finais a critério do CEP:
Tendo em vista a legislação vigente (Resolução CNS 466/12), o CEP-UFMG recomenda aos Pesquisadores: comunicar toda e qualquer alteração do projeto e do termo de consentimento via emenda na Plataforma Brasil, informar imediatamente qualquer evento adverso ocorrido durante o desenvolvimento da pesquisa (via documental encaminhada em papel), apresentar na forma de notificação relatórios parciais do andamento do mesmo a cada 06 (seis) meses e ao término da pesquisa encaminhar a este Comitê um sumário dos resultados do projeto (relatório final).

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_1834121_E1.pdf	21/10/2021 14:51:28		Aceito
Outros	Carta_Resposta_ao_Parecer_Consubstanciado_do_CEPversao_4_parecer_5030177.docx	21/10/2021 14:48:48	THIAGO HENRIQUE DA SILVA MARTINS	Aceito

UNIVERSIDADE FEDERAL DE MINAS GERAIS

Continuação do Parecer: 5.064.416

TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_Projeto_UULEX_versao_4_parecer_5030177.docx	21/10/2021 14:47:05	THIAGO HENRIQUE DA SILVA MARTINS	Aceito
Outros	Carta_Justificativa_UULEX_nova_versao_2021_nova_emenda.pdf	28/09/2021 23:11:30	THIAGO HENRIQUE DA SILVA MARTINS	Aceito
Projeto Detalhado / Brochura Investigador	Projeto_UULEX_nova_versao_2021_nova_emenda.docx	28/09/2021 23:08:46	THIAGO HENRIQUE DA SILVA MARTINS	Aceito
Outros	Carta_Explicativa_ao_Parecer_Consubstanciado_do_CEP_2021.docx	15/01/2021 18:04:00	THIAGO HENRIQUE DA SILVA MARTINS	Aceito
Outros	Carta_Resposta_ao_Parecer_Consubstanciado_do_CEP_nova_versao_2021.docx	15/01/2021 18:03:12	THIAGO HENRIQUE DA SILVA MARTINS	Aceito
Outros	Declaracao_anuencia_LabCare.pdf	04/12/2020 17:38:12	THIAGO HENRIQUE DA SILVA MARTINS	Aceito
Folha de Rosto	folhaDeRosto_Assinada_2.pdf	22/07/2020 12:02:45	Marcelo Velloso	Aceito
Declaração de Instituição e Infraestrutura	Parecer_Camara_departamental_06_04_2020.pdf	21/07/2020 16:24:02	THIAGO HENRIQUE DA SILVA MARTINS	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

BELO HORIZONTE, 26 de Outubro de 2021

Assinado por:
Crissia Carem Paiva Fontainha
(Coordenador(a))

Endereço: Av. Presidente Antonio Carlos, 6627 ¿ 2º. Andar ¿ Sala 2005 ¿ Campus Pampulha
Bairro: Unidade Administrativa II **CEP:** 31.270-901
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APÊNDICE

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO (TCLE)

O(A) Sr.(a) está sendo convidado a participar de um projeto de pesquisa a ser desenvolvido no Departamento de Fisioterapia da Escola de Educação Física, Fisioterapia e Terapia Ocupacional da Universidade Federal de Minas Gerais (UFMG), intitulado: **MODIFICAÇÃO DO UNSUPPORTED UPPER LIMB EXERCISE TEST E AVALIAÇÃO DE SUAS PROPRIEDADES PSICOMÉTRICAS EM INDIVÍDUOS COM DOENÇAS RESPIRATÓRIAS CRÔNICAS E PÓS-COVID.**

Responsáveis pela pesquisa

1- Prof. Dr. Marcelo Velloso - Departamento de Fisioterapia da Universidade Federal de Minas Gerais – MG - Brasil.
2- Liliane Patrícia de Souza Mendes – fisioterapeuta, co-coordenadora do projeto de reabilitação pulmonar da UFMG.
3- Thiago Henrique da Silva Martins – fisioterapeuta, discente de mestrado do programa de Pós-Graduação em Ciências da Reabilitação da UFMG.
4- Bianca Louise Carmona Rocha – fisioterapeuta, discente de doutorado do programa de Pós-Graduação em Ciências da Reabilitação da UFMG.

Informações

A pesquisa tem como objetivo avaliar a modificação do teste de exercícios de membros superiores sem suporte (*Unsupported upper limb exercise test* - UULEX) de forma que ele reflita melhor a capacidade de indivíduos com doenças respiratórias crônicas, realizar exercícios utilizando os membros superiores.

Este projeto será desenvolvido no programa de pós-graduação em Ciências da Reabilitação da Escola de Educação Física, Fisioterapia e Terapia Ocupacional da Universidade Federal de Minas Gerais, podendo ser realizado presencialmente e a distância no período de pandemia da COVID-19.

DESCRIÇÃO DOS TESTES A SEREM REALIZADOS

Inicialmente, serão coletadas informações para a sua identificação, e dados de caracterização de saúde como história da doença, aferição de pressão arterial, peso e altura. Para garantir o seu anonimato, serão utilizadas senhas numéricas. Assim, em momento algum haverá divulgação do seu nome. Concordando em participar do estudo, inicialmente, o Sr.(a) irá realizar a prova

de função pulmonar que mede a quantidade de ar que entra e sai dos pulmões por meio do sopro, em um aparelho específico (espirometria). Em seguida, você terá a força de preensão de suas mãos medida por um aparelho específico (dinamômetro). Os pesquisadores irão fazer algumas perguntas a respeito das suas atividades diárias para classificação do seu grau de funcionalidade segundo a escala do estado funcional do pós-COVID (PCFS). Se durante a pandemia do COVID-19, você irá realizar dois testes, com intervalo de 30 minutos entre eles, que são:

- ***Unsupported Upper Limb Exercise Test*** **(UULEX)-** Neste teste, o sr. (a) será orientado(a) a levantar uma barra com as duas mãos em um intervalo constante de 30 batidas por minuto, ritmadas pelo sinal sonoro. O sr. (a) começará com uma barra de 200 gramas e será orientado a mover os braços da cintura para o primeiro nível do painel que será posicionado na altura do joelho e esse movimento será realizado por dois minutos como aquecimento. Em seguida, a cada minuto, o sr. (a) será orientado(a) a alcançar um nível mais alto do painel. Ao atingir o oitavo nível do painel, a barra de 200 gramas será substituída por uma de 500 gramas, depois por 1,0 kg, 1,5 kg e 2,0 kg até você alcançar o seu máximo ou até que sinta que não pode continuar mais do teste.

- ***Unsupported Upper Limb Exercise Test – teleavaliação*** **(UULEX-M)** Neste teste, o sr. (a) será orientado(a) a levantar um objeto de 1Kg com as duas mãos em um intervalo constante de 30 batidas por minuto, ritmadas pelo sinal sonoro. O sr. (a) será orientado a mover os braços à frente e retornar no nível da cintura. Em seguida, a cada minuto, o sr. (a) será orientado(a) a elevar os braços à níveis cada vez mais altos, sendo nível acima do umbigo, nível dos ombros, nível do nariz e nível acima da cabeça. Ao atingir o quinto nível que é acima da cabeça, você permanecerá realizando o movimento até que sinta que não pode continuar mais o teste. Este teste será realizado novamente em um outro dia através de chamada de vídeo antes do início da reabilitação pulmonar, junto com os outros dois testes a seguir:

-**Teste de senta e levanta de 1 minuto e 30 segundos:** Neste teste o sr.(a) onde será orientado(a) a realizar o máximo de movimentos de levantar e sentar da cadeira em um período de 1 minuto, sendo possível descansar neste período caso se sinta cansado, e retornar caso o tempo não tenha se esgotado.

-***Timed up and Go*** **(TUG):** Neste teste o sr.(a) onde será orientado(a) a percorrer uma distância de três (3) metros demarcados com uso de fita métrica ou trena, partindo da posição sentada de uma cadeira, onde você deve se levantar, caminhar pelos três metros, dar a volta e sentar na

cadeira novamente. Será considerado o tempo necessário para realizar a caminhada neste percurso. Você deverá percorrer esta distância três vezes.

Espera-se que esta avaliação presencial seja realizada em um período de 3 horas em apenas um dia. E a avaliação a distância seja realizada em um período máximo de 1 hora com acompanhamento de um responsável, seja ele cuidador ou familiar.. As avaliações não terão gravação de vídeo e/ou tela, ou mesmo captura de imagens.

Se você for convidado a participar do estudo em um período fora da pandemia do COVID-19 ou em momento considerado seguro para população, a avaliação ocorrerá em 4 dias. Espera-se que esta avaliação presencial seja realizada em um período máximo de 3 horas, em cada dia. No primeiro dia, será realizado dois testes, duas vezes, com aplicação de um questionário entre eles. Os dois testes realizados no primeiro dia são:

- **Teste de caminhada de seis minutos -** Neste teste você terá de caminhar durante seis minutos, em um corredor reto com superfície plana de trinta metros. Caso se sinta cansado(a) durante o teste é permitido descansar, no entanto, o tempo continuará sendo cronometrado.
- ***Unsupported Upper Limb Exercise Test*** **(UULEX)-** Neste teste, o sr. (a) será orientado(a) a levantar uma barra com as duas mãos em um intervalo constante de 30 batidas por minuto, ritmadas pelo sinal sonoro. O sr. (a) começará com uma barra de 200 gramas e será orientado a mover os braços da cintura para o primeiro nível do painel que será posicionado na altura do joelho e esse movimento será realizado por dois minutos como aquecimento. Em seguida, a cada minuto, o sr. (a) será orientado(a) a alcançar um nível mais alto do painel. Ao atingir o oitavo nível do painel, a barra de 200 gramas será substituída por uma de 500 gramas, depois por 1,0 kg, 1,5 kg e 2,0 kg até você alcançar o seu máximo ou até que sinta que não pode continuar mais do teste.

No segundo dia o Sr.(a) irá realizar dois testes:

- ***Endurance Shuttle Walk Test*** **-** Neste teste o sr. (a) terá de caminhar em um corredor plano de 10 metros, demarcado por dois cones, com distância de nove metros entre eles.

O Sr.(a) deve caminhar pelo maior tempo possível mantendo a velocidade determinada pelos sinais sonoros durante todo o teste.

- ***Unsupported Upper Limb Exercise Test*****- MODIFICADO 60 (UULEX-M60) -** Este teste, será realizado da mesma forma que o UULEX descrito anteriormente, entretanto não haverá aquecimento. O sr.(a) começará com uma barra de 200 gramas. Ao atingir o oitavo nível do

painel, essa barra será substituída por uma de 400 gramas, depois por 600 gramas, 800 gramas e 1,0 kg, e assim por diante até você alcançar o seu máximo ou até que não consiga continuar o teste.

No terceiro dia o Sr.(a) irá realizar dois testes:

- Teste de AVD-Glittre sem mochila - O sr.(a) irá levantar de uma cadeira, caminhará por uma pista de 10 metros, subirá e descerá uma escada com dois degraus que estará na metade da pista e transferirá objetos, um a um (com 1 Kg cada) de uma prateleira alta para uma prateleira baixa e depois para o chão, em seguida retornará com os objetos para a prateleira baixa e finalmente para a prateleira alta de uma estante localizada no final da pista. Em seguida o sr. (a) retornará fazendo o mesmo caminho até chegar e sentar-se na cadeira; imediatamente reiniciará outra volta percorrendo o mesmo circuito. O teste consiste em cinco voltas. Você deverá realizar o teste o mais rápido possível podendo parar para descansar.

No quarto dia o Sr.(a) irá realizar dois testes:

- ***Unsupported Upper Limb Exercise Test*- MODIFICADO 30 (UULEX-M30)** Este teste será semelhante ao anterior, entretanto a mudança de níveis será realizada a cada 30 segundos até você alcançar o seu máximo ou até que não consiga continuar o teste.

Os testes serão realizados em quatro dias diferentes com um intervalo máximo de 7 dias entre eles, no mesmo local: Laboratório de Avaliação e Pesquisa em Desempenho Cardiorrespiratório (LabCare) situado no primeiro andar, sala 1104, da Escola de Educação Física, Fisioterapia e Terapia Ocupacional (EEFFTO) da Universidade Federal de Minas Gerais (UFMG). Nos quatro dias da coleta, haverá um tempo de descanso entre os testes.

Reabilitação Pulmonar

Se durante o período de pandemia, você será encaminhado para a telereabilitação pulmonar, onde serão realizados exercícios aeróbicos como caminhada e dança, exercícios de força e exercícios respiratórios sob supervisão de fisioterapeutas e alunos da graduação, durante 8 semanas, sendo 2 atendimentos por semana através de chamada de vídeo com duração aproximada de 1 hora e 30 minutos. Estes atendimentos não terão gravação de vídeo e/ou tela, ou mesmo captura de imagens. Assim como na avaliação realizada por vídeo chamada, a telereabilitação precisará de um acompanhante, seja ele um familiar ou cuidador, que irá receber instruções como o(a) Sr(a) para melhor condução e segurança durante o atendimento.

Se durante o período fora da pandemia ou em um momento considerado seguro para a população, você será encaminhado para a reabilitação pulmonar presencial, onde serão

realizados exercícios aeróbicos como caminhada, bicicleta, esteira, exercícios de força e exercícios respiratórios sob supervisão de fisioterapeutas e alunos da graduação, durante 8 semanas, sendo 2 atendimentos por semana com duração aproximada de 1 hora e 30 minutos.
Em qualquer que seja a modalidade de reabilitação (presencial ou online) você terá sua participação garantida na reabilitação pulmonar nos dois formatos, desde que tenha redução das medidas de distanciamento social com a vacinação da população e fim da pandemia. Ao final do período de 8 semanas de reabilitação, você será convidado a participar do projeto em outra modalidade.

Possíveis Riscos ou Desconfortos:

O sr.(a) poderá sentir dores musculares nas pernas e nos braços durante e após a realização dos testes, pois ambos os testes exigem esforço físico maior do que aquele que está acostumado(a). Essas dores podem durar por até cinco dias, entretanto essas dores são passageiras e não te impedirão de seguir com suas atividades do dia a dia. O sr.(a) poderá sentir cansaço e aumento dos seus batimentos cardíacos. Essas alterações são normais durante qualquer esforço e serão monitoradas pela equipe durante todo o tempo. Se for percebido qualquer sintoma diferente do habitual, o procedimento será imediatamente interrompido. E em caso de persistência do desconforto o SAMU será acionado estando garantida a presença do pesquisador até a chegada do socorro. Como alguns testes oferecem risco de queda, como o teste de sentar e levantar e o TUG, as avaliações por videochamada só serão realizadas com a presença de um acompanhante, seja ele um familiar ou cuidador. Além disso, o(a) Sr.(a) pode se recusar a responder os questionários caso se sinta constrangido.

Benefícios esperados:

Os resultados encontrados com o estudo contribuirão para melhorar a avaliação da capacidade de exercício de braço de indivíduos com doença pulmonar crônica e/ou pós COVID-19 utilizando as modificações do ***Unsupported Upper Limb Exercise test (UULEX)***. Ao se verificar a precisão das medidas fornecidas por um novo teste, ele se torna acessível para ser utilizado na prática clínica e em pesquisas. Além disso, o(a) Sr(a) receberá uma avaliação do seu sistema respiratório (espirometria) e estará pronto(a) para realizar a reabilitação pulmonar por 8 semanas, presencialmente ou a distância. O senhor(a) pode se recusar a participar da pesquisa, ficando garantida, mesmo assim, a sua participação na reabilitação durante as 8 semanas.

Garantia de esclarecimento:

Em qualquer momento da pesquisa, o(a) Sr.(a) tem o direito de receber informações acerca da pesquisa, podendo fazer contato com o pesquisador responsável.

Esse documento será assinado em duas vias, uma ficará com os pesquisadores e outra para você levar para casa. SOMENTE em caso dúvidas do ponto de vista ético da pesquisa, o voluntário poderá entrar em contato com o Comitê de Ética em Pesquisa da UFMG (COEP). Os respectivos telefones e contato seguem na última página deste termo.

Garantia de sigilo: As informações obtidas nesta pesquisa poderão ser divulgadas em encontros científicos como congressos, ou em revistas científicas, mas não possibilitarão sua identificação. Desta forma garantimos o sigilo sobre todos os dados relativos à sua participação nesse estudo.

Direito de recusa:

Como voluntário (a), o(a) Sr.(a) poderá se recusar a participar ou retirar seu consentimento em qualquer fase da pesquisa, sem qualquer penalização ou prejuízo.

Ressarcimento e indenização:

Não haverá gastos adicionais aos participantes, visto que os mesmos já estavam na lista de convocação para a reabilitação do projeto de extensão Respirar - Pulmões pela Vida, e não receberá remuneração por sua participação na pesquisa.

Diante destas informações, se for de sua vontade participar deste estudo, favor preencher o consentimento abaixo:

CONSENTIMENTO:

Declaro que li e entendi as informações acima e que todas as dúvidas referentes à minha participação neste estudo foram esclarecidas. Desta forma, eu_____ concordo em participar desse estudo.

Como acompanhante responsável, a(o) _____, com grau de parentesco _____.

_____ _____

Assinatura do voluntário Assinatura do pesquisador

_____

Assinatura do acompanhante

Belo Horizonte, ___/ ___/ _____.

Telefones e endereços para contato:

● Professor Marcelo Velloso e Thiago Henrique da Silva Martins

Endereço: Av. Presidente Antônio Carlos, 6627 – Pampulha, Belo Horizonte. Escola de Educação Física, Fisioterapia e Terapia Ocupacional.

Telefone: (031) 3409- 4777

●Comitê de Ética em Pesquisa da UFMG (COEP)

Endereço: Avenida Antônio Carlos, 6627. Unidade Administrativa II – 2º andar. Sala 2005. Campus Pampulha. Belo Horizonte. Telefone: (031) 3409-4592