Universidade Federal de Minas Gerais

The University of Sydney

FATORES RELACIONADOS À ATIVIDADE FÍSICA PÓS ACIDENTE VASCULAR ENCEFÁLICO

FACTORS RELATED TO PHYSICAL ACTIVITY AFTER STROKE

Belo Horizonte/Sydney

2015

Janaine Cunha Polese

FATORES RELACIONADOS À ATIVIDADE FÍSICA PÓS ACIDENTE VASCULAR ENCEFÁLICO

Tese apresentada ao Programa de Pós Graduação em Ciências da Reabilitação, nível doutorado da Escola de Educação Fisica, Fisioterapia e Terapia Ocupacional da Universidade Federal de Minas Gerais e Healthy Sciences Department da The University of Sydney, como requisito parcial à obtenção do título de Doutor em Ciências da Reabilitação e Doctor of Philosophy.

Área de concentração: Desempenho Funcional Humano.

Linha de Pesquisa: Estudos em Reabilitação Neurológica no Adulto.

Orientadora: Profª Luci Fuscaldi Teixeira-Salmela, Ph.D., UFMG
Co-Orientadora: Profª Louise Ada, Ph.D., USYDNEY

Universidade Federal de Minas Gerais
Belo Horizonte
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Janaine Cunha Polese

FACTORS RELATED TO PHYSICAL ACTIVITY AFTER STROKE

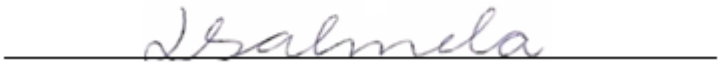
Thesis submitted to the Graduate Program in Rehabilitation Sciences, doctorate level of the School of Physical Education, Physiotherapy, and Occupational Therapy, Universidade Federal de Minas Gerais and Healthy Science Department of The University of Sydney, as a partial requirement for the award of the degree in Doctor of Rehabilitation Sciences and Doctor of Philosophy.

Supervisor: Luci Fuscaldi Teixeira-Salmela, Ph.D., UFMG
Co- Supervisor: Louise Ada, Ph.D., USYDNEY

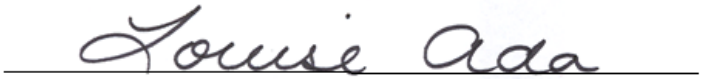
The University of Sydney
Sydney
2015

Supervisors' Statment

As supervisors of Janaine Cunha Polese's doctoral work, we certify that we consider her thesis "*Factors related to Physical Activity after Stroke"* to be suitable for examination.



Professor Luci Fuscaldi Teixeira Salmela
Universidade Federal de Minas Gerais
Date: 22.02.2015

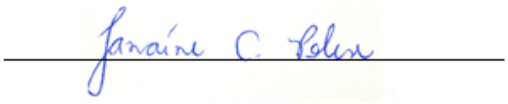


Professor Louise Ada
The University of Sydney
Date: 22.02.2015

Candidate' Statment

I, Janaine Cunha Polese, hereby declare that this submission is my own work and that it contains no material previously published or written by another person except where acknowledge in the text. Nor does it contain material which has been accepted for the award of another degree.

I, Janaine Cunha Polese, understand that if I am awarded a higher degree for my thesis entitled "*Factors related to Physical Activity Post Stroke"* being lodged herewith for examination, the thesis will be lodged in the Universidade Federal de Minas Gerais and The University of Sydney libraries and be available immediately for use. I agree that the University Librarian (or in the case of a Department, the Head of Department) may supply a photocopy or microform of the thesis to an individual for research or study or to a library.



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ATA DE NÚMERO 43 (QUARENTA E TRES) DA SESSÃO DE ARGUIÇÃO E DEFESA DE TESE APRESENTADA PELA CANDIDATA **Janaine Cunha Polese** DO PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS DA REABILITAÇÃO.

Aos 27 (vinte e sete) dias do mês de fevereiro do ano de dois mil e quinze, realizou-se na Escola de Educação Física, Fisioterapia e Terapia Ocupacional, a sessão pública para apresentação e defesa da Tese de Doutorado intitulada: **"FATORES RELACIONADOS À ATIVIDADE FÍSICA PÓS ACIDENTE VASCULAR ENCEFÁLICO"**. A comissão examinadora foi constituída pelas seguintes Professoras Doutoras: Luci Fuscaldi Teixeira-Salmela, Clarissa Cardoso dos Santos Couto Paz, Camila Torriani-Pasin, Fátima Valéria Rodrigues de Paula e Giane Amorim Ribeiro Samora sob a Presidência da primeira. Os trabalhos iniciaram-se às 08h30min com apresentação oral da candidata, seguida de arguição dos membros da Comissão Examinadora. Após avaliação, os examinadores consideraram a candidata ***aprovada e apta a receber o título de Doutora após a entrega da versão definitiva da Tese***. Nada mais havendo a tratar, eu, Marilane Soares, secretária do Colegiado de Pós-Graduação em Ciências da Reabilitação dos Departamentos de Fisioterapia e de Terapia Ocupacional da Escola de Educação Física, Fisioterapia e Terapia Ocupacional, lavrei a presente Ata, que depois de lida e aprovada será assinada por mim e pelos membros da Comissão Examinadora.
Belo Horizonte, 27 de fevereiro de 2015.-.

Professora Dra. Luci Fuscaldi Teixeira-Salmela ____________________

Professora Dra. Clarissa Cardoso dos Santos Couto Paz ____________________

Professora Dra. Camila Torriani-Pasin ____________________

Professora Dra. Fátima Valéria Rodrigues de Paula ____________________

Professora Dra. Giane Amorim Ribeiro Samora ____________________

Marilane Soares – SIAPE: 084190 ____________________
Secretária do Colegiado de Pós-Graduação em Ciências da Reabilitação

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PARECER

Considerando que a Tese de Doutorado de **Janaine Cunha Polese** intitulada: **"FATORES RELACIONADOS À ATIVIDADE FÍSICA PÓS ACIDENTE VASCULAR ENCEFÁLICO"**, defendida junto ao Programa de Pós-Graduação em Ciências da Reabilitação, nível: Doutorado cumpriu sua função didática, atendendo a todos os critérios científicos, a Comissão Examinadora **APROVOU** a Tese de doutorado, conferindo-lhe as seguintes indicações:

Nome do Professor (a)/Banca	Aprovação	Assinatura
Profa. Dra. Luci Fuscaldi Teixeira-Salmela	Aprovada	
Profa. Dra. Clarissa Cardoso dos Santos Couto Paz	Aprovada	
Profa. Dra. Camila Torriani-Pasin	Aprovada	
Profa. Dra.Fátima Valéria Rodrigues de Paula	APROVADA	
Professora Dra. Giane Amorim Ribeiro Samora	APROVADA	

Belo Horizonte, 27 de fevereiro de 2015.

Colegiado de Pós-Graduação em Ciências da Reabilitação/EEFFTO/UFMG

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Dedico esta obra e este imenso aprendizado a todos aqueles que depositaram sua confiança em mim.

Em especial aos meus pilares: Ana, Celso e Nathália.

A maior paixão da minha vida, meu ombro e aquele que compra todos os meus sonhos sem medo: meu marido e amigo Lucas.

”Foi o tempo que dedicastes à tua rosa que a fez tão importante”

(Antoine de Saint-Exupéry)

AGRADECIMENTOS

À querida professora Luci Fuscaldi Teixeira-Salmela, que foi mais do que uma orientadora nestes quatro anos de convivência. Agradeço por ter sido amiga, mentora, guia, e muitas vezes meu ombro amigo. Você é responsável em grande parte pela pesquisadora, professora e pessoa que me tornei hoje. Que eu possa retribuir sempre e em triplo tanta dedicação, ensinamentos e carinho recebidos nesta jornada. A minha admiração por você vai além das palavras.

À professora Louise Ada: *thanks for dividing with me so many things about physiotherapy and research, it was an honor learning with you. Thanks for opening my mind and teaching me other ways to understand and see science.*

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À minha mãe, que foi e sempre será meu maior pilar: obrigada por todos os joelhos dobrados... Obrigada por me ligar exatamente no momento em que eu precisei do teu ouvido. Pai, obrigada por apoiar todos os meus sonhos loucos. Vocês viram só onde fui parar? A culpa é toda de vocês, que deram as asas e o combustível... Agradeço a minha irmã-amiga Nathalia, que fez papel de irmã mais velha em vários momentos nestes anos, literalmente me cuidando. Obrigada por ser meu escudo. Amo vocês, meus amores. Quero que sintam o gosto das minhas realizações juntinho comigo, sempre.

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Obrigada meu Deus, que esteve caminhando ao meu lado fielmente desde o dia que saí de casa, que me deu coragem para me mudar para o outro lado do país e para o outro lado do mundo. Obrigada por ter colocado no meu caminho pessoas tão boas, que me pegaram pela mão nos momentos que pensei em desistir de alguma forma. Obrigada meus anjos Elenir e Laura, que continuam a zelar pelo meu sono.

Que eu seja “um bom arco na mão do Arqueiro”.

Por fim, agradeço a todos aqueles que de uma forma ou de outra, na alegria ou tristeza, me fizeram ser a pessoa que sou hoje. Sem dúvidas, o aprendizado destes quatro anos não se resume apenas nesta obra. Espero utilizar este imenso aprendizado na construção de uma vida com melhor qualidade para nossos pacientes, que doam humildemente seu tempo e depositam todas as esperanças em nossas pesquisas.

...E vamos lá para novos desafios!

PREFÁCIO

O presente trabalho foi elaborado conforme as normas do Colegiado do Programa de Pós-Graduação em Ciências da Reabilitação da Universidade Federal de Minas Gerais (UFMG) e em conformidade com as normas estabelecidas pela University of Sydney (USYDNEY), de acordo com os pré -requisitos determinados pelo acordo realizado pelas duas instituições (Acordo de Cotutela – ANEXO I). Este trabalho foi desenvolvido como requisito parcial à obtenção do título de Doutor em Ciências da Reabilitação e Doctor of Philosophy, pelos programas de Pós Graduação em cotutela entre a UFMG, Brasil e USYDNEY, Austrália.

O programa de doutorado do Programa de Pós Graduação em Ciências da Reabilitação da UFMG requer: (1) cumprimento de no mínimo 36 créditos; (2) elaboração e desenvolvimento de um projeto de pesquisa e (3) produção de artigos relacionados e não relacionados à pesquisa.

Desta forma, a fim de atender as exigências de ambas as Instituições de ensino, o programa de cotutela compreendeu três fases distintas. A primeira delas foi realizada na UFMG durante o ano de 2011, que compreendeu o cumprimento de créditos exigidos pelo programa, além da elaboração do projeto de pesquisa e atualização bibliográfica. As disciplinas realizadas estão descritas no Anexo II. A segunda fase do programa foi compreendida pelo estágio sanduiche realizado na USYDNEY, Austrália, no período de janeiro de 2012 a janeiro de 2013, onde o delineamento da pesquisa foi refinado, além da realização do curso de formação em Systematic Review pela Cochrane (Anexo III) e do aprendizado, elaboração e publicação de duas revisões sistemáticas, publicadas no Journal of Physiotherapy:

1. POLESE, J. C.; ADA, L.; DEAN, C. M.; NASCIMENTO, L.; R.; TEIXEIRA-SALMELA, L. F. Treadmill training is effective for ambulatory adults with stroke: a systematic review. Journal of Physiotherapy, v. 59, p. 73-80, 2013.

2. NASCIMENTO, L. R.; MICHAELSEN, S. M.; ADA, L.; POLESE, J. C.; TEIXEIRA-SALMELA, L. F. Cyclical electrical stimulation increases strength and improves activity after stroke: a meta-analysis. Journal of Physiotherapy, v. 60, p. 22-30, 2014 (Anexo IV).

A terceira fase, por sua vez, foi realizada no período de fevereiro de 2013 a fevereiro de 2015 na UFMG, onde ocorreu a coleta de dados, processamento e elaboração da tese.

Respeitando o acordo de cotutela, a presente tese foi estruturada a partir das normas do Programa de Pós Graduação em Ciências da Reabilitação da UFMG, sendo compreendida por **seis** capítulos.

O **primeiro** capítulo se refere à introdução, abrangendo a problematização do tema e sua justificativa, bem como os objetivos dos quatro estudos. Por apresentarem objetivos diferentes, os quatro estudos apresentados na presente tese podem ser lidos separadamente.

O **segundo** capítulo se refere a uma revisão sistemática com metanálise, sobre os efeitos do uso da esteira na marcha de indivíduos deambuladores pós-AVE, o qual foi publicado no *Journal of Physiotherapy:*

- POLESE, J. C.; ADA, L.; DEAN, C. M.; NASCIMENTO, L.; R.; TEIXEIRA-SALMELA, L. F. Treadmill training is effective for ambulatory adults with stroke: a systematic review. Journal of Physiotherapy, v. 59, p. 73-80, 2013.

O **terceiro** capítulo se refere a um estudo observacional, que investigou a intensidade e duração das sessões de fisioterapia convencional em indivíduos pós-AVE, o qual foi publicado no *Journal of Physical Medicine and Rehabilitation:*

- POLESE, J. C.; SCIANNI, A. A.; KUYS, S.; ADA, L.; TEIXEIRA-SALMELA, L. F. Cardiorespiratory Stress is not Achieved During Routine Physiotherapy in Chronic Stroke. International Journal of Physical Medicine and Rehabilitation, v. 2, p. 211-6, 2014.

O **quarto** capítulo se refere a um estudo metodológico, o qual investigou a confiabilidade teste-reteste do ergoespirômetro portátil Cortex MetMax 3B durante o teste de caminhada de 6 minutos em indivíduos pós-AVE, o qual foi publicado no *Physical Medicine and Rehabilitation – International*:

- POLESE, J. C.; ADA, L.; PARREIRA, V. F., FARIA, G. S., AVELINO, P.; TEIXEIRA-SALMELA, L. F. Test-retest reliability of the cardiorespiratory variables measured with the Metamax 3B during the six-minute walking test after stroke. Physical Medicine and Rehabilitation – International, v. 2, n.1, 1028, 2015.

O **quinto** capítulo se refere ao estudo principal desta tese, o qual será submetido para publicação à *Stroke* após a defesa (Anexo VII). Dessa forma, o

método detalhado e resultados acerca deste estudo são apresentados previamente ao artigo.

O **sexto** capítulo contém as considerações finais, além das referências bibliográficas utilizadas, as quais estão de acordo com as normas da Associação Brasileira de Normas Técnicas (ABNT NBR 14724:2005). Finalmente, estão incluídos os anexos e apêndices pertinentes a presente tese.

Ao final da tese encontra-se o minicurrículo da doutoranda, com as atividades acadêmicas desenvolvidas e produção científica durante o período do doutoramento.

PREFACE

This thesis was prepared in compliance with the rules of the Board of the Graduate Program in Rehabilitation Sciences of the Universidade Federal de Minas Gerais (UFMG) and the standards established by The University of Sydney (USYDNEY), according to pre-requisites established by the agreement reached by the two institutions (Cotutelle agreement – *Anexo I*). This thesis was conducted as a partial requirement for obtaining the degree of Doctor in Rehabilitation Sciences and Doctor of Philosophy, co-tutelle program between UFMG, Brazil and USYDNEY, Australia.

The requirements of the Graduate program in Rehabilitation Sciences of the UFMG comprises: (1) the accomplishment of at least 36 credits (2) the writing and development of a research project, and (3) the production of related papers and others, apart from the research project.

Thus, in order to meet the requirements of both institutions, the co-tutelle program comprised three distinct phases. The first was held at UFMG during 2011 and included the completion of the required coursework, writing of the research project, and a bibliographic update. The completed courses are described in *Anexo II*. The second phase included the “sandwich” period held at USYDNEY, from January 2012 to January 2013, where the research design was refined, the Systematic Review training course by Cochrane was completed (*Anexo III*), besides learning, writing, and publication of the following two systematic reviews, which were published in the Journal of Physiotherapy:

1. POLESE, J. C.; ADA, L.; DEAN, C. M.; NASCIMENTO, L.; R.; TEIXEIRA-SALMELA, L. F. Treadmill training is effective for ambulatory adults with stroke: a systematic review. Journal of Physiotherapy, v. 59, p. 73-80, 2013.

2. NASCIMENTO, L. R.; MICHAELSEN, S. M.; ADA, L.; POLESE, J. C.; TEIXEIRA-SALMELA, L. F. Cyclical electrical stimulation increases strength and improves activity after stroke: a meta-analysis. Journal of Physiotherapy, v. 60, p. 22-30, 2014 (*Anexo IV*).

The third phase was held at UFMG, from February 2013 to February 2015, where data collection, processing, and writing of the thesis were carried out.

Respecting the co-tutelle agreement, this thesis was elaborated based upon

the rules of the Graduate program in Rehabilitation Sciences, UFMG, and is comprised of **six** chapters.

The **first** chapter refers to the introduction, including the rationale of the studied topic, and the objectives of the four studies. Since they have different objectives, the four studies presented in this thesis can be read separately.

The **second** chapter refers to a systematic review and meta-analysis on the effects of the treadmill training on gait for ambulatory individuals post stroke, which was published in the Journal of Physiotherapy:

- POLESE, J. C.; ADA, L.; DEAN, C. M.; NASCIMENTO, L.; R.; TEIXEIRA-SALMELA, L. F. Treadmill training is effective for ambulatory adults with stroke: a systematic review. Journal of Physiotherapy, v. 59, p. 73-80, 2013.

The **third** chapter refers to an observational study, which investigated the intensity and duration of conventional physical therapy sessions with stroke individuals, which was published in the Journal of Physical Medicine and Rehabilitation:

- POLESE, J. C.; SCIANNI, A. A.; KUYS, S.; ADA, L.; TEIXEIRA-SALMELA, L. F. Cardiorespiratory Stress is not Achieved During Routine Physiotherapy in Chronic Stroke. International Journal of Physical Medicine and Rehabilitation, v. 2, p. 211-6, 2014.

The **fourth** chapter refers to a methodological study, which investigated the test-retest reliability of portable ergospirometer Cortex MetMax 3B during the 6-minute walk test in stroke individuals, which was published in Physical Medicine and Rehabilitation - International:

- POLESE, J. C.; ADA, L.; PARREIRA, V. F., FARIA, G. S., AVELINO, P.; TEIXEIRA-SALMELA, L. F. Test-retest reliability of the cardiorespiratory variables measured with the Metamax 3B during the six-minute walking test after stroke. Physical Medicine and Rehabilitation – International, v. 2, n.1, 1028, 2015.

The **fifth** chapter refers to the main study of this thesis, which will be submitted for publication to the Stroke journal, after the oral defense (*Anexo VII*). In this sense, the detailed methods and results of this study are described in details.

The **sixth** chapter contains the relevant final considerations, besides the references, which are in accordance with the standards of the Brazilian Association

of Technical Standards (ABNT NBR 14724: 2005). Finally, there were included attachments and appendices relevant to this thesis.

At the end of the thesis, there is the mini-curriculum of the Ph.D. candidate, with academic activities and scientific production developed during the course of her Ph.D.

RESUMO

Indivíduos pós Acidente Vascular Encefálico (AVE) permanecem com diversas incapacidades a longo prazo. Nesse sentido, abordagens terapêuticas devem ser implementadas para uma visão ampla das deficiências em estrutura e função corporal e limitações em atividade e participação social dessa população. Dessa forma, há um crescente interesse em se entender os mecanismos globais relacionados à atividade física pós-AVE, já que a inatividade provoca um ciclo vicioso, levando ao sedentarismo, diminuição do condicionamento cardiorrespiratório e, por conseguinte, diminuição da participação social desses indivíduos. Procurando atender a tais pressupostos, quatro estudos foram desenvolvidos na presente tese, a fim de contribuir com a lacuna existente na literatura acerca de fatores relacionados à atividade física pós-AVE. O **primeiro estudo** objetivou verificar se o treino da marcha mecanicamente assistida poderia promover aumento da velocidade da marcha e distância percorrida em indivíduos pós-AVE deambuladores, quando comparada com nenhuma intervenção, intervenção sem o treino de marcha ou treino da marcha no solo. Para tanto, foi realizada uma revisão sistemática de ensaios clínicos aleatorizados (Registro PROSPERO CRD 42012002622). Para serem incluídos na revisão sistemática, os estudos deveriam ter como intervenção o treino de marcha mecanicamente assistida sem suporte parcial de peso; desfechos relacionados à marcha, tais como velocidade e distância percorrida. Foram incluídos nove estudos que utilizaram o treino com esteira, compreendendo 977 participantes. A metanálise demonstrou que o treino em esteira resultou em maiores velocidades de marcha, quando comparado a nenhuma intervenção ou intervenção sem o treino de marcha (MD 0,14 m/s, IC95% 0,09 a 0,19) imediatamente após a intervenção. Tais benefícios foram mantidos além do período de intervenção (MD 0,12 m/s, IC95% 0,08 a 0,17). O treino de marcha em esteira também proporcionou um aumento na distância percorrida imediatamente após a intervenção (MD 40 m, IC95% 27 a 53), sendo que este aumento se manteve além do período de intervenção (MD 40 m, IC95% 24 a 55). Não foram observadas diferenças estatisticamente significativas imediatamente após a intervenção quando comparou-se o treino em esteira e treino de marcha no solo em termos de velocidade (MD 0,05 m/s, IC95% 0,12 a 0,21) ou distância percorrida (MD –6 m, IC95% –45 a 33). O **segundo estudo**, por sua vez, objetivou determinar se sessões convencionais de

fisioterapia proporcionariam duração (>10 minutos) e intensidade (>40% frequência cardíaca de reserva) suficientes para induzir estresses cardiorrespiratórios adequados em indivíduos pós-AVE crônicos. A partir de um estudo observacional transversal, foram observadas duas sessões, com intervalo de uma semana entre elas, de 20 hemiparéticos (média de idade de 58 anos, 45% homens, tempo médio pós-lesão de 26 meses). As atividades foram categorizadas como: atividades de membros superiores, ficar em pé, dar passos, marcha básica e marcha avançada. Estatísticas descritivas demonstraram que não houve diferenças entre a intensidade e duração das atividades entre as sessões analisadas. Nenhuma das atividades foi realizada com intensidade ou duração suficiente para proporcionar estresses cardiorrespiratórios suficientes. A atividade que proporcionou a maior intensidade foi a marcha avançada, sendo que os pacientes alcançaram, em média, 32% da frequência cardíaca de reserva. As atividades de membros superiores foram as com a maior duração (25 minutos). O **terceiro estudo** objetivou avaliar a confiabilidade teste-reteste do ergoespirômetro Cortex MetaMax 3B® para mensuração de variáveis cardiorrespiratórias em indivíduos pós-AVE crônico, durante a realização do teste de caminhada de 6 minutos (TC6min). Neste estudo metodológico, 21 hemiparéticos (13 homens, média de idade de 59 anos, tempos médio pós-lesão de 30 meses) realizaram o TC6min com o Cortex MetaMax 3B®, com intervalo de uma semana entre as medidas. Foram calculados o coeficiente de correlação intraclasse, teste *t*, erro padrão da medida e gráfico *Bland-Altman* para variáveis cardiorrespiratórias (consumo de oxigênio absoluto, consumo de oxigênio relativo, produção de dióxido de carbono, razão da troca respiratória, ventilação minuto e frequência cardíaca) durante o TC6min. Foram observados valores de correlação intraclasse que variaram entre 0,76 a 0,97. A diferença média entre os testes variou entre 0 e 3% e o erro padrão de medida entre 1 a 12%. Todos os métodos utilizados demonstraram valores adequados para a confiabilidade teste-reteste do instrumento Cortex MetaMax 3B®. O **quarto estudo** objetivou avaliar se o custo energético de indivíduos pós-AVE durante a realização de atividades relacionadas à marcha poderia ser predito pelo nível funcional. Fizeram parte desse estudo experimental 55 hemiparéticos crônicos, sendo 33 homens, com média de idade de 59 anos e tempo médio pós-lesão de 25 meses. A variável preditora foi o nível funcional, determinado pela velocidade de marcha, avaliada por meio do teste de caminhada em 10 metros.

O desfecho de interesse foi o custo energético durante atividades relacionadas à marcha (marcha habitual, marcha rápida e subir e descer escadas), o qual foi mensurado por meio do ergoespirômetro portátil Cortex MetaMax 3B®. O consumo relativo de oxigênio foi dividido pela distância percorrida durante as atividades, resultando no custo energético. A média de velocidade de marcha observada na amostra estudada foi 0,84 m/s. O custo energético durante a marcha habitual foi de 0,24±0,11 $ml \cdot kg^{-1} \cdot m^{-1}$ e durante a marcha rápida de 0,24±0,10 $ml \cdot kg^{-1} \cdot m^{-1}$. Já durante a atividade de subir e descer escadas, o custo energético observado foi 1.13± 0.43 $ml \cdot kg^{-1} \cdot m^{-1}$. O modelo quadrático utilizado para a regressão demonstrou que o nível funcional explicou 81% da variância do gasto energético durante as atividades avaliadas. Uma equação foi desenvolvida para predizer o custo energético durante a realização de atividades relacionadas à marcha: Custo energético ($ml \cdot kg^{-1} \cdot m^{-1}$) = 0,95 – 1,28*nível funcional (velocidade de marcha em m/s) + 0,47* nível funcional ^{2} + 0,91*atividade (marcha = *0; escadas = 1*). Os resultados observados nos estudos incluídos no corpo da presente tese permitem concluir que, em indivíduos pós-AVE, o treino em esteira sem o suporte parcial de peso resulta em maior velocidade de marcha e distância percorrida para indivíduos deambuladores, quando comparada a nenhuma intervenção ou intervenção sem a prática de marcha, sendo que tais benefícios se mantem além do período de intervenção. Além disso, não foram observadas diferenças imediatamente após a intervenção, quando comparou-se o treino em esteira e treino de marcha no solo em termos de velocidade ou distância percorrida. Adicionalmente, pôde-se concluir que as sessões de fisioterapia convencional não proporcionam intensidade e duração suficientes para induzir estresses cardiorrespiratórios adequados. Observou-se uma adequada confiabilidade teste-reteste do ergoespirômetro portátil Cortex MetaMax 3B® durante o TC6min em hemiparéticos crônicos. Finalmente, os achados observados demonstraram uma relação quadrática entre o nível funcional e o gasto energético de indivíduos pós-AVE durante atividades relacionadas aos membros inferiores, tais como a marcha habitual e rápida e subir e descer escadas. Tais achados permitiram a elaboração de uma equação de predição, considerando o nível funcional, para o gasto energético de indivíduos pós-AVE.

Palavras-chave: Acidente Vascular Cerebral. Atividade Física. Aptidão Física. Metabolismo Energético. Marcha. Reprodutibilidade. Consumo de Oxigênio.

ABSTRACT

Individuals after stroke remain with several long-term disabilities. In this sense, therapeutic approaches should be implemented for a broad view of the deficiencies in structure and body function, and limitations in activity and restrictions of social participation of these individuals. Thus, there is growing interest in understanding the global mechanisms related to post-stroke physical activity, since the inactivity cause a vicious cycle, leading to sedentary lifestyles, decreasing cardiorespiratory fitness, and, therefore, decreasing the social participation of these individuals. In this theses, four studies were carried-out, in order to fill the gap in the literature regarding the factors related to post-stroke physical activity. The **first study** aimed to verify if the mechanically assisted walking training would increase walking speed or distance in ambulatory people with stroke, compared with no intervention/non-walking intervention, or overground walking. In this sense, a systematic review of randomized clinical trials (PROSPERO CRD 42012002622) was performed. To be included in the systematic review, the studies should have mechanically assisted gait without partial body weight support as intervention; outcomes related to gait, such as speed and distance covered. Nine studies, which used the treadmill training as intervention, were included, comprising 977 participants. The meta-analysis showed that treadmill training resulted in greater gains in gait speed, when compared to no intervention or non-walking intervention (MD 0.14 m/s, 95% CI 0.09 to o.19), immediately after the training. These benefits were maintained beyond the intervention period (MD 0.12 m/s, 95% CI 0.08 to 0.17). The treadmill gait training also provided increases in the distance covered immediately after the intervention (MD 40 m, 95% CI 27 to 53), and this increase was maintained beyond the intervention period (MD 40 m, 95% CI 24 to 55). No statistically differences were observed immediately after the intervention, when treadmill and overground walking training were compared, in terms of speed (MD 0.05 m/s, 95% CI 0.12- to 0.21) or distance covered (MD -6 m, 95% CI -45 to 33). The **second study** aimed to determine whether conventional physiotherapy sessions provide appropriate duration (>10 minutes) and intensity (>40% heart rate reserve) to induce adequate cardiorespiratory stress in individuals with chronic stroke. Two sessions were observed, with one week interval between them of 20 stroke individuals (mean age 58 years, 45% male, post-onset time 26 months). The activities were categorized as: upper limb activities, standing, stepping, basic

walking, and advanced walking. Descriptive statistics showed that there were no differences between the activity intensity and duration between the sessions. None of the activities were carried out with sufficient intensity or duration to provide cardiorespiratory stress. The activity that provided the greatest intensity was advanced walking, and the individuals achieved, on average, 32% of their heart rate reserve values. The upper limb activities were the ones with longest duration (25 minutes).The **third study** aimed to evaluate the test-retest reliability of Cortex MetaMax 3B® ergospirometer in chronic stroke individuals during the 6-minute walk test (6MWT). For this methodological study, 21 stroke individuals (13 men, mean age of 59 years, and mean time post-stroke of 30 months) performed two sessions of the 6MWT with the Cortex MetaMax 3B®, with one week interval between the measurements. Statistical analyses were based upon intra-class correlation coefficients, t tests, standard errors of the measurement, and Bland-Altman plots for the cardiorespiratory variables (absolute oxygen consumption, relative oxygen consumption, carbon dioxide production, respiratory exchange ratio, minute ventilation, and heart rate) during the 6MWT. The intra-class correlation coefficients ranged from 0.76 to 0.97. The mean difference between the tests varied between 0 and 3% and the standard error of measurement from 1 to 12%.The results showed appropriate values for the test-retest reliability of the Cortex MetaMax 3B®. The **fourth study** aimed to evaluate if the energy cost of stroke individuals during the performance of functional activities related to the lower limbs could be predicted by their functional levels. This experimental study included 55 chronic stroke individuals, 33 men, mean age of 59 years, and mean time post stroke of 25 months. The predictor variable was the functional level, determined by the walking speed, assessed by the 10 meter walking test. The outcome of interest was the energy cost during the performance of functional activities (comfortable and fast gait speeds and stair ascent/descent), which was measured by the portable ergospirometer Cortex MetaMax 3B®. The relative oxygen consumption was divided by the distance covered during the functional activities, resulting in the energy cost. The mean walking speed was 0.84 m/s. The energy cost during comfortable walking was 0.24±0.11 ml $ml \cdot kg^{-1} \cdot m^{-1}$ and during fast walking, 0.24±0.10 $ml \cdot kg^{-1} \cdot m^{-1}$. For the stairs, the energy cost was 1.13±0.43 $ml \cdot kg^{-1} \cdot m^{-1}$. The quadratic regression model demonstrated that the functional level explained 81% of the variance in the energy

cost. The energy cost can be predicted by the following equation: EC *(ml·kg^{-1}·m^{-1})* = 0.95 – 1.28* *comfortable walking speed, in m/s* + 0.47*comfortable walking speed^2 + 0.91*activity (*walking speed = 0; stairs = 1*). The findings of the studies included in this thesis support the following conclusions: In post stroke individuals, the treadmill training without partial body weight support resulted in higher walking speed and distance covered for ambulatory individuals, when compared to no intervention or intervention without walking training, and these benefits were kept beyond the intervention. In addition, no differences were observed immediately after the intervention, when treadmill and overground walking training were compared, in terms of speed or distance covered. Moreover, conventional physical therapy sessions do not provide adequate intensity and duration to induce cardiorespiratory stress. Adequate test-retest reliability was found for the portable ergospirometer Cortex MetaMax 3B® in stroke individuals. Finally, the observed findings showed a quadratic relationship between the functional level and energy cost of stroke individuals during activities related to the lower limbs, such as the comfortable/fast gait speeds and managing stairs. These findings led to the establishment of a prediction equation regarding the energy cost of stroke individuals, based upon their functional levels.

Keywords: Stroke. Physical Activity. Physical Fitness. Energy Metabolism. Gait. Reproducibility. Oxygen Consumption.

SUMÁRIO

Capítulo 1 – INTRODUÇÃO

1.1 Contextualização

De acordo com dados atuais, aproximadamente 800 mil pessoas são vítimas do Acidente Vascular Encefálico (AVE) a cada ano somente nos Estados Unidos, sendo que 200 mil destes eventos são recorrentes (GO *et al*., 2014). Estima-se que, em média, a cada 40 segundos uma pessoa sofre o AVE (GO *et al*., 2014). Essa condição de saúde é considerada a quarta causa de morte no mundo, ficando atrás apenas de doenças cardíacas, câncer e doenças respiratórias crônicas (GO *et al*., 2014). Esses dados mundiais retratam também a realidade do Brasil, onde um dado alarmante chama atenção: o país possui uma das mais altas taxas de morte do hemisfério ocidental decorrentes do AVE (LOTUFO; BENSENOR, 2013).

Considerando a prevalência do AVE de 22% no ano de 2013, projeções demonstram que até o ano de 2030 quatro milhões de pessoas sofrerão um episódio de AVE no mundo, demonstrando a importância desta condição de saúde para os sistemas de saúde pública (Go *et al*., 2014). Um estudo de coorte realizado entre os anos de 1993 e 2005 encontrou um aumento da incidência de AVE em indivíduos adultos jovens na faixa etária de 20 a 54 anos e, em contrapartida, um decréscimo da incidência entre os indivíduos a partir de 75 anos (KISSELA *et al*., 2012). Similarmente, Wang, Rudd e Wolfe (2013) observaram em um estudo de coorte realizado em um período de 15 anos que a incidência total de AVE reduziu 38,5% durante o período do estudo. Entretanto, esta redução não foi observada em indivíduos de 15 a 44 anos (WANG; RUDD; WOLF, 2013).

Estes achados refletem um paradigma atual, uma vez que qualquer declínio na incidência de AVE poderia ser considerado positivo a partir de uma perspectiva de saúde pública. Entretanto, a redução da incidência do AVE em idades mais avançadas é contrabalanceada pela alta incidência em indivíduos jovens, o que significa substanciais anos produtivos perdidos e um alto custo com despesas médicas ao longo dos anos, além do alto impacto para o mercado de trabalho (KISSELA *et al*., 2012). Adicionalmente, foi observado que um quarto dos indivíduos que sobrevivem ao AVE tem idade inferior a 65 anos, ou seja, além desta parcela de

indivíduos ser economicamente ativa, ainda possui responsabilidades com o cuidado de crianças e/ou pessoas idosas (PEARN; O'CONNOR, 2013).

Em contrapartida, tem sido observado ao longo dos anos um declínio na taxa de mortalidade pós-AVE em todo o mundo, o que pode ser justificado pelos cuidados específicos no controle e manejo da fase aguda pós-AVE, além de pesquisas desenvolvidas no sentido de prevenir a recorrência do AVE pelo apontamento e manejo de fatores de risco modificáveis (LACKLAND *et al*., 2014). Este fato tem sido observado em todas as regiões do Brasil, o que pode ser traduzido em um número crescente de indivíduos que conviverão com as sequelas decorrentes do AVE pelo resto de suas vidas (FEIGIN *et al*., 2003; LOTUFO *et al*., 2013). Cabe ressaltar ainda, que de acordo com dados recentes, o AVE é a condição de saúde mais incapacitante no Brasil (LOTUFO; BENSENOR, 2013). Visto o impacto motor que o AVE pode trazer para a vida dos indivíduos, atualmente há a necessidade do uso de abordagens terapêuticas individualizadas, interativas e personalizadas, permitindo que as necessidades funcionais de indivíduos com doenças crônicas sejam completamente consideradas (STEINER *et al*., 2002, SABARIEGO *et al*., 2013), levando-se em consideração principalmente as queixas dos indivíduos, além da percepção dos terapeutas (STEINER *et al*., 2002).

Nesse sentido, a Classificação Internacional de Funcionalidade, Incapacidade e Saúde (CIF) tem sido recomendada como uma forma de estabelecer um consenso para o cuidado e manejo de indivíduos com doenças crônicas, como o AVE, por exemplo (OMS, 2003; SAMPAIO *et al*., 2005). A CIF pressupõe que todo indivíduo pode ser exposto a uma perda ou diminuição na sua saúde e, desta forma, experimentar alguma incapacidade. Mudando o foco da causa para o impacto funcional sofrido, todas as condições de saúde são colocadas no mesmo nível de comparação, permitindo que uma medida comum seja utilizada entre profissionais, serviços de saúde e pacientes (DI NUBILA, 2010). A CIF é uma classificação da funcionalidade e incapacidade relacionada às estruturas e funções do corpo, às atividades e à participação, que são concebidas em uma interação dinâmica entre as condições de saúde e os fatores contextuais (pessoais e ambientais), cuja unidade de análise é o indivíduo em atividade em um determinado contexto ou condição (OMS, 2003). De acordo com o modelo da CIF, estruturas e funções do corpo, tais como hemiparesia, espasticidade e afasia são as desordens neurológicas primárias

que são causadas pelo AVE. Limitações em atividades são manifestadas pela redução da habilidade de realizar funções diárias, tais como tomar banho, vestir-se ou caminhar, por exemplo. Acredita-se que a magnitude das limitações em atividade seja geralmente relacionada à gravidade da lesão encefálica, não sendo, no entanto completamente dependente da mesma (ROTH *et al*., 1998).

Os diversos comprometimentos motores residuais apresentados pelos indivíduos tais como fraqueza muscular, déficits de equilíbrio e de destreza, mobilidade reduzida, dentre outros, podem levar o indivíduo à inatividade física e a um estilo de vida sedentário (MAYO *et al*., 1999). Devido à característica comum de fraqueza muscular contralateral à lesão encefálica ser geralmente apresentada pelos indivíduos pós-AVE, na presente tese esses também serão referidos como hemiparéticos.

1.2 Mudança de paradigma na reabilitação de hemiparéticos

O mais importante déficit apresentado pós-AVE é a hemiparesia, que é observada em aproxidamente 85% dos indivíduos pós-lesão (BOHANNON, 2007). Todavia, até a década de 90, havia um receio por parte dos clínicos em realizar o fortalecimento muscular na prática clínica, pela crença histórica até então existente de que o aumento da força geraria um aumento da espasticidade e padrões anormais de movimento. Após uma importante publicação no final da década de 90 (TEIXEIRA-SALMELA *et al*., 1999), onde foi observado que após um programa de fortalecimento muscular em hemiparéticos crônicos não houve alteração da espasticidade, sendo permitido que uma nova abordagem em termos de estratégias terapêuticas fosse utilizada na reabilitação. Desde então, diversas revisões sistemáticas já foram publicadas enfatizando a eficácia do fortalecimento muscular em desfechos como: força muscular, atividade e percepção da qualidade de vida, sem o aumento da espasticidade de hemiparéticos (ADA *et al*., 2006; BOHANNON, 2007; PAK; PATTEN *et al*., 2008).

Dessa forma, com a evolução científica da área, tem-se observado que, apesar de grandes avanços relacionados à reabilitação pós-AVE, hemiparéticos são aqueles que possuem as maiores incapacidades a longo prazo, quando comparados a sobreviventes de outras condições de saúde (ROGER *et al*., 2012). Assim,

considerando que é observado uma diminuição da mortalidade pós-AVE, ou seja, estes indivíduos estão atualmente sobrevivendo mais com as sequelas deixadas pelo AVE (LACKLAND *et al*., 2014), novas abordagens terapêuticas e relacionadas às demais incapacidades observadas, e não só à fraqueza muscular, devem ser enfatizadas e estudadas na comunidade científica.

Nesse sentido, desde 2006, a *American Heart Association Statistics Committee and Stroke Statistics Subcommittee* (THOM *et al*., 2006) traz o AVE sob uma nova perspectiva em suas publicações anuais, como uma condição de saúde primariamente cardiovascular, e não caracterizada (como historicamente realizado) como neurológica. Desde a primeira publicação, a Associação Americana pontuou, embora timidamente, a importância da prática de atividade física na redução de episódios e recorrências de AVE (THOM *et al*., 2006). Já em 2014, a mesma reporta a inatividade física como um fator de risco para o AVE (GO *et al*., 2014), enfatizando a necessidade do aumento da aptidão cardiorrespiratória desses indivíduos. Ainda em 2014, a *American Heart Association/American Stroke Association* publicou um guia clínico direcionado especificamente às recomendações para a prática de atividades e exercícios físicos pós-AVE (BILLINGER *et al*., 2014).

Dessa forma, há um crescente interesse em se entender os mecanismos relacionados à atividade física pós-AVE, uma vez que os déficits motores residuais acarretam um estilo de vida sedentário, levando a limitações em atividades e restrições em participação social desses indivíduos (HORNNES; LARSEN; BOYSEN, 2010). Além disso, é reportado que os programas de exercício durante a reabilitação pós-AVE devem ser desenvolvidos de acordo com três principais objetivos: (1) prevenir as complicações decorrentes da inatividade, (2) reduzir o risco de novos eventos cardiovasculares e novos eventos de AVE e (3) proporcionar o condicionamento cardiorrespiratório (GORDON *et al*., 2004), para enfim reintegrar o indivíduo em todas as suas atividades na sociedade.

1.3 Atividade Física/Aptidão Física

Atividade física é definida como qualquer movimento corporal produzido pelos músculos, que requer gasto de energia (CASPERSEN; POWELL; CHRISTENSON, 1985). Níveis mais elevados de atividade física estão associados com resultados

benéficos relacionados à saúde, além da prevenção de doenças crônicas (WARBURTON; NICOL; BREDIN, 2006). Já o exercício físico refere-se a um subconjunto de atividade física que é planejada, estruturada, repetitiva e deliberadamente realizada para treinar (melhorar) um ou mais componentes da aptidão física (PHYSICAL ACTIVITY GUIDELINES ADVISORY COMMITTEE REPORT, 2009).

Em contraste com a atividade física, que está relacionada com movimentos habituais de uma pessoa, a aptidão física é um conjunto de atributos que os indivíduos têm ou alcançam. Aptidão física pode ser entendida como "a capacidade de realizar tarefas diárias com vigor e vivacidade, sem fadiga e com energia suficiente para desfrutar de atividades de lazer e para atender emergências imprevistas" (CASPERSEN; POWELL; CHRISTENSON, 1985). A aptidão física é composta didaticamente por alguns componentes, tais como:

- Aptidão ou condicionamento cardiorrespiratório, que é definido como a capacidade de transporte e utilização de oxigênio e é geralmente expressa como consumo máximo de oxigênio ($VO_{2máx}$). A aptidão cardiorrespiratória confere “resistência” ao sistema corpóreo, sendo que possuir boa aptidão cardiorrespiratória significa capacidade de realizar atividades físicas por um período prolongado;
- Força muscular, que se refere à capacidade de um músculo ou grupo muscular específico para exercer uma força;
- Potência muscular, que se refere à taxa que o trabalho muscular pode ser realizado durante uma única contração durante movimentos vigorosos.

Além disso, outros componentes da aptidão podem influenciar a capacidade de realizar atividades físicas, incluindo a flexibilidade, equilíbrio e composição corporal (PHYSICAL ACTIVITY GUIDELINES ADVISORY COMMITTEE REPORT, 2009).

Em relação ao AVE, evidências científicas demonstraram que elevados níveis de atividade física são associados a um menor risco de desenvolver essa condição de saúde, além de uma menor severidade dos déficits motores residuais e uma melhor recuperação após o evento (BOYSEN; KRARUP, 2009). Além disso, a falta de condicionamento cardiorrespiratório representa o mais importante fator de risco modificável para o AVE (THOMPSON *et al*., 2003). Em um estudo de coorte

realizado durante nove anos, observou-se que a prática de atividade física com intensidade moderada foi associada a uma redução em 35% de AVE isquêmico, quando comparada com a não-realização de atividade física pelos indivíduos (WILLEY *et al*., 2009a). Entretanto, a prática de atividades físicas leves (como caminhada, por exemplo), não demonstrou efeito benéfico em relação à incidência do AVE (WILLEY *et al*., 2009b).

De acordo com os guias clínicos mais atuais, é recomendado que indivíduos pós-AVE realizem pelo menos 30 minutos de atividades físicas com intensidade moderada (definida, de forma geral, como uma atividade que provoque produção de suor ou alteração perceptível da frequência cardíaca), com frequência de pelo menos três vezes por semana, somando no mínimo, 150 minutos de atividades (FURIE *et al*., 2011; BILLINGER *et al*., 2014; GO *et al*., 2014), para alcançarem uma aptidão física adequada. Entretanto, achados revelaram que cerca de 77% dos sobreviventes pós-AVE são sedentários ou possuem baixos níveis de atividade física (SENES, 2006). Invariavelmente, quando a aptidão cardiorrespiratória do indivíduo é reduzida, a prática de atividades físicas pode ser limitada, sendo que níveis de aptidão abaixo de um limiar necessário para realizar as atividades de vida diária (AVD) podem significar a perda de independência dos indivíduos (SHEPHARD, 2009).

Nesse sentido, foi observado que após o AVE os indivíduos, em geral, apresentam baixa aptidão física, o que pode limitar a capacidade de realizar atividades cotidianas e também piorar qualquer deficiência relacionada à ocorrência da condição de saúde (SAUNDERS *et al*., 2013). A ausência da prática de atividades físicas regulares pode desencadear um ciclo vicioso, englobando uma pobre aptidão física, o aumento do risco de doenças cardiovasculares, a deterioração de função física e, finalmente, redução da qualidade de vida. Adicionalmente, é bem documentado na literatura o alto índice de novos eventos de AVE e condições cardiovasculares associadas nesta população (HARDIE *et al*., 2004), o que pode ser ainda desencadeado por esse ciclo vicioso.

1.4 Gasto Energético

A mensuração do gasto energético ou consumo de oxigênio durante a realização de atividades é o método padrão-ouro para a determinação da capacidade funcional, aptidão física e as necessidades de energia do indivíduo (AMERICAN THORACIC SOCIETY AND AMERICAN COLLEGE OF CHEST PHYSICIANS, 2003)

A mensuração do gasto energético pode ser realizada por meio da calorimetria direta ou indireta (LEVINE, 2005). A calorimetria direta é a medida do calor produzido por processos metabólicos, para quantificar o gasto energético total. A produção total de calor do corpo é medida diretamente através de uma câmara selada termicamente, que permite a medida do calor sensível liberado pelo organismo, além do vapor de água liberado pela respiração e pela pele. Embora seja um método preciso, trata-se de uma avaliação com altos custos, além de exigir recursos humanos especializados (LEVINE, 2005).

A calorimetria indireta, por sua vez, mensura a produção de energia a partir das trocas gasosas do organismo com o meio ambiente (LEVINE, 2005). A denominação indireta indica que a produção de energia é calculada a partir dos equivalentes calóricos do oxigênio consumido e do gás carbônico produzido. Admitindo-se que todo o oxigênio consumido é utilizado para oxidar os substratos energéticos e que todo o gás carbônico produzido é eliminado pela respiração, é possível calcular a quantidade total de energia produzida (DIENER, 1997; LEVINE, 2005; HAUGEN; CHAN, 2007). A calorimetria indireta pode ser realizada por meio de sistemas de circuito fechado e/ou aberto. No sistema de circuito fechado, o consumo de oxigênio (VO_2) e a produção de dióxido de carbono (VCO_2) são medidos por alterações no volume dentro de um reservatório fechado contendo oxigênio, o que restringe as atividades e posições a serem analisadas (LEVINE, 2005). Já no sistema de circuito aberto, utilizam-se dispositivos que compreendem um bocal ou uma máscara ligada a uma válvula que conduz o ar ao instrumento. A vantagem do sistema de circuito aberto é permitir que os gases sejam analisados em diversas situações de vida diária, uma vez que instrumentos portáteis podem ser utilizados (LEVINE, 2005; STRATCH et al., 2013), como por exemplo ergoespirômetros portáteis (BRANDES et al., 2012).

1.4.1 Gasto energético pós-AVE

A literatura reporta que indivíduos pós-AVE possuem maior gasto energético durante a marcha quando comparados a indivíduos saudáveis, entretanto os mecanismos relacionados a tal aumento não são totalmente compreendidos (IJMKER *et al*., 2013).

O gasto energético, que é geralmente avaliado nos estudos pelo consumo de oxigênio (VO_2) dividido pela unidade de medida durante atividades máximas ou submáximas (distância percorrida ou velocidade), encontram-se 50-80% abaixo dos valores obtidos em indivíduos sedentários pareados pela idade e sexo (MACKAY-LYONS; MAKRIDES, 2004). Em uma revisão sistemática realizada em 2012 (SMITH; SAUNDERS; MEAD, 2012), onde foram incluídos 41 estudos com um total de 1.569 indivíduos pós-AVE nas fases aguda, subaguda e crônica, observou-se que em 31 estudos, os valores de VO_2 pico observados durante o exercício máximo e submáximo na esteira e cicloergômetro variaram entre 45 a 60% daqueles esperados para indivíduos saudáveis. Entretanto, cabe ressaltar que tais estudos utilizaram parâmetros de comparação embasados em estudos de predição com algoritmos desenvolvidos para indivíduos saudáveis (SMITH; SAUNDERS; MEAD, 2012).

Embora os protocolos descritos nos estudos para realização dos testes máximos e submáximos estejam de acordo com as recomendações da *American College of Sports Medicine,* ressalta-se que as diretrizes foram criadas e estabelecidas para indivíduos saudáveis (OVANDRO *et al*., 2010). Além disso, os estudos que avaliaram tais parâmetros em indivíduos pós-AVE os realizaram durante atividades em equipamentos sofisticados, tais como esteiras e cicloergômetros, refletindo a capacidade do indivíduo, e não o desempenho, o que não seria traduzido na realização de atividades no seu ambiente cotidiano. Cabe ressaltar ainda que o VO_2 pico observado nos estudos que realizaram testes máximos e submáximos não refletem o panorama geral do *status* cardiorrespiratório dos indivíduos pós-AVE. Para a realização desses testes, os indivíduos precisam, *a priori*, ter um nível mínimo de condicionamento cardiorrespiratório. Desta forma, tais valores reportados pela literatura podem não refletir indivíduos com *status* funcionais mais pobres.

Apesar de saber-se que uma pobre aptidão cardiorrespiratória pode acarretar comprometimentos até mesmo em atividades de vida diária (BILLINGER *et al*., 2014), poucos estudos que avaliaram o gasto energético por meio do VO_2 durante a realização de atividades cotidianas foram desenvolvidos. Recentemente, Kafri *et al*. (2014) observaram em 11 hemiparéticos crônicos um elevado gasto energético, quando comparados a indivíduos saudáveis pareados por idade e sexo, nas atividades: sentado para caminhar, marcha com obstáculos, marcha habitual e alcance na posição sentada. Já Platts, Rafferty e Paul (2006) observaram elevados valores de gasto energético de 13 hemiparéticos nas fases subaguda e crônica pós-lesão quando comparados a indivíduos saudáveis durante a marcha habitual auto selecionada. Dois recentes estudos observaram os efeitos do uso de dispositivos auxiliares no gasto energético de indivíduos pós-AVE (IJMKER *et al*., 2013; JEONG *et al.*, 2014). O primeiro estudo comparou o gasto energético de 12 indivíduos dependentes e 12 indivíduos não dependentes de dispositivos auxiliares para deambulação, e observaram um menor gasto energético com o uso dos dispositivos auxiliares. Entretanto, os grupos avaliados não eram similares em termos de equilíbrio (avaliado por meio da Escala de Equilíbrio de Berg) e nível funcional (avaliado por meio do teste de caminhada em 10 metros) (IJMKER *et al*., 2013). Já o segundo estudo investigou o gasto energético de 30 hemiparéticos crônicos deambuladores com diferentes dispositivos auxiliares: bengala de um apoio, bengala de quatro apoios e andador de três apoios (*hemi-walker).* Os autores observaram que os indivíduos apresentaram um menor gasto energético durante a marcha em velocidade habitual auto selecionada com a bengala de um apoio, quando comparados com os outros dispositivos auxiliares (JEONG *et al.*, 2014).

1.5 JUSTIFICATIVA

Com o aumento da expectativa de vida da população associada ao aumento da sobrevida pós-AVE, faz-se necessário o enfoque em estratégias que aumentem a independência e participação na comunidade para estes indivíduos. É reconhecido que a modificação de fatores de risco por meio de intervenções no estilo de vida e o aumento do nível de atividade física associado com a terapia farmacológica adequada são as pedras angulares para a prevenção da recorrência do AVE e

eventos cardíacos agudos em sobreviventes pós-lesão (SMITH *et al*., 2001). Hemiparéticos frequentemente possuem lesões ateroscleróticas, que contribuem para o aumento do risco de doenças cardiovasculares. Por outro lado, a redução do condicionamento cardiorrespiratório associada ao sedentarismo representa o maior fator de risco modificável para novas lesões isquêmicas (THOMPSON *et al*., 2003).

Para realização das atividades de vida diária de forma satisfatória, que permita introduzir os indivíduos em atividades na comunidade, um dos requisitos a priori é a aptidão cardiorrespiratória, e desta forma, a diminuição desta poderia ser um fator limitante para a transferência de novas habilidades adquiridas na reabilitação para a vida comunitária (KELLY *et al*., 2003). Neste contexto, embora seja reportado que hemiparéticos sejam capazes de alcançar níveis de exercício mínimos para provocar estresse cardiovascular (MARZOLINI *et al*., 2012), este tipo de treinamento tem recebido pouca atenção durante a reabilitação (MACKAY-LYONS; MAKRIDES, 2002b). Mesmo em países desenvolvidos, como a Austrália (KUYS; BRAUER, ADA, 2006) e Canadá (MACKAY-LYONS; MAKRIDES, 2002b), que teoricamente possuem os melhores recursos direcionados aos cuidados de saúde, podendo traduzir-se em avanços maiores em termos de reabilitação, foi observado que a intensidade de exercício utilizada durante os programas de reabilitação não é adequada para produzir um efeito de treinamento cardiorrespiratório.

Apesar de saber-se que hemiparéticos possuem alto risco para novos eventos cardiovasculares, poucos estudos definiram parâmetros de treinamento seguros para este tipo de treinamento (CUNHA-FILHO *et al*., 2003), uma vez que se tem somente parâmetros de referência para indivíduos saudáveis. Genericamente, pesquisadores e clínicos utilizam algoritmos de predição para prescrição de exercícios baseados em equações desenvolvidas para indivíduos saudáveis, os quais consideram fatores como o índice de massa corporal do indivíduo (VINKEN *et al*., 1999) e desta forma, determinam a intensidade de certo esforço físico realizado. No entanto, como indivíduos pós-AVE apresentam diferentes características físicas, quando comparados com indivíduos saudáveis devido à natureza de suas sequelas motoras e alterações decorrentes da lesão encefálica, suposições feitas em relação a algoritmos de predição de gasto energético não poderiam ser aplicadas a esta população, por exemplo. Hemiparéticos apresentam diversos fatores que podem

interferir no gasto energético; não somente fatores como idade, massa e peso corporal, parâmetros considerados nos algoritmos de predição. De acordo com MARZOLINI *et al*. (2012), hemiparéticos possuem uma “constelação” de fatores que podem influenciar negativamente nos seus níveis de atividade física.

A literatura suporta que mensurações do nível de atividade realizadas com monitores de atividade, tais como pedômetros ou acelerômetros, não são as melhores formas de estimar o gasto energético de hemiparéticos pós-AVE. Alzahrani, Ada e Dean (2011) observaram que indivíduos pós-AVE apresentam uma menor frequência de realização de atividades cotidianas, entretanto utilizam o mesmo tempo para realizar tais atividades, quando comparados com indivíduos saudáveis pareados por idade e sexo, durante atividades como marcha e subir escadas (ALZAHRANI; ADA; DEAN, 2011). Dessa forma, avaliações diretas do gasto energético por meio da análise do VO_2 poderiam, portanto, ser a melhor forma de estimar esta variável em hemiparéticos.

Desta forma, compreender o gasto energético em hemiparéticos pós-AVE durante a realização de atividades funcionais se faz de extrema importância, uma vez que este parâmetro pode determinar se indivíduos hemiparéticos estão em risco de eventos cardiovasculares ou novos episódios de AVE. Adicionalmente, há um novo foco científico emergente direcionado às alterações cardiorrespiratórias dessa população, visto a grande lacuna existente na literatura acerca deste escopo. Assim, faz-se necessário examinar o gasto energético destes indivíduos durante a realização de atividades comumente realizadas no dia-a-dia, de acordo com o nível funcional, determinado pela velocidade de marcha.

1.6 Objetivos

- Verificar se o treino de marcha mecanicamente assistida promoveria aumento da velocidade da marcha e distância percorrida em indivíduos pós-AVE, quando comparada com nenhuma intervenção, intervenção sem o treino de marcha ou treino de marcha no solo. (**Estudo 1**)
- Determinar se sessões convencionais de fisioterapia proporcionariam duração (>10 minutos) e intensidade (>40% frequência cardíaca de reserva) suficientes para induzir estresses cardiorrespiratórios adequados em indivíduos pós-AVE crônicos. (**Estudo 2**)
- Avaliar a confiabilidade teste-reteste do ergoespirômetro Cortex MetaMax 3B® para mensuração de variáveis cardiorrespiratórias em indivíduos pós-AVE crônico, durante a realização do teste de caminhada de 6 minutos. (**Estudo 3**)
- Avaliar se o custo energético durante a realização de atividades relacionadas aos membros inferiores poderia ser predito pelo nível funcional de indivíduos pós-AVE crônico, determinado pela velocidade de marcha. (**Estudo 4**)

Capítulo 2 – ARTIGO 1

Estudos prévios demonstram que a aquisição da marcha é um dos principais objetivos da reabilitação, de acordo com o relato de pacientes pós-AVE (BOHANNON; ANDREWS; SMITH, 1988; JORGENSEN et al., 1995). A capacidade de deambulação é um fator importante a ser considerada para o aumento do condicionamento cardiorrespiratório. A partir da capacidade de marcha independente, diversas estratégias de treinamento podem ser utilizadas objetivando o aumento do condicionamento de indivíduos pós-AVE. Dentre as estratégias mais utilizadas, o treino com o auxílio mecânico, tais como *gait trainer*, esteira, etc, são amplamente reconhecidos e recomendados na literatura, por proporcionar o uso forçado do membro inferior parético (ADA et al., 2003).

Revisões sistemática prévias já demonstraram evidências acerca do uso do treino em esteira (MOSELEY et al., 2005) e treino assistido mecanicamente com diversos equipamentos (MEHRHOLZ, 2010) na melhora da marcha em indivíduos pós-AVE. Entretanto, tais estudos incluíram amostras mistas, isto é, indivíduos deambuladores e não deambuladores, além do uso do suporte parcial de peso durante o treino. Todavia, há uma lacuna na literatura acerca dos efeitos da prática da marcha mecanicamente assistida em indivíduos pós-AVE, que já possuem capacidade de deambulação. Esses indivíduos seriam aqueles com maior potencial para a inclusão do treino cardiorrespiratório durante a reabilitação.

Desta forma, o objetivo da revisão sistemática com metanálise, a seguir, foi verificar se o treino de marcha mecanicamente assistida poderia promover aumento da velocidade da marcha e distância percorrida em indivíduos pós-AVE, quando comparada com nenhuma intervenção, intervenção sem o treino de marcha ou treino de marcha no solo

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Treadmill training is effective for ambulatory adults with stroke: a systematic review

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Question: Does mechanically assisted walking increase walking speed or distance in ambulatory people with stroke compared with no intervention/non-walking intervention, or with overground walking? **Design:** Systematic review with meta-analysis of randomised trials. **Participants:** Ambulatory adults with stroke. **Intervention:** Mechanically assisted walking (treadmill or gait trainer) without body weight support. **Outcome measures:** Walking speed measured in m/s during the 10-m Walk Test and walking distance measured in m during the 6-min Walk Test. **Results:** Nine studies of treadmill training comprising 977 participants were included. Treadmill training resulted in faster walking than no intervention/non-walking intervention immediately after the intervention period (MD 0.14 m/s, 95% CI 0.09 to 0.19) and this was maintained beyond the intervention period (MD −0.12 m/s, 95% CI 0.08 to 0.17). It also resulted in greater walking distance immediately after the intervention period (MD 40 m, 95% CI 27 to 53) and this was also maintained beyond the intervention period (MD 40 m, 95% CI 24 to 55). There was no immediate, statistically significant difference between treadmill training and overground training in terms of walking speed (MD 0.05 m/s, 95% CI 0.12 to 0.21) or distance (MD −6 m, 95% CI −45 to 33). **Conclusion:** This systematic review provides evidence that, for people with stroke who can walk, treadmill training without body weight support results in faster walking speed and greater distance than no intervention/non-walking intervention and the benefit is maintained beyond the training period. **Review registration:** PROSPERO (CRD 42012002622). **[Polese JC, Ada L, Dean CM, Nascimento LR, Teixeira-Salmela LF (2013) Treadmill training is effective for ambulatory adults with stroke: a systematic review. *Journal of Physiotherapy* 59: 73–80]**

Key words: Stroke, Treadmill, Walking, Systematic review, Meta-analysis, Randomised controlled trials

Introduction

Although the majority of individuals achieve an independent gait after stroke, many do not reach a walking level that enables them to perform all their daily activities (Flansbjer et al 2005). Typically, the mean walking speed for the majority of community-dwelling people after stroke ranges from 0.4 m/s to 0.8 m/s (Duncan et al 1998, Eng et al 2002, Green et al 2002, Pohl et al 2002, Ada et al 2003). This slow speed frequently prevents their full participation in community activities. Additionally, people report a lack of ability to cover long distances after stroke, restricting their participation in work and social activities (Combs et al 2012). Moreover, walking ability has been found to be related to community participation (Robinson 2011).

While the goal of inpatient rehabilitation is independent and safe ambulation, once individuals return home, rehabilitation aims to enhance community ambulation skills by increasing walking speed and endurance. Lord et al (2004) found that the ability to confidently negotiate uneven terrain, private venues, malls and other public venues is the most relevant predictor of community ambulation. Therefore, in order to enhance community participation, rehabilitation has focused on identifying the best approach to optimise walking speed and walking distance. One approach to improving gait is the use of mechanically assisted walking devices, such as treadmills or gait trainers. Two Cochrane systematic reviews have examined these devices separately: Moseley et al (2005) reported on treadmill training and Mehrholz (2010) examined electromechanically-assisted training. We wanted to examine all devices that will help improve walking in the one review. In ambulatory stroke, mechanically assisted walking, whether by treadmills or gait trainers, allows an intensive amount of stepping practice by working as a 'forced use'. Mechanically assisted walking also facilitates the practice of a more normal walking pattern because it forces appropriate timing between lower limbs, promotes hip extension during the stance phase of walking and discourages common compensatory behaviours such as circumduction (Harris-Love et al 2001, Ada et al 2003, Moore et al 2010). We have already taken this approach in

What is already known on this topic: Mechanically assisted walking training, which can involve interventions such as treadmill training or electromechanical gait trainers, increases independent walking among people who have been unable to walk after stroke. However, previous systematic reviews have not drawn clear conclusions about the effect of treadmill training or gait trainers among ambulatory stroke survivors specifically.

What this study adds: Compared with no intervention or with an intervention with no walking training component, treadmill training improved walking speed and distance among ambulatory people after stroke. These benefits were maintained beyond the intervention period, but may not be greater than the effects of overground walking training.

relation to non-ambulatory stroke, where our systematic review demonstrated that mechanically assisted walking results in more independent walking (Ada et al 2010).

Therefore, this systematic review focuses on the efficacy of mechanically assisted walking for improving walking speed and distance in ambulatory people with stroke. Comparisons between mechanically assisted walking and overground walking were also examined in order to assist clinicians to decide the most appropriate intervention for adults with stroke. The specific research questions for this review were, in ambulatory people after stroke:

1. Does mechanically assisted walking result in immediate improvements in walking speed and distance compared with no intervention or a non-walking intervention?
2. Does it result in immediate improvements in walking speed and distance compared with overground walking?
3. Are any benefits maintained beyond the intervention period?

In order to make recommendations based on the highest level of evidence, this review included only randomised or quasi-randomised trials.

Box 1. Inclusion criteria.

Design
- Randomised or quasi-randomised trial

Participants
- Adults (> 18 yr)
- Stroke (> 24 hr)
- Ambulatory (Functional Ambulatory Category ≥ 3, walking speed ≥ 0.2 m/s at baseline or when the inclusion criteria stated 'able to walk without help, with or without walking aids' or, where mixed participants, data for ambulatory participants reported separately.)

Interventions
- Experimental. Mechanically assisted walking training (eg, treadmill training or a gait trainer) without body weight support
- Control. No intervention/non-walking intervention, or overground walking

Outcomes measured
- Walking speed
- Walking distance

Method

Identification and selection of studies

Searches for relevant studies were conducted of the following databases: Medline (1946 to April Week 1 2012, CINAHL (1986 to April Week 1 2012), EMBASE (1980 to April Week 1 2012) and PEDro (to April Week 1 2012), without language or date restrictions. Search terms included words relating to stroke, mechanically assisted walking, and locomotion (see Appendix 1 on the eAddenda for the full search strategy). In addition, we contacted authors about trials that we knew were in progress from trial registration. Titles and abstracts were displayed and screened by one reviewer to identify relevant studies. Only peer-reviewed papers were included. Full paper copies of relevant studies were retrieved and hand searching of reference lists was carried out to identify further relevant studies. The methods and abstracts of the retrieved papers were extracted so that reviewers were blinded to authors, journal, and outcomes. Two independent reviewers examined the papers for inclusion against predetermined criteria (Box 1). Conflict was resolved after discussion with a third reviewer.

Assessment of characteristics of studies

Quality: The quality of included studies was determined using PEDro scale scores extracted from the Physiotherapy Evidence Database (www.pedro.org.au). The PEDro scale rates the methodological quality of randomised trials with a score between 0 and 10 (Maher et al 2003). Where a study was not included on the PEDro database, it was scored by a reviewer following the PEDro guidelines.

Participants: Participants had to be ambulatory adults in the subacute or chronic phase after stroke. *Ambulatory* was defined as a score of at least 3 on the Functional Ambulatory Category (Holden et al 1984) or a walking speed of at least 0.2 m/s at baseline or when the included participants were able to walk without help, with or without walking aids. Studies were included when at least 80% of sample comprised ambulatory participants. Number of participants, age, time since stroke, and baseline walking speed were recorded to assess the similarity of the studies.

Intervention: The experimental intervention was mechanically assisted walking training, such as treadmill or gait trainer *without* body weight support because the participants were able to walk *a priori*. The control intervention was defined as no intervention or an intervention that did not involve walking training, ie, non-walking intervention. The experimental intervention was also compared with overground training. Session duration, session frequency, and program duration were recorded in order to assess the similarity of the studies.

Outcome measures: Two walking outcomes were of interest – speed (typically measured using 10-m Walk Test) and distance (typically measured using 6-min Walk Test). The timing of the measurements of outcomes and the procedure used to measure walking speed and distance were recorded in order to assess the similarity of the studies.

Data analysis

Data were extracted from the included studies by a reviewer and cross checked by another reviewer. Information about the method (ie, design, participants, intervention, outcome measures) and outcome data (ie, mean (SD) walking speed and walking distance) were extracted. Authors were contacted where there was difficulty with data.

The post-intervention scores were used to obtain the pooled estimate of the effect of intervention immediately (ie, post intervention) and beyond the intervention period (ie, after a period of no intervention). A fixed effects model was used. In the case of significant statistical heterogeneity ($I^2 > 50\%$), a random effects model was applied to check the robustness of the results. The analyses were performed using The MIX–Meta-Analysis Made Easy program[a] (Bax et al 2006, Bax et al 2009). The pooled data for each outcome were reported as the weighted mean difference (MD) (95% CI).

Results

Flow of studies through the review

The search returned 5305 studies. After screening the titles, abstracts and reference lists, 65 papers were retrieved for evaluation of full text. Fifty-six papers failed to meet the inclusion criteria and therefore nine papers (Pohl et al 2002, Ada et al 2003, Eich et al 2004, Weng et al 2006, Langhammer and Stanghelle 2010, Ivey et al 2011, Kuys et al 2011, Olawale et al 2011, Ada et al 2013) were included in the review. See Appendix 2 on the eAddenda for a summary of the excluded papers. Figure 1 outlines the flow of studies through the review.

Description of studies

Six randomised trials investigated the effect of mechanically assisted walking training on walking speed and walking distance, two on walking speed, and one on walking distance. The quality of the included studies is outlined in Table 1 and a summary of the studies is presented in Table 2.

Quality: The mean PEDro score of the included studies was 6.7. Randomisation was carried out in 100% of the studies, concealed allocation in 67%, assessor blinding in 67%, and intention-to-treat analysis in 44%. No studies blinded participants or therapists, due to the inherent difficulties associated with blinding physical interventions.

Participants: The mean age of participants across the studies ranged from 50 to 74 years. The mean time after stroke ranged from 1.6 to 27 months, and one study did not report this information. Participants were recruited from people living in the community in 55% of the trials.

Intervention: In all studies, the experimental group received treadmill training without body weight support. Participants undertook training for 25 to 40 min, 3–5/wk, for 2.5 to 26 wk. The control group received no intervention (three studies), a non-walking intervention (four studies), or overground walking (three studies).

Outcome measures: Walking speed was measured using the 10-m Walk Test (eight studies) and results were converted to m/s. Walking distance was measured using the 6-min Walk Test (seven studies) and results were converted to m.

Effect of intervention

Walking speed: The immediate effect of treadmill training versus no intervention or a non-walking intervention on walking speed was examined by pooling data from seven studies (Ada et al 2003, Eich et al 2004, Weng et al 2006, Ivey et al 2011, Kuys et al 2011, Olawale et al 2011, Ada et al 2013) involving 275 participants. Treadmill training increased walking speed 0.14 m/s (95% CI 0.09 to 0.19) more than no intervention/non-walking intervention (Figure 2a, see Figure 3a on the eAddenda for the detailed forest plot). The effect of treadmill training beyond the intervention period compared with no intervention/non-walking intervention on walking speed was examined by pooling data from four studies (Ada et al 2003, Eich et al 2004, Kuys et al 2011, Ada et al 2013) involving 167 participants. Treadmill training increased walking speed 0.12 m/s (95% CI 0.08 to 0.17) more than no intervention/non-walking intervention (Figure 2b, see Figure 3b on the eAddenda for the detailed forest plot).

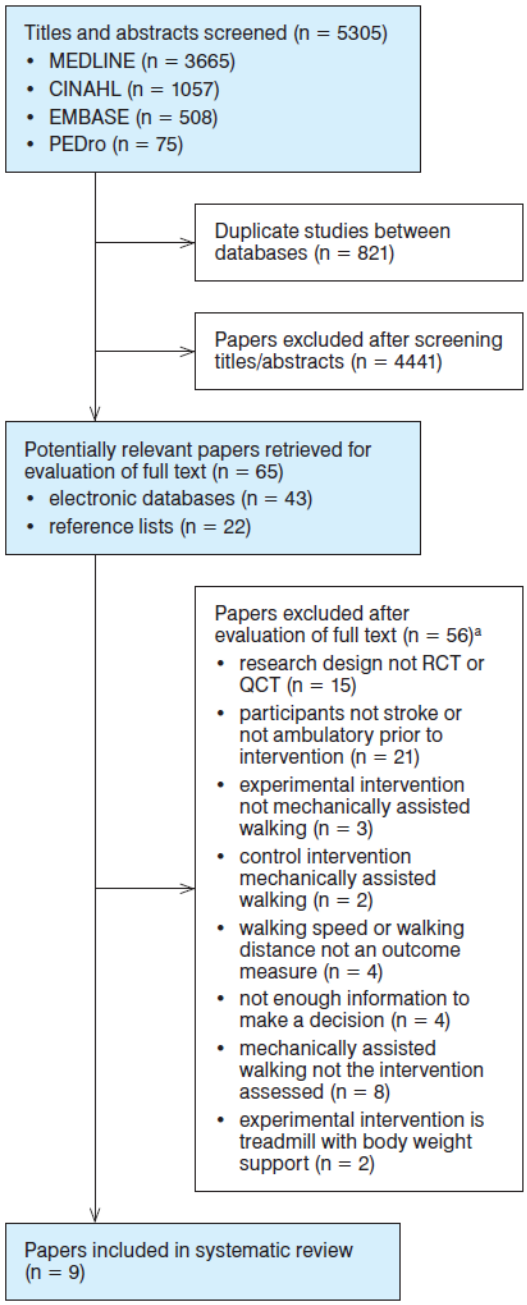

Figure 1. Flow of studies through the review. [a]Papers may have been excluded for failing to meet more than one inclusion criterion. RCT = randomised clinical trial, QCT = quasi-randomised clinical trial.

Table 1. PEDro criteria and scores for included studies (n = 9).

Study	Random allocation	Concealed allocation	Groups similar at baseline	Participant blinding	Therapist blinding	Assessor blinding	< 15% dropouts	Intention-to-treat analysis	Between-group difference reported	Point estimate and variability reported	Total (0 to 10)
Ada et al 2003	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
Ada et al 2013	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Eich et al 2004	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Ivey et al 2011	Y	N	Y	N	N	N	Y	N	Y	Y	5
Kuys et al 2011	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Langhammer & Stanghelle 2010	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Olawale et al 2011	Y	N	Y	N	N	N	Y	N	N	Y	4
Pohl et al 2002	Y	N	Y	N	N	Y	Y	N	Y	Y	6
Weng et al 2006	Y	Y	Y	N	N	N	Y	N	Y	Y	6

Y = yes, N = no

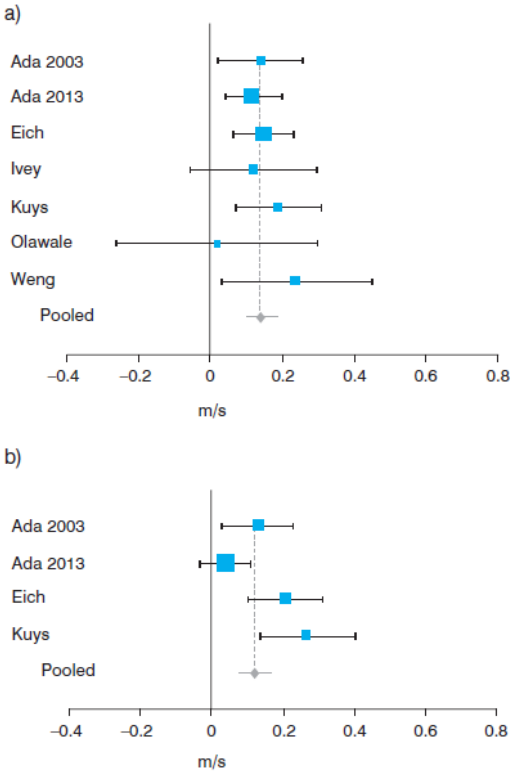

Figure 2. Mean difference (95% CI) of effect of treadmill training versus no intervention or a non-walking intervention for walking speed (m/s) a) immediately after the intervention period (n = 275) and b) beyond the intervention period (n = 167).

The immediate effect of treadmill versus overground training on walking speed was examined by pooling data from three studies (Pohl et al 2002, Langhammer and Stanghelle 2010, Olawale et al 2011) involving 119 participants. There was no significant difference in walking speed between treadmill training and overground training (MD 0.05 m/s, 95% CI −0.12 to 0.21) (Figure 4, see Figure 5 on the eAddenda for a detailed forest plot). No studies measured the effect of treadmill training versus overground walking on walking speed beyond the intervention period.

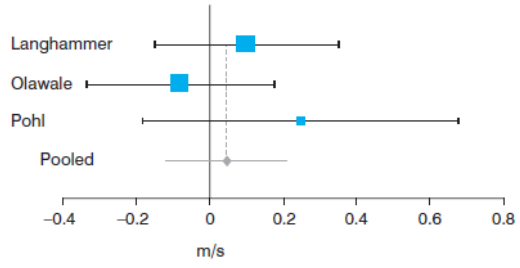

Figure 4. Mean difference (95% CI) of effect of treadmill training versus overground for walking speed (m/s) immediately after the intervention period (n = 119).

Table 2. Summary of included studies (n = 9).

Study	Design	Participants	Intervention	Outcome measures
Ada et al 2003	RCT	n = 29 Age (yr) = 66 (SD 12) Time since stroke (months) = 27 WS = Exp: 0.62 (SD 0.24); Con: 0.53 (SD 0.30)	Exp = TM 30 min x 3/wk x 4 wk Con = NW (strength, co-ord, balance) 30 min x 3/wk x 4 wk	Speed = 10-m walk test Distance = 6-min walk test Timing: 0, 4, 16 wk
Ada et al 2013	RCT	n = 102 Age (yr) = 67 (SD 12) Time since stroke (months) = 21 WS = Exp1: 0.51 (SD 0.27); Exp2: 0.49 (SD 0.29); Con: 0.50 (SD 0.24)	Exp = TM 30 min x 3/wk x 8 wk Con = no intervention	Speed = 10-m walk test Distance = 6-min walk test Timing: 0, 16, 26 wk
Eich et al 2004	RCT	n = 50 Age (yr) = 63 (SD 5) Time since stroke (months) = 1.6 WS = Exp: 0.40 (SD 0.17); Con: 0.44 (SD 0.22)	Exp = TM 30 min x 5/wk x 6 wk Con = no intervention Both = OG 30 min x 5/wk x 6 wk	Speed = 10-m walk test Distance = 6-min walk test Timing: 0, 6, 18 wk
Ivey et al 2011	RCT	n = 38 Age = 61 (SD 9) Time since stroke (months) = not reported WS = Exp: 0.54 (SD 0.27); Con: 0.49 SD (0.27)	Exp = TM 40 min x 3/wk x 26 wk Con = NW (stretch) 40 min x 3/wk x 26 wk	Distance = 6-min walk test Timing: 0, 26 wk
Kuys et al 2011	RCT	n = 30 Age (yr) = 68 (SD16) Time since stroke (months) = 1.7 WS = Exp: 0.34 (SD 0.20); Con: 0.58 (SD 0.36)	Exp = TM 30 min x 3/wk x 6 wk Con = no intervention Both = usual care 60 min x 3/wk x 6 wk	Speed = 10-m walk test Distance = 6-min walk test Timing: 0, 6, 18 wk
Langhammer and Stanghelle 2010	RCT	n = 39 Age (yr) = 74 (SD 12) Time since stroke (months) = 12 WS = Exp: 0.8 (SD 0.5); Con: 0.8 (SD 0.4)	Exp = TM 30 min x 5/wk x 2.5 wk Con = OG 30 min x 5/wk x 2.5 wk Both = usual care 170 min x 5/wk x 2.5 wk	Speed = 10-m walk test Distance = 6-min walk test Timing: 0, 2.5 wk
Olawale et al 2011	RCT	n = 60 Age (yr) = 56 (SD 6) Time since stroke (months) = 10 WS = Exp1: 0.36 (SD 0.95); Exp2: 0.39 (SD 1.19); Con: 0.39 (SD 0.90)	Exp = TM 25 min x 3/wk x 12 wk Con1 = OG 25 min x 3/wk x 12 wk Con2 = NW (stretch, strength, balance) 25 min x 3/wk x 12 wk All = usual care 35 min x 3/wk x 12 wk	Speed = 10-m walk test Distance = 6-min walk test Timing: 0, 12 wk
Pohl et al 2002	RCT	n = 60 Age (yr) = 59 (SD 11) Time since stroke (months) = 4 WS = Exp: 0.61 (SD 0.32); Con: 0.66 (SD 0.42)	Exp = TM 30 min x 3/wk x 4 wk Con = OG 45 min x 2/wk x 4 wk Both = usual care 45 min x 2/wk x 4 wk	Speed = 10-m walk test Timing: 0, 4 wk
Weng et al 2006	RCT	n = 26 Age (yr) = 50 (SD 13) Time since stroke (months) = 2 WS = Exp: 0.53 (SD 0.33); Con: 0.55 (SD 0.28)	Exp = TM 30 min x 5/wk x 3 wk Con = NW (exercise, stepping) 30 min x 5/wk x 3 wk Both = usual care 30 min x 5/wk x 3 wk	Speed = 10-m walk test Timing: 0, 3 wk

RCT= randomised controlled trial, WS = walk speed at baseline (m/s), Exp = experimental group, Con = control group, TM = treadmill walking, OG = overground walking, NW = non-walking intervention.

Walking distance: The immediate effect of treadmill training versus no intervention or a non-walking intervention on walking distance was examined by pooling data from six studies (Ada et al 2003, Eich et al 2004, Ivey et al 2011, Kuys et al 2011, Olawale et al 2011, Ada et al 2013) involving 249 participants. Treadmill training increased walking distance 40 m (95% CI 27 to 53) more than no intervention/non-walking intervention (Figure 6a, see Figure 7a on the eAddenda for the detailed forest plot). The effect of treadmill training versus no intervention/non-walking intervention on walking distance beyond the intervention period was examined by pooling data from four studies (Ada et al 2003, Eich et al 2004, Kuys et al 2011, Ada et al 2013) involving 167 participants. Treadmill training increased walking distance 40 m (95% CI 24 to 55) more than no intervention/non-walking intervention (Figure 6b, see Figure 7b on the eAddenda for the detailed forest plot).

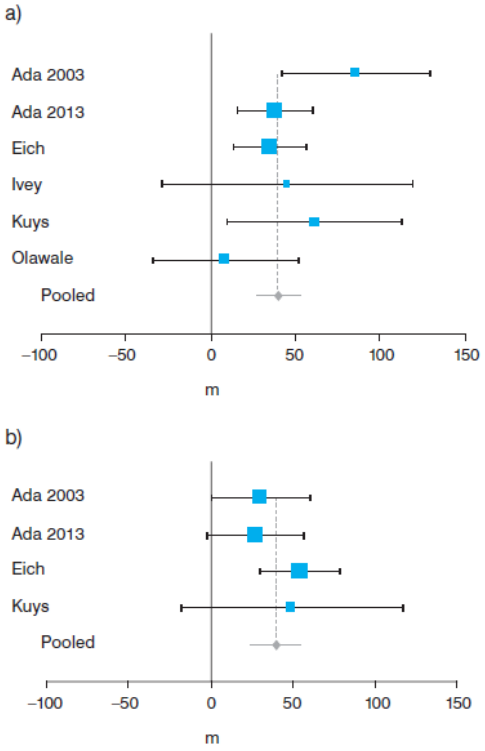

Figure 6. Mean difference (95% CI) of effect of treadmill training versus no intervention/non-walking intervention for walking distance (m) a) immediately after the intervention period (n = 249) and b) beyond the intervention period (n = 167).

The immediate effect of treadmill training versus overground on walking distance was examined by pooling data from two studies (Langhammer and Stanghelle 2010, Olawale et al 2011) involving 79 participants. There was no statistical difference in walking distance between treadmill training and overground training (MD –6 m, 95% CI –45 to 33) (Figure 8, see Figure 9 on the eAddenda for the detailed forest plot). No studies measured the effect of treadmill training versus overground walking on walking distance beyond the intervention period.

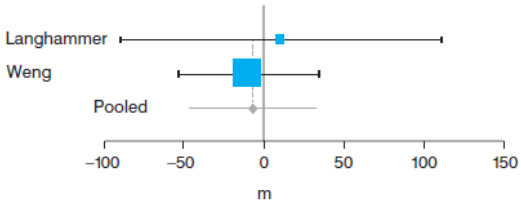

Figure 8. Mean difference (95% CI) of effect of treadmill training versus overground for walking distance (m) immediately after the intervention period (n = 79).

Discussion

This review provides evidence that treadmill training without body weight support is effective at improving walking in people who are ambulatory after stroke. Furthermore, the benefits appear to be maintained beyond the intervention period. However, whether treadmill training is more beneficial than overground training is not known.

Meta-analysis indicated that treadmill training produced benefits in terms of both walking speed and distance. Treadmill training produced 0.14 m/s faster walking and 40 m greater distance than no intervention/non-walking intervention immediately after intervention and these benefits were maintained beyond the intervention period. This effect is likely to be a conservative estimate of the effect of treadmill training, since some of the non-walking interventions given to the control group (such as strengthening) may have had some effect on walking. Importantly, these benefits appear to be clinically meaningful. For example, Tilson et al (2010) demonstrated that a between-group difference in walking speed after stroke of 0.16 m/s resulted in a 1-point improvement in the modified Rankin scale. Furthermore, there is no indication that the effect of treadmill training is different when carried out with subacute stroke undergoing hospital-based rehabilitation or with chronic stroke after discharge from formal rehabilitation. This may be because the length and frequency of treadmill training sessions delivered was similar across studies (mean length 30 min, SD 4; mean frequency 4/wk, SD 1) despite the variation in duration of training program (mean duration 9 wk, SD 7).

There are insufficient data to provide evidence as to whether treadmill training is better than overground training. Only three studies (Pohl et al 2002, Langhammer and Stanghelle 2010, Olawale et al 2011) investigating this question were found. Meta-analysis indicates no significant difference between treadmill training and overground training for both walking speed and distance. However, the confidence intervals are wide and include worthwhile effects in both cases, suggesting that further studies are necessary to answer this question.

Although we sought trials of any type of mechanically assisted walking training, all of the studies included in this review examined treadmill training. A previous Cochrane systematic review of treadmill training (Moseley et al 2005)

concluded that it did not have a statistically significant effect on walking speed (three studies) or distance (one study) compared with any other physiotherapy intervention in people who could already walk after stroke. Neither did treadmill training have a statistically significant effect on walking speed or distance when combined with other task-specific training (three studies). The inclusion of nine studies in the current meta-analysis is probably the main reason that our review came to a different conclusion.

This review has both limitations and strengths. A source of bias in the studies included in this review was lack of blinding of therapist and patients, since it is not possible to blind the therapist or the participants during the delivery of complex interventions. Another source of bias was lack of reporting whether an intention-to-treat analysis was undertaken. The number of participants per group (mean 21, SD 7.5) was quite low, opening the results to small trial bias. Only four of the nine included studies measured the outcomes after the cessation of intervention, which meant that the maintenance of the effect of intervention could not be evaluated well. In spite of these shortcomings, the mean PEDro score of 6.7 for the trials included in this review represents high quality. Another strength, unusual in rehabilitation studies, was that the outcome measures were the same, with walking speed always measured using the 10-m Walk Test and walking distance measured using the 6-min Walk Test. Finally, publication bias inherent to systematic reviews was avoided by including studies published in languages other than English.

This systematic review provides evidence that treadmill training without body weight support results in faster walking speed and greater distance than no intervention/non-walking intervention, both immediately after intervention and beyond the intervention period. Clinicians should therefore be confident in prescribing treadmill training for ambulatory stroke individuals when the primary objective of rehabilitation is to improve walking speed and distance, regardless of whether the individuals are at the subacute or chronic stage of their recovery. The parameters of gait training, such as speed, duration, and treadmill inclination, can be tailored to individuals to ensure training is challenging and to provide motivating feedback about the distance walked and the amount of work performed. ■

Footnotes: [a]The MIX–Meta-Analysis Made Easy program Version 1.7. http://www.meta-analysis-made-easy.com/

eAddenda: Appendix 1 and 2, and Figures 3a and 3b, 5, 7a and 7b, and 9, available at jop.physiotherapy.asn.au

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References

Ada L, Dean CM, Hall JM, Bampton J, Crompton S (2003) A treadmill and overground walking program improves walking in persons residing in the community after stroke: a placebo-controlled, randomised trial. *Archives of Physical Medicine & Rehabilitation*. 84: 1486–1491.

Ada L, Dean CM, Lindley R (2013) Randomized trial of treadmill training to improve walking in community-dwelling people after stroke: the AMBULATE trial. *International Journal of Stroke* doi: 10.1111/j.1747-4949.2012.00934.x.

Ada L, Dean CM, Vargas J, Ennis S (2010) Mechanically assisted walking with body weight support results in more independent walking than assisted overground walking in non-ambulatory patients early after stroke: a systematic review. *Journal of Physiotherapy* 56: 153–161.

Bax L, Yu LM, Ikeda N, Tsuruta H, Moons KG (2006) Development and validation of MIX: comprehensive free software for meta-analysis of causal research data. *BMC Medical Research Methodology* 13: 50.

Bax L, Ikeda N, Fukui N, Yaju Y, Tsuruta H, Moons KG (2009) More than numbers: the power of graphs in meta-analysis. *American Journal of Epidemiology* 169: 249–255.

Combs SA, Van Puymbroeck M, Altenburger PA, Miller KK, Dierks TA, Schmid AA (2012) Is walking faster or walking farther more important to persons with chronic stroke? *Disability & Rehabilitation* 5. [Epub ahead of print]

Duncan P, Richards L, Wallace D, Stoker-Yates J, Pohl P, Luchies C, et al (1998) A randomised, controlled pilot study of a home-based exercise program for individuals with mild and moderate stroke. *Stroke* 29: 2055–2060.

Eich HJ, Mach H, Werner C, Hesse S (2004) Aerobic treadmill plus Bobath walking training improves walking in subacute stroke: a randomised controlled trial. *Clinical Rehabilitation* 18: 640–651.

Eng JJ, Chu KS, Dawson AS, Kim MC, Hepburn KE (2002) Functional walk tests in individuals with stroke: relation to perceived exertion and myocardial exertion. *Stroke* 33: 756–761.

Flansbjer UB, Holmbäck AM, Downham D, Patten C, Lexell J (2005) Reliability of gait performance tests in men and women with hemiparesis after stroke. *Journal of Rehabilitation Medicine* 37: 75–82.

Green J, Forster A, Bogle S, Young J (2002) Physiotherapy for patients with mobility problems more than 1 year after stroke: a randomised controlled trial. *Lancet* 359: 199–203.

Harris-Love ML, Forrester LW, Macko RF, Silver KH, Smith GV (2001) Hemiparetic gait parameters in overground versus treadmill walking. *Neurorehablitation and Neural Repair* 15: 105–112.

Holden MK, Gill KM, Magliozzi MR, Nathan J, Piehl-Baker L (1984) Clinical gait assessment in the neurologically impaired. Reliability and meaningfulness. *Physical Therapy* 64: 35–40.

Ivey FM, Ryan AS, Hafer-Macko CE, Macko RF (2011) Improved cerebral vasomotor reactivity after exercise training in hemiparetic stroke survivors. *Stroke* 42: 1994–2000.

Kuys SS, Brauer SG, Ada L (2011) Higher-intensity treadmill walking during rehabilitation after stroke is feasible and not detrimental to walking pattern or quality: a pilot randomised trial. *Clinical Rehabilitation* 25: 316–326.

Langhammer B, Stanghelle JK (2010) Exercise on a treadmill or walking outdoors? A randomised controlled trial comparing effectiveness of two walking exercise programmes late after stroke. *Clinical Rehabilitation* 24: 46–54.

Lord SE, McPherson KM, McNaugton HK, Rochester L, Weatherall M (2004) Community ambulation following stroke: how important and obtainable is it, and what

measures appear predictive? *Archives of Physical Medicine & Rehabilitation* 85: 234–239.

Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M (2003) Reliability of the PEDro scale for rating quality of randomized controlled trials. *Physical Therapy* 83: 713-721.

Mehrholz J, Werner C, Kugler J, Pohl M (2010) Electromechanical-assisted training for walking after stroke. *Cochrane Database of Systematic Reviews* 4: CD006185.

Moore JL, Roth EJ, Killian C, Hornby TG (2010) Locomotor training improves daily stepping activity and gait efficiency in individuals poststroke who have reached a 'plateau' in recovery. *Stroke* 41: 129–135.

Moseley AM, Stark A, Cameron ID, Pollock A (2005) Treadmill training and body weight support for walking after stroke. *Cochrane Database of Systematic Reviews* 4: CD002840.

Olawale OA, Jaja SI, Anigbogu CN, Appiah-Kubi KO, Jones-Okai D (2011) Exercise training improves walking function in an African group of stroke survivors: a randomised controlled trial. *Clinical Rehabilitation* 25: 442–450.

Pohl M, Mehrholz J, Ritschel C, Rückriem S (2002) Speed-dependent treadmill training in ambulatory hemiparetic stroke patients: a randomised controlled trial. *Stroke.* 33: 553–558.

Robinson CA, Shumway-Cook A, Matsuda PN, Ciol MA (2011) Understanding physical factors associated with participation in community ambulation following stroke. *Disability & Rehabilitation.* 33: 1033–1042.

Tilson JK, Sullivan KJ, Cen SY, Rose DK, Koradia CH, Azen SP, et al (2010) Meaningful gait speed improvement during the first 60 days poststroke: minimal clinically important difference. *Physical Therapy* 90: 196–208.

Weng CS, Wang J, Pan XY, Yu ZZ, Wang G, Gao LP, et al (2006) [Effectiveness of backward walking treadmill training in lower extremity function after stroke]. *Zhonghua Yi Xue Za Zhi* 86: 2635–2638.

eAddenda

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Luci F Teixeira-Salmela

Treadmill training improves walking speed and distance in ambulatory adults with stroke: a systematic review

Journal of Physiotherapy 59: 73–80

Appendix 2: Detailed search strategy

Databases: MEDLINE, EMBASE CINAHL, PEDro

MEDLINE Search Strategy

1. Stroke/ or stroke.mp.
2. Cerebrovascular disorders/ or Cerebrovascular disorders.mp.
3. Cerebrovascular disorders/ or cerebral vascular.mp. or Cerebral Hemorrhage/
4. (cerebral or cerebellar or brain$or vertebrobasilar).mp.
5. (infarct$ or isch?emi$ or thrombo$ or emboli$ or apoplexy).mp.
6. 4 and 5
7. (cerebral or brain$ or subarachnoid).mp.
8. (haemorrhage or hemorrhage or haematoma or hematoma or bleeding).mp.
9. 7 and 8
10. Hemiplegia.mp. or hemiplegia/
11. (hemipleg$ or hemipar$ or poststroke or post-stroke).mp.
12. Gait Disorders, Neurologic/
13. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12
14. Electromechanical.mp.
15. Electro-mechanical.mp
16. Mechanized.mp.
17. Mechanized.mp.
18. Body-weight.mp. or Body Weight/
19. (body and weight and (support$ or relief)).mp.
20. Orthos$.mp.
21. Orthotic.mp.
22. Exercise Test.mp. or Exercise Test/
23. Treadmill.pm.
24. (fitness and train$).tw.
25. Lokomat.mp.
26. Locomat.mp.
27. Gait Trainer.mp.
28. 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27
29. Walking/ or Walking.mp.
30. Gait.mp. or Gait/
31. Locomotion.mp. or Locomotion/
32. Range of Motion, Articular/
33. walk$ or gait$ or ambulat$ or mobil$ or locomotor$ or balanc$ or stride).mp.
34. recovery of function.mp.
35. 29 or 30 or 31 or 32 or 33 or 34
36. 13 and 28 and 35
37. Limit 36 to humans

EMBASE search strategy

1. 'stroke'/exp OR stroke

2. cerebrovasc* AND ('disease'/exp OR disease OR 'accident'/exp OR accident)
3. cerebr* OR cerebellar OR brain*
4. infarct* OR isch?emi* OR thrombo* OR emboli* OR 'apoplexy'/exp OR apoplexy OR attack
5. #3 AND #4
6. cerebr* OR brain* OR subarachnoid
7. 'haemorrhage'/exp OR haemorrhage OR 'hemorrhage'/exp OR hemorrhage OR 'haematoma'/exp OR haematoma OR 'hematoma'/exp OR hematoma OR 'bleeding'/exp OR bleeding
8. #6 AND #7
9. 'hemiplegia'/exp OR hemiplegia OR 'hemiparesis'/exp OR hemiparesis
10. hemipleg* OR hemipar*
11. #1 OR #2 OR #5 OR #8 OR #9 OR #10
12. treadmill'/exp OR treadmill
13. gaittrainer OR 'gait'/exp OR gait AND trainer OR 'gait trainer'
14. functional AND electric* AND ('stimulation'/exp OR stimulation)
15. 'walking'/exp OR walking
16. 'training'/exp OR training
17. body AND ('weight'/exp OR weight) AND (support OR relief)
18. 'exercise'/exp OR exercise
19. 'gait'/exp OR 'gait' OR walk* OR locomot* OR ambulat* OR mobil* OR stride
20. overground AND walk*
21. harness
22. #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #20 OR #22 OR #23
23. patient* OR subject* OR individual* OR participant*
24. ambulatory
25. #23 AND #24
26. #11 AND #22 AND #25

CINAHL search strategy

1. (MH “Stroke”) OR “Stroke”
2. (MH “Cerebrovascular Disorders+") OR “Cerebrovascular Disorders”OR (MH “Gait Disorders, Neurologic+”)
3. “ cva*”
4. “cerebral”
5. “cerebellar”
6. “brain”
7. “vertebrobasilar”
8. “infarct$”
9. “ich?emi*”
10. “thrombo$”
11. “emboli$”
12. “apoplexy”

13. S4 or S5 or S6 or S7
14. S8 or S9 or S10 or S11 or S12
15. S13 and S14
16. Hemiplegia
17. (hemipleg$ or hemipar$ or poststroke or post-stroke)
18. (cerebral or brain$ or subarachnoid)
19. (haemorrhage or haemorrhage or haematoma or hematoma or bleeding)
20. S1 or S2 or S3 or S4 or S5 or S6 or S7 or S8 or S9 or S10 or S11 or S12 or S13 or S14 or S15 or S16 or S17 or S18 or S19
21. Treadmills/
22. therapeutic exercise/
23. exp exercise/
24. gait training/
25. exercise test/
26. body weight/
27. weight bearing/
28. (treadmill or harness$ or exercise$)
29. (body and weight and (support$ or relief))
30. (fitness and train$)
31. S21 or S22 or S23 or S24 or S25 or S26 or S27 or S28 or S29 or S30
32. Walking/
33. Gait/
34. Gait analysis/
35. Locomotion/
36. Range of motion/
37. (walk$ or gait$ or ambulat$ or mobil$ or locomot$ or stride)
38. S32 or S33 or S34 or S35 or S36 or S37
39. S20 and S31 and S38

PEDro search strategy
Search option: Advanced
Abstract and Title: Treadmill AND stroke
Subdiscipline: Neurology

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Appendix 2: Excluded studies (n = 56)

Table 1. Excluded studies (n = 56).

Studies	Reasons for exclusion							
	1	2	3	4	5	6	7	8
Ada et al. (2010)a		✓						
Ada et al. (2010)b	✓							
Banala et al. (2009)	✓							
Barbeau et al. (2003)								✓
Bayat et al. (2005)							✓	
Chang et al. (2011)		✓						
Da Cunha et al. (2001)							✓	
da Cunha et al. (2002)		✓						
Daily et al. (2006)			✓					
Dean et al. (2010)		✓						
DePaul et al. (2011)	✓							
Dias et al. (2007)		✓						
Fisher et al. (2011)		✓						
Franceschini et al (2009)		✓						

Freivojel et al. (2009)		✓						
Fung et al. (2006)	✓							
Globas et al. (2012)	✓							
Hansen et al. (2002)	✓							
Harris-Love et al. (2001)					✓			
Hesse et al. (1999)	✓							
Hornby et al. (2008)				✓				
Hoyer et al. (2012)		✓						
Husemann et al. (2007)		✓						
Jaffe et al. (2004)			✓					
Kendrick et al. (2001)	✓							
Kosak et al. (2000)		✓						
Krewer et al. (2007)								✓
Lau et al. (2011)			✓					
Laufer et al. (2001)		✓						
Liston et al. (2000)		✓						
Macko et al. (2005)				✓				
Mayr et al. (2007)		✓						
Moore et al. (2010)					✓			
Moseley (2005)	✓							
Ng et al., (2008)		✓				✓		
Norman et al. (1995)	✓							
Page et al. (2008)					✓	✓		
Peurala et al. (2009)		✓						
Poh et al. (2007)		✓						
Puh and Baer (2009)	✓							

Silver et al. (2000)	✓						
Schwartz et al. (2009)		✓			✓		
Skvortsova et al. (2008)						✓	
Smith and Thompson (2008)				✓			
Srivastava et al. (2011)	✓						
Sullivan et al. (2007)						✓	
Takami and Wakayama (2010)						✓	
Tong et al. (2006)		✓					
Trueblood et al. (2001)	✓						
Visintin et al. (1998)						✓	
Werner et al (2002)a		✓					
Werner et al (2002)b	✓						
Westlake and Patten (2009)						✓	
Yagura et al. (2006)		✓					
Yang et al (2008)					✓		
Yang et al. (2010)							✓

1 = Research design not RCT or QCT

2 = Participants not stroke or not ambulatory prior to intervention

3 = Experimental intervention is not mechanically assisted walking

4 = Control intervention is mechanically assisted walking

5 = Walking speed or walking capacity is not an outcome measure

6 = Not enough information to make a decision

7 = Mechanically assisted walking is not the intervention assessed

8 = Experimental intervention is treadmill with body weight support

Capítulo 3 – ARTIGO 2

Em estudos prévios realizados em países desenvolvidos, como o Canadá (MACKAY-LYONS; MAKRIDES, 2002a) e Austrália (KUYS; BRAUER; ADA, 2006), foi observado que a duração e intensidade dos exercícios realizados durante os programas de reabilitação não são suficientes para gerar estresse cardiorrespiratório adequado, de forma que possa induzir efeitos de treinamento em indivíduos pós-AVE. Já no Brasil, uma vez que foi observado em um estudo que a maioria dos profissionais da reabilitação reportou a existência de parâmetros seguros para a prescrição do treinamento cardiorrespiratório para indivíduos pós-AVE (POLESE *et al*., 2013), fez-se necessário conduzir um estudo, no qual parâmetros cardiorrespiratórios fossem, de fato, observados e analisados durante sessões de fisioterapia.

Assim, a partir do estudo transversal a seguir, investigou-se a duração e intensidade de atividades que seriam capazes de induzir estresse cardiorrespiratório durante sessões rotineiras de fisioterapia em indivíduos pós-AVE, além da sua progressão em termos de duração e intensidade ao longo de uma semana de intervalo.

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Research Article Open Access

Cardiorespiratory Stress is not Achieved During Routine Physiotherapy in Chronic Stroke

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Abstract

Background: Cardiorespiratory deconditioning is a well-established sequel of stroke and this may interfere with integration into community. In the chronic phase, when motor recovery has plateaued, rehabilitation should include cardiorespiratory training.

Objective: To determine whether physiotherapy rehabilitation in the chronic phase of stroke provides enough stress in terms of duration (>10 min) and intensity (>40% of heart rate reserve - HRR) to induce cardiorespiratory benefits.

Methods: Two physiotherapy sessions, at least one week apart, of 20 chronic stroke patients (mean time since the onset of the stroke of 26 months, mean age of 58 years, 45% male) were observed, in terms of duration (time) and intensity (40 %HRR). The activities were categorized as upper limb tasks, standing, stepping, basic walking, and advanced walking. Average duration and intensity for each participant across the two sessions were determined.

Results: Lower limb activities, such as standing and walking were undertaken for 25 (SD 5) minutes; comprising 57% of the total session. The remainder of the session was taken up with upper limb activities (27%) or inactivity (16%). None of the activities reached the target intensity, with the highest average intensity being achieved during advanced walking (mean 32% HRR, SD 2).

Conclusions: Routine physiotherapy did not provide sufficient duration or intensity to induce cardiorespiratory stress in this group of chronic stroke patients. The evidence practice gap needs to be closed for cardiorespiratory fitness to be trained.

Keywords: Cerebrovascular disorders; Physiotherapy (speciality); Exercise; Physical fitness; Cardiovascular deconditioning; Walking, Rehabilitation

Introduction

Significant cardiorespiratory deconditioning is a well-established sequel of stroke and contributes to disability [1]. The latest update of the Cochrane systematic review on physical fitness showed that cardiorespiratory training during both the acute/subacute and chronic phases improves walking performance [2]. Furthermore, it appears both feasible and safe [2] and, can therefore, be confidently included in physiotherapy rehabilitation for stroke survivors. Despite this, previous studies have demonstrated that the extent of cardiorespiratory stress induced by routine inpatient physiotherapy rehabilitation is low [3-5]. As people with chronic stroke are able to achieve minimum recommended exercise levels [6], it would seem reasonable to expect that cardiorespiratory fitness training would be a focus of physiotherapy rehabilitation in the chronic phase following stroke.

It has been found that the intensity of inpatient physiotherapy rehabilitation is not sufficient to provide cardiorespiratory benefit. In Canada, patients spent three (SD 1) minutes within the targeted heart rate zones per physiotherapy session, i.e., above 40% of the heart rate reserve (HRR) [3]. More recently, Prajapati et al. [5] found that things had not changed in 10 years; i.e., patients did not meet the minimum cumulative requirements of walking intensity (>40% HRR) and duration (>10 minutes) continuously. In Australia, patients spent only 22 minutes in standing and walking activities at 24% of their HRR per physiotherapy session [4].

In Brazil, stroke rehabilitation commences later and continues well into the chronic phase [7]. As a result, it is possible that these stroke survivors are even more deconditioned than the inpatient survivors [8, 9]. Targeting cardiorespiratory fitness during outpatient rehabilitation in the chronic phase is, therefore, of paramount importance. At this stage, recovery of motor impairments, such as weakness, has largely taken place with strength of large muscle mass enough to enable walking at an intensity sufficient to promote cardiorespiratory stress. The inclusion of cardiorespiratory training in this phase of stroke

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recovery could positively influence the overall health [10], physical activity levels [11] integration into the community, and ultimately quality of life [12].

Therefore, the aim of this study was to determine whether physiotherapy rehabilitation in the chronic phase of stroke provided enough stress in terms of duration (>10 min) and intensity (>40% of HRR) to induce cardiorespiratory benefits.

Methods

Design

A cross-sectional observational study with repeated measures was carried out. Participants were a sample of convenience recruited from three metropolitan outpatient clinics, one public and two private. Two sessions of physiotherapy rehabilitation, at least one week apart, of at least 40 min duration were observed for each participant. There was no attempt to influence the content of physiotherapy intervention, ie, the sessions observed were of routine physiotherapy. While both patients and therapists were aware that they were being observed, they were blind to the objectives of the study, and were asked to carry on as normal. The duration (time) and intensity (%HRR) of activities undertaken by the participants during these sessions were collected. This study was approved by the Research Ethical Review Board of the Pontificia Universidade Católica de Minas Gerais and all participants provided written consent, prior to data collection.

Participants

Volunteers were included if they had at least six months after the onset of a unilateral stroke; were clinically stable; were undergoing physiotherapy rehabilitation; had no cognitive deficits, as defined by their Mini-Mental State Examination scores >24 [13]; and had no other neurological or orthopedic conditions. Characteristics such as age, sex, body mass, height, time since the onset of the stroke, side of hemiparesis, number and type of medications, walking speed (10-m Walk Test) [14,15], and levels of independence (Barthel Index) [16], were collected for characterization purposes.

Measurements

Duration of activity: The duration of the total session, of the activities undertaken during the sessions, and any periods of inactivity were timed with a digital stopwatch. The activities were categorized, according to Kuys et al. [4], as follows:

Standing: standing up, standing still, shifting weight from one leg to the other, and reaching while standing;

Stepping: single stepping practice or stepping onto and off individual blocks;

Basic walking: walking on flat, firm surfaces, regardless of the walked distance or how much assistance was required;

Advanced walking: walking backwards, on uneven surfaces, outdoors, climbing stairs, or walking on the treadmill.

Upper limb: any movement performed by the paretic limb, including passive and active movements in sitting or lying positions;

Inactive: resting or not engaged in any therapeutic activities;

Intensity of activity: The intensity of the activities was measured as the percentage of the HRR. A Polar heart rate strap was applied to the participants' chests, with the receiver placed on the non-paretic upper limb before the beginning of the sessions. Then, the resting heart rate was recorded for each participant after five minutes of sitting. Heart rate was continuously measured and manually recorded after the end of each performed activity [5]. If the activity continued for longer than 10 minutes, additional heart rate measures were recorded at 10-minute intervals. The average heart rate was calculated for each activity [4]. The 40%HRR, i.e., the minimal intensity to induce cardiorespiratory stresses, was defined by the Karvonen formula, as follows: HR_{target}= [40% ($HR_{max\text{-}pred}$-HR_{rest})]+HR_{rest}. The maximal age-predicted heart rate was adjusted for those participants, who were taking beta-blocker medications, as follows: (85% [220-age]) [17].

Data analysis

Descriptive statistics (means, standard deviations) and tests for normality (Shapiro–Wilk) and homogeneity of variances (Levene) were performed for all outcomes. Since no differences in duration or intensity were observed between the sessions (Z=-1.8; p>0.05 and Z=-2.2; p>0.05, respectively) for any activity, the data were averaged across the two physiotherapy sessions. All statistical analyses were carried out using the SPSS software for Windows (version 17.0) with a significance level of 5%.

Results

Characteristics of the participants

Twenty individuals with chronic stroke, nine men, with a mean age of 58 (SD 16) years and a mean time since the onset of the stroke of 26 (SD 15) months, participated. All individuals were taking oral medications, including anti-hypertensive drugs and beta-blockers. Their characteristics are summarized in Table 1. Each participant was observed during two sessions. The mean time between the sessions was 14 (SD=7) days.

Characteristic	n=20
Age (years), mean (SD)	58 (16)
Sex, *n* male (%)	9 (45)
Body mass index (kg/m2), mean (SD)	25 (4)
Time since stroke (months), mean (SD)	26 (15)
Side of hemiparesis, n right (%)	9 (45)
Number of medications, mean (SD)	3 (2)
Walking speed (m/s), mean (SD)	0.77 (0.31)
Barthel Index (scores: 0 to 20), mean (SD)	17 (3)

Table 1: Demographic, anthropometric, and clinical characteristics of theparticipants. SD: standard deviation.

Duration and intensity of activities

Forty sessions were observed, with a mean duration of 44 (Session 1) and 43 (Session 2) minutes, respectively. Table 2 provides the average duration and intensity (%HRR) of each activity across the two

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sessions. Lower limb activities, such as standing and walking, were undertaken for 25 (SD 5) minutes; comprising 57% of the total session. The remainder of the sessions were taken up with upper limb activities (27%) or inactivity (16%). None of the activities was undertaken at 40% HHR (Figure 1). The highest intensity of 32% HHR (SD 2) was achieved during advanced walking.

Activity	Duration	Intensity
Total session	44 (5)	24 (5)
Lower limb activities	25 (5)	25 (5)
Standing	5 (4)	20 (3)
Stepping	5 (3)	19 (4)
Basic walking	6 (3)	26 (4)
Advanced walking	9 (5)	32 (2)
Upper limb activities	12 (5)	20 (4)
Inactive	7 (2)	24 (5)

Table 2: Mean (SD) duration (minutes) and intensity (% Heart rate reserve) of the activities averaged across the two sessions (n=40 sessions). SD=standard deviation; %HRR=percentage heart rate reserve.

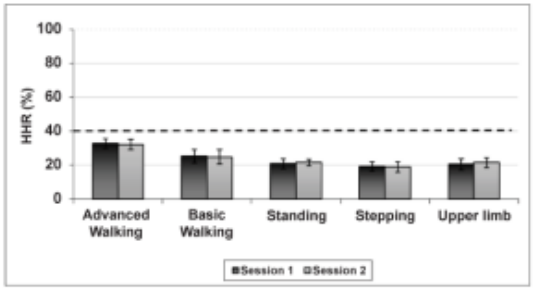

Figure 1: Mean (SD) intensity (% Heart rate reserve - HHR) during advanced walking, basic walking, standing, stepping, and upper limb activities for session 1 (n=20) and session 2 (n=20). The dashed line represents the minimum intensity required to induce a cardiorespiratory training effect.

Discussion

This cross-sectional study found that routine outpatient physiotherapy for people with chronic stroke did not generate enough cardiorespiratory stress to induce training effects. The mean maximum intensity reached was 32% HRR, which occurred during advanced walking for about 10 minutes. Interestingly, the mean intensity of the standing and stepping activities did not exceed that of the upper limb.

Similar duration and intensity of routine physiotherapy were found by previous studies [3-5]. For example, maximum average HRR achieved in the present study (32%) was similar to 35% reported by Kuys et al. [4] for stepping. Duration was also similar; 25 minutes for standing and walking activities. It may be that the emphasis in the early stages of rehabilitation has been more on the quality of the movement, than on cardiorespiratory fitness.

It is difficult, soon after stroke, to make newly ambulatory patients, walk fast enough to raise their heart rate sufficiently to induce cardiorespiratory stresses. However, in the present study, the participants were chronic, i.e., at least two years after stroke. At this stage, it would seem reasonable to concentrate on improving cardiorespiratory fitness as a way of reducing activity limitations and participation restrictions [18], given that it is unlikely that motor impairments, such as muscle weakness, will be amenable to changes. Furthermore, the participants in the present study were functionally independent, i.e., modified Barthel index of 17/20 and walked quite well (0.8 m/s) at about 2/3 of normal speed [19]. Therefore, it would appear to be feasible to increase the intensity of the exercises, either by increasing walking speeds or walking loads or introducing activities, which require higher physical demands, such as ascending and descending stairs [20].

Stroke clinical practice guidelines [21] inform us that exercises should be intense enough to promote cardiorespiratory stress. There are now four international studies [3-5], including the present one (Canada, Australia, Brazil) that informed us that physiotherapists do not do it. Why? There are two potential explanations. First, perhaps physiotherapists are afraid to push their patients too hard, in case there is a negative effect on the quality of walking. However, this fear is unfounded, since Kuys et al. [22] reported that even when walking newly ambulatory stroke patients at speeds on a treadmill that induced intensities up to 60% HRR for six weeks, the training was not detrimental to walking patterns.

Second, although the scientific evidence supporting stroke rehabilitation in physiotherapy has been growing over recent decades [23], the transfer of evidence into clinical practice remains a challenge. The most commonly observed barriers to implementation of evidence-based practice are the lack of confidence and knowledge to interpret, synthesize and apply research findings, negative attitudes, and habitual ways of practicing [24].

In this sense, although the scientific literature supports the importance of interventions, which incorporate aerobic training to induce cardiorespiratory benefits even during the acute stages [2,8,25], the results of this study demonstrated that like their international counterparts [3-5] Brazilian physiotherapists do not employ exercises with sufficient intensity nor duration to induce cardiorespiratory stress during routine physiotherapy rehabilitation. This, in turn, highlights the fact that physiotherapists are not currently directing their efforts to three of the main goals of stroke rehabilitation, i.e., to prevent complications related to prolonged inactivity, to decrease the risk of recurrent stroke or cardiovascular events [26], and to improve cardiorespiratory fitness [27]. It appears that cardiorespiratory training is not being targeted in acute and subacute settings [3-5], possibly due to the focus being on other aspects of recovery and shorter lengths of stay [28]. If this is the case, then perhaps, the focus of rehabilitation post discharge from acute and subacute services, as stroke survivors enter the chronic phase, should include cardiorespiratory training.

The evidence gap exists pertaining to cardiorespiratory training, regardless of the phase of stroke recovery. Clinicians are often aware of the content of clinical practice guidelines, but specific strategies to help

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facilitate implementation of research findings into clinical practice need to be tailored to the individuals' contexts and settings [29].

The results of the current study and previous work in this area continue to highlight that cardiorespiratory fitness training must be planned in order to be included in physiotherapy interventions. The lack of physical activity undertaken by stroke survivors [30] cannot be ameliorated, until cardiorespiratory fitness is improved.

Conclusions

The findings of this study demonstrated that routine physiotherapy did not provide the appropriate duration and intensities to induce cardiorespiratory stress in people with chronic stroke. The individuals did not achieve their minimal target heart rate zones. The loss of conditioning is an important impairment observed in post-stroke patients, which could lead to serious consequences including preventing individuals returning to their social activities, i.e., going to church, supermarkets, and practicing sports. The evidence gap around implementation of cardiorespiratory training during stroke rehabilitation needs to be addressed. Activities which provide appropriate intensities to induce cardiorespiratory stress should form part of the physiotherapists' checklist during the planning of the intervention.

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Ethical Approval

Pontifica Universidade Católica de Minas Gerais (#0xxx. 0.213.000-06).

References

1. Adamson J, Beswick A, Ebrahim S (2004) Is stroke the most common cause of disability? J Stroke Cerebrovasc Dis 13: 171-177.
2. Brazzelli M, Saunders DH, Greig CA, Mead GE (2011) Physical fitness training for patients with stroke: updated review. Cochrane Database Syst Rev 11.
3. MacKay-Lyons MJ, Makrides L (2002) Cardiovascular stress during a contemporary stroke rehabilitation program: is the intensity adequate to induce a training effect? Arch Phys Med Rehabil 83: 1378-1383.
4. Kuys S, Brauer S, Ada L (2006) Routine physiotherapy does not induce a cardiorespiratory training effect post-stroke, regardless of walking ability. Physiother Res Int 11: 219-227.
5. Prajapati SK, Mansfield A, Gage WH, Brooks D, McIlroy WE (2013) Cardiovascular responses associated with daily walking in subacute stroke. Stroke Res Treat 2013: 612458.
6. Marzolini S, McIlroy W, Oh P, Brooks D (2012) Can individuals participating in cardiac rehabilitation achieve recommended exercise training levels following stroke? J Cardiopulm Rehabil Prev 32: 127-134.
7. O'Dwyer G, Konder MT, Machado CV, Alves CP, Alves RP (2013) The current scenario of emergency care policies in Brazil. BMC Health Serv Res 13: 70.
8. Kelly JO, Kilbreath SL, Davis GM, Zeman B, Raymond J (2003) Cardiorespiratory fitness and walking ability in subacute stroke patients. Arch Phys Med Rehabil 84: 1780-1785.
9. Mackay-Lyons MJ, Makrides L (2004) Longitudinal changes in exercise capacity after stroke. Arch Phys Med Rehabil 85: 1608-1612.
10. Billinger SA, Mattlage AE, Ashenden AL, Lentz AA, Harter G, et al. (2012) Aerobic exercise in subacute stroke improves cardiovascular health and physical performance. J Neurol Phys Ther 36: 159-165.
11. Hildebrand M, Brewer M, Wolf T (2012) The impact of mild stroke on participation in physical fitness activities. Stroke Res Treat 2012: 548682.
12. Aidar FJ, de Oliveira RJ, Silva AJ, de Matos DG, Carneiro AL, et al. (2011) The influence of the level of physical activity and human development in the quality of life in survivors of stroke. Health Qual Life Outcomes 9: 89.
13. Brucki SM, Nitrini R, Caramelli P, Bertolucci PH, Okamoto IH (2003) [Suggestions for utilization of the mini-mental state examination in Brazil]. Arq Neuropsiquiatr 61: 777-781.
14. Salbach NM, Mayo NE, Higgins J, Ahmed S, Finch LE, et al. (2001) Responsiveness and predictability of gait speed and other disability measures in acute stroke. Arch Phys Med Rehabil 82: 1204-1212.
15. Nascimento LR, Caetano LC, Freitas DC, Morais TM, Polese JC, et al. (2012) Different instructions during the ten-meter walking test determined significant increases in maximum gait speed in individuals with chronic hemiparesis. Braz J Phys Ther 16: 122-127.
16. Quinn TJ, Langhorne P, Stott DJ (2011) Barthel index for stroke trials: development, properties, and application. Stroke 42: 1146-1151.
17. Pollock ML, Lowenthal DT, Foster C, Pels A, Rod J, et al. (1991) Acute and chronic responses to exercise in patients treated with beta blockers. J Cardiopulm Rehabil 11: 132-144.
18. Mead G, Bernhardt J, Kwakkel G (2012) Stroke: physical fitness, exercise, and fatigue. Stroke Res Treat 2012: 632531.
19. Bohannon RW (1997) Comfortable and maximum walking speed of adults aged 20-79 years: reference values and determinants. Age Ageing 26: 15-19.
20. Alzahrani MA, Dean CM, Ada L (2009) Ability to negotiate stairs predicts free-living physical activity in community-dwelling people with stroke: an observational study. Aust J Physiother 55: 277-281.
21. National Stroke Foundation (2010) Clinical Guidelines for Stroke Management. Australia.
22. Kuys SS, Brauer SG, Ada L, Russell TG (2008) Increasing intensity during treadmill walking does not adversely affect walking pattern or quality in newly-ambulating stroke patients: an experimental study. Aust J Physiother 54: 49-54.
23. Salbach NM, Guilcher SJ, Jaglal SB, Davis DA (2010) Determinants of research use in clinical decision making among physical therapists providing services post-stroke: a cross-sectional study. Implement Sci 5: 77.
24. Lal S, Korner-Bitensky N (2013) Motivational interviewing: a novel intervention for translating rehabilitation research into practice. Disabil Rehabil 35: 919-923.
25. Smith AC, Saunders DH, Mead G (2012) Cardiorespiratory fitness after stroke: a systematic review. Int J Stroke 7: 499-510.
26. Arsura E (2005) Evaluating cardiorespiratory fitness after stroke: does the best provide less? Chest 127: 1473-1474.
27. Gordon NF, Gulanick M, Costa F, Fletcher G, Franklin BA, et al. (2004) Physical activity and exercise recommendations for stroke survivors. Circulation 109: 2031–2041.
28. Tistad M, Ytterberg C, Sjöstrand C, Holmqvist LW, von Koch L (2012) Shorter length of stay in the stroke unit: comparison between the 1990s and 2000s. Top Stroke Rehabil 19: 172-181.

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29. McCluskey A, Vratsistas-Curto A, Schurr K (2013) Barriers and enablers to implementing multiple stroke guideline recommendations: a qualitative study. BMC Health Serv Res 13: 323.

30. Alzahrani MA, Ada L, Dean CM (2011) Duration of physical activity is normal but frequency is reduced after stroke: an observational study. J Physiother 57: 47-51.

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Capítulo 4 – ARTIGO 3

É claramente estabelecido que, em indivíduos pós-AVE, o gasto energético é diferente daquele apresentado por indivíduos saudáveis pareados por idade e sexo, durante atividades submáximas e máximas (KELLY *et al*., 2003; BILLINGER *et al*., 2012; SMITH; SAUNDERS; MEAD, 2012). Desta forma, o gasto energético é um tema relevante, a ser amplamente estudado e compreendido em indivíduos pós-AVE. Assim, o uso de instrumentos confiáveis para mensurar variáveis cardiorrespiratórias é de extrema relevância. Entretanto, até o presente momento, somente um estudo avaliou a confiabilidade teste-reteste do ergoespirômetro portátil Cortex MetaMax 3B® (MACFARLANE; WONG, 2012), sendo que este utilizou uma amostra composta por indivíduos saudáveis. Não foram encontrados estudos na literatura que avaliaram a confiabilidade teste-reteste do instrumento Cortex MetaMax 3B® em indivíduos pós-AVE.

Desta forma, o estudo a seguir objetivou avaliar a confiabilidade teste-reteste do instrumento Cortex MetaMax 3B® indivíduos pós-AVE crônico para mensuração de variáveis cardiorrespiratórias, durante a realização de teste de caminhada de 6 minutos.

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Special Article - Stroke Rehabilitation

Test-retest Reliability of Cardiorespiratory Variables Measured with the Metamax 3b During the Six-minute Walking Test after Stroke

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Abstract

Introduction: Subjects after stroke expend more energy, when performing the same activity as healthy controls, but it is not known whether subjects after stroke expend the same amount of energy during daily life activities. However, to allow the measurement during daily activities is necessary to use portable equipment. Thus, the aim of this study was determine the test-retest reliability of cardiorespiratory variables measured with the Metamax 3B and polar heart rate monitor during the 6-minute Walking Test (6MWT) after stroke.

Methods: Twenty-one individuals with chronic stroke (13 men, mean age of 59 years, mean time since the onset of stroke of 30 months) underwent two 6MWT within an interval of 7 days wearing a Metamax 3B and a polar heart rate monitor. Intra-class correlations coefficients ($ICC_{2,1}$), within-participant t-tests, standard errors of measurement and Bland-Altman plots were calculated for cardiorespiratory variables (relative and absolute oxygen consumption, carbon dioxide production, respiratory exchange ratio, minute ventilation and heart rate) during the 6MWT. Results: The $ICC_{2,1}$ values ranged from 0.76-0.97. Mean differences between test 1 and 2 ranged from 0-4%.The SEM% ranged from 1-12%.

Conclusions: The present findings support the test-retest reliability of the Metamax 3B during overground walking after stroke.

Keywords: Stroke; Walking; Portable gas analysis; Oxygen consumption; Measurement; Reliability

Introduction

Stroke is the leading cause of disability worldwide, which lead to serious disabilities [1]. According to the latest statement by the American Heart Association, the central goal for the current decade is a sufficient level of physical activity, with the aim of improving cardiovascular health and reducing deaths caused by stroke [2]. This goal is based on the finding that physical activity has a neuro protective effect against recurrent stroke [3] and decreasing recurrent stroke will decrease the incidence of stroke [4,5]. However, subjects after stroke have low levels of physical activity, compared with healthy individuals and very rarely meet the American Guidelines for Stroke which recommend at least 150 minutes of moderate-intensity physical activity per week [2,3]. A recent systematic review on physical activity after stroke found that subjects with stroke took 53% steps/day of healthy controls [6]. On the other hand, the findings from two studies [7,8] suggested that although there is a decrease in frequency of activity, subjects after stroke spend much the same amount of time being active as normal. Given that subjects after stroke expend more energy when performing the same *standardised* activity as healthy controls [9], the question raised as to whether subjects after stroke would expend the same amount of energy during everyday life as healthy controls, in spite of their reduced frequency of activity.

Gas analysis is the gold standard measure to investigate energy expenditure [10]. However, most gas analysis in subjects with stroke has been done during incremental tests on a treadmill or cycle ergometer in order to measure *maximum* oxygen consumption [10]. To investigate energy consumption during everyday life, it is necessary to use portable monitoring equipment, which allows the person to move freely around the environment.

The aim of this study was, therefore, to investigate the test-retest reliability of portable monitor's equipment during an everyday activity – overground walking. The Metamax 3B (Cortex, Germany) is a portable, gas analysis system which is light (1.4 kg) and allows the transmission "online" of respiratory variables for a distance of up to 800 meters. With the addition of a heart rate monitor, this allows the collection of both cardiac and respiratory variables during everyday activities such as walking. The cardiorespiratory variables are adjusted in real time, according to the environmental conditions, by means of temperature sensors, internal pressure sensors and an electronic barometer. The Metamax 3B is valid and reliable when used to measure cardio respiratory variables during everyday activities in healthy individuals [11]. However, no studies have thus been conducted to assess cardiorespiratory variables during overground walking in stroke individuals using the Metamax 3B. To investigate test-retest reliability, subjects with chronic stroke (time since stroke >1 year) were studied. The specific research question for this study was:

Citation: Polese JC, Ada L, Parreira VF, Faria GS, Avelino P, Teixeira-Salmela LF. Test-retest Reliability of Cardiorespiratory Variables Measured with the Metamax 3b During the Six-minute Walking Test after Stroke. Phys Med Rehabil Int. 2015;2(1): 1028.

What is the test-retest reliability of cardiorespiratory variables measured with a Metamax 3B and a polar heart rate monitor during the 6-minute Walk Test (6MWT)?

The establishment of reliability of portable monitoring equipment under stable conditions (i.e., in chronic stroke) is the first step in investigating energy expenditure during everyday activities after stroke.

Methods

Design

Subjects with chronic stroke were recruited from the general community in a metropolitan city in Brazil. Individuals came to a University laboratory twice within 7 days. On each occasion, they performed a 6MWT while metabolic monitoring equipment collected their cardiorespiratory variables. The 6MWT was performed at the same time of day and at least 500 ml of water was provided prior to each test, to guarantee normal hydration. First, the participants walked the course of 30 meters without monitoring equipment to familiarise themselves with the 6MWT. Then, after familiarisation, they rested for 3 minutes to stabilise the Metamax 3B. After, they performed the 6MWT, following the procedures and recommendations of the American Thoracic Society [12,13]. This study was approved by the Research Review Board of the Universidad Federal de Minas Gerais and all participants provided written consent prior to data collection.

Participants

Volunteers were eligible if they: were ≥ 20 years old; had a mean time since the onset of a unilateral stroke between one and five years; were able to walk independently with or without assistive devices; had no cognitive deficits, as determined by the Mini-Mental State Examination Brazilian cut-off scores, which were adjusted for levels of education [14]; were not undergoing rehabilitation, and had no other neurological or orthopaedic disorders.

Characteristics, such as age, gender, body mass index, side of hemiparesis, time since onset of stroke, number of medications and co-morbidities, levels of physical activity (adjusted activity scores of the Human Activity Profile) [15], levels of independence (Barthel Index) [16], walking speed (10-m Walk Test) [17] and walking capacity (distance covered during the 6MWT) [17] were collected for characterization purposes.

Measurement of cardiorespiratory variables

Participants wore a Metamax 3B for the collection of the following respiratory variables: Relative and absolute oxygen consumption [Vo_2] in ml/min/kg and L/min), carbon dioxide production [VCo_2] in L/min, respiratory exchange ratio [RER], minute ventilation [VE] in L/min). In addition, the polar heart rate monitor provided the cardiac variables (heart rate [HR], in bpm). The Metamax 3B was calibrated in three ways before each test: barometric, gas, and volume calibration. The means of the final three minutes of the 6MWT (steady state condition) were used for analyses [18].

Analysis of test-retest reliability

Test-retest reliability was assessed in four ways. Firstly, intra-class correlation coefficients ($ICC_{2,1}$) and 95% confidence intervals (CI) were calculated for all cardiorespiratory variables obtained at Tests 1 and 2. An ICC value < 0.4 was considered poor, 0.4 to 0.75 as fair to good, and > 0.75 as excellent [19]. Secondly, within-participant t-tests (mean and 95% CI) were calculated between the tests 1 and 2. Third, the standard errors of measurement (SEM) were calculated, as follows: $SEM = s\sqrt{(1.00 - r)}$, where s is the standard deviation and r is the test-retest ICC [20,21]. The SEM was expressed as a percentage of the average values of tests 1 and 2. SEM values < 15% were considered acceptable [21]. Lastly, Bland & Altman plots were generated for relative Vo_2 to assess the agreement between the tests 1 and 2 [22]. All analyses were carried out with the SPSS for Windows software (release 17.0) with a significance level of 5%.

Table 1: Characteristics of participants.

Characteristic		n=21
Age (years), mean (SD)		59 (15)
Gender, n male (%)		13 (62)
Body mass index (kg/m2), mean (SD)		26 (4)
Paretic side, n right (%)		10 (48)
Time since the onset of stroke (months), mean (SD)		30 (17)
Medications (number), mean (SD)		5 (2)
Associated pathologies (number), mean (SD)		2 (1)
Human Activity Profile (0-94), mean (SD)		58 (16)
Barthel Index (0-20), mean (SD)		19 (1)
Walking speed (m/s), mean (SD)		0.89 (0.30)
Walking distance (m), mean (SD)	Test 1	359 (140)
	Test 2	366 (139)

SD: standard deviation, AAS: adjusted activity scores.

Results

Twenty-one individuals with stroke (13 men), with a mean age of 59 (SD 15) years, a mean time since the onset of stroke of 30 (SD 17) months participated. All participants were taking oral medications, primarily anti-hypertensive drugs. Eight individuals required assistive devices (cane = 4 individuals; walker = 4 individuals) to walk during the 6MWT. The distance covered during the 6MWT was very similar between the tests, illustrating that the participants' walking was stable. Their characteristics are summarized in Table 1.

The cardiorespiratory variables for both tests along with the correlation coefficients are given in Table 2. The $ICC_{2,1}$ values ranged from 0.76 to 0.97 the mean differences between the tests 1 and 2 ranged from 0-3%.The SEM% ranged from 1 to 12%.

The Bland and Altman plot in Figure 1 showed the within-participant change across tests 1 and 2 in relative Vo_2 as a function of the individual mean on tests 1 and 2 relative to the Vo_2. The mean difference between tests 1 and 2 was approximately 1%. Second, the SD (2.3) was also small compared with the relative Vo_2 (11.0). Third, there appeared to be no relations between the differences in the two tests and the mean of the two tests.

Discussion

This study investigated the test-retest reliability of cardiorespiratory variables measured with a Metamax 3B and polar heart rate monitor during overground walking after stroke. All ICCs were greater than 0.76, demonstrating excellent reliability. In addition, the mean difference between the tests was small (0-4%) and the

Table 2: Cardiorespiratory variables for each 6-min Walk Test and the relation between tests (n=21).

Cardiorespiratory variables	Test 1	Test 2	Average of Tests		Test-retest reliability		
	Mean (SD)	Mean (SD)	Mean (SD)		ICC2,1 (95% CI)	MD (95%IC)	SEM (%)
Relative VO2 (ml/min/kg)	11.0 (2.4)	10.9 (3.1)	10.9 (2.5)		0.80 (0.51 to 0.92)	-0.1 (-1.1 to 1.0)	1.1 (10)
Absolut VO2 (L/min)	0.76 (0.18)	0.78 (0.18)	0.77 (0.17)		0.85 (0.62 to 0.94)	0.01 (-0.04 to 0.07)	0.07 (9)
VCO2 (L/min)	0.70 (0.18)	0.76 (0.18)	0.73 (0.16)		0.76 (0.42 to 0.90)	0.06 (-0.01 to 0.12)	0.09 (12)
RER	0.91 (0.04)	0.91 (0.04)	0.91 (0.04)		0.97 (0.92 to 0.99)	0.00 (-0.01 to 0.00)	0.01 (1)
VE (L/min)	27 (6)	28 (9)	28 (7)		0.81 (0.52 to 0.92)	1 (-2 to 3)	3 (9)
HR (bpm)	101 (18)	104 (20)	103 (18)		0.92 (0.80 to 0.97)	3 (-2 to 7)	5 (5)

ICC = Intraclass Correlation Coefficient; CI = Confidence Interval; VO_2 =, Oxygen Consumption; VCO_2 = carbon dioxide production; RER = *Respiratory Exchange* Ratio; VE = Ventilation; HR = Heart Rate; MD = Mean Difference; SEM = Standard Error of Measurement.

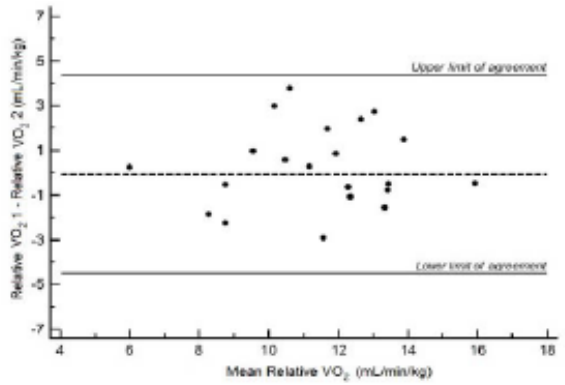

Figure 1: Bland and Altman plot. Individual difference in relative VO_2 (mL/kg/min) between Test 1 and 2, plotted against individual mean (Test 1 and 2) relative VO_2 (mL/kg/min). Dashed line shows the group mean relative Vo_2 between Test 1 and 2 (-0.1 mL/kg/min). The 95% upper and lower limits of agreement represent 2 standard deviations above and below the group mean difference in relative VO_2 between Test 1 and 2 (-4.5 to 4.4).

SEM% was below 15%. The Bland Altman plot of the relative Vo_2 also indicated high agreement between the tests. Since all four methods of investigating test-retest reliability produced similar results, it can be concluded the Metamax 3B is stable during overground walking in subjects with stroke.

The investigation of test-retest reliability was carried-out, following rigorous methods. The sample of subjects with stroke had a time after stroke (mean 30 months, SD 17) and was not undergoing rehabilitation. This sample was chosen to ensure stability of their walking patterns across the tests. The similarity in distance covered during the 6MWT between tests 1 and 2 illustrates that walking capacity contributed little to the error in test-retest reliability. In addition, the sample reflects a broad range of walking ability, contributing to generalization of the results. While on average they walked at 66% of normal speed according to their ages [23], and covered 67% of the normal distance during 6MWT [23], their walking speeds ranged from 0.4 to 1.1 m/s and walking distances from 115 to 618 m.

The reliability and use of the Metamax 3B has been firmly established for healthy individuals during everyday activities and incremental tests [11,24,25]. In subjects with stroke, the reliability of another portable monitoring equipment – K4b2 (COSMED USA; Chicago, IL) has been recently established [26]. The ICCs of the cardiorespiratory variables between the two 6MWT with 23 chronic stroke individuals ranged from 0.66 to 0.95. The ICC values from the K4b2 plus polar the heart rate monitor were similar to the findings of the present study with the Metamax 3B plus polar heart rate monitor and both reflected excellent reliability (> 0.75) [19] for relative Vo_2 (0.90 vs 0.80), absolute Vo_2 (0.93 vs 0.85), VCO_2 (0.93 vs 0.76), VE (0.95 vs 0.81) and HR (0.76 vs 0.92). Only RER was not excellent from the K4b2 (0.66 vs 0.97). The combination of these findings suggests that portable monitoring equipment is reliable for the assessment of cardiorespiratory variables during an everyday activity – overground walking – after stroke. This is important for the investigation of energy expenditure of subjects after stroke during everyday activity within community settings.

Conclusions

The results of the present study reinforce the reliability of the Metamax 3B, since excellent ICCs were found for all cardiorespiratory variables during the 6MWT. Therefore, the Metamax 3B can provide stable measurement during overground walking by subjects with stroke.

References

1. Lauretani F, Saccavini M, Zaccaria B, Agosti M, Zampolini M, Franceschini M; et al. Rehabilitation in patients affected by different types of stroke. A one-year follow-up study. Eur J Phys Rehabil Med. 2010; 46: 511-516.
2. Kernan WN, Ovbiagele B, Black HR, Bravata DM, Chimowitz MI, Ezekowitz MD, et al. Guidelines for the prevention of stroke in patients with stroke and transient ischemic attack: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2014; 45: 2160-2236.
3. Gordon NF, Gulanick M, Costa F, Fletcher G, Franklin BA, Roth EJ, et al. Physical activity and exercise recommendations for stroke survivors: an American Heart Association scientific statement from the Council on Clinical Cardiology, Subcommittee on Exercise, Cardiac Rehabilitation, and Prevention; the Council on Cardiovascular Nursing; the Council on Nutrition, Physical Activity, and Metabolism; and the Stroke Council. Circulation 2004; 16: 2031-2041.
4. Wendel-Vos GC, Schuit AJ, Feskens EJ, Boshuizen HC, Verschuren WM, Saris WH, et al. Physical activity and stroke. A meta-analysis of observational data. Int J Epidemiol. 2004; 33: 787-798.
5. Lee CD, Folsom AR, Blair SN. Physical activity and stroke risk: a meta-analysis. Stroke. 2003; 34: 2475-2481.
6. English C, Manns PJ, Tucak C, Bernhardt J. Physical activity and sedentary behaviors in people with stroke living in the community: a systematic review. Phys Ther. 2014; 94: 185-196.

7. Alzahrani MA, Ada L, Dean CM. Duration of physical activity is normal but frequency is reduced after stroke: an observational study. J Physiother. 2011; 57: 47-51.

8. Sakamoto K, Nakamura T, Sajima Y, Miyake T, Yamanaka M, Tajima F. Physical activities and steps in daily living after stroke. Journal of the Wakayama Medical Society 2008; 59: 67–72.

9. Galea SL, Lee MJ, English C, Ada L. Sedentary versus active behaviour in people after stroke: a systematic review. Phys Ther Rev [in press].

10. Smith AC, Saunders DH, Mead G. Cardiorespiratory fitness after stroke: a systematic review. Int J Stroke. 2012; 7: 499-510.

11. Macfarlane DJ, Wong P. Validity, reliability and stability of the portable Cortex Metamax 3B gas analysis system. Eur J Appl Physiol. 2012; 112: 2539-2547.

12. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. Am J Respir Crit Care Med. 2002; 166: 111-117.

13. Britto RR, Probst VS, de Andrade AF, Samora GA, Hernandes NA, Marinho PE, et al. Reference equations for the six-minute walk distance based on a Brazilian multicenter study. Braz J Phys Ther. 2013; 17: 556-563.

14. Bertolucci PH, Brucki SM, Campacci SR, Juliano Y. [The Mini-Mental State Examination in a general population: impact of educational status]. Arq Neuropsiquiatr. 1994; 52: 1-7.

15. Souza AC, Magalhaes LC, Teixeira-Salmela LF. Adaptação transcultural e Análise das propriedades psicométricas da versão brasileira do Perfil de Atividade Humana. Cad Saude Publica 2006; 22: 2623-2636. [article in Portuguese] .

16. Quinn TJ, Langhorne P, Stott DJ. Barthel index for stroke trials: development, properties, and application. Stroke. 2011; 42: 1146-1151.

17. Flansbjer UB, Holmbäck AM, Downham D, Patten C, Lexell J. Reliability of gait performance tests in men and women with hemiparesis after stroke. J Rehabil Med. 2005; 37: 75-82.

18. Wasserman K, Hansen JE, Sue DY, Stringer W, Whipp B. Clinical Exercise Testing. In: Weinberg A, ed. Principles of Exercise Testing and Interpretation, 4th edition. Philadelphia: Lippincott, Williams and Wilkins, 2005:133-159.

19. Shrout PE, Fleiss JL. Intraclass correlations: uses in assessing rater reliability. Psychol Bull. 1979; 86: 420-428.

20. de Vet HC, Terwee CB, Knol DL, Bouter LM. When to use agreement versus reliability measures. J Clin Epidemiol. 2006; 59: 1033-1039.

21. Beckerman H, Roebroeck ME, Lankhorst GJ, Becher JG, Bezemer PD, Verbeek AL. Smallest real difference, a link between reproducibility and responsiveness. Qual Life Res. 2001; 10: 571-578.

22. Euser AM, Dekker FW, le Cessie S. A practical approach to Bland-Altman plots and variation coefficients for log transformed variables. J Clin Epidemiol. 2008; 61: 978-982.

23. Bohannon RW, Williams Andrews A. Normal walking speed: a descriptive meta-analysis. Physiotherapy. 2011; 97: 182-189.

24. Brandes M, VAN Hees VT, Hannöver V, Brage S. Estimating energy expenditure from raw accelerometry in three types of locomotion. Med Sci Sports Exerc. 2012; 44: 2235-2242.

25. Vogler AJ, Rice AJ, Gore CJ. Validity and reliability of the Cortex MetaMax3B portable metabolic system. J Sports Sci. 2010; 28: 733-742.

26. Stookey AD, McCusker MG, Sorkin JD, Katzel LI, Shaughnessy M, Macko RF, et al. Test-retest reliability of portable metabolic monitoring after disabling stroke. Neurorehabil Neural Repair 2013; 27: 872-877.

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Capítulo 5

Uma vez que o artigo 4 será submetido para publicação, o presente capítulo abordará detalhadamente os materiais e métodos do mesmo, bem como a caracterização da amostra e recrutamento.

MATERIAIS E MÉTODO

5.1 Delineamento do Estudo

Trata-se de um estudo experimental com uma amostra selecionada por conveniência, no qual o gasto energético de hemiparéticos crônicos foi coletado durante a realização de atividades funcionais.

5.2 Local de realização

O estudo foi realizado no Laboratório de Avaliação e Pesquisa em Desempenho Cardiorrespiratório (LabCare) do Departamento de Fisioterapia da Escola de Educação Física, Fisioterapia e Terapia Ocupacional da Universidade Federal de Minas Gerais (UFMG), Belo Horizonte, Minas Gerais, Brasil.

5.3 Amostra

Indivíduos pós-AVE foram recrutados da comunidade em geral, por meio de seleção dos pacientes atendidos pelos Centros de Reabilitação de Belo Horizonte (CREAB) da Prefeitura Municipal de Belo Horizonte, de acordo com os seguintes critérios de inclusão: (1) ter idade superior a 20 anos; (2) possuir um tempo médio pós-lesão de um a cinco anos; (3) possuir hemiparesia em um dos membros superiores e inferiores, avaliada pela Escala Modificada de Ashworth (BOHANNON e SMITH, 1987) e pela dinamometria manual (BOHANNON, 1997); (4) ser capaz de deambular; (5) não possuir déficits cognitivos, determinado pelos pontos de corte no Mini Exame do Estado Mental (BERTOLUCCI *et al*., 1994); e (6) não possuir outra desordem de

ordem neuromusculoesquelética não relacionado ao AVE, ou respiratória. Este estudo foi aprovado pelo Comitê de Ética em Pesquisa da Universidade Federal de Minas Gerais (CAAE – 0254.0.203.000-11) (Anexo V) e Prefeitura Municipal de Belo Horizonte (Parecer 0254.0.203.000-11A) (Anexo VI). Todos os indivíduos foram esclarecidos em relação à pesquisa e assinaram o Termo de Consentimento Livre e Esclarecido (Apêndice A).

5.4 Cálculo Amostral

Devido a escassez de estudos prévios analisando o VO_2 relativo de hemiparéticos crônicos durante a realização de atividades funcionais, inicialmente considerou-se a inclusão de no mínimo cinco indivíduos para cada variável independente, de acordo com as recomendações estabelecidas por Tabachnick e Fidell (1989) e Hair Junior *et al*. (2009).

Para adequação do tamanho amostral considerando os dados coletados com a amostra da presente tese a posteriori, foi realizado o cálculo considerando a média do VO_2 relativo (mL/min/kg) após os três primeiros minutos de coleta para as atividades incrementais (velocidade habitual, velocidade máxima, teste de caminhada de seis minutos – TC6min e subir e descer escadas). A análise foi realizada por meio do software GPower 3.1, utilizando-se o teste F – regressão linear múltipla. Os dados podem ser observados na tabela a seguir:

Tabela 1. Dados observados no programa G Power 3.1 para cálculo amostral.

Entrada de Dados						**Saída de dados**	
Condição experimental	**d**	**α**	**Power**	**VI**	**VD**	**Tamanho da amostra**	**Power atual**
Velocidade Habitual	0,67	0,05	0,80	11	1	21	0.81
Velocidade Máxima	0,89	0,05	0,80	11	1	16	0.80
TC6min	0,86	0,05	0,80	11	1	19	0.84
Subir e descer escadas	0,82	0,05	0,80	11	1	19	0.81

D = tamanho de efeito; α = nível de significância; VI = número de variáveis independentes; VD = número de variáveis dependentes. TC6min = teste de caminhada de seis minutos.

Como pode ser observado na Tabela 1, os cálculos demonstraram a necessidade de inclusão de 16 a 21 indivíduos no presente estudo, para um tamanho de efeito moderado a grande (0,67<d<0,89) (COHEN, 1992). Entretanto, para se atingir um número suficiente de indivíduos com todos os níveis funcionais (diferentes velocidades de marcha), foram incluídos no presente estudo 55 indivíduos.

5.5 Instrumentação e Medidas

5.5.1 Medidas de desfecho

5.5.1.1 Gasto Energético (consumo de oxigênio)

O consumo de oxigênio foi registrado a cada respiração, determinados através de um sistema portátil de ergoespirometria computadorizado de circuito aberto (MetaMax 3B®, Cortex, Alemanha). O instrumento permite a transmissão de dados *"on-line"* para uma distância de até 800 metros, além de possuir um baixo peso, permitindo assim, explorar as respostas fisiológicas humanas em atividades funcionais (Figura 1). As medidas são corrigidas em tempo real de acordo com as condições ambientais do teste, por meio de sensores de temperatura, sensor de pressão interno e barômetro eletrônico. A máscara facial possui baixo volume de espaço morto e duas válvulas inspiratórias com baixa resistência inspiratória e permite a remoção dos gases exalados durante o teste, o que acarreta a melhora da qualidade analítica dos gases. O instrumento apresenta adequada validade e confiabilidade, quando utilizado em diversas atividades em indivíduos saudáveis e hemiparéticos pós AVE (BRANDES et al., 2012; POLESE et al., 2015).

Previamente a cada dia de coleta, o instrumento, após ter sido ligado por no mínimo 30 minutos, foi calibrado em três etapas: (1) pressão barométrica, (2) gás e (3) fluxo, de acordo com as instruções do fabricante. A pressão barométrica foi informada ao sistema por meio de um barômetro digital, a qual

foi transferida para o software. Posteriormente, a calibração do gás foi realizada com a captação do ar ambiente pelo instrumento seguida do fornecimento de um gás de referência conhecido ao instrumento (12,0% O2, 5,0% CO2, balance N2: ±0.02% absolute, *Micromed Industry*), sendo esta captação do gás de referência utilizada para comparação com o ar ambiente pelo software. Finalmente, o fluxo foi calibrado por meio de uma seringa de três litros (Seringa volumétrica 3L, Hans Rudolph, Inc., MO, USA).

O instrumento, após calibração, foi colocado no tórax do indivíduo, inserido em um colete com ajustes com velcros, a fim de provocar o mínimo desconforto possível ao indivíduo. Os gases foram coletados por no mínimo um minuto antes do início efetivo da coleta de dados, para confirmação que todos os parâmetros estavam sendo captados.

Figura 1. Cortex Metamax *3B* inserido no colete, juntamente com a máscara de silicone. Fonte: arquivos da autora.

Foram considerados para análise no presente estudo, nas atividades incrementais (velocidade habitual, velocidade máxima, TC6min e escadas), a

média do consumo de oxigênio relativo (mL/min/kg) após os três primeiros minutos de coleta de cada atividade que, de acordo com Wasserman *et al*. (2005), trata-se este do tempo necessário para alcançar o *steady state* do oxigênio. Para as demais atividades (repouso nas posições sentado e deitado e ficar em pé) foi utilizada para a análise a média do consumo de oxigênio relativo (mL/min/kg) de todo o teste (FINESTONE *et al*., 2003).

5.5.1.2 Nível Funcional (velocidade de marcha)

O nível funcional dos participantes foi determinado pela velocidade de marcha, avaliada por meio do teste de caminhada em 10 metros. Este parâmetro tem sido utilizado como referência para definição do grau de independência de hemiparéticos (PERRY *et al.*, 1995). As velocidades de marcha habitual e máxima foram avaliadas de forma aleatorizada, seguindo critérios descritos por SALBACH *et al*. (2001) e de acordo com os seguintes comandos padronizados recomendados por Nascimento *et al*. (2012):

- Velocidade habitual: “Eu vou medir a sua velocidade confortável para andar. Quando eu disser ‘já’, ande em linha reta em uma velocidade que você considerar confortável e segura, até aquela cadeira”.
- Velocidade máxima: “Eu vou medir a sua velocidade máxima para andar. Quando eu disser ‘já’, você vai caminhar até aquela cadeira o mais rápido que puder com segurança e sem correr, como se você fosse perder um ônibus e tivesse que alcançá-lo”.

Foi utilizada uma única repetição para análise em cada condição, conforme recomendações de Faria *et al.* (2012). A velocidade de marcha apresenta propriedades de medida adequadas para indivíduos pós-AVE (SALBACH *et al*., 2011).

5.5.1.3 Força muscular de membros inferiores

Os indivíduos tiveram a força isométrica dos extensores de joelho e dorsiflexores de tornozelo (em kjF) avaliada por meio do dinamômetro manual Hand Held (*Model* BK-7454), sempre pelo mesmo avaliador, que foi previamente treinado. Estes grupos musculares foram especificamente

selecionados, uma vez que foi demonstrado que ambos são responsáveis por 34% da variância da velocidade da marcha (DORSH *et al*., 2012). O posicionamento adotado foi realizado de acordo com as recomendações de Dorsh *et al*. (2012), conforme descrito a seguir, sendo que para todas as posições o indivíduo permaneceu na posição supina, com o membro inferior a ser testado mantendo joelhos e quadril fletidos a 90º (Figura 2). Foram utilizados apoios com tamanhos selecionados individualmente para manter o posicionamento adequado dos joelhos e quadris dos indivíduos.

- Extensores de joelho: dinamômetro na região anterior da perna, no terço médio;
- Dorsiflexores de tornozelo: dinamômetro no terço médio do dorso do pé.

A contração foi estimulada durante 5 segundos, a partir do estímulo sonoro: “força, força, força!”. O membro inferior não parético foi avaliado primeiro. Respeitou-se um intervalo de 30 segundos entre as mensurações. Foi utilizada uma única repetição para análise, conforme recomendações de Martins *et al*. (2014).

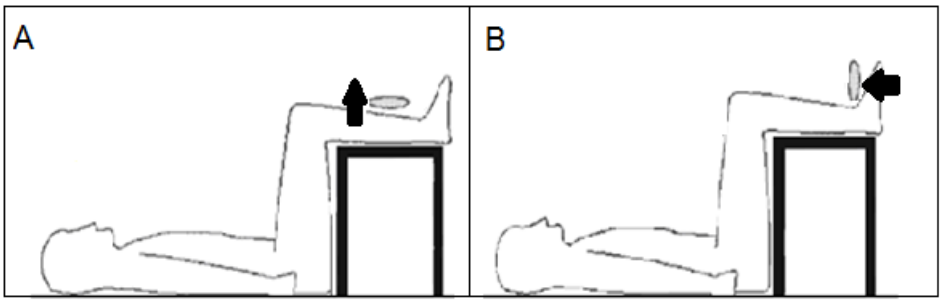

Figura 2. Posicionamento para realização do teste de força muscular para (A) extensores de joelho e (B) dorsiflexores de tornozelo.

5.5.1.4 Capacidade para a marcha (Teste de Caminhada de 6 minutos)

Os indivíduos tiveram a sua capacidade para a marcha determinada pelo Teste de Caminhada de 6 minutos (TC6min). Os mesmos foram instruídos a caminhar em um corredor plano demarcado em uma distância de 30 metros por cones durante seis minutos, de acordo com os critérios estabelecidos pela *American Thoracic Society* (ATS, 2002). Os indivíduos tiveram a sua pressão arterial, frequência cardíaca, saturação periférica e sensação de esforço

(Escala de Borg Modificada) avaliados no início e término do teste. Instruções padronizadas por meio de comando verbal foram dadas aos indivíduos por avaliadores treinados, de acordo com critérios estabelecidos previamente (BRITTO, SOUZA, 2006; BRITTO *et al*., 2013). O TC6min possui propriedades de medida adequadas para indivíduos pós-AVE (FULK *et al.,* 2008; SALBACH *et al*., 2011).

5.5.1.5 Funcionalidade (Índice de Barthel)

O Índice de Barthel (IB) foi utilizado para avaliar a funcionalidade dos indivíduos. Esse índice apresenta uma pontuação máxima de 100 pontos, no caso dos pacientes que apresentam total independência. Em situação oposta, onde os pacientes apresentam dependência total, o IB é igual a zero. O IB pode ser considerado como uma escala que avalia atividades básicas de vida diária, tais como autocuidados e mobilidade (HARRISON; MCARTHUR; QUINN, 2013), possuindo propriedades de medidas adequadas, quando utilizada com hemiparéticos (DUFFY *et al*., 2013).

5.5.1.6 Nível de Atividade Física (Perfil de Atividade Humana)

O Perfil de Atividade Humana (PAH) foi utilizado para avaliar o nível de atividade física dos indivíduos. O PAH - versão brasileira - objetiva avaliar o nível de atividade física de indivíduos saudáveis em qualquer faixa etária ou com algum grau de disfunção. É composto por 94 itens referentes a atividades rotineiras, sendo que para cada um deles existem três possíveis respostas: “ainda faço”, “parei de fazer” ou “nunca fiz”. A classificação do nível de atividade física é estabelecida, de acordo com pontos de corte pré-definidos, conhecidos como escore ajustado de atividade, sendo os indivíduos classificados como inativos (pontuação inferior a 53), moderadamente ativos (entre 53 e 74) ou ativos (superior a 74) (SOUZA; MAGALHAES; TEIXEIRA-SALMELA, 2006; DAVIDSON; MORTON, 2007).

5.5.1.7 Retorno Motor de Membros Inferiores (Escala de Fugl-Meyer)

A escala de Fugl-Meyer (subitens motores para membros inferiores) foi utilizada para avaliar o estágio de retorno motor dos membros inferiores (FUGL-MEYER *et al*., 1975). A subescala para membros inferiores pontua um total de 34 pontos, sendo que maiores valores correspondem um melhor grau de retorno motor. O retorno motor pode ser classificado em severo (pontuação inferior a 17), moderadamente severo (entre 18 e 22), moderado (entre 23 e 28) e leve (superior a 29) (DUTIL *et al*., 1989). A escala possui propriedades de medida adequadas para hemiparéticos brasileiros (MICHAELSEN *et al*., 2011).

5.6 Procedimentos

O estudo foi conduzido em dois dias distintos (Diagrama 1): o primeiro, onde inicialmente os indivíduos foram esclarecidos sobre os objetivos do estudo e convidados a assinar o termo de consentimento livre e esclarecido previamente aprovado pelo comitê de ética em pesquisa da UFMG e Prefeitura Municipal de Belo Horizonte. Os indivíduos foram solicitados, por telefone, a comparecerem para a coleta com uma roupa confortável e calçado habitual, continuar tomando os medicamentos rotineiros e não ingerir alimentos ou bebidas que contivessem estimulantes, tais como chocolate, café e chá preto. Todas as coletas, em ambos os dias, foram realizadas no período da tarde.

Os indivíduos, no primeiro dia, foram submetidos à avaliação inicial para a identificação, caracterização por meio da aplicação dos instrumentos, coleta de dados clínicos e verificação dos critérios de inclusão e de exclusão, por pesquisadores previamente treinados. Adicionalmente, os indivíduos tiveram seu consumo basal de oxigênio avaliado nas posições sentada e deitada, além da realização do teste de marcha de 10 metros e TC6min. Adicionalmente, os indivíduos realizaram o TC6min associado à coleta dos gases expirados. No segundo dia, por sua vez, o indivíduo foi submetido à coleta dos gases expirados durante as demais condições experimentais.

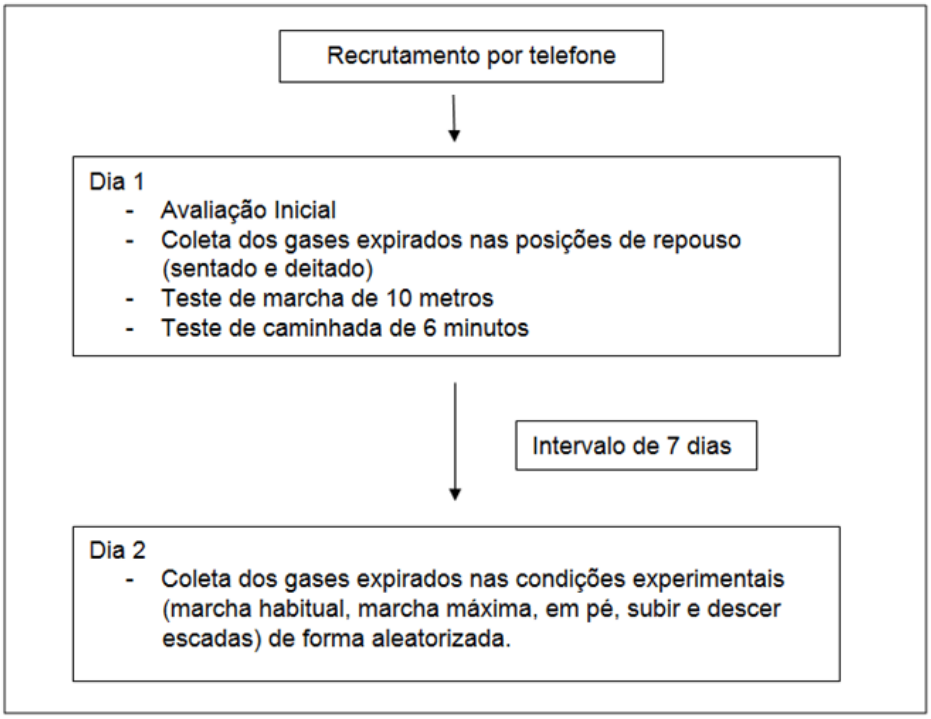

Diagrama 1. Fluxograma da coleta de dados.

5.6.1 Condições experimentais

O consumo de oxigênio foi coletado durante o repouso e durante a realização das atividades listadas a seguir, as quais foram selecionadas por estar no escopo daquelas atividades básicas e necessárias para a autonomia dos indivíduos. A coleta foi realizada após a calibração do equipamento, durante as seguintes atividades funcionais:

- Sentado: O indivíduo foi solicitado a sentar em uma cadeira padronizada com encosto e sem apoio para os braços (Figura 3). O indivíduo recebeu as seguintes instruções previamente à coleta: “você deverá permanecer sentando durante 10 minutos, com os braços apoiados no colo e os pés apoiados no chão. Tente realizar o mínimo de movimentos possível. Se você sentir qualquer desconforto, levante o braço que iremos parar o teste. A partir deste momento, você não pode mais falar”. Não foi permitido também, que o indivíduo dormisse durante a realização do teste.

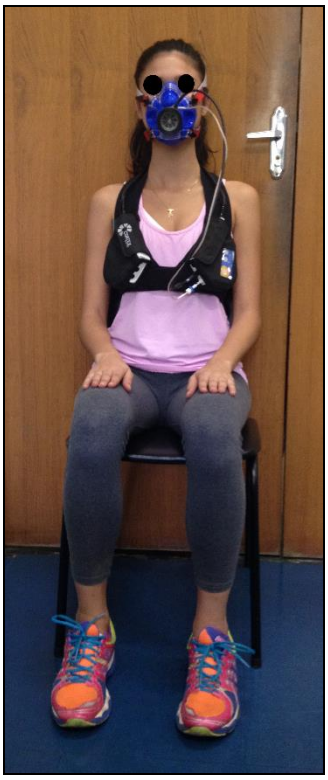

Figura 3. Posicionamento para realização da condição experimental sentado.
Fonte: Arquivos da autora.

- Deitado: O indivíduo foi solicitado a deitar em uma maca, em supino, com os braços estendidos ao lado do corpo, coluna cervical em neutro e membros inferiores alinhados. O indivíduo recebeu a seguinte instrução previamente à coleta: “você deverá permanecer deitado durante 10 minutos. Tente realizar o mínimo de movimentos possível. Se você sentir qualquer desconforto, levante o braço que iremos parar o teste. A partir deste momento, você não pode mais falar”. Nesta condição experimental, também não foi permitido que o indivíduo dormisse.
- Em pé: o indivíduo permaneceu na posição em pé durante cinco minutos jogando o jogo “resta um”, com o braço apoiado em uma mesa com a altura ajustada na linha mamilar, a fim de minimizar movimentos de grande amplitude de membros superiores, o que poderia influenciar nos dados obtidos (Figura 4). A escolha da realização do jogo “resta um” justificou-se pelo fato de que a posição em pé cotidianamente é acompanhada por alguma atividade de membros superiores. Foi dada a seguinte instrução ao indivíduo previamente à coleta: “você deverá permanecer durante cinco minutos nesta posição jogando

resta um. Tente realizar o mínimo de movimentos com o seu corpo, movimente somente com os braços. Se você sentir qualquer desconforto, levante o braço que iremos parar o teste. A partir deste momento, você não pode mais falar".

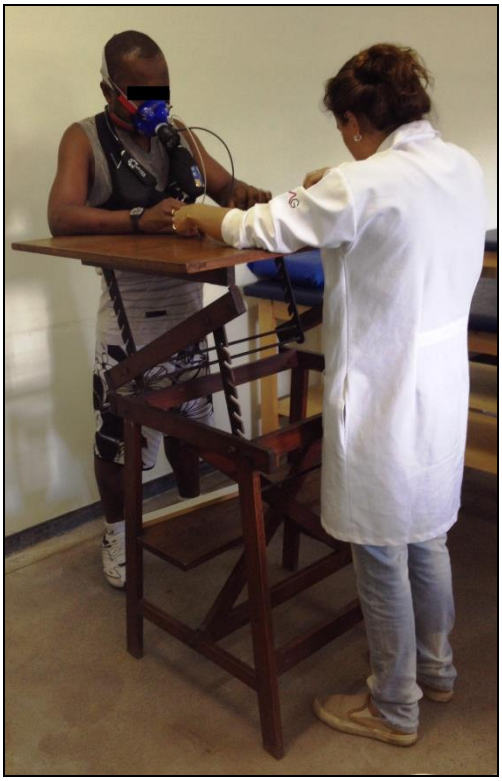

Figura 4. Posicionamento para realização da condição experimental em pé.
Fonte: Arquivos da autora.

- Marcha habitual: o indivíduo foi solicitado a deambular em um corredor plano em uma velocidade habitual durante cinco minutos em um trajeto de 10 metros (Figura 5), demarcados por dois cones alinhados entre si. Os indivíduos receberam o seguinte comando verbal: "caminhe até o cone e retorne com a sua velocidade de marcha normal e confortável durante cinco minutos. Se você sentir qualquer desconforto, levante o braço que iremos parar o teste. A partir deste momento, você não pode mais falar". O número de voltas foi registrado para posterior cálculo da velocidade.
- Marcha rápida: o indivíduo foi solicitado a deambular em um corredor plano em uma velocidade rápida durante cinco minutos em um trajeto de 10 metros (Figura 5), demarcados por dois cones alinhados entre si. Os indivíduos receberam o seguinte comando verbal: "caminhe o mais rápido que puder com

segurança e sem correr até o cone, como se você fosse perder um ônibus e tivesse que alcançá-lo durante cinco minutos (Nascimento et al., 2012). Se você sentir qualquer desconforto, levante o braço que iremos parar o teste. A partir deste momento, você não pode mais falar". O número de voltas foi registrado para posterior cálculo da velocidade.

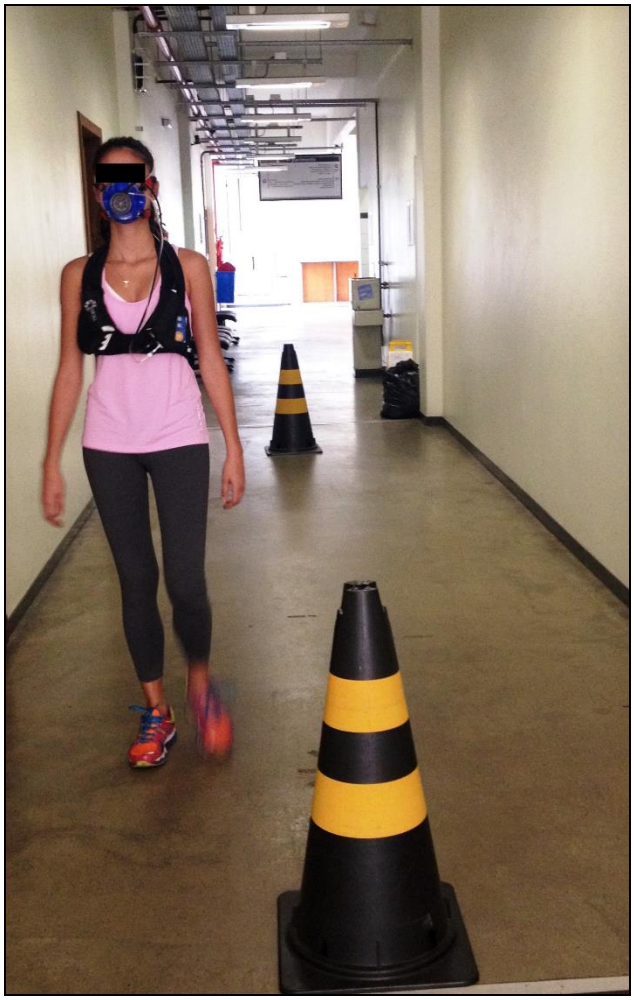

Figura 5. Posicionamento para realização das condições experimentais marcha habitual e marcha rápida. Fonte: Arquivos da autora.

- Subir e descer escadas: os indivíduos foram orientados a subir e descer um lance de escadas com 11 degraus com altura de 18 cm cada durante cinco minutos. Todos os indivíduos foram orientados a utilizar o corrimão, tanto durante a subida, quanto durante a descida (Figura 6). Eles receberam o seguinte comando verbal: "você deve subir e descer este lance de escadas durante cinco minutos da forma que você preferir. Você deve utilizar o corrimão

com ajuda do seu braço mais forte tanto na subida quanto na descida. Se você sentir qualquer desconforto, levante o braço que iremos parar o teste. A partir deste momento, você não pode mais falar". O número de degraus foi registrado para posterior cálculo da velocidade.

Figura 6. Posicionamento para realização da condição experimental subir e descer escadas. Fonte: Arquivos da autora.

A ordem da realização das atividades se deu de forma aleatorizada por meio de sorteio prévio de sequências de números geradas pelo programa *Microsoft Excel*. Para garantir que todos os indivíduos estavam hidratados, os mesmos ingeriram pelo menos 500ml de água potável previamente a coleta dos gases em ambos os dias de coleta. Os indivíduos tiveram a saturação periférica de oxigênio (SpO_2) mensurada por meio de um oxímetro de pulso com sensor de dedo e sua percepção subjetiva da intensidade do esforço por meio da Escala Categórica de Borg Modificada (AMERICAN COLLEGE OF SPORTS MEDICINE, 2003) no início e término de todas as atividades. A frequência cardíaca (FC) foi obtida *online* durante todos os testes por meio de um monitor de FC (Vantage XL, Polar, Finlândia) com registro a cada cinco

segundos (captado pelo próprio software do Metamax 3B). A temperatura e umidade do ambiente foram registradas em todos os dias de coleta. Todos os indivíduos tiveram um período de descanso entre as atividades até que a FC e a SpO_2 retornassem aos valores de repouso (VELLOSO *et al*., 2003).

5.7. Resultados

5.7.1 Recrutamento

De uma lista inicial de 169 indivíduos com diagnóstico de AVE, 27 não atenderam aos critérios de inclusão. Os 142 restantes foram recrutados por telefone, sendo que não se conseguiu contato com 31 indivíduos e 56 se recusaram a participar do estudo. Daqueles que participaram do primeiro dia de avaliação, sete não compareceram para o segundo dia. Desta forma, 48 indivíduos foram recrutados e participaram dos dois dias de avaliação (Diagrama 2).

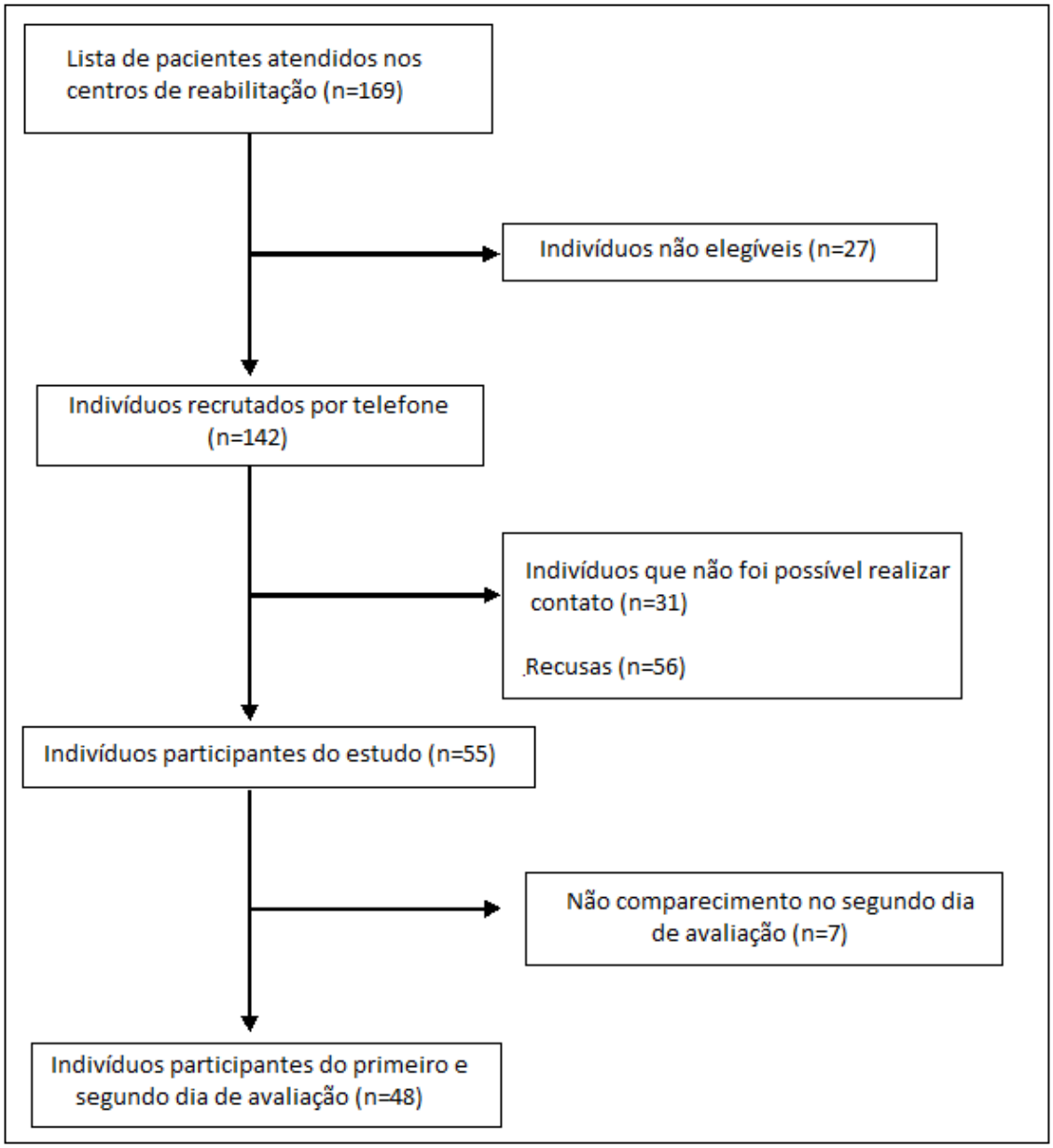

Diagrama 2. Fluxograma do recrutamento do estudo.

Os indivíduos que não foram elegíveis a participar do presente estudo foram excluídos devido às seguintes razões: 12 possuíam tempo pós-lesão superior a cinco anos, 12 possuíam o tempo pós-lesão inferior a 12 meses, dois faziam uso de cadeira de rodas e um não era capaz de falar e permanecer em pé devido a um novo episódio de AVE. Todas essas informações foram obtidas através do prontuário dos indivíduos nos centros de reabilitação aos quais eram acompanhados.

Já em relação às recusas, as razões principais apresentadas para a não participação podem ser observadas na Tabela 1.

Tabela 1. Razões principais apresentadas para a não participação no estudo.

Razões para a recusa	***n*= 56**
Desinteresse	20
Distância e transporte	14
Problemas de saúde	7
Não querer de sair da casa	6
Ocupado ou falta de tempo	5
Dificuldade em caminhar ou subir escadas	2
Mudou de endereço	1
Trabalho	1

5.7.2 Características dos participantes

Dos 55 participantes, a média de idade foi de 58,8±13,5 anos; 39% eram homens, com índice de massa corpórea de 26±5. A maioria (93%) tinha sofrido o episódio de AVE isquêmico, com média de tempo de evolução pós-AVE de 25,5±13,9 meses. Grande parte dos indivíduos considerou possuir uma saúde razoável (40%) e boa (34%). Todos utilizavam algum medicamento de uso contínuo e apresentavam doenças associadas, entre elas hipertensão arterial sistêmica, diabetes mellitus, hipercolesterolemia, dentre outras. A maioria dos indivíduos utilizava medicamentos betabloqueadores (89%). Poucos indivíduos (24%) reportaram praticar algum tipo de atividade física. Cerca de um terço dos participantes (33%) utilizavam algum tipo de dispositivo auxiliar, sendo bengalas ou muletas canadenses.

A média observada no Mini Exame do Estado Mental foi de 25,3±2,9. As velocidades habitual e máxima apresentadas foram de 0,84±0,3m/s e 1,21±0,5m/s, respectivamente. Os indivíduos percorreram, em média, 332±129m no teste de caminhada de seis minutos. A média no índice de Barthel observado foi de 18±2 pontos; cerca de metade da amostra (51%) foi considerada moderadamente ativa. A pontuação média na escala Fugl-Meyer- membros inferiores foi de 23±6 pontos.
Tabela 2. Características dos participantes (n=55).

Característica		*n*=55
Idade (anos), média±DP, (min-max)		58,8 ±13,5 (30-84)
Sexo, masculino, n (%)		33 (39)
Tipo de AVE, Isquêmico, n (%)		51 (93)
Tempo pós-lesão (meses) média±DP, (min-max)		25,5 ±13,9 (12-60)
Uso de medicamentos (número), média±DP, (min-max)		5±3
Uso de Betabloqueadores, sim, n (%)		49 (89)
IMC (kg/m^2), média±DP		26±5
Doenças associadas (número), média±DP		2±1
Prática de atividade física, sim, n (%)		13 (24)
Uso de dispositivo auxiliar, sim, n (%)		18 (33)
MEEM (pontuação: 0-30), média±DP		25,3±2,9
Fugl-Meyer (pontuação: 0-34), média±DP		23±6
Teste de caminhada de seis minutos (m), média±DP		332±129
Índice de Barthel (pontuação: 0-20), média±DP		18±2
Percepção de saúde, n (%)	Excelente	2 (4)
	Muito boa	6 (11)
	Boa	19 (34)
	Razoável	22 (40)
	Ruim	7 (11)
Perfil de Atividade Humana (pontuação: 0-94), média±DP		71±10
Escore Ajustado de Atividade, n (%)	Inativo	22 (40)
	Moderadamente ativo	28 (51)
	Ativo	5 (9)
Velocidade de marcha em 10 metros (m/s), média±DP	Habitual	0,84±0,3
	Máxima	1,21±0,5
Força dos extensores do joelho (Nm), média±DP	Lado parético	9,7±4,1
	Lado não parético	11,3±4,0
Força dos dorsiflexores de tornozelo (Nm), média±DP	Lado parético	7,1±2,9
	Lado não parético	8,2±2,8
Tônus dos extensores do joelho (escala modificada de Asworth), n (%)	0	20 (36)
	1	16 (29)
	1+	11 (20)
	2	2 (4)
	3	6 (11)
	4	0

DP= desvio padrão; IMC=Índice de massa corpórea; MEEM = Mini exame do estado mental.

5.7.3 ARTIGO 4

ENERGY COST OF WALKING IS PREDICTED BY THE LEVEL OF DISABILITY IN AMBULATORY INDIVIDUALS WITH CHRONIC STROKE

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Tables: 4
Figures: 1
Key words: Walking, Energy Metabolism, Rehabilitation, Stroke.
Word Count: 245 abstract
2,672 text

POLESE, J. C.; ADA, L; TEIXEIRA-SALMELA, L. F. Energy cost of walking is predicted by the level of disability in ambulatory individuals with chronic stroke. Artigo a ser submetido à **Stroke.**

ABSTRACT

Background and Purpose: We know that individuals with stroke use more energy than healthy individuals for the same activity and that this increase with level of disability. The purpose of this study was to produce a prediction equation of energy cost during walking activities in individuals with chronic stroke according to level of disability. **Methods:** This observational study investigated the energy cost of walking activities in 55 ambulatory individuals living in the community after stroke. The predictor was the level of disability measured by 10-meter Walking Test (10MWT). The outcome of interest was the energy cost during overground walking (comfortable and fast speed) and stair walking. Energy cost was calculated from energy expenditure (measured using a portable monitoring system [Metamax 3B - Cortex, Germany]) divided by distance covered during the walking activities. **Results**: One quadratic model accounted for 81% (95% CI 74 to 88) of the variance in energy cost during overground (comfortable and fast speeds) and stair walking. Energy cost was predicted by the following equation:

Energy cost $(ml \cdot kg^{-1} \cdot m^{-1})$ = 0.95

– 1.28 x disability (*m/s*)

+ 0.47 x disability ^{2} (*m/s*)

+ 0.91 x walking activity (overground = 0; stairs = 1).

Conclusion: This study found that the energy cost of overground and stair walking was predicted by the level of disability in individuals with chronic stroke. A prediction equation allows clinicians to target those individuals who end up with an unacceptably high energy cost of walking and make alternative arrangements for independent mobility.

INTRODUCTION

Measuring energy expenditure is a way to gain insight into the intensity of physical activity. Energy expenditure is commonly ascertained from activity monitors that contain accelerometers or mechanical devices that measure walking speed from which energy expenditure is estimated from equations. However, there are almost 30 equations that estimate energy expenditure from accelerometer outputs in healthy individuals.[1,2] Furthermore, these equations produce widely different values,[3] suggesting that the findings regarding the relationship between energy expenditure and intensity of activity are not robust. For example, in healthy individuals, it is assumed that there is a linear relationship between an increase in walking speed and the resulting increase in energy expenditure.[4-6] However, even the assumption of a linear relationship between speed and energy expenditure has been questioned.[7]

Physical inactivity is common after stroke.[8-10] Individuals after stroke use more energy for the same activity as healthy individuals,[11] suggesting that a lower level of physical activity may not render them as vulnerable to the risks of inactivity as healthy individuals. In contrast to this finding, inactivity is the major risk factor for a new episode of stroke.[12] It is therefore important to be able to understand energy expenditure in individuals after stroke. In addition, it should not be assumed that the energy cost of walking slowly in healthy individuals is the same as in the slow walking that is the result of a stroke. We know that a healthy individual walking very slowly will use more energy than walking at their preferred speed but not as much as an individual walking slowly after stroke.[13] Individuals after stroke are walking slowly not from choice, but from the motor impairments resulting from their stroke. These motor impairments, in turn, make walking inefficient, ie, more energy is expended than if a healthy individual walked at the same speed. Furthermore, there is evidence that individuals with stroke do

not walk at optimal efficiency.[14,15] Thus, equations predicting energy expenditure in healthy individuals are not likely to be applicable to this population.

It is not possible to investigate individuals after stroke walking at a range of speeds since after stroke, if an individual walks at a slow speed, it is unlikely that he can walk much faster, although they are likely to be able to walk slower. Therefore, in order to be able to compare the intensity of activity across individuals with differing levels of disability after stroke, it is necessary to examine the oxygen consumption in terms of the amount of energy used to perform an activity, i.e., the energy cost. Therefore, the aim of this study was to produce equations that predicted energy cost during walking activities, such as overground walking and stair walking, according to level of disability in individuals living with stroke.

A non-linear relationship between level of disability and energy cost of walking has been found previously in small groups (n = 13-20) of severely disabled (walking speed = 0.40-0.48 *m/s*) of individuals after stroke.[13,16] In the present study, we aimed to collect a large sample of individuals with stroke with widely varying levels of disability in order to have enough power to produce robust findings. We chose to represent level of disability as comfortable walking speed since it has been shown to be related to community ambulation and participation.[17,18] The development of equations that predict energy cost according to level of disability will enable the clinicians to determine when energy cost is unacceptably high or low and to then provide targeted intervention.

METHOD

Design

An observational study investigating the effect of level of disability on energy cost during walking activities after stroke was conducted. Individuals with stroke who

could walk were recruited from outpatient clinics in a metropolitan city in Brazil. Data were collected over two days, seven days apart at a university laboratory. On the first day, they were screened for eligibility, informed consent was gained and information to describe the participants was collected. On the second day, oxygen consumption was measured using a portable monitoring system, at rest and during walking activities: comfortable speed, fast speed, and stair ascent/descent, in a random order. Rest intervals were provided between the activities until the heart rate returned to the basal levels. At least 500 ml of water was provided prior to data collection to guarantee normal hydration, and participants were instructed to avoid stimulants, such as coffee, black tea, or chocolate on the day of data collection. Participants were asked to keep to their normal routine, including taking their medications, and all measurements were performed at the same time of the day (in the evening). This study was approved by the Universidade Federal de Minas Gerais Research Review Board and all participants provided written consent prior to data collection.

Participants

Individuals with chronic stroke were included if they were ≥ 20 years old, were between one and five years since the onset of stroke, and were able to walk without walking aids. They were excluded if they had cognitive impairments, as determined by the Mini-Mental State Examination cut-off scores[19] and other neurological or orthopaedic disorders. Information such as age, gender, body mass index, paretic side, type of stroke (ischaemic or haemorrhagic), time since the onset of stroke, medications and β-blockers taken, associated conditions, cognition (MMSE), independence (Barthel Index), walking distance (6MWT) were collected to describe the participants. Oxygen

consumption at rest (lying and sitting) was collected to check the basal metabolic rate of the participants.

Measurement of the predictor and outcome of interest

The predictor was the level of disability, measured by the 10-m Walk Test.[17,18,20] Participants performed the test once in their usual shoes at their comfortable speed that was recorded in m/s.

The outcome of interest was energy cost during walking activities (comfortable speed, fast speed, and stairs). Participants wore a portable monitoring system (Metamax 3B - Cortex, Germany) while they walked a 10-m course back and forth, and ascended/descended a flight of stairs with 11 steps (18 cm high). For the comfortable walking speed, they received the following standardized verbal command: "walk at your normal and comfortable pace" and for the fast speed: "walk as fast as possible and safely, but without running, as if to reach a bus that is about to pull out".[21] For the stairs, they were asked to ascend and descend a flight of stairs holding the handrail with their non-paretic arm. Each walking activity was performed for 5 min and the last 2 min (steady state condition) were used for analysis.[22] The Metamax returned speed in *m/s* during overground walking, *stairs/s* during stair walking, and relative oxygen consumption in $ml \cdot kg^{-1} \cdot min^{-1}$. In order to be able to compare energy expenditure across participants, it was converted to energy cost by dividing by the distance covered in metres and reported as $ml \cdot kg^{-1}\ m^{-1}$. For stair walking, the distance covered was calculated using the hypotenuse of the stair height and depth.

Data analysis

The characteristics of the participants are presented as mean (SD) or number

(%). The relative oxygen consumption obtained during sitting and lying positions was compared with the values predicted for healthy individuals for lying and sitting.[23]

Linear regression analysis was used to examine if the level of disability predicted energy cost during walking activities. Given that the participants were the same in all three walking activities, a sandwich estimator was used to account for clustering. A likelihood ratio test revealed that a quadratic term improved the regression model ($p<0.01$). One prediction equation was developed from the coefficients (B) for all three walking activities. Bootstrap resampling (x 1000 replications) was used to obtain a 95% CI for R^2. Mean absolute and root mean square prediction errors were generated.

RESULTS

Flow of participants through the study

Fifty-five individuals with stroke (33 men), with a mean age of 59 (SD 14) years, a mean time since the onset of stroke of 25 (SD 14) months participated. Approximately half were right hemiplegic and most were ischemic. All participants were taking oral medications, primarily anti-hypertensive drugs, and were largely independent (18/20 on the Barthel Index). The walking distance over 6 min was 332 m (SD 129). Five individuals were not able to perform the fast walking speed test with the portable monitoring system. The characteristics of the participants are summarized in Table I.

Energy expenditure measured at rest (during lying and sitting) and predicted by Harris and Benedict (1919) is presented in Table II. Energy expenditure in lying was 8% higher than that predicted for healthy individuals of the same gender, height and weight, and 3% higher in sitting.

Prediction of energy cost for walking activities from level of disability

The level of disability, defined as comfortable walking speed during a 10MWT with usual shoes, was 0.84 m/s (SD 0.30, range 0.17 to 1.50).

The outcome of interest (energy cost derived from energy expenditure) is presented in Table III. The mean energy cost of overground walking was very similar whether the walking was at comfortable speed (0.24 [SD 0.11] $ml \cdot kg^{-1} \cdot m^{-1}$at 0.70 *m/s*) or fast speed (0.24 [SD 0.10] $ml \cdot kg^{-1} \cdot m^{-1}$at 0.85 *m/s*). The mean energy cost of stair walking was higher (1.13 [SD 0.43] $ml \cdot kg^{-1} \cdot m^{-1}$at 0.68 *stairs/s*). It should be noted that participants walked slower with the portable monitoring system attached than when unencumbered for both comfortable (0.84 versus 0.70 *m/s*) and fast (1.21 versus 0.84 *m/s*) walking speeds.

Level of disability predicted the energy cost of all three walking activities, accounting for 81% of the variance in energy cost. The coefficient (B) for fast speed was small (mean 0.001, 95% CI -0.005 to 0.008). The likelihood ratio test showed that the coefficient for the fast walking speed did not contribute to the model and that a quadratic term improved the model ($p<0.01$). Therefore, one prediction equation was developed from the coefficients for all three walking activities. The regression coefficients of the predictors, prediction equation from the linear regression analysis and accuracy of the prediction of the energy cost during walking activities are presented in Table IV. Energy cost is predicted by the following equation:

Energy cost $(ml \cdot kg^{-1} \cdot m^{-1})$ = 0.95

– 1.28 x disability (*m/s*)

+ 0.47 x disability ^{2} (*m/s*)

+ 0.91 x walking activity (overground = 0; stairs = 1).

Plots of energy cost according to the level of disability for overground walking

(comfortable and fast speeds) and stair walking are presented in Figure 1. The curves are non-linear with similar shapes but different magnitudes for overground and stairs.

DISCUSSION

This study found that the energy cost of walking activities was predicted by the level of disability in individuals with chronic stroke. The more disabled the individual, the higher the energy cost for the same activity. The relation between level of disability and energy cost was non-linear and similar for both overground and stair walking, with energy cost rising exponentially as disability level increased. A prediction equation shows level of disability explaining over eighty percent of the variance in energy cost.

Oxygen consumption at rest (both lying and sitting) was collected to check the basal metabolic rate of the individuals with chronic stroke. When compared with predicted oxygen consumption in healthy individuals of the same gender, height and weight, it was very similar, only 3-8 % higher. These findings are in line with those reported for individuals at the acute and sub-acute stages of stroke.[24] That is, neither acute nor chronic stroke demonstrate hyper-metabolism. This suggests that the higher energy cost of overground and stair walking is attributable to the motor impairments resulting from the stroke, rather than any change in physiological function. In turn, this explains why the more disabled the individual, the higher the energy cost of walking.

The advantage of converting oxygen consumption into energy cost is that it allows comparison between various levels of disability and different types of walking. The findings of the present study are in line with three previous studies that investigated the energy cost of overground comfortable walking in small groups of chronic stroke individuals with similar levels of disability (walking speed ranging from 0.81-0.84 *m/s*).[25-27] The energy cost previously reported is similar our findings (0.20–0.24 $ml \cdot kg^{-}$

$^{1}\cdot m^{-1}$). Only one study has previously investigated the energy cost of overground fast walking,[26] and found a similar energy cost of the present study (0.26 versus 0.24 $ml\cdot kg^{-1}\cdot m^{-1}$). Only one study has previously investigated the energy cost of stair walking[28] and reported the mechanical efficiency as 100 kJ. However, the authors took into consideration the resting metabolic rate and external work to calculate the mechanical efficiency.

The findings of the present study provide important implications for rehabilitation research and clinical practice. First, activity monitors cannot be used to accurately predict energy cost in disabled individuals after stroke. The most common algorithms used to predict energy cost are based upon the assumption that energy expenditure increases linearly with an increase in intensity of the activity.[29,30] However, even for healthy individuals, it has been suggested that this linear relationship is not a correct assumption.[31] We found a non-linear relationship between level of disability and energy cost of walking and this relationship has been found previously in small groups of severely disabled individuals.[13,16] In addition, it should not be assumed that the energy cost of walking slowly in healthy individuals is the same as the slow walking that is the result of a stroke. We know that a healthy individual walking very slowly will use more energy than walking at their preferred speed but not as much as an individual after stroke.[13] It therefore appears important to develop conversion factors that take into account level of disability that can be applied to produce accurate values of energy cost that has been collected from activity monitors attached to individuals after stroke.

Second, the energy cost of walking in very disabled individuals with stroke is unacceptably high. The Compendium of Physical Activities[32] provides estimation of energy cost in METS of hundreds of activities for healthy individuals. Even for elderly individuals, the energy cost is substantially higher than normal,[33] and this is increased

again for individuals with severe motor impairments after stroke. For example, an individual after stroke categorized as a community ambulator (defined by Perry et al.[17] as walking between 0.8-1.2 *m/s*) would have an energy cost of 0.14 $ml \cdot kg^{-1} \cdot m^{-1}$, that is similar to the normal energy cost of walking at a comfortable speed, whereas a household ambulator (defined as walking between 0.1-0.4 *m/s*[17]) would have over quadruple the energy cost at 0.66 $ml \cdot kg^{-1} \cdot m^{-1}$. This is unacceptably high and suggests that individuals with stroke who remain so disabled that they can only walk slowly should have other means of transport (such as scooters and disabled taxi schemes) available to them in order that they do not become housebound and socially isolated. On the other hand, the goal for individuals with sub-acute stroke undergoing rehabilitation should be to reach walking speeds that are at least indicative of community ambulation using evidence-based strategies such as cueing of cadence[34] and treadmill walking[35].

This study has both strengths and weaknesses. Its main strength is that it has a larger sample size (n = 55) than previous studies (n = 7-12), thereby increasing the power of the findings. Furthermore, the sample is normally distributed in terms of the predictor – level of disability (0.84 *m/s*, SD 0.30, range 0.17-1.50, Z = 0.77, p = 0.60). Finally, determining an equation that explains the data allows the prediction of the energy cost according to level of disability. The main weakness is that age-matched participants were not measured, and therefore comparison with "normal" behavior was not possible.

CONCLUSIONS

This study investigated the energy cost of walking activities in chronic ambulatory individuals after stroke. In contrast to the acute and sub-acute phase of rehabilitation that is directed at decreasing impairments such as weakness and loss of

coordination, the chronic phase of rehabilitation should target community reintegration and increasing physical activity. Thus, an equation that predicts energy cost of walking activities according to level of disability is useful, since it allows clinicians to target those individuals who end up with an unacceptably high energy cost of comfortable walking and make alternative arrangements for independent mobility.

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Ethics approval: The Universidade Federal de Minas Gerais and Secretaria da Saude de Belo Horizonte Ethical Committees approved this study. All participants provided written consent before data collection started.

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REFERENCES

1. Crouter SE, Churilla JR, Bassett DR Jr. Estimating energy expenditure using accelerometers. *Eur J Appl Physiol*. 2006;98(6):601–12.
2. Rothney MP, Schaefer EV, Neumann MM, Choi L, Chen KY. Validity of physical activity intensity predictions by ActiGraph, Actical, and RT3 accelerometers. *Obesity (Silver Spring).* 2008;16(8):1946–52.
3. Kozey SL, Lyden K, Howe CA, Staudenmayer JW, Freedson PS. Accelerometer output and MET values of common physical activities. *Med Sci Sports Exerc.* 2010;42(9):1776-84.
4. Shetty PS, Henry CJ, Black AE, Prentice AM. Energy requirements of adults: an update on basal metabolic rates (BMRs) and physical activity levels (PALs). *Eur J Clin Nutr.* 1996;50 Suppl 1:S11-23.
5. Goran MI. Estimating energy requirements: regression based prediction equations or multiples of resting metabolic rate. *Public Health Nutr.* 2005;8(7A):1184-6.
6. Vinken AG, Bathalon GP, Sawaya AL, Dallal GE, Tucker KL, Roberts SB. Equations for predicting the energy requirements of healthy adults aged 18-81 y. *Am J Clin Nutr.* 1999;69(5):920-6.
7. Pober DM, Staudenmayer J, Raphael C, Freedson PS. Development of novel techniques to classify physical activity mode using accelerometers. *Med Sci Sports Exerc*. 2006;38(9): 1626–34.
8. Alzahrani MA, Ada L, Dean CM. Duration of physical activity is normal but frequency is reduced after stroke: an observational study. *J Physiother*. 2011;57(1):47-51.

9. Billinger SA, Arena R, Bernhardt J, Eng JJ, Franklin BA, Johnson CM, et al. Physical activity and exercise recommendations for stroke survivors: a statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2014;45(8):2532-53.

10. Kunkel D, Fitton C, Burnett M, Ashburn A. Physical inactivity post-stroke: a 3-year longitudinal study. *Disabil Rehabil.* 2014 May 14:1-7. [Epub ahead of print]

11. Galea SL, Lee MJ, English C, Ada L. Sedentary versus active behavior in people after stroke. *Phys Ther Reviews.* 2014.

12. Go AS, Mozaffarian D, Roger VL, Benjamin EJ, Berry JD, Blaha MJ, et al. Heart disease and stroke statistics—2014 update: a report from the American Heart Association. *Circulation.* 2014;129(3):e28-e292.

13. Platts MM, Rafferty D, Paul L. Metabolic cost of over ground gait in younger stroke patients and healthy controls. *Med Sci Sports Exerc*. 2006;38(6):1041-6.

14. Olney SJ, Monga TN, Costigan PA. Mechanical energy of walking of stroke patients. *Arch Phys Med Rehabil*. 1986;67(2):92-8.

15. Stoquart G, Detrembleur C, Lejeune TM. The reasons why stroke patients expend so much energy to walk slowly. *Gait Posture.* 2012;36(3):409-13.

16. Zamparo P, Francescato MP, De Luca G, Lovati L, di Prampero PE. The energy cost of level walking in patients with hemiplegia. *Scand J Med Sci Sports*.1995;5(6):348-52.

17. Perry J, Garrett M, Gronley JK, Mulroy SJ. Classification of walking handicap in the stroke population. *Stroke*. 1995;26(6):982-9.

18. van de Port IG, Kwakkel G, Lindeman E. Community ambulation in patients with chronic stroke: how is it related to gait speed? *J Rehabil Med.* 2008;40(1):23-7.

19. Bertolucci PH, Brucki SMD, Campacci SR, Juliano Y. Suggestions for utilization of the mini-mental state examination in Brazil. *Arq. Neuropsiquiatr.* 1994;52:1-7. [article in Portuguese] .

20. Salbach NM, Mayo NF, Higgins J, Ahmed S, Finch LE, Richards CL. Responsiveness and predictability of gait speed and other disability measures in acute stroke. *Arch Phys Med Rehabil.* 2001;82(9):1204-12

21. Nascimento LR, Caetano LC, Freitas DC, Morais TM, Polese JC, Teixeira-Salmela LF. Different instructions during the ten-meter walking test determined significant increases in maximum gait speed in individuals with chronic hemiparesis. *Braz J Phys Ther*. 2012;16(2):122-7.

22. Wasserman K, Hansen JE, Sue DY, Stringer W, Whipp B. Clinical Exercise Testing. In: Weinberg A, ed. *Principles of Exercise Testing and Interpretation*, 4th edition. Philadelphia: Lippincott, Williams and Wilkins, 2005:133-159.

23. Harris JA, Benedict FG. *Biometric studies of basal metabolism in man*. Washington, DC: Carnegie Institute of Washington, 1919 (Publication Number 297).

24. Finestone HM, Greene-Finestone LS, Foley NC, Woodbury MG. Measuring longitudinally the metabolic demands of stroke patients: resting energy expenditure is not elevated. *Stroke.* 2003;34(2):502-7.

25. Carver T, Nadeau S, Leroux A. Relation between physical exertion and postural stability in hemiparetic participants secondary to stroke. *Gait Posture.* 2011;33(4):615-9.

26. Ganley KJ, Herman RM, Willis WT. Muscle metabolism during overground walking in persons with poststroke hemiparesis. *Top Stroke Rehabil.* 2008;15(3):218-26.

27. Kafri M, Myslinski MJ, Gade VK, Deutsch JE. High metabolic cost and low energy expenditure for typical motor activities among individuals in the chronic phase after stroke. *J Neurol Phys Ther.* 2014;38(4):226-32.

28. Harries N, Loeppky JA, Shaheen S, Al-Jarrah M, Molteni F, Hutzler Y, et al. A stair-climbing test for measuring mechanical efficiency of ambulation in adults with chronic stroke. *Disabil Rehabil*. 2014 [Epub ahead of print]

29. Waters RL, Lunsford BR, Perry J, Byrd R. Energy-speed relationship of walking: standard tables. *J Orthop Res.* 1988;6(2):215-22.

30. Freedson PS, Melanson E, Sirard J. Calibration of the Computer Science and Applications, Inc. accelerometer. *Med Sci Sports Exerc.* 1998;30(5):777–81.

31. Pober DM, Staudenmayer J, Raphael C, Freedson PS. Development of novel techniques to classify physical activity mode using accelerometers. *Med Sci Sports Exerc.* 2006;38(9): 1626–34.

32. Ainsworth BE, Haskell WL, Herrmann SD, Meckes N, Bassett DR Jr, Tudor-Locke C, et al. 2011 Compendium of Physical Activities: a second update of codes and MET values. *Med Sci Sports Exerc*. 2011;43(8):1575-81.

33. Knaggs JD, Larkin KA, Manini TM.Metabolic cost of daily activities and effect of mobility impairment in older adults. *J Am Geriatr Soc.* 2011;59(11):2118-23.

34. Nascimento LR, de Oliveira CQ, Ada L, Michaelsen SM, Teixeira-Salmela LF. Walking training with cueing of cadence improves walking speed and stride length after stroke more than walking training alone: a systematic review. *J Physiother*. 2015;61(1):10-5.

35. Polese JC, Ada L, Dean CM, Nascimento LR, Teixeira-Salmela LF. Treadmill training is effective for ambulatory adults with stroke: a systematic review. *J Physiother*. 2013;59(2):73-80.

Figure Legend

Figure 1. Energy cost of walking according to the level of disability: (A) overground walking (comfortable and fast speeds), (B) stair walking, and (C) overground and stair walking.

Table I. Characteristics of the participants

Characteristic	*n*=55
Age (*years*), mean (SD)	59 (14)
Gender, *n* male (%)	33 (60)
Body mass index (kg/m^2), mean (SD)	26 (5)
Paretic side, *n* right (%)	34 (62)
Type of stroke, *n* ischemic (%)	51 (93)
Time since the onset of stroke (*months*), mean (SD)	25 (14)
Medications taken (*number*), mean (SD)	5 (3)
Beta blockers taken, *n* yes (%)	49 (89)
Associated diseases (*number*), mean (SD)	2 (1)
Cognition (*MMSE score 0-30*), mean (SD)	25 (3)
Independence (*Barthel Index 0-20*), mean (SD)	18 (1)
Walking speed (*10MWT m/s*), mean (SD)	
Comfortable	0.84 (0.30)
Fast	1.21 (0.44)
Walking distance (*6MWT m*), mean (SD)	332 (129)

SD = standard deviation; 10MWT = 10-m Walk Test, 6MWT = six-min Walk Test; MMSE = Mini Mental State Examination

Table II. Mean (SD) energy expenditure (relative VO_2) measured at rest (lying and sitting) and predicted from Harris and Benedict (1919), mean difference (95% CI) between measured and predicted energy expenditure, and measured energy expenditure as a proportion (95% CI) of predicted energy expenditure.

Activity	Energy expenditure		Difference in energy expenditure	
	Measured	Predicted	Measured - predicted	Measured/predicted
Lying	3.1 (0.5) *ml·kg^{-1}·min^{-1}*			
	1511 (316) *kcal·day^{-1}*	1406 (207) *kcal·day^{-1}*	105 (42 to 167) *kcal·day^{-1}*	1.08 (1.03 to 1.12)
Sitting	3.0 (0.5) *ml·kg^{-1}·min^{-1}*			
	1456 (305) *kcal·day^{-1}*	1406 (207) *kcal·day^{-1}*	50 (-3 to 103) *kcal·day^{-1}*	1.03 (1.00 to 1.07)

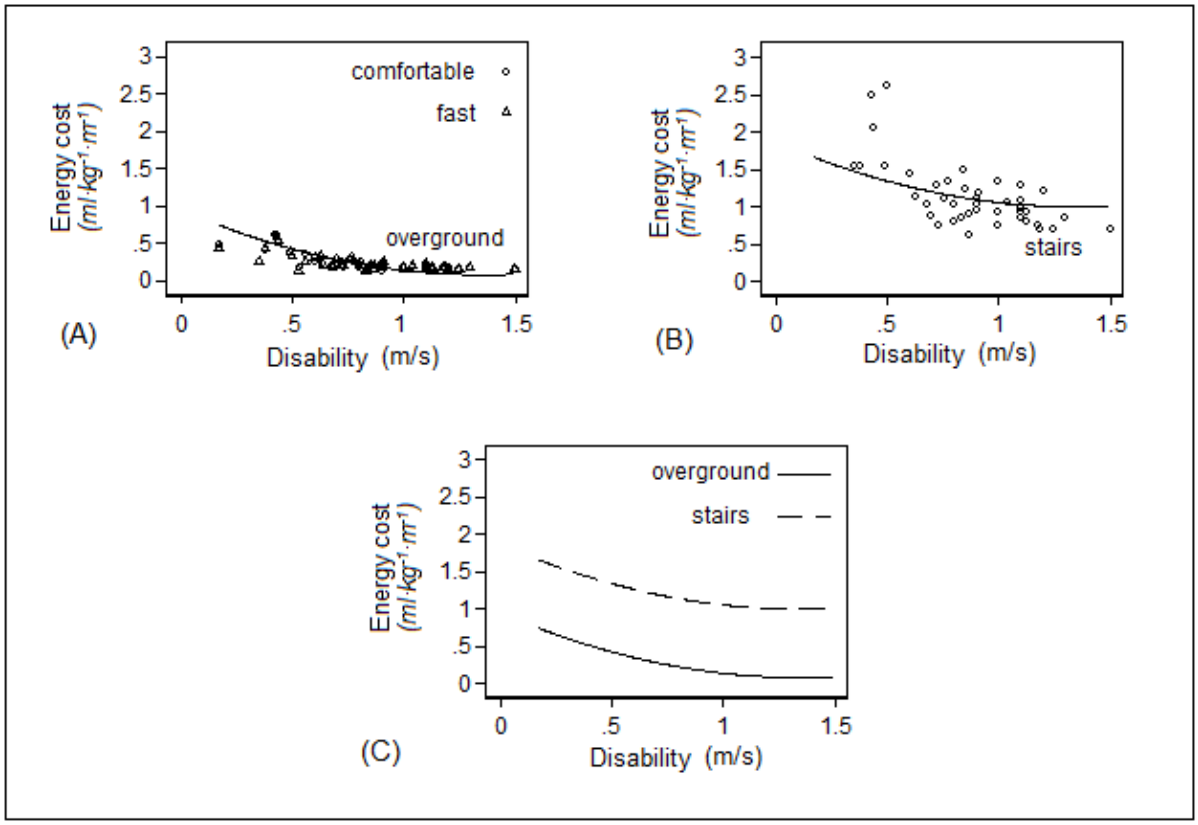
Table III. Mean (SD) energy expenditure and energy cost during walking.

Walking	Energy expenditure	Energy cost
Comfortable	8.9 (1.8) $ml \cdot kg^{-1} \cdot min^{-1}$	0.24 (0.11) $ml \cdot kg^{-1} \cdot m^{-1}$
0.70 m/s	2.5 (0.5) *METS*	5.02 (2.3) J $kg^{-1} \cdot m^{-1}$
Fast	11.1 (3.0) $ml \cdot kg^{-1} \cdot min^{-1}$	0.24 (0.10) $ml \cdot kg^{-1} \cdot m^{-1}$
0.85 m/s	3.2 (0.9) *METS*	5.02 (2.1) J $kg^{-1} \cdot m^{-1}$
Stairs	14.3 (4.0) $ml \cdot kg^{-1} \cdot min^{-1}$	1.13 (0.43) $ml \cdot kg^{-1} \cdot stair^{-1}$
0.68 stairs/s	4.1 (1.1) *METS*	23.64 (9.0) J $kg^{-1} \cdot m^{-1}$

Table IV. Mean (95% CI) regression coefficients of the predictors, prediction equation from the linear regression analysis and accuracy of the prediction of the energy cost (EC) during walking activities.

Regression coefficients of predictors
Constant = 0.95 (0.52 to 1.39)
Disability = -1.28 (-2.22 to -0.35)
Disability squared= 0.47 (0.00 to 0.95)
Walking activity (overground) = 0.00 (-0.01 to 0.01)
Walking activity (stairs) = 0.91 (0.80 to 1.03)
Prediction equation
EC $(ml \cdot kg^{-1} \cdot m^{-1})$ = 0.95 – 1.28 x disability (*m/s*) + 0.47 x disability ^{2} (*m/s*) + 0.91 x walking activity (overground = 0; stairs = 1)
Accuracy of the prediction equation
R^2 = 0.81 (0.74 to 0.88)
Mean absolute prediction error = 0.13 $ml \cdot kg^{-1} \cdot m^{-1}$
Root mean square prediction error = 0.21 $ml \cdot kg^{-1} \cdot m^{-1}$

Figure 1. Energy cost of walking activities according to the level of disability: (A) overground walking (comfortable and fast speeds), (B) stair walking, and (C) overground and stair walking.



Capítulo 6 – CONSIDERAÇÕES FINAIS

A presente tese de doutorado foi desenvolvida junto aos Programas de Pós Graduação em co-tutela entre a UFMG, Brasil e a USYDNEY, Austrália. O presente estudo se inseriu na proposta do Programa de Pós-Graduação em Ciências da Reabilitação (UFMG), que possui a estrutura conceitual do modelo biopsicossocial da CIF, como fundamentação e modelo teórico.

A escolha do objeto de estudo foi baseada no estado da arte observado atualmente na ciência para a população de indivíduos pós-AVE, onde a necessidade da pesquisa direcionada para os componentes relacionados à atividade física associados ao desempenho funcional, emerge fortemente. Desta forma, quatro estudos fizeram parte do corpo da presente tese, sendo que os três primeiros proporcionaram subsídios para desenvolvimento do raciocínio científico para a condução do quarto estudo, que foi considerado o estudo principal da tese.

4.1 Implicações dos achados dos estudos realizados

A partir dos estudos desenvolvidos, pôde-se observar achados relevantes que podem influenciar e direcionar as futuras pesquisas da área, fornecendo subsídios para a continuação do entendimento dos fatores relacionados à atividade física pós-AVE e endossando o corpo de conhecimento científico desta área.

Considerando que revisões sistemáticas têm como objetivo sumarizar a evidência, a fim de responder uma pergunta clínica relevante (MANCINI et al., 2014), o primeiro estudo desenvolvido proporciona subsídios aos clínicos para o uso do treino em esteira sem suporte parcial de peso para indivíduos pós-AVE deambuladores, quando o objetivo da intervenção for o aumento da velocidade de marcha e distância percorrida.

A partir do segundo estudo desenvolvido, sendo este o primeiro que investigou a intensidade e duração das sessões convencionais de fisioterapia em uma população de indivíduos pós-AVE no Brasil, pôde-se observar que os exercícios utilizados durante as sessões não proporcionam intensidade ou duração adequada para induzir estresses cardiorrespiratórios satisfatórios.

Apesar dos guias clínicos mais atuais enfatizarem a necessidade da implementação de condutas que proporcionem o aumento da aptidão cardiorrespiratória dessa população, observou-se que ainda há uma lacuna entre a prática clínica e os achados científicos da área.

Já o terceiro estudo, o primeiro a investigar a confiabilidade teste-reteste do ergoespirômetro portátil Cortex MetaMax 3B® para a mensuração de variáveis cardiorrespiratórias durante o teste de caminhada de 6 minutos em hemiparéticos crônicos, demonstrou que este é um instrumento que proporciona medidas confiáveis durante a realização deste teste para a população pós-AVE. Desta forma, o instrumento pode ser utilizado para a mensuração de variáveis cardiorrespiratórias em indivíduos pós-AVE.

O quarto estudo, por sua vez, demonstrou uma relação quadrática entre o nível funcional e o gasto energético de indivíduos pós-AVE durante atividades, tais como a marcha habitual e rápida e subir e descer escadas. Os resultados desse estudo permitiram a elaboração de equações de predição para o gasto energético de indivíduos pós-AVE, o que poderá auxiliar no entendimento dos componentes fisiológicos de indivíduos hemiparéticos. Os clínicos, poderão utilizar a equação de predição na prática clínica para determinar se um indivíduo possui um gasto energético extremamente alto durante atividades relacionadas à marcha. Assim, o clínico poderá lançar mão de estratégias alternativas que proporcionem o deslocamento dos indivíduos pós-AVE, até que o mesmo possua pré-requisitos suficientes para alcançar um nível funcional onde o gasto energético seja menor, e desta forma, garantir a marcha menos laboriosa.

4.2 Limitações dos estudos

Apesar de somente 29% dos contatos em potencial obtidos nos centros de reabilitação terem participado do terceiro estudo incluído na presente tese em ambos os dias de avaliação, observou-se um *power* adequado para os achados (>0,80). Desta forma, a grande perda dos indivíduos entre o primeiro contato no recrutamento e a avaliação não pôde ser considerada como uma limitação efetiva. Esta grande discrepância entre os indivíduos contatados e os que participaram da coleta de dados demonstra a realidade do recrutamento

para estudos transversais, onde a há uma dificuldade substancial em se alcançar amostras adequadas.

É importante ressaltar que os achados dos estudos incluídos na presente tese são especificamente direcionados a indivíduos pós-AVE deambuladores. Apesar de indivíduos com baixos níveis funcionais (velocidade habitual: 0,17m/s e distância percorrida no teste de caminhada de 6 minutos: 50m) terem sido incluídos nos estudos, cabe pontuar que somente aqueles com capacidade de deslocamento foram avaliados. Ou seja, somente os indivíduos com condições físicas mínimas param se deslocarem por meio de transporte público, subir rampas e degraus até os locais de avaliação, por exemplo, constituíram a amostra dos estudos incluídos. Desta forma, os achados do presente estudo não podem ser extrapolados para indivíduos com características funcionais diferentes daquela investigada.

Outra limitação a ser pontuada é aquela inerente aos desenhos de estudo que foram utilizados em alguns dos estudos desenvolvidos (observacionais), os quais não permitem a realização de conclusões direcionadas à causalidade. Todavia, visto a necessidade de estudos transversais para endossar o corpo de conhecimento da área, visto a situação em que o estado da arte se encontra, tal limitação se justifica.

4.3 Pesquisas futuras

A partir dos achados do segundo estudo desenvolvido, torna-se importante a investigação de meios de se incentivar a implementação dos achados científicos na prática clínica dos profissionais da reabilitação, bem como as barreiras encontradas pelos profissionais para a implementação das evidências científicas na prática. Estudos futuros que investiguem a viabilidade e eficácia de meios incentivadores da aplicação de achados científicos na prática, tais como palestras e mini cursos, são sugeridos. Além disso, estudos que investiguem fatores relacionados a não-implementação de condutas que provoquem estresse cardiorrespiratório são necessários, para que a atenção seja direcionada para tais fatores.

Uma vez determinada a confiabilidade teste-resteste do ergoespirômetro portátil Cortex MetaMax 3B®, são sugeridos estudos que investiguem as

variáveis cardiorrespiratórias de indivíduos pós-AVE durante a realização das outras atividades funcionais e laborais, para que o comportamento de tais variáveis possa ser compreendido e, assim, guiar as condutas e raciocínios clínicos durante o processo de reabilitação. Adicionalmente, é importante determinar o comportamento das variáveis cardiorrespiratórias em atividades predominantemente de membros superiores, a fim de compreender se os mecanismos relacionados ao não-uso estão relacionados ao gasto energético, por exemplo.

Além disso, estudos que comparem o gasto energético durante a realização de diversas atividades funcionais de hemiparéticos com indivíduos saudáveis são recomendados. Tais estudos indicariam as alterações em termos de consumo de oxigênio e outras variáveis provenientes do AVE. Por fim, estudos que procurem investigar a relação e diferentes interações entre os componentes físicos e funcionais com as variáveis cardiorrespiratórias são indicados, para que fatores potenciais de modificação e melhora possam ser identificados.

4 CONCLUSÕES

Os resultados observados nos estudos incluídos no corpo da presente tese permitem concluir, em indivíduos pós-AVE, o treino em esteira sem o suporte parcial de peso resulta em maior velocidade de marcha e distância percorrida quando comparada a nenhuma intervenção ou intervenção sem a prática de marcha em indivíduos deambuladores, sendo que tais benefícios se mantêm além do período de intervenção. Observou-se que não há diferenças em termos de aumento de velocidade e distância percorrida quando comparados o treino em esteira e o treino de marcha no solo, imediatamente após a intervenção. Adicionalmente, observou-se que as sessões de fisioterapia convencional não proporcionam intensidade e duração adequada para induzir suficiente estresse cardiorrespiratório. Observou-se que há confiabilidade teste-reteste do ergoespirômetro portátil Cortex MetaMax 3B® para mensuração de variáveis cardiorrespiratórias durante o teste de caminhada de 6 minutos em hemiparéticos crônicos. Finalmente, observou-se a existência de uma relação quadrática entre o nível funcional e o gasto energético de indivíduos pós-AVE durante atividades relacionadas à marcha, tais como a marcha habitual e rápida e subir e descer escadas, o que permitiu a elaboração de equações de predição para o gasto energético de indivíduos pós-AVE.

REFERÊNCIAS BIBLIOGRÁFICAS

ADA, L. *et al.* A treadmill and overground walking program improves walking in persons residing in the community after stroke: a placebo-controlled, randomized trial. **Archives of Physical Medicine and Rehabilitation**, v. 84, n. 10, p. 1486-91, 2003.

ADA, L.; DORSCH, S.; CANNING, C. G. Strengthening interventions increase strength and improve activity after stroke: a systematic review. **Australian Journal of Physiotherapy**, v.42, n. 4, p. 241-8, 2006.

ALZAHRANI, M. A.; ADA, L.; DEAN, C. M. Duration of physical activity is normal but frequency is reduced after stroke: an observational study. **Journal of Physiotherapy**, v. 57, n. 1, p. 47-51*,* 2011.

ATS COMMITTEE ON PROFICIENCY STANDARDS FOR CLINICAL PULMONARY FUNCTION LABORATORIES. ATS statement: guidelines for the six-minute walk test. **American Journal of Respiratory and Critical Care Medicine**, v. 166, n. 1, p. 111-7, 2002*.*

AMERICAN THORACIC SOCIETY AND AMERICAN COLLEGE OF CHEST PHYSICIANS. American Thoracic Society/American College of Chest Physicians statement of cardiopulmonary exercise testing. **American Journal *of* Respiratory *and* Critical Care Medicine**, v. 167, p. 211-77*,* 2003*.*

BERTOLUCCI, P. H. *et al.* Brucki SMD, Campacci SR, Juliano Y. Suggestions for utilization of the mini-mental state examination in Brazil. **Arquivos de Neuropsiquiatria**, v. 51, p. 1-7, 1994.

BILLINGER, S. A. *et al.* Reduced cardiorespiratory fitness after stroke: biological consequences and exercise-induced adaptations. **Stroke Research and Treatment,** v. 959120, 2012.

BILLINGER, S. A. *et al.* Physical activity and exercise recommendations for stroke survivors: a statement for healthcare professionals from the American Heart Association/American Stroke Association. **Stroke**, v. 45, n. 8, p. 2532-53, 2014.

BOYSEN, G.; KRARUP, L. H. Benefits of physical activity for stroke survivors. **Expert Review of Neurotherapeutics**, v. 9, n. 2, p. 147-9, 2009.

BRANDES, M.; VAN HEES, V. T.; HANNÖVER, V.; BRAGE, S. Estimating energy expenditure from raw accelerometry in three types of locomotion. **Medicine & Science in Sports & Exercise**, v. 44, n. 11, p.2235-42, 2012.

BRITTO, R. R.; SOUZA, L. A. P. Six minute walk test: A Brazilian Standardization. **Fisioterapia em Movimento**, v. 18, n. 4, p. 49-54, 2006.

BRITTO, R. R. *et al*. Reference equations for the six-minute walk distance based on a Brazilian multicenter study. **Brazilian Journal of Physical Therapy**, v. 17, n. 6, p. 556-563, 2013.

BOHANNON, R. W.; ANDREWS, A. W.; SMITH, M. B. Rehabilitation goals of patients with hemiplegia. **International Journal of Rehabilitation Research**, v. 11, n. 2, p. 181-3, 1988.

BOHANNON, R. W. Muscle strength and muscle training after stroke. **Journal of Rehabilitation Medicine**, v. 39, n. 1, p. 14-20*,* 2007.

BOHANNON, R. W. Reference values for extremity muscle strength obtained by hand-held dynamometry from adults aged 20 to 79 years. **Archives of Physical Medicine and Rehabilitation**, v. 78, n. 1, p. 26-32, 1997.

BOHANNON, R. W.; SMITH, M. B. Interrater reliability of a modified Ashworth scale of muscle spasticity. **Physical Therapy**, v. 67, n. 2, p. 206- 207, 1987.

CASPERSEN, C. J.; POWELL, K. E.; CHRISTENSON, G. M. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. **Public Health Reports**, v. 100, n. 2, p. 126-31, 1985.

COHEN, J. A power primer. **Psychological Bulletin**, v. 112, p. 155-9, 1992.

CUNHA-FILHO, I. T. *et al*. Reliability of measures of gait performance and oxygen consumption with stroke survivors. **Journal of Rehabilitation Research and Development**, v. 40, n. 1, p. 19-26, 2003.

DAVIDSON, M.; MORTON, N. A systematic review of the Human Activity Profile. **Clinical Rehabilitation**, v. 21, n. 2, p. 151-62, 2007.

DI NUBILA, H. B. V. Uma introdução à CIF – Classificação Internacional de Funcionalidade, Incapacidade e Saúde. **Revista Brasileira de Saúde Ocupacional**, v. 35, n. 121, p. 122-123, 2010.

DIENER, J. R. C. Calorimetria indireta. **Revista da Associação Médica Brasileira**, v. 43, n. 3, p. 245-253, 1997.

DORSCH, S. *et al.* The strength of the ankle dorsiflexors has a significant contribution to walking speed in people who can walk independently after stroke: an observational study. **Archives of Physical Medicine and Rehabilitation**, v. 93, n. 6, p. 1072-6*,* 2012.

DUFFY, L. *et al.* Reliability (inter-rater agreement) of the Barthel Index for assessment of stroke survivors: systematic review and meta-analysis. **Stroke**, v. 44, n. 2, p. 462-8, 2013.

DUTIL, E. *et al.* **Protocole d'évaluation de la fonction sensori-motrice: Test de Fugl-Meyer.** Montreal, Canada: La librairie de l'Université de Montréal; 1989.

FARIA, C. D. *et al.* Performance-based tests in subjects with stroke: outcome scores, reliability and measurement errors. **Clinical Rehabilitation**, v. 26, n. 5, p. 460-9, 2012.

FEIGIN, V. L.; LAWES, C. M. M.; BENNETT, D. A.; ANDERSON, C. S. Stroke epidemiology: a review of population-based studies of incidence, prevalence, and case-fatality in the late 20th century. **Lancet Neurology**, v. 2, n. 1, p. 43-53, 2003

FINESTONE, H. M. *et al.* Measuring longitudinally the metabolic demands of stroke patients: resting energy expenditure is not elevated. **Stroke**, v. 34, n. 2, p. 502-7, 2003.

FURIE, K. L. *et al*. Guidelines for the prevention of stroke in patients with stroke or transient ischemic attack: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. **Stroke**, v. 42, p. 227-276, 2011.

FUGL-MEYER, A. R. *et al.* The post-stroke hemiplegic patient. A method for evaluation of physical performance. **Scandinavian Journal of Rehabilitation Medicine**, v. 7, n. 1, p. 13-31, 1975.

FULK, G. D., e*t al.* Clinometric properties of the six-minute walk test in individuals undergoing rehabilitation poststroke. **Physiotherapy Theory and Practice**, v. 24, n. 3, p. 195-204, 2008.

GO, A. S. *et al.* Heart Disease and Stroke Statistics – Stroke Statistics –2014 Update: A Report From the American Heart Association. **Circulation**, v. 129, n. 3, p. e28-e292, 2014.

GORDON, N. F. *et al.* Physical activity and exercise recommendations for stroke survivors: an American Heart Association scientific statement from the Concil on Clinical Cardiology, Subcommittee on Exercise, Cardiac

Rehabilitation, and Prevention; the Council on Cardiovascular Nursing; the Council on Nutrition, Physical Activity, and Metabolism; and the Stroke Council. **Circulation**, v. 109, n. 16, p. 2031-41, 2004.

HAIR JUNIOR, J. F. *et al.* **Análise multivariada de dados**. Porto Alegre: Bookman, 2009. 688 p.

HARDIE, K. *et al.* Ten-year risk of first recurrent stroke and disability after first-ever stroke in the Perth Community Stroke Study. **Stroke**, v. 35, p. 731-5, 2004.

HARRISON, J. K.; MCARTHUR, K. S.; QUINN T. J. Assessment scales in stroke: clinimetric and clinical considerations. **Clinical Interventions in Aging**, v. 8, p. 201-11, 2013.

HAUGEN, H. A.; CHAN, L. N.; LI F. Indirect calorimetry: a practical guide for clinicians. **Nutrition in Clinical Practice**, v. 22, n. 4, p. 377-88, 2007.

HORNNES, N.; LARSEN, K.; BOYSEN, G. Little change of modifiable risk factors 1 year after stroke: a pilot study. **International Journal of Stroke**, v. 5, n.l 3, p. 157-62, 2010.

IJMKER, T. *et al.* Effect of balance support on the energy cost of walking after stroke. **Archives of Physical and Medicine Rehabilitation**, v. 94, n. 11, p. 2255-61, 2013.

JEONG, Y. G. *et al.* A randomized comparison of energy consumption when using different canes, inpatients after stroke. **Clinical Rehabilitation**, 2014 [Epub ahead of print]

JORGENSEN, H. S. *et al.* Recovery of walking function in stroke patients: the Copenhagen Stroke Study. **Archives of Physical and Medicine Rehabilitation**, v. 76, n. 1, p. 27-32, 1995.

KAFRI, M. *et al.* High metabolic cost and low energy expenditure for typical motor activities among individuals in the chronic phase after stroke. **Journal of Neurologic Physical Therapy**, v. 38, n. 4, p. 226-32, 2014.

KELLY, J. O. *et al.* Cardiorespiratory fitness and walking ability in subacute stroke patients. **Archives of Physical and Medicine Rehabilitation**, v. 84, p. 1780-5, 2003.

KISSELA, B. M. *et al.* Age at stroke: temporal trends in stroke incidence in a large, biracial population. **Neurology**, v. 79, n. 17, p. 1781-7, 2012.

KUYS, S.; BRAUER, S.; ADA, L. Routine physiotherapy does not induce a cardiorespiratory training effect post-stroke, regardless of walking ability. **Physiotherapy Research International**, v. 11, n. 4, p. 219-27, 2006.

LACKLAND, D. T. *et al.* Factors influencing the decline in stroke mortality: a statement from the American Heart Association/American Stroke Association. **Stroke**, v. 45, n. 1, p. 315-53, 2014.

LEVINE, J. A. Measurement of energy expenditure. **Public Health Nutrition**, v. 8, n. 7A, p. 1123-32, 2005.

LOTUFO, P. A.; BENSENOR, IJ. Raça e mortalidade cerebrovascular no Brasil. **Revista de Saúde Pública**, v. 47, n. 6, p. 1201-4, 2013.

LOTUFO, P. A. *et al.* A reappraisal of stroke mortality trends in Brazil (1979-2009). I**nternational Journal of Stroke**, v. 8, n. 3, p. 155-63, 2013.

MACFARLANE, D. J.; WONG, P. Validity, reliability and stability of the portable Cortex Metamax 3B gas analysis system. **European Journal of Applied Physiology**, v. 112, n. 7, p. 2539-47, 2012.

MACKAY-LYONS, M. J.; MAKRIDES, L: Cardiovascular stress during a contemporary stroke rehabilitation program: Is the intensity adequate to induce a training effect? **Archives of Physical and Medicine Rehabilitation**, v. 83, p. 1378-83, 2002.a

MACKAY-LYONS, M. J.; MAKRIDES, L. Longitudinal changes in exercise capacity after stroke. **Archives of Physical and Medicine Rehabilitation**, v. 85, p. 1608-1612, 2004.b

MANCINI, M. C. *et al.* Tutorial for writing systematic reviews for the Brazilian Journal of Physical Therapy (BJPT). **Brazilian Journal of Physical Therapy**, v. 18, n. 6, p. 471-80, 2014.

MARTINS, J. C. *et al.* Avaliação da força muscular de indivíduos com AVE: quantas repetições são necessárias? In: 3o Congresso Brasileiro de Fisioterapia Neurofuncional (COBRAFIN), 2014, Belo Horizonte. **Anais do 3o Congresso Brasileiro de Fisioterapia Neurofuncional (COBRAFIN)**, p. 21-21, 2014.

MARZOLINI, S. *et al.* Can individuals participating in cardiac rehabilitation achieve recommended exercise training levels following stroke? **Journal of Cardiopulmonary Rehabilitation and Prevention**, v. 32, n. 3, p. 127-34, 2012.

MAYO, N. E. *et al.* Disablement following stroke. **Disability and Rehabilitation**, v. 21, p. 258-68, 1999.

MICHAELSEN, S. M. *et al.* Translation, adaptation and inter-rater reliability of the administration manual for the Fugl-Meyer assessment. **Brazilian Journal of Physical Therapy**, v. 15, n. 1, p. 80-9, 2011.

NASCIMENTO, L. *et al.* Different instructions during the ten-meter walking test determined significant increases in maximum gait speed in individuals with chronic hemiparesis. **Brazilian Journal of Physical Therapy**, v. 16, n. 2, p. 122,7, 2012.

ORGANIZAÇÃO MUNDIAL DE SAÚDE - OMS, ORGANIZAÇÃO PANAMERICANA DE SAÚDE - OPAS. **CIF - Classificação Internacional de Funcionalidade, Incapacidade e Saúde.** São Paulo: Editora da Universidade de São Paulo; 2003.

PEARN, J.; O'CONNOR, R. J. Community stroke rehabilitation helps patients return to work. **Practitioner**, v. 257, n. 1764, p. 23-7, 2013.

OVANDO, A. C. *et al*. Treinamento De Marcha, Cardiorrespiratório E Muscular Após Acidente Vascular Encefálico: Estratégias, Dosagem E Desfechos. **Fisioterapia em Movimento (PUCPR. Impresso)**, v. 23, p. 253-269, 2010.

PAK, S.; PATTEN, C. Strengthening to promote functional recovery poststroke: an evidence-based review. **Topics in Stroke Rehabilitation**, v. 15, n. 3, p. 177-99, 2008.

PEARN, J.; O'CONNOR, R. J. Community stroke rehabilitation helps patients return to work. Practitioner., v. 257, n. 1764, p. 2-3, 2013.

PERRY, J. *et al.* Classification of walking handicap in the stroke population. **Stroke**, v. 26, n. 6, p. 982-9, 1995.

PHYSICAL ACTIVITY GUIDELINES ADVISORY COMMITTEE REPORT. TO THE SECRETARY OF HEALTH AND HUMAN SERVICES. Part A: Executive summary. **Nutrition Reviews**, v. 67, n. 2, p. 114-20, 2009.

PLATTS, M. M.; RAFFERTY, D.; PAUL, L. Metabolic cost of over ground gait in younger stroke patients and healthy controls. **Medicine** & **Science in Sports** & **Exercise**, v. 38, n. 6, p. 1041-6, 2006.

POLESE, J. C. *et al*. Percepção de profissionais da saúde acerca de parâmetros e treinamento cardiorrespiratório utilizados na reabilitação pós Acidente Vascular Encefálico. **Terapia Manual**, v. 11, p. 373-377, 2013.

POLESE, J. C.; *et al.* Test-retest reliability of the cardiorespiratory variables measured with the Metamax 3B during the six-minute walking test after stroke. **Physical Medicine and Rehabilitation – International**, v. 2, n. 1, 1028, 2015.

ROGER, V. L. *et al.* Heart disease and stroke statistics—2012 update: a report from the American Heart Association. **Circulation**, v. 125, n. 1, p. e2-e220, 2012.

ROTH, E. J. *et al.* Impairment and disability: their relation during stroke rehabilitation. **Archives of Physical and Medicine Rehabilitation**, v. 79, n. 3, p. 329-35, 1998.

SABARIEGO, C. *et al.* Evaluation of an ICF based patient education programme for stroke patients: a randomized, single-blinded, controlled, multicentre trial of the effects on self-efficacy, life satisfaction and functioning. **British Journal of Health Psychology**, v. 18, n. 4, p. 707-28*,* 2013.

SALBACH, N. M. *et al. R*esponsiveness and predictability of gait speed and other disability measures in acute stroke. **Archives of Physical and Medicine Rehabilitation**, v. 82, n. 9, p. 1204-12, 2001.

SAMPAIO, R. F. *et al.* Aplicação da Classificação Internacional de Funcionalidade, Incapacidade e Saúde (CIF) na Prática Clínica do Fisioterapeuta. **Brazilian Journal of Physical Therapy**, v. 9, n. 2, p. 129-36, 2005.

SAUNDERS, D. H. Physical fitness training for stroke patients. **Cochrane Database Systematic Reviews**, 2013.

SENES, S. **How We Manage Stroke in Australia**. Canberra, Australia: Australian Institute of Health and Welfare; 2006.

SHEPHARD, R. J. Maximal oxygen intake and independence in old age. **British Journal of Sports Medicine**, v. 43, n. 5, p. 342-6, 2009.

SMITH, S. C. e*t al.* AHA/ACC guidelines for preventing heart attack and death in patients with atherosclerotic cardiovascular disease: 2001 update: a statement for healthcare professionals from the American Heart Association and the American College of Cardiology. **Circulation***,* v. 104, p. 1577-9*,* 2001.

SMITH, A. C.; SAUNDERS, D. H.; MEAD, G. Cardiorespiratory fitness after stroke: a systematic review. **International Journal of Stroke**, v. 7, n. 6, p. 499-510, 2012.

SOUZA, A. C.; MAGALHAES, L. C.; TEIXEIRA-SALMELA, L. F. Cross-cultural adaptation and analysis of the psychometric properties in the Brazilian version of the Human Activity Profile. **Reports Public Health**, v. 22, n.12, p. 2623-36, 2006.

STEINER, W. A. *et al.* Use of the ICF model as a clinical problem-solving tool in physical therapy and rehabilitation medicine. **Physical Therapy**, v. 82, n. 11, p. 1098-107, 2002.

STRATH, S. J. *et al.* Guide to the assessment of physical activity: Clinical and research applications: a scientific statement from the American Heart Association. **Circulation**, v. 128, n. 20, p. 2259-79, 2013.

TABACHNICK, B. G.; FIDELL, L. S. **Using Multivariate Statistics**. 2nd ed. New York: HarperCollins, 1989, 746 p.

TEIXEIRA-SALMELA, L. F. *et al.* Muscle strengthening and physical conditioning to reduce impairment and disability in chronic stroke survivors. **Archives of Physical and Medicine Rehabilitation**, v, 80, n. 10, p. 1211-8, 1999.

THOM, T. *et al.* Heart disease and stroke statistics—2006 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. **Circulation**, v. 113, n. 6, p. e85-151, 2006.

THOMPSON, P. D. *et al*. Exercise and physical activity in the prevention and treatment of atherosclerotic cardiovascular disease: a statement from the Council on Clinical Cardiology (Subcommittee on Exercise, Rehabilitation, and Prevention) and the Council on Nutrition, Physical Activity, and Metabolism (Subcommittee on Physical Activity). **Circulation**, v. 107, p. 2109-16, 2003.

WANG, Y.; RUDD, A. G.; WOLFE, C. D. Age and ethnic disparities in incidence of stroke over time: the South London Stroke Register. **Stroke**, v. 44, n. 12, p. 3298-304, 2013.

WARBURTON, D. E.; NICOL, C. W.; BREDIN, S. S. Health benefits of physical activity: the evidence. **Canadian Medical Association Journal**, v. 174, n. 6, p. 801-9, 2006.

WASSERMAN, K, *et al.* **Principles of Exercise Testing and Interpretation - Including Pathophysiology and Clinical Applications**.4th ed. Philadelphia: Lippincott Williams and Wilkins, 2005. 585 p.

WILLEY, J. Z. *et al.* Physical activity and risk of ischemic stroke in the Northern Manhattan Study. **Neurology**, v. 73, p. 1774-9, 2009. a

WILLEY, J. Z. *et al.* Lipid profile components and risk of ischemic stroke: the Northern Manhattan Study (NOMAS). **Archives of Neurology**, v. 66, p. 1400-6, 2009. b

VELLOSO, M. *et al.* Metabolic and ventilatory parameters of four activities of daily living accomplished with arms in COPD patients. **Chest**, v. 123, n. 4, p. 1047-53, 2003.

VINKEN, A. G. *et al.* Equations for predicting the energy requirements of healthy adults aged 18-81 y. **The American Journal of Clinical Nutrition,** v. 69, n. 5, p. 920-6,1999.

ANEXO I- Acordo de Cotutela/ Student Cotutelle Agreement

THE UNIVERSITY OF SYDNEY

Contrato de Co-tutela do Estudante

Este Acordo é feito em 1 de Setembro de 2011

Entre

A **Universidade Federal de Minas Gerais (UFMG),**

Localizada na Avenida Antônio Carlos, no. 6627, Belo Horizonte, Minas Gerais, Brasil, CNPJ no 17.217.985/0001-04, neste ato representada pelo Reitor Professor Clélio Campolina DINIZ

e

A **Universidade de Sydney**, Austrália University of Sydney NSW 2006 - Austrália ABN 15 211 513 464, CRICOS

Janaine Cunha Polese Rua João Antônio Cardoso, número 157/301, Bairro Ouro Preto, CEP 31310-390, Belo Horizonte - MG, Brasil,

('o Estudante')

('as Partes')

Antecedentes

A. A Universidade de Sydney e a UFMG firmaram o Acordo Principal da Co-tutela, datado em maio de 2011.

B. A Escola de Medicina de Sydney e a Faculdade de Ciências da Saúde da Universidade de Sydney e Programa de Pós Graduação em Ciências da Reabilitação do Departamento de Fisioterapia da Escola de Ed. Física Fisioterapia e Terapia Ocupacional da Universidade Federal de Minas Gerais compartilham um compromisso para desenvolver a colaboração na investigação cooperativa.

C. Janaine Cunha Polese, sexo feminino, nascida em Passo Fundo -Rio Grande do Sul Brasil, no dia 05 de fevereiro de 1986 de nacionalidade brasileira, portadora de carteira de identidade numero 695409, CPF 010.563.741-60 e Passaporte FE 494576, deseja realizar um doutorado oferecido e atribuído conjuntamente pela Universidade de Sydney e pela Universidade Federal de Minas Gerais.

D. As partes concordaram em firmar um acordo para a Co-tutela de Janaine Cunha Polese nos termos previstos no presente Acordo.

Termos Acordados

1. **Definições e Interpretação**

1.1 Definições

No presente acordo:

Ano Letivo:

No presente Acordo:

(a) na Universidade de Sydney, compreende de Janeiro de 2012 a Janeiro de 2013.

(b) na UFMG compreende de Março de 2011 a Dezembro de 2011 e Fevereiro de 2013 a Março de 2015.

Propriedade Intelectual abrange todos os direitos registrados e não registrados, títulos e interesses presentes e futuros em relação a direitos da marca, formato, patentes, informações confidenciais e toda a propriedade intelectual, tal como definido no Artigo 2 da Convenção que institui a Organização Mundial de Propriedade Intelectual de 1967;

Grau Concedido pela Universidade de Sydney: significa Doutor em Filosofia, PhD; **Grau Concedido pela Universidade de Minas Gerais:** Doutor em Ciências da Reabilitação, área de concentração: Desempenho Funcional Humano

Supervisor (orientador): significa um professor devidamente qualificado da Universidade de Sydney ou da UFMG que será responsável pela supervisão da conduta e progresso da candidatura do estudante, inclusive por meio de conselhos, instrução e orientação.

2. Termos do Acordo

2.1 Este Acordo entra em vigor a partir de dezembro de 2011 e termina na data de graduação do Estudante, a não ser que uma data anterior seja determinada de acordo com a cláusula 2.2.

2.2 Este Acordo pode ser terminado em qualquer momento por qualquer das Partes, mediante notificação escrita às outras Partes da suspensão ou rescisão da candidatura do Estudante.

3. Administração

3.1 O Estudante irá oferecer-se a Tricia para o Grau Conjuntamente Concedido com bases em pesquisas realizadas na área Fisioterapia pesquisando com o tema de estudo em Fisioterapia Neurológica. Titulo do projeto: *Avaliação de parâmetros metabólicos e ventilatórios de hemiparéticos durante a realização de atividades funcionais.*

3.2 A UFMG é a instituição de origem do aluno. A candidatura do Estudante será dividida entre a Universidade de Sydney e a UFMG, com um mínimo de 30% da candidatura a ser realizada em cada instituição.

3.3 O estudante se baseará e passará seu tempo entre a Universidade de Sydney e UFMG como segue:
(a) Março de 2011 a Dezembro de 2011: UFMG;
(b) Janeiro de 2012 a Janeiro de 2013: Universidade de Sydney/UFMG;
(c) Fevereiro de 2013 a Março de 2015: Universidade de Sydney/UFMG

3.4 Salvo acordo contrário por escrito entre as Partes (observando-se o potencial impacto na cobertura do seguro do Estudante), o Estudante irá simultaneamente matricular-se na Universidade de Sydney e na UFMG para cada ano da candidatura.

3.5 O Estudante terá os mesmos direitos e privilégios (incluindo serviços de biblioteca e serviços de apoio ao aluno) da Universidade de Sydney e UFMG como outros estudantes matriculados.

3.6 A UFMG e a Universidade de Sydney serão responsáveis por administrar a candidatura do Estudante.

3.7 No caso de incompatibilidade entre as regras e regulamentos da Universidade de Sydney e da UFMG, as regras serão estudadas e acordadas entre as partes.

4. Supervisão

4.1 O estudante de doutorado desenvolverá sua tese sob responsabilidade de um supervisor na Austrália e outro no Brasil, ambos com colaboração previamente estabelecida.

4.2 A Universidade de Sydney e a UFMG irão cada uma designar um Supervisor de acordo com as normas vigentes na pós-graduação

4.3 A Universidade de Sydney e a UFMG podem mudar ou substituir o supervisor em qualquer momento.

4.4 Na data do acordo, os supervisores são:
(a) Universidade de Sydney: Professora Dra Louise Ada
(b) UFMG: Professora Dra Luci Fuscaldi Teixeira-Salmela

4.5 Ambos os supervisores estão empenhados em exercer plenamente a função de tutor na orientação do estudante de doutorado. Eles exercem conjuntamente o poder concedido na Austrália e no Brasil para supervisão da tese do doutorado.

5. Tese e Exame

5.1 A UFMG e Universidade de Sydney serão responsáveis por organizar e administrar o processo de exame.

5.2 A primeira data para submissão da tese do Estudante para exame é o segundo semestre de 2014.

5.3 A última data para submissão da tese do Estudante para exame é o primeiro semestre de 2015.

5.4 O(s) examinador(es) será(ão) designado(s) através de um acordo escrito entre a Universidade de Sydney e a UFMG.

5.5 A data da defesa será em Março de 2015. A tese dará lugar a uma defesa única, reconhecida pelos dois estabelecimentos. A banca da defesa é composta no máximo por oito cientistas designados em paridade pelos dois estabelecimentos parceiros. A banca compreenderá obrigatoriamente os dois orientadores da tese e uma pessoa externa aos dois estabelecimentos

5.6 A divisão das taxas assumidas por cada uma das partes para reunir os membros da banca no momento da defesa da tese é determinada segundo as condições abaixo:

(a) A Universidade Federal de Minas Gerais - UFMG assumirá, para a composição da banca, os ônus que assume tradicionalmente para uma defesa de tese no país, a saber: os gastos com o deslocamento interno e hospedagem.

(b) As duas partes que assinam esse convênio se comprometem, em caso de dificuldades financeiras no momento da defesa, a buscar todos os meios possíveis para que a defesa conjunta da tese tenha lugar, inclusive lançando mão de meios de comunicação à distância do tipo videoconferência.

5.7 O Estudante irá submeter a tese para exame e posteriormente apresentar-se para exame na UFMG, de acordo com as normas e regulamentos da UFMG sujeito à s seguintes condições:

(a) O Estudante irá escrever em português e defender a tese em português, e irá incluir na tese um resumo substancial escrito em inglês;
(b) O Estudante irá submeter duas cópias da tese para a Universidade de Sydney, das quais uma será para utilização e retenção da Universidade de Sydney;
(c) O Estudante irá submeter três copias da tese para a UFMG das quais uma será para utilização e retenção da UFMG

5.8 O estudante será considerado aprovado na defesa somente se obtiver aprovação unânime de todos os membros da Comissão Examinadora. Em caso de uma nova defesa de tese, a mesma será realizada no prazo máximo de seis meses mediante justificativa da Comissão Examinadora. No caso de uma disputa entre a Universidade de Sydney e a UFMG a respeito do resultado do exame, a Universidade de Sydney e a UFMG irão em conjunto nomear uma pessoa externa devidamente qualificada para re-examinar a tese e, se necessário, conduzir um adicional exame oral ('Re-examinador Externo'). A decisão do Re-examinador Externo será a definitiva.

6. Graduação

6.1 Se as condições para a graduação forem seguidas, o diploma de Doutor será conferido pela UFMG e pela Universidade de Sydney;

6.2 O estudante tem a garantia de receber um documento que:
(a) disponha que o diploma de Doutor recebido pelo estudado é de cotutela; e
(b) possua os nomes das Universidades de Sydney e UFMG.

6.3 A Universidade de Sydney poderá conferir o documento de acordo com a clausula 6.2.

7. Disposições Financeiras

7.1 Salvo acordo contrário por escrito pela Universidade de Sydney e pela UFMG, o Estudante não pagará anuidades na Universidade de Sydney ou na UFMG durante a duração da candidatura.

7.2 Salvo acordo contrário por escrito entre as Partes, o Estudante será responsável por todas as outras despesas pessoais ligadas a candidatura, incluindo moradia, deslocamento, seguro (incluindo a cobertura adicional de seguro saúde e contra acidentes) e despesas adicionais.

7.3 Salvo acordo contrário por escrito entre as Partes, os supervisores são responsáveis pelos custos com viagens e acomodações necessárias para um supervisor ou examinador para atender a um exame oral ou de qualquer outro tipo

7.4 seguridade social e a responsabilidade civil do doutorando serão asseguradas nas seguintes condições:
(a) Na UFMG, o estudante deverá pagar por cobertura privada de saúde.
(b) Na Universidade de Sydney, o estudante será responsável pela manutenção e pagamento do Seguro de Saúde do Estudante Internacional (OSHC) enquanto estiver na Australia, como condição do Visto de estudante.

8. Propriedade Intelectual

8.1 Salvo acordo contrário por escrito entre as Partes, todos os direitos de Propriedade Intelectual desenvolvida pelo aluno durante sua candidatura reverterão a favor de Janaine Cunha Polese.

8.2 A Universidade de Sydney e a UFMG não irão se valer das propriedades dos direitos autorais do Estudante, sendo os direitos autorais do Estudante.

9. Das condições de alojamento e ajudas financeiras as quais o doutorando pode se candidatar

9.1 O Estudante será responsável por organizar sua própria acomodação.

9.2 A Universidade de Sydney e a UFMG forneceram informações sobre acomodações temporárias e permanentes.

9.3 Nem a Universidade de Sydney ou UFMG poderá garantir acomodações para o estudante em seus Campus.

10. Obrigações do Estudante

10.1 O Estudante deverá:

(a) em todos os momentos cumprir e estar vinculado a qualquer pertinentes leis, normas, regulamentos e códigos de conduta aplicáveis a candidatura, incluindo:

a. qualquer requisitos de entrada e visto;
b. a pesquisa realizada pelo Estudante; e
c. a presença do Estudante na terra ou imóveis pertencentes, ocupados ou sobre controle da Universidade de Sydney ou da UFMG;

(b) obter seguro médico durante a estadia do Estudante na UFMG;

(c) ser matriculado na Universidade de Sydney e na UFMG como um estudante internacional, ser o único responsável pela aquisição e manutenção do Seguro de Saúde do Estudante Internacional (OSHC) enquanto estiver na Austrália, como condições do visto do Estudante.

11. Indenização

11.1 Sujeito às leis aplicáveis, a Universidade de Sydney e a UFMG indenizam e concordam em manter indenizado (**'Instituição Indenizadora'**) a outra instituição (**'Instituição Indenizada'**) contra toda e qualquer responsabilidade, perda, custos, danos ou despesas (incluindo despesas e custos legais) incorridos ou sofridos pela Instituição Indenizada como resultado de qualquer conduta dolorosa ou ato negligente ou de omissão pela Instituição Indenizadora, ou uma violação material deste Contrato pela Instituição Indenizadora.

11.2 Sujeito às leis aplicáveis, a Universidade de Sydney e a UFMG não serão responsáveis uma pela outra por qualquer dano acidental, como perda de lucros, bens e oportunidades, e a responsabilidade de cada instituição no presente Acordo é reduzido à medida em que qualquer responsabilidade, perda, custos, danos ou despesas decorrentes de ou atribuídas a qualquer ato intencional negligente ou de omissão por parte da Instituição Indenizada.

11.3 Referencias a Instituição Indenizadora e a Instituição Indenizada nesta cláusula incluem os diretores, funcionários, agentes e estudantes das instituições.

11.4 A Universidade de Sydney e a UFMG irão manter seguro adequado de proteção para a responsabilidade pública e profissional (que pode ser auto-assegurado) para cobrir as suas obrigações no presente Acordo, e fornecerá à outra instituição um certificado de moeda e renovação de tais seguros, se solicitado a fazê-lo.

12. Força Maior

12.1 Nenhuma das instituições será responsável, ou será considerada em situação de incomprimento ou violação do presente Acordo, por qualquer atraso, falha, ou incapacidade de cumprir as suas obrigações do presente Acordo (além de qualquer obrigação para o pagamento de dinheiro) causado por ou resultantes de qualquer motivo que seja inevitável ou fora do controle da instituição, incluindo Guerra, operações bélicas, rebeliões, insurreição, ordens do governo, greves, bloqueios, emergências de saúde pública, quarentenas, distúrbios ou qualquer ato de Deus ou outra causa que frustra o desempenho do presente Acordo.

13 Alteração e Natureza do Acordo

13.1 Este Acordo é vinculado e constitui a totalidade do acordo entre as Partes, em adição apenas a um Contrato Principal entre as partes, em que foi acordado por ambas as partes e que define as obrigações gerais relativas ao regime de Co-tutela.

13.2 Nada contido ou implícito no presente Acordo tem por objetivo criar uma parceria entre qualquer das partes ou, salvo disposição contrária no presente Acordo, estabelecer qualquer das Partes como um agente ou representante de qualquer outra parte

13.3 Este Acordo e qualquer prazo vinculado a ele pode ser alterado, modificado, prorrogado ou renovado apenas com o consentimento mútuo escrito pelas Partes.

13.4 As Partes concordam que o presente Acordo e todos os documentos relacionados devem ser escritos em inglês e em português (3 copias), sendo que a cópia em português prevalece.

Assinado:

Janaine Cunha Polese
Candidata
Data: 02/12/2011

Em nome de:

UFMG

Professora Luci Fuscaldi Teixeira Salmela
Supervisora
Data: 02/12/2011

Professor Dr. Clelio Campolina Diniz
Reitor, UFMG
Data: 02/12/2011

Professor Dr Ricardo Santiago Gomez
Pró-Reitor de Pós-Graduação, UFMG
Data: 02/12/2011

Universidade de Sydney

Professora Louise Ada
Supervisora
Data: 7/12/11

Professor Gwynnyth Llewellyn
Dean, Faculty of Health Sciences
12/12/11

Professor Derrick Armstrong
Deputy Vice-Chancellor (Education) & Registrar
Data: 14.12.2011

Prof Livia de Castro Magalhães
Coordenadora do Programa de Pós Graduação em Ciências da Reabilitação
Data: 02/12/2011

THE UNIVERSITY OF SYDNEY

Student Cotutelle Agreement

This Agreement **is made on 1 September 2011**

Between

Universidade Federal de Minas Gerais (UFMG)
located on 6627 Avenida Antônio Carlos, Belo Horizonte, Minas Gerais, Brazil, CNPJ number 17.217.985/0001-04, hereby represented by the Dean Professor Clélio Campolina Diniz,

and

The University of Sydney, Australia
located on The University of Sydney NSW 2006 – Australia ABN 15 211 513 464, CRICOS Provider 00026A,

and

Janaine Cunha Polese 157 João Antônio Cardoso, Bairro Ouro Preto Postal Zone 31310-390, Belo Horizonte, Minas Gerais, Brazil (**'the Student'**)

('the Parties')

Background

A. The University of Sydney and UFMG have entered into a Principal Cotutelle Agreement, dated May 2011.

B. The Sydney Medical School and the Faculty of Health Sciences at the University of Sydney and the Post-Graduate Program in Rehabilitation Science of the Physical Therapy Department, Physical Education, Physiotherapy and Occupational Therapy School at Federal University of Minas Gerais, UFMG share a developing commitment to cooperative research collaboration.

C. Janaine Cunha Polese was born on 5th February, 1986, in Passo Fundo - Rio Grande do Sul - Brazil; identification number 695409, CPF 010.563.741-60 and passport number FE 494576, desires to undertake a doctoral degree jointly offered and awarded by the University of Sydney UFMG

D. The Parties have agreed to enter into a cotutelle arrangement for Janaine Cunha Polese on the terms set out in this Agreement.

Agreed Terms

1. Definitions and Interpretation

1.1 Definitions

In this Agreement:

Academic Year:

(a) at the University of Sydney, means from January 2012 to January 2013;

(b) at the UFMG means from March 2011 to December 2011 and February 2013 to March 2015.

Intellectual Property means all registered and unregistered rights, titles and interests in relation to present and future copyright, trade marks, designs, know-how, patents, confidential information and all other intellectual property as defined in article 2 of the Convention establishing the World Intellectual Property Organisation 1967;

Jointly Awarded Degree means Doctor of Philosophy PhD by the University of Sydney and by UFMG Doctor in Rehabilitation Sciences, area Human Functional Development.
Supervisor means an appropriately qualified employee of the University of Sydney or the UFMG who is jointly responsible for supervising the conduct and progress of the Student's candidature, including by means of instruction, advice and mentoring.

2. Term of Agreement

2.1 This Agreement is effective from 1 December 2011 and ends on the date of the Student's graduation, unless it is terminated at an earlier time in accordance with **clause 2.2**.

2.2 This Agreement may be terminated at any time by any of the Parties giving written notice to the other Parties of the suspension or termination of the Student's candidature.

3. Administration

3.1 The Student will offer herself Tricia for the Jointly Awarded Degree on the basis of research undertaken in the area of Physical Therapy: *Evaluation of metabolic and ventilator parameters during performance of functional activities with individuals with hemiparesis.*

3.2 The Student's candidature will be divided between the University of Sydney and the UFMG, with a minimum of 30% of the candidature to be undertaken at each institution.

3.3 The Student will be based and spend the their time in attendance at the University of Sydney and the UFMG as follows:

(a) Academic Year March 2011 to December 2011: UFMG

(b) Academic Year January 2012 to January 2013: The University of Sydney/UFMG

(c) Academic Year February 2013 – March 2015: The University of Sydney/UFMG

3.4 Unless otherwise agreed by the Parties in writing (noting the potential impact on the Student's insurance coverage), the Student will simultaneously enrol at the University of Sydney and the UFMG for each year of the candidature.

3.5 The Student will be entitled to the same rights and privileges (including library services and student support services) at the University of Sydney and the UFMG as other enrolled students.

3.6 The University of Sydney/UFMG will be responsible for administering the Student's candidature.

3.7 To the extent of any inconsistency between the rules and regulations of the University of Sydney and the UFMG the rules and regulations of the UFMG will apply to the Student's candidature.

4. Supervision

4.1 The PhD student develops her thesis under the joint responsibility of a supervisor in Australia and a supervisor in Brazil having both supervisors previously established collaboration.

4.2 The University of Sydney and the UFMG will each appoint a Supervisor.

4.3 The University of Sydney and the UFMG may change or substitute a Supervisor at any time.

4.4 At the date of this Agreement, the Supervisors are:

(a) The University of Sydney: Associate Professor Louise Ada and

(b) UFMG : Professor Dr Luci Fuscaldi Teixeira-Salmela.

4.5 Both supervisors are committed to full exert the tutor function with the PhD student. They jointly exercise the power granted in Australia and Brazil as thesis supervisors.

5. Thesis and Examination

5.1 The University of Sydney and UFMG will be responsible for organising and administering the examination process.

5.2 The earliest date for submission of a thesis by the Student for examination is second semester, 2014.

5.3 The latest date for submission of a thesis by the Student for examination is first semester 2015.

5.4 The examiner(s) will be appointed by written agreement between the University of Sydney and UFMG.

5.5 The date of defense will be in March 2015.The thesis defense will be done once only and will be recognised by both institutions. The defense committee is made up of eight scientists appointed in parity by both partner institutions. At least one member of the defense committee must be external to the two institutions.

5.6 The division of fees borne by each party to meet the committee members at the time of the thesis defense is determined according to the following conditions:

(a) UFMG will assume to the board composition the burden that is traditionally taken for a thesis defense in Brazil: international dislocation accommodation expenses.

(b) Both institutions commit themselves, in the case of financial activities at the time of the defense to see all possible means so that the joint defense of the thesis takes place, including making use of distance communications such as video-conferencing.

5.7 The Student will submit a thesis for examination and thereafter present herself for examination at the UFMG in accordance with the rules and regulations UFMG subject to the following conditions:

(a) the Student will write and (where applicable) defend the thesis in Portuguese, and will include in the thesis a substantial abstract written in English;

(b) the Student will submit two copies of the thesis to the University of Sydney, of which one will be for the University of Sydney's use and retention;

(c) the Student will submit three copies of the thesis to the UFMG of which one will be for the UFMG use and retention.

5.8 Both institutions will respect the examination outcome, provided the process above is followed. In the event of a dispute between the University of Sydney and the UFMG regarding the examination outcome (due to incorrect procedures), the University of Sydney and the UFMG will jointly appoint a suitably qualified external person to re-examine the thesis and, if necessary, conduct an additional oral examination ('**External Re-Examiner**'). The decision of the External Re-Examiner will be final.

6. Graduation

6.1 If the conditions for graduation are met, the Jointly Awarded Degree will be conferred by UFMG and University of Sydney.

6.2 The Student is entitled to receive a testamur that:

(a) states that the Jointly Awarded Degree was undertaken by the Student through a cotutelle arrangement; and

(b) lists the names of both the University of Sydney and the UFMG.

6.3 The University of Sydney may also confer a testamur in accordance with **clause 6.2**, at its sole discretion.

7. Financial Arrangements

7.1 Unless otherwise agreed in writing by the University of Sydney and the UFMG, the Student will pay tuition fees at UFMG and be exempt from payment of tuition fees at the University of Sydney for the duration of the candidature.

7.2 Unless otherwise agreed in writing by the Parties, the Student will be responsible for all other personal costs in connection with the candidature, including all living, travel, insurance (including additional medical coverage, liability and accident insurance) and ancillary costs.

7.3 Unless otherwise agreed in writing by the University of Sydney and the UFMG, the supervisors will be responsible for the cost of any flights and accommodation required for a Supervisor or examiner to attend any oral or other examination.

7.4 The social security and civil responsibility of the PhD student will be assured under the following conditions:

(a) At the institution of her origin (UFMG) the PhD student must purchase private health insurance coverage.

(b) When enrolled at the University of Sydney as an overseas student, be solely responsible for the purchase and maintenance of Overseas Student Health Cover (OSHC) while staying in Australia, as a condition of the Student's visa.

8. Intellectual Property

8.1 Unless otherwise agreed by the Parties in writing, all Intellectual Property rights developed by the Student during his or her candidature will vest in Janaine Cunha Polese

8.2 The University of Sydney and UFMG will not assert copyright ownership over the Student's doctoral thesis, as the copyright vests in the Student.

9. Student Accommodation

9.1 The Student will be responsible for organising their own accommodation.

9.2 The University of Sydney and the UFMG will provide information to the Student regarding temporary and longer-term accommodation on and off campus.

9.3 Neither the University of Sydney nor the UFMG guarantees that accommodation on campus will be available.

10. Student obligations

10.1 The Student will:

(a) at all times comply with and be bound by any relevant laws, rules, regulations and codes of practice applicable to the candidature, including in respect of:

a. any entry and visa requirements;

b. the research conducted by the Student; and

c. the Student's presence in or on land or buildings owned, occupied or under the control of the University of Sydney or the UFMG;

(b) obtain medical insurance for the duration of the Student's time at the UFMG

(c) if enrolled at the University of Sydney as an overseas student, be solely responsible for the purchase and maintenance of Overseas Student Health Cover (OSHC) while staying in Australia, as a condition of the Student's visa.

11. Indemnification

11.1 Subject to applicable laws, the University of Sydney and the UFMG indemnify and agree to keep indemnified ('**Indemnifying Institution**') the other institution ('**Indemnified Institution**') against all liability, loss, costs, damages or expenses (including legal costs and expenses) incurred or suffered by the Indemnified Institution as a result of any wilful misconduct or negligent act or omission by the Indemnifying Institution, or a material breach of this Agreement by the Indemnifying Institution.

11.2 Subject to applicable laws, the University of Sydney and the UFMG will not be liable to one another for incidental damages, such as loss of profits, revenue, goodwill or opportunities, and each institution's liability under this Agreement is reduced to the extent that any liability, loss, costs, damages or expenses arise from or are attributable to any wilful or negligent act or omission by the Indemnified Institution.

11.3 References to the Indemnifying Institution and the Indemnified Institution in this clause include the institution's directors, officers, employees, agents and students.

11.4 The University of Sydney and the UFMG will maintain adequate insurance protections for public liability and professional indemnity (which may be self-insurance) to cover their obligations under this Agreement, and will provide to the other institution a certificate of currency and renewals of such insurance, if requested to do so.

12. Force Majeure

12.1 Neither institution will be held responsible or liable, or be deemed to be in default or breach of this Agreement, for any delay, failure or inability to meet its obligations under this Agreement (other than any obligation to pay money) caused by or arising from any cause that is unavoidable or beyond the reasonable control of the institution, including war, warlike operations, riot, insurrection, orders of government, strikes, lockouts, public health emergencies, quarantines, disturbances or any act of God or other cause which frustrates the performance of this Agreement.

13. Nature of Agreement and Amendment

13.1 This Agreement is binding and constitutes the entire agreement between the Parties, in addition only to a Principal Agreement between the parties which has been agreed to by both parties and which sets out their general obligations regarding Cotutelle arrangements.

13.2 Nothing contained or implied in this Agreement is intended to create a partnership between any of the Parties or, except as otherwise provided in this agreement, establish any of the Parties as an agent or representative of any other party.

13.3 This Agreement and any Schedule to it may be amended, modified, extended or renewed only with the written, mutual consent of the Parties.

13.4 The Parties agree that this Agreement and all documents related to may be written in both English and the language chosen by UFMG with the Portuguese version prevailing.

Signed:

Janaine C. Polese

Janaine Cunha Polese
Candidate

Date: 02/12/2011

On behalf of:

UFMG

Professor Dr Luci Fuscaldi Teixeira Samela
Supervisor

Date: 02/12/2011

Professor Dr. Clelio Campolina Diniz
Dean, UFMG

Date:

Professor Dr. Ricardo Santiago Gomes
Pro-Dean of Postgraduate Students

Date: 02/12/2011

Professor Livia de Castro Magalhães
Coordinator of Postgraduate Program in Science of Rehabilitation

Date: 02/12/2011

The University of Sydney

Associate Professor Louise Ada
Supervisor

Date: 7/12/11

Professor Gwynyth Llewellyn
Dean, Faculty of Health Sciences

Date: 12/12/11

Professor Derrick Armstrong
Deputy Vice-Chancellor (Education) & Registrar

Date: 14 · 12 · 2011

ANEXO II – Disciplinas realizadas no Programa de Pós Graduação em Ciências da Reabilitação UFMG

Universidade Federal de Minas Gerais

Pós-Graduação *Stricto Sensu*

Histórico Escolar

Emissão 16/09/2014

Página 1 de 2

Nome do Aluno JANAINE CUNHA POLESE	Número de Registro 2011676791	Forma de Admissão EXAME SELECAO	Data de Início 2011/1 10/03/2011
Nome do Pai CELSO JOSE POLESE	Exame de Língua Estrangeira 04/11/2008 INGLES	30/10/2010 ESPANHOL	CPF 01056374160
Nome da Mãe ANA DEGE CUNHA POLESE	Identidade [redacted]	Orgão Emissor [redacted]	UF [redacted]
Curso 3581 - CIÊNCIAS DA REABILITAÇÃO	Doc. Militar [redacted]	R.M. 00	Circunscrição [redacted]
Nível DOUTORADO	Data Criação 18/08/2005	Resolução 0505	Título de Eleitor [redacted]
Área de Concentração DESEMPENHO FUNCIONAL HUMANO	Data de Nascimento [redacted]	Cidade de Nascimento [redacted]	UF [redacted]
Linha de Pesquisa **********	País Nascimento BRASIL	Nacionalidade BRASIL	
Orientador LUCI FUSCALDI TEIXEIRA SALMELA	Curso de Graduação BACHARELADO FISIOTERAPIA		
Coorientador	Estabelecimento UNIVERSIDADE DE PASSO FUNDO		Término 2008/1
	Cidade/País PASSO FUNDO BRASIL		UF RS

Atividades Acadêmicas Cursadas

Ano/Sem.	Descrição	TUR	NAT	CR	CH	FR	NOTA	CONC	SF
2011/1	DIP FIT810 - ESTÁGIO EM DOCÊNCIA	U	OP	4	60	S	100.0	A	A
2011/1	DIP FIT825 - ASPECTOS DE AVALIACAO DO DESEMPENHO CARDIORRESPIRATORIO	U	OP	3	45	S	91.0	A	A
2011/2	DIP DTO815 - SEMINARIOS DE DOUTORADO	U	OB	2	30	S	100.0	A	A
2011/2	DIP EFI816 - FISIOLOGIA DO EXERCICIO	U	EL	3	45	S	91.0	A	A
2012/1	ETF GER000 - ELABORACAO DE TRABALHO FINAL								
2012/2	ETF GER000 - ELABORACAO DE TRABALHO FINAL								
2013/1	EQP CRE005 - EXAME DE QUALIFICAÇÃO		OB						A
2013/1	ETF GER000 - ELABORACAO DE TRABALHO FINAL								
2013/2	ETF GER000 - ELABORACAO DE TRABALHO FINAL								
2014/1	ETF GER000 - ELABORACAO DE TRABALHO FINAL								
2014/2	ETF GER000 - ELABORACAO DE TRABALHO FINAL								

** Atividades utilizadas como origem de dispensa

Estudos

Ano/Sem.	Código/Local/Descrição	CH	CR	NOTA
2009/1	DTO808 UFMG METODOLOGIA DA PESQUISA	60	04	88

Belo Horizonte, 16 de 09 de 14

Secretário(a)

Profa. Dra. Aline Alvim Scianni

Coordenador(a) (Coordenadora do Colegiado)

Pós-graduação em Ciências da Reabilitação

Inscrição UFMG: 24717-0 SIAPE 2287391

(Este documento é válido somente com carimbo e assinatura do(a) coordenador(a) do curso ou do DRCA, em todas as páginas)

Legenda:

NAT = Natureza (OP=Optativa, OB=Obrigatória, EL=Eletiva, (*)=extracurricular)
CH = Carga Horária CR = Créditos TUR = Turma
FR = Frequência (S=Suficiente, I=Insuficiente) CONC = Conceito
SF = Situação Final (A=Aprovado, R=Reprovado, T=Trancado, D=Dispensado)

Tipo da Origem da Dispensa ou do Aproveitamento de Créditos
AE = Aproveitamento de Estudo
AM = Aproveitamento de Créditos de Pós-Graduação
EQ = Equivalência

(Até 30/07/1990)		(Após 30/07/1990)	
A - Excelente	(90 a 100)	A - Excelente	(90 a 100)
B - Ótimo	(75 a 89)	B - Ótimo	(80 a 89)
C - Regular	(60 a 74)	C - Bom	(70 a 79)
D - Insuficiente	(40 a 59)	D - Regular	(60 a 69)
E - Rendimento Nulo	(0 a 39)	E - Fraco	(40 a 59)
		F - Rendimento Insuficiente	(0 a 39)

Universidade Federal de Minas Gerais

Pós-Graduação *Stricto Sensu*

Histórico Escolar

Emissão 16/09/2014

Página 2 de 2

Aluno 2011676791 JANAINE CUNHA POLESE

Estudos

Ano/Sem.	Código/Local/Descrição		CH	CR	NOTA
2009/1	EST814	UFMG PRINCIPIOS DE BIOESTATISTICA	60	04	96
2009/1	FIT814	UFMG AVANÇOS NO ESTUDO DO MOVIMENTO HUMANO	60	04	86
2009/1	FIT819	UFMG MEDIDAS E INSTRUMENTOS DE AVALIAÇÃO I	45	03	95
2009/2	FIT809	UFMG SEMINARIOS DE DISSERTAÇÃO	30	05	100
2009/2	FIT818	UFMG BIOMECANICA CLINICA	60	04	90
2009/2	FIT820	UFMG MEDIDAS E INSTRUMENTOS DE AVALIAÇÃO II	60	04	88
2012/2	000	UFMG ESTÁGIO COTUTELA NA UNIVERSITYOF SYDNEY- AUSTRALIA	60	04	100

Exame de Qualificação

Resultado Final: APROVADO Data da Realização: 07/05/2013

Integralização

Créditos Exigidos: 36 Créditos Cursados: 12 Créditos aproveitados/dispensados: 0

Créditos Utilizados para a Integralização: 9

Correspondência Carga Horária/Crédito: 15 Horas / 1 Crédito

Pós - Graduado: NÃO

Belo Horizonte, 16 de 09 de 14

Secretário(a)

Profa. Dra. Aline Alvim Scianni
-coordenadora do Colegiado
Pós-Graduação em Ciências da Reabilitação
Inscrição UFMG: 24717-0 SIAPE 2287391

Coordenador(a)

(Este documento é válido somente com carimbo e assinatura do(a) coordenador(a) do curso ou do DRCA, em todas as páginas)

Legenda:

NAT = Natureza (OP=Optativa, OB=Obrigatória, EL=Eletiva, (*)=extracurricular)
CH = Carga Horária CR = Créditos TUR = Turma
FR = Frequência (S=Suficiente, I=Insuficiente) CONC = Conceito
SF = Situacão Final (A=Aprovado, R=Reprovado, T=Trancado, D=Dispensado)

Tipo da Origem da Dispensa ou do Aproveitamento de Créditos
AE = Aproveitamento de Estudo
AM = Aproveitamento de Créditos de Pós-Graduação
EQ = Equivalência

(Até 30/07/1990)		(Após 30/07/1990)	
A - Excelente	(90 a 100)	A - Excelente	(90 a 100)
B - Ótimo	(75 a 89)	B - Ótimo	(80 a 89)
C - Regular	(60 a 74)	C - Bom	(70 a 79)
D - Insuficiente	(40 a 59)	D - Regular	(60 a 69)
E - Rendimento Nulo	(0 a 39)	E - Fraco	(40 a 59)
		F - Rendimento Insuficiente	(0 a 39)

ANEXO III – Curso realizado durante o estágio sanduiche

CERTIFICATE

THIS IS TO CERTIFY THAT

Janaine Polese

attended the workshop

Introduction to Writing a Systematic Review Short Course
Melbourne, Australia

3,4 and 7 May, 2012

D. O'Connor

Denise O'Connor and Sharon Kramer
Systematic Review Trainers
Australasian Cochrane Centre

AUSTRALASIAN
COCHRANE CENTRE

ANEXO IV - Revisão sistemática publicada

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Research

Cyclical electrical stimulation increases strength and improves activity after stroke: a systematic review

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KEY WORDS

Stroke
Electrical stimulation
Strength
Systematic review
Meta-analysis
Randomised controlled trial

ABSTRACT

Question: Does electrical stimulation increase strength after stroke and are any benefits maintained beyond the intervention period or carried over to activity? **Design:** Systematic review with meta-analysis of randomised or controlled trials. **Participants:** Adults who have had a stroke. **Intervention:** Cyclical electrical stimulation applied in order to increase muscle strength. **Outcome measures:** Strength measures had to be representative of maximum voluntary contraction and were obtained as continuous measures of force or torque, or ordinal measures such as manual muscle tests. Activity was measured using direct measures of performance that produced continuous or ordinal data, or with scales that produced ordinal data. **Results:** Sixteen trials representing 17 relevant comparisons were included in this systematic review. Effect sizes were calculated as standardised mean differences because various muscles were studied and different outcome measures were used. Overall, electrical stimulation increased strength by a standardised mean difference (SMD) of 0.47 (95% CI 0.26 to 0.68) and this effect was maintained beyond the intervention period (SMD 0.33, 95% CI 0.07 to 0.60). Electrical stimulation also improved activity (SMD 0.30, 95% CI 0.05 to 0.56) and this effect was also maintained beyond the intervention period (SMD 0.38, 95% CI 0.09 to 0.66). **Conclusion:** Cyclical electrical stimulation increases strength and improves activity after stroke. These benefits were maintained beyond the intervention period with a small-to-moderate effect size. The sustained effect on activity suggests that the benefits were incorporated into daily life. **Review registration:** PROSPERO (CRD42013003895). **[Nascimento LR, Michaelsen SM, Ada L, Polese JC, Teixeira-Salmela LF (2014) Cyclical electrical stimulation increases strength and improves activity after stroke: a systematic review. *Journal of Physiotherapy* 60: 22–30]**

Introduction

Recent data indicates that 30.7 million people in the world have experienced and survived a stroke.[1] After a stroke, the loss of ability to generate normal amounts of force is a major contributor to activity limitations and also contributes to participation restrictions.[2,3] Consequently, there has been a move to implement strengthening interventions into rehabilitation after stroke. Strength training is commonly considered to be progressive resistance exercise, but any intervention that involves attempted repetitive effortful muscle contraction can result in increased motor unit activity and strength after stroke.[4] For example, electrical stimulation may have the potential to improve strength after stroke by increasing the activation of motor units and/or the cross sectional area of a muscle, even when patients are unable to undertake interventions involving resistance exercises.[5]

According to de Kroon et al[6] electrical stimulation can be broadly divided into two categories: functional electrical stimulation and cyclical electrical stimulation. In functional electrical stimulation, one or more muscles are electrically stimulated during the performance of an activity with the aim of improving that activity. In cyclical electrical stimulation, a muscle is repetitively electrically stimulated at near maximum contraction with the aim of strengthening that muscle. Given that these two categories of electrical stimulation have different purposes, as well as different methods of application, it is important to examine them separately. There have been two systematic reviews examining the efficacy of electrical stimulation at increasing strength after stroke. A Cochrane review[7] reported an effect size of 1.0 (95% CI 0.5 to 1.6) on wrist extensor strength; this was based on one randomised trial[8] of cyclical electrical stimulation to the wrist and finger extensors versus no intervention. A second review[5] reported a modest beneficial effect

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on strength based on 11 trials of both functional and cyclical electrical stimulation versus no intervention or any other intervention. However, a meta-analysis was not performed due to statistical heterogeneity. Furthermore, both reviews are now over five years old. In addition, there has been no examination of the efficacy of electrical stimulation compared with other strengthening interventions or the efficacy of different doses or modes of electrical stimulation.

Therefore, the aim of this systematic review was to examine the efficacy of cyclical electrical stimulation (from now on referred to as electrical stimulation). The specific research questions were:

1. Does electrical stimulation increase strength after stroke? Are any benefits maintained beyond the intervention period or carried over to activity?
2. What is the effect of electrical stimulation on strength after stroke compared to each other type of strengthening intervention?
3. What is the effect of different doses or modes of electrical stimulation on strength after stroke?

In order to make recommendations based on a high level of evidence, this review included only randomised or controlled trials. Subgroup analyses based on time after stroke and initial level of strength were planned.

Box 1. Inclusion criteria.

Design
- Randomised or controlled trial

Participants
- Adults (>18 years old)
- Diagnosis of stroke
- Muscle weakness (Manual Muscle Test < Grade 4)

Intervention
- Electrical stimulation in order to increase strength (ie, it is clearly stated that the aim of the intervention is to increase strength or strength is an outcome measure)

Outcomes measures
- Strength measured as peak force/torque and congruent with the stimulated muscle/s

Comparisons
- Electrical stimulation versus placebo/nothing or non-strengthening intervention
- Electrical stimulation versus any other strengthening intervention
- Electrical stimulation versus different dose/mode of electrical stimulation

Method

Identification and selection of trials

Searches were conducted in MEDLINE (1946 to December 2012), CINAHL (1986 to December 2012), EMBASE (1980 to December 2012) and PEDro (to December 2012) for relevant studies without date or language restrictions. Search terms included: words related to *stroke*; words related to *randomised*, *quasi-randomised* or *controlled trials*; and words related to *electrical stimulation* (such as electric stimulation, neuromuscular stimulation, nerve stimulation and functional stimulation) (see Appendix 1 on the eAddenda for the full search strategy). Title and abstracts were displayed and screened by two reviewers in order to identify relevant studies. Full text copies of peer-reviewed relevant papers were retrieved and their reference lists were screened to identify further relevant studies. The method section of the retrieved papers was extracted and reviewed independently by two reviewers using predetermined criteria (Box 1). Both reviewers were blinded to authors, journals and results. Disagreement or ambiguities were resolved by consensus after discussion with a third reviewer.

Assessment of characteristics of trials

Quality

The quality of the included trials was assessed by extracting PEDro scores from the Physiotherapy Evidence Database[26]. The PEDro scale is a 11-item scale designed for rating the methodological quality (internal validity and statistical information) of randomised trials. Each item, except for Item 1, contributes one point to the total PEDro score (range: 0–10 points). Where a trial was not included in the database, it was scored by a reviewer who had completed the PEDro Scale training tutorial.

Participants

Trials involving adult participants of either gender at any time following stroke were included. The number of participants, age and time since stroke were recorded in order to describe the trials. Participants who were unable to move a limb through full range of movement against gravity were categorised as *very weak*; participants who could move through full range against gravity, but had less than normal strength, were categorised as *weak*. At admission to the trial, participants who were less than six months after stroke were categorised as *sub-acute* and those who were more than six months after stroke were categorised as *chronic*.

Intervention

The experimental intervention was electrical stimulation that produced strong repetitive muscle contractions applied in order to increase muscle strength. The control intervention was defined according to each research question: (1) to examine the efficacy of electrical stimulation, the control intervention could be nothing, placebo or any other non-strengthening intervention; (2) to examine the effect of electrical stimulation compared with other strengthening interventions, the control intervention could be any other type of strengthening intervention; (3) to compare different doses or modes of electrical stimulation, the control intervention could be any other dose or mode.

Measures

The strength measurement had to be reported as peak force/torque generation and representative of maximum voluntary contraction (eg, manual muscle test or dynamometry). When multiple measures of strength were reported, the measure that reflected the trained muscle/s was used. If it was appropriate to use the measures from several different muscles (ie, these muscles had been targeted in the intervention), the means and SD of the individual measurements were summed.[4] For measurement of activity, direct measures of performance were used regardless of whether they produced continuous data (eg, The Box and Block Test) or ordinal data (eg, Action Research Arm Test). Measures of general activity (eg, Barthel Index) were used if they were the only available measure of activity.

Data analysis

Information about the method (ie, design, participants, intervention and measures) and results (ie, number of participants, mean and SD of strength and activity) were extracted by two reviewers and checked by a third reviewer. Where information was not available in the published trials, details were requested from the corresponding author.

Since more trials reported pre-intervention and post-intervention scores than change scores, post-intervention scores were used to obtain the pooled estimate of the effect of intervention immediately (ie, post intervention) and long-term (ie, after a period of no intervention). Sub-group analyses were performed for the primary outcome (ie, strength measure) according to the time after stroke (sub-acute, chronic), and the initial level of strength (very weak, weak). If only the median and range of outcomes were available, additional data were requested from the author. The effect size was reported as Cohen's standardised mean difference (95% CI), because different outcome measures were used. A fixed-effects model was used. In the case of significant statistical heterogeneity ($I^2 > 50\%$), a random effects model was applied to check the robustness of the results. Post-hoc sensitivity analysis was performed if there was significant statistical heterogeneity. The analyses were performed using The MIX-Meta-Analysis Made Easy program[27] Version 1.7.[9,10] Where data were not available to be included in the pooled analysis, the between-group result was reported. For all outcome measures, the critical value for rejecting H_0 was set at a level of 0.05 (2-tailed).

Results

Flow of trials through the review

The electronic search strategy identified 6796 papers (excluding duplicates). After screening titles, abstracts and reference lists, 64 potentially relevant full papers were retrieved. Forty-eight papers failed to meet the inclusion criteria; therefore 16 papers were included in this systematic review. One of the papers reported a trial with three arms (cyclical electrical stimulation group, no-intervention group and alternative strengthening intervention group). Therefore, 17 relevant comparisons were reported among the 16 included trials. Figure 1 presents the flow of papers

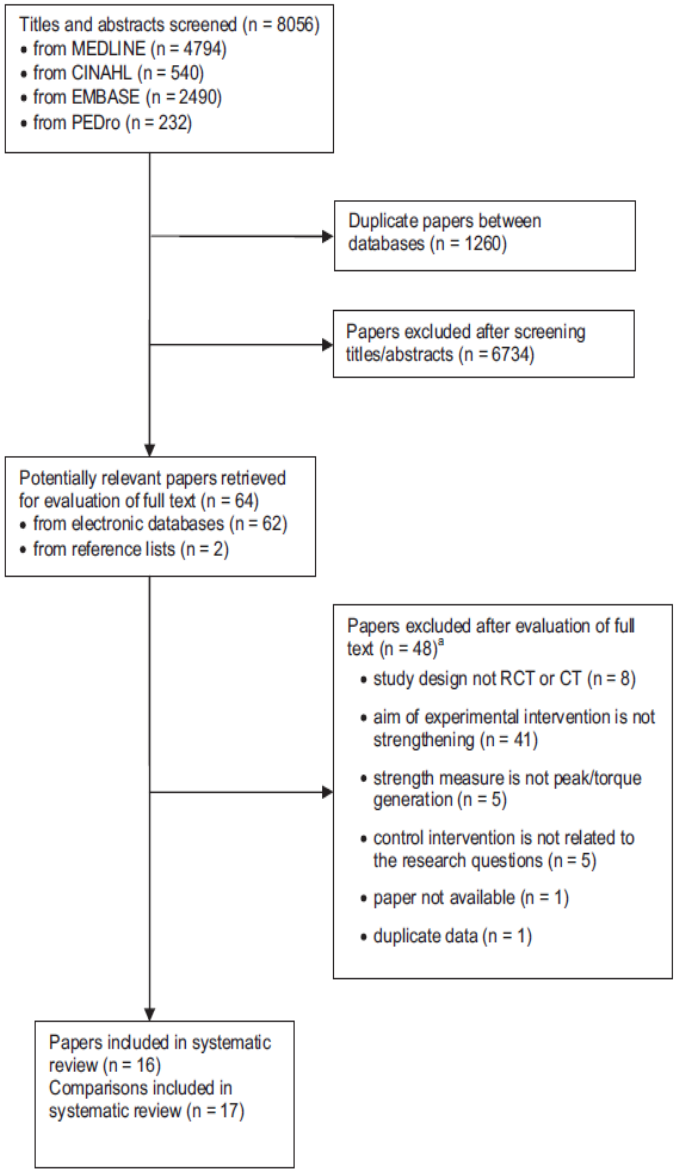

Figure 1. Flow of studies through the review. [a]Papers may have been excluded for failing to meet more than one inclusion criterion.

through the review. See Appendix 2 on the eAddenda for a summary of the excluded papers.

Characteristics of included trials

The 16 trials involved 638 participants and investigated the efficacy of electrical stimulation for increasing muscle strength after stroke. Details of the individual trials are presented in Table 1. Thirteen trials compared electrical stimulation with nothing/placebo, providing data to answer the first study question.[8,11–22] Three trials compared electrical stimulation with other strengthening interventions, providing data to answer the second study question.[16,23,24] One trial[25] compared different doses/modes of electrical stimulation (ie, the third study question). Additional information was obtained from the authors for four papers.[8,11,18,21]

Quality

The mean PEDro score of the papers was 5 (range 2 to 7) (Table 2). The majority of trials: randomly allocated participants (88%); had similar groups at baseline (75%); had blinded assessors (56%); reported loss to follow-up of 15% or less (69%); reported between-group differences (81%); and reported point estimate and variability (94%). However, the majority of trials did not report that they concealed allocation (81%) or carried out an intention-to-treat analysis (88%). All trials, except one, did not blind therapists and participants, which is difficult for this intervention involving near maximum muscle contraction.

Participants

The mean age of participants ranged from 52 to 75 years old. In the trials of sub-acute participants, the mean time after stroke ranged from 1 week to 6 months (nine trials), whereas in trials of chronic participants it ranged from 2 to 5 years (seven trials) including additional information from the authors for two trials.[11,18] Ten trials included very weak participants and six trials included weak participants.

Intervention

The experimental intervention was electrical stimulation (ten trials), position-triggered electrical stimulation (one trial), EMG-triggered electrical stimulation (three trials), and a combination of EMG-triggered or position-triggered electrical stimulation and electrical stimulation (two trials). Ten trials delivered usual therapy to both experimental and control groups. Fourteen trials applied electrical stimulation to one or two muscles per limb with only two trials[13,22] applying it to four different muscles.

Outcome measures

Measures of strength were mainly maximum voluntary force production, either continuous measures of force or torque (14 trials), or ordinal measures such as manual muscle tests (two trials). Most trials used direct measures of activity (five trials reported continuous data, and three trials reported ordinal data), and only one trial used an indirect measure. Seven trials did not measure activity.

Effect of electrical stimulation

Strength

The overall effect of electrical stimulation on strength immediately after intervention was examined by pooling post-intervention data from 11 trials with a mean PEDro score of 5.1, representing moderate quality (Figure 2a, see Figure 3a on the eAddenda for the detailed forest plot). Overall, the effect size was 0.47 (95% CI 0.26 to 0.68) in favour of electrical stimulation. Two trials,[8,12] that were unable to be included in the pooled analysis, also reported significant between-group differences in strength in favour of electrical

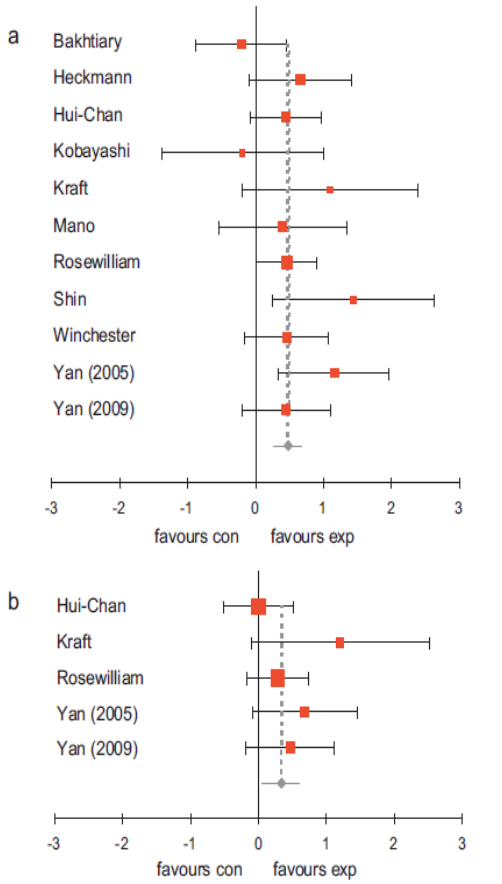

Figure 2. (a) Standardised mean difference (95% CI) of effect of electrical stimulation versus nothing/placebo on strength immediately after intervention (n = 359). (b) Standardised mean difference (95% CI) of effect of electrical stimulation versus nothing/placebo on strength beyond the intervention period (n = 211).

stimulation. Maintenance of the benefit was examined by pooling post intervention data from five trials that measured strength beyond the intervention period. Overall, the increase in strength was maintained with an effect size of 0.33 (95% CI 0.07 to 0.60) (Figure 2b, see Figure 3b on the eAddenda for the detailed forest plot).

When the trials were grouped according to the initial level of strength, electrical stimulation increased the strength in very weak participants (eight trials) with an effect size of 0.40 (95% CI 0.17 to 0.65), and in weak participants (three trials) with an effect size of 0.66 (95% CI 0.21 to 1.11). When the trials were grouped according to the time after stroke, electrical stimulation increased the strength in sub-acute participants (six trials) with an effect size of 0.55 (95% CI 0.28 to 0.81), while in chronic participants (five trials) the effect size was 0.33 (95% CI −0.02 to 0.69).

Activity

The overall effect of electrical stimulation on activity immediately after intervention was examined by pooling post intervention data from six trials with a mean PEDro score of 5.7 out of 10 (Figure 4a, see Figure 5a on the eAddenda for the detailed forest plot). Overall, electrical stimulation improved activity with an effect size of 0.30 (95% CI 0.05 to 0.56). Of the two trials unable to be included in the pooled analysis, one trial[16] reported that most of the participants were not able to perform the activity tests, and one trial[8] reported a significant between-group effect on activity in

Table 1
Characteristics of included papers (n = 16).

Study	Design	Participants	Intervention[a]	Electrical stimulation	Outcome measures[a]
Bakhtiary[11]	RCT	n = 40 Age (*yr*) = mean 55, range 42 to 65 Time since stroke (mo) = not reported Weakness = very weak	Exp = ES 9 min × 5/wk × 4 wk Con = nothing Both = usual therapy (Bobath)	Muscles = ankle dorsiflexors Frequency = 100 Hz Duration = 4 s Progression = ↑ intensity	Strength = MMT (0 to 5); Ankle DF Activity = not measured Timing: 0, 4 wk
Bowman[12]	RCT	n = 30 Age (*yr*) = not reported Time since stroke (mo) = range 0.7 to 4.0 Weakness = weak	Exp = position-triggered ES 100 contractions × 5/wk × 4 wk Con = nothing Both = usual therapy	Muscles = wrist extensors Frequency = 35 Hz Duration = 8 s Progression = ↑ number of contractions	Strength = dynamometry (*Nm*); wrist Ext Activity = not measured Timing: 0, 4 wk
de Kroon[6,25]	RCT	n = 22 Age (*yr*) = mean 59, SD 9 Time since stroke (mo) = mean 22, range 6 to 115 Weakness = weak	Exp = ES 30 min × 5/wk × 6 wk Con = EMG-triggered ES 30 min × 5/wk × 6 wk	Muscles = wrist and finger extensors Frequency = 35 Hz Duration = 6 s Progression = ↑ threshold	Strength = dynamometry (*Kg*); grip strength Activity = ARAT (0 to 57) Timing: 0, 4, 6, 12 wk
Heckmann[13]	RCT	n = 28 Age (*yr*) = 52, SD 23 Time since stroke (mo) = mean 2, SD 0.1 Weakness = very weak	Exp = EMG-triggered ES 15 contractions × 5/wk × 4wk Con = nothing Both = usual therapy (Bobath)	Muscles = elbow and wrist extensors, knee flexors, ankle plantarflexors Frequency = 80 Hz Duration = 1 s Progression = ↑ threshold	Strength = MMT (0 to 5); Σ wrist Ext and ankle PF Activity = Barthel index Timing: 0, 4 wk
Hui-Chan[14]	RCT	n = 109 Age (*yr*) = mean 57, SD 8 Time since stroke (mo) = mean 56, SD 41 Weakness = weak	Exp = ES 60 min × 5/wk × 4 wk Con = nothing	Muscles = ankle dorsiflexors and plantarflexors Frequency = 100 Hz Duration = not reported Progression = not reported	Strength = dynamometry (*Nm*); Σ ankle DF and PF Activity = TUG (*s*) Timing: 0, 4, 8 wk
Kimberley[23]	Cross-over RCT	n = 16 Age (*yr*) = mean 60, SD 15 Time since stroke (mo) = mean 35, SD 25 Weakness = very weak	Exp = EMG-triggered ES + ES 6 h × 3.3/wk × 3wk Con = voluntary effort + nothing 6 h × 3.3/wk × 3wk	Muscles = wrist and finger extensors Frequency = 20 Hz Duration = 5 s Progression = not reported	Strength = dynamometry (*N*); finger Ext Activity = BBT (# blocks) Timing: 0, 3 wk
Kobayashi[15]	RCT	n = 24 Age (*yr*) = mean 64, SD 11 Time since stroke (mo) = mean 31 Weakness = very weak	Exp = ES 30 min × 5/wk × 6 wk Con = nothing Both = usual therapy	Muscles = shoulder abductors Frequency = 20 Hz Duration = 10 s Progression = not reported	Strength = dynamometry (*N*); shoulder abd Activity = not measured Timing: 0, 6 wk
Kraft[16]	CT	n = 22 Age (*yr*) = mean 63, SD 9 Time since stroke (mo) = mean 26, SD 13 Weakness = weak	Exp = EMG-triggered ES 60 min × 3/wk × 12 wk Con 1 = nothing Con 2 = strengthening (PNF) 60 min × 3/wk × 12 wk	Muscles = wrist extensors Frequency = 30 to 90 Hz Duration = 10 s Progression = ↑ threshold	Strength = dynamometry (*lb*); grip strength Activity = JTHFT (*s*) Timing = 0, 12, 24, 48
Lima[24]	CT	n = 17 Age (*yr*) = not reported Time since stroke (mo) = not reported Weakness = weak	Exp = ES 15 min × 10 sessions Con = strengthening (isotonic) 3 × 15 reps × 10 sessions	Muscles = knee extensors Frequency = 50 Hz Duration = 10 s Progression = not reported	Strength = dynamometry (*Nm/s*); knee Ext Activity = not measured Timing: 0, 10 sessions
Mano[17]	RCT	n = 18 Age (*yr*) = mean 74, SD 7 Time since stroke (mo) = mean 6, SD 3 Weakness = very weak	Exp = ES 30 min × 3/wk × 8 wk Con = nothing Both = usual therapy	Muscles = wrist and finger extensors Frequency = 50 Hz Duration = 5 s Progression = ↑ number of contractions	Strength = dynamometry (*Kg*); grip strength Activity = not measured Timing: 0, 8 wk

Table 1 (*Continued*)

Study	Design	Participants	Intervention[a]	Electrical stimulation	Outcome measures[a]
Powell[8]	RCT	n = 60 Age (*yr*) = mean 68, SD 12 Time since stroke (mo) = mean 0.8, SD 0.2 Weakness = very weak	Exp = ES 90 min × 5/wk × 8 wk Con = nothing Both = usual therapy	Muscles = wrist and finger extensors Frequency = 20 Hz Duration = 5 s Progression = ↑ number of contractions	Strength = dynamometry (*Nm*) (15 deg); wrist Ext Activity = ARAT (0 to 57) Timing: 0, 8, 20, 32 wk
Rosewilliam[18]	RCT	n = 90 Age (*yr*) = mean 75, SD 11 Time since stroke (mo) = not reported Weakness = very weak	Exp = ES 60 min × 5/wk × 6 wk Con = nothing Both = usual therapy	Muscles = wrist and finger extensors Frequency = 40 Hz Duration = 3 s Progression = ↑ intensity	Strength = dynamometry (*N*); wrist Ext Activity = ARAT (0 to 57) Timing: 0, 6, 12, 24, 36 wk
Shin[19]	RCT	n = 14 Age (*yr*) = mean 58, SD 10 Time since stroke (mo) = mean 19, SD 6 Weakness = weak	Exp = EMG-triggered ES 30 min × 5/wk × 10 wk Con = nothing	Muscles = wrist and finger extensors Frequency = 35 Hz Duration = 5 s Progression = ↑ threshold	Strength = dynamometry, (*Kg*); wrist Ext Activity = BBT (# blocks) Timing: 0, 10 wk
Winchester[20]	RCT	n = 40 Age (*yr*) = mean 58, SD 12 Time since stroke (mo) = mean 2, SD 1 Weakness = very weak	Exp = Positional-triggered ES + ES 30 min × 5/wk × 4 wk + 2 hr × 5/wk × 4 wk Con = nothing Both = usual therapy	Muscles = knee extensors Frequency = 30 Hz Duration = 10 s Progression = ↑ number and duration of contractions	Strength = dynamometry (*Nm*); knee Ext Activity = not measured Timing: 0, 4 wk
Yan (2005)[22]	RCT	n = 46 Age (*yr*) = mean 71, SD 8 Time since stroke (mo) = mean 0.3, SD 0.1 Weakness = very weak	Exp = ES 30 min × 5/wk × 3 wk Con = Sham stimulation 30 min × 5/wk × 3 wk Both = usual therapy	Muscles = knee flexors and extensors, ankle dorsiflexors and plantarflexors Frequency = 30 Hz Duration = not reported Progression = not reported	Strength = dynamometry (*Nm*); ankle DF Activity = TUG (*s*) Timing: 0, 3, 8 wk
Yan (2009)[21]	RCT	n = 62 Age (*yr*) = mean 70, SD 7 Time since stroke (mo) = mean 0.3, SD 0.1 Weakness = very weak	Exp = ES 60 min × 5/wk × 3 wk Con = nothing Both = usual therapy	Muscles = ankle dorsiflexors and plantarflexors Frequency = 100 Hz Duration = not reported Progression = not reported	Strength = dynamometry (*Nm*); ankle DF Activity = TUG (*s*) Timing: 0, 3, 8 wk

ARAT, action research arm test; abd, abduction; BBT, box and block test; Con, control group; CT, controlled trial; DF, dorsiflexion; Exp, experimental group; ES, electrical stimulation; Ext, extension; JTHFT, Jebsen-Taylor hand function test; MAL, motor activity log; MMT, manual muscle test; MVC, maximum voluntary contraction; PF, plantarflexion; PNF, proprioceptive neuromuscular facilitation; RCT, randomised clinical trial; TUG, Timed Up and Go test; Σ, summed.

[a] Groups and outcome measures listed are those that were analysed in this systematic review; there may have been other groups or measures in the paper.

Table 2
PEDro criteria and scores for included papers (n = 16).

Study	Random allocation	Concealed allocation	Groups similar at baseline	Participant blinding	Therapist blinding	Assessor blinding	<15% dropouts	Intention-to-treat analysis	Between-group difference reported	Point estimate and variability reported	Total (0 to 10)
Bakhtiary[11]	Y	N	Y	N	N	Y	Y	N	Y	Y	6
Bowman[12]	Y	N	N	N	N	Y	N	N	Y	N	3
de Kroon[6,25]	Y	Y	N	N	N	Y	Y	N	Y	Y	6
Heckmann[13]	Y	N	Y	N	N	N	Y	N	Y	Y	5
Hui-Chan[14]	Y	N	Y	N	N	Y	Y	Y	Y	Y	7
Kimberley[23]	Y	N	Y	Y	N	Y	Y	N	N	Y	6
Kobayashi[15]	Y	N	N	N	N	N	Y	N	N	Y	3
Kraft[16]	N	N	Y	N	N	N	Y	N	Y	Y	4
Lima[24]	N	N	N	N	N	N	Y	N	N	Y	2
Mano[17]	Y	N	Y	N	N	N	Y	N	Y	Y	5
Powell[8]	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
Rosewilliam[18]	Y	Y	Y	N	N	Y	N	Y	Y	Y	7
Shin[19]	Y	N	Y	N	N	N	N	N	Y	Y	4
Winchester[20]	Y	N	Y	N	N	N	N	N	Y	Y	4
Yan (2005)[22]	Y	N	Y	N	N	Y	Y	N	Y	Y	6
Yan (2009)[21]	Y	N	Y	N	N	Y	N	N	Y	Y	5

Y = yes, N = no.

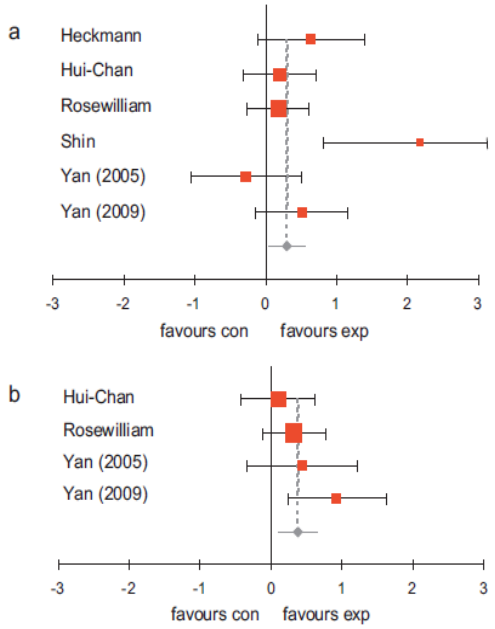

Figure 4. (a) Standardised mean difference (95% CI) of effect of electrical stimulation versus nothing/placebo on activity immediately after intervention (n = 242). (b) Standardised mean difference (95% CI) of effect of electrical stimulation versus nothing/placebo on activity beyond the intervention period (n = 198).

favour of the electrical stimulation group. Maintenance of the benefit was examined by pooling data from the four trials that reported results beyond the intervention period. A significant improvement in activity was maintained with an overall effect size of 0.38 (95% CI 0.09 to 0.66) (Figure 4b, see Figure 5b on the eAddenda for the detailed forest plot).

Effect of electrical stimulation on strength compared with other strengthening interventions

The effect of electrical stimulation compared with other strengthening interventions was examined by three trials, with a mean PEDro score of 4 out of 10. The alternative strengthening interventions were maximum voluntary effort,[23] external resistance applied during proprioceptive neuromuscular facilitation,[16] or isotonic exercises.[24] Although two trials[16,23] reported no significant difference between electrical stimulation and another strengthening intervention, a meta-analysis was not possible because only one trial[23] reported post-intervention data. The mean difference between groups in this trial was 4 *N* (95% CI −2.0 to 10.0). A third trial[24] did not report a between-group statistical comparison.

Effect of different dose/mode of electrical stimulation on strength

One trial,[25] with a PEDro score of 6 out of 10, compared the effect of electrical stimulation with EMG-triggered electrical stimulation. There was no significant difference in the ratio of paretic/non-paretic strength between the groups (MD 0.04, 95% CI −0.04 to 0.12).

Discussion

This systematic review provides evidence that electrical stimulation can increase strength and improve activity after stroke, and that benefits are maintained beyond the intervention period. However, the evidence about whether electrical stimulation is more beneficial than another strengthening intervention is sparse, and the relative effect of different doses or modes is still uncertain.

This systematic review set out to answer three questions. The first examined whether *electrical stimulation increases strength and improves activity after stroke*. The meta-analyses show that the implementation of electrical stimulation has a moderate positive effect on strength, which is accompanied by a small-to-moderate positive effect on activity. The slightly smaller effect on activity may be because only one trial[22] applied electrical stimulation to more than two muscles per limb. This is unlikely to have a large impact on activities performed by that limb, because most activities require contraction of many muscles at one time or another. The improvements in strength and activity were maintained beyond the intervention period with a small-to-moderate effect size, suggesting that the benefits were incorporated into daily life. Furthermore, meta-analyses of the subgroups suggest that electrical stimulation can be applied effectively to both weak

and very weak people after stroke, subacutely, and may be applied chronically.

Two previous systematic reviews[5,7] concluded that electrical stimulation was beneficial in increasing muscle strength after stroke. However, these conclusions were based on few trials, no meta-analysis and included trials of both cyclical and functional electrical stimulation. The results of the current systematic review provide stronger evidence of the efficacy of electrical stimulation for increasing strength and improving activity; this is because the conclusions are based on a meta-analysis of nine randomised trials and two controlled trials of reasonable quality. In addition, the trials included in the meta-analysis were similar with regard to the stimulation parameters (frequency and duration of the stimulus) and the amount of intervention delivered. Although the length of the individual sessions varied (mean 45 min per muscle, SD 38), the trials were very similar in their frequency (mean 4.6/wk, SD 0.7) and duration (mean 5.8 wk, SD 3.0) of intervention. The evidence appears strong enough to recommend that daily sessions of electrical stimulation with high repetitions of maximum muscle contractions be used to increase strength after stroke.

The second question examined whether *electrical stimulation is more effective than other strengthening interventions for increasing strength after stroke.* There are insufficient data to determine whether electrical stimulation is better than another strengthening intervention. Only three trials investigating this question were included and a meta-analysis could not be performed. Furthermore, the mean PEDro score of 4.0 from the three trials related to this question represents low quality, with considerable performance, attrition and detection bias present.

The third question examined *the most effective dose or mode of electrical stimulation for increasing strength after stroke.* There are insufficient data to provide evidence regarding the effect of different doses/modes of electrical stimulation. Only one trial[25] directly compared two different modes and found no difference between electrical stimulation and EMG-triggered electrical stimulation, with an effect size near zero.

This review has both strengths and limitations. The mean PEDro score of 5.0 for the 16 trials included in this review represents moderate quality. A source of bias in the included trials was lack of blinding of therapists and participants, since it is very difficult to blind therapists or participants during the delivery of complex interventions. Other sources of bias were lack of reporting concealed allocation or whether an intention-to-treat analysis was undertaken. On the other hand, the main strength of this review is that only trials where electrical stimulation was applied in order to increase strength and with a clear measure of force generation were included; this makes the results specific to the research questions. Additionally, publication bias inherent to systematic reviews was avoided by including studies published in languages other than English.[17,24]

In conclusion, this systematic review provides evidence that cyclical electrical stimulation is effective (ie, it results in a greater increase in muscle strength compared with placebo/nothing). Electrical stimulation appears to be effective regardless of the initial level of strength or the time after stroke and the benefits are maintained beyond the intervention period. Clinicians should therefore be confident in prescribing daily electrical stimulation for people after a stroke, when the primary objective of the intervention is to increase muscle strength. In particular, it may be a useful intervention in the presence of cognitive impairments or profound weakness when it is difficult for the person to carry out strengthening exercises independently. In addition, the results of this systematic review are valuable since they show that electrical stimulation can have a beneficial effect not only on strength but also on activity, with improvements maintained beyond the intervention period. Further studies are necessary to investigate whether electrical stimulation is more effective than other strengthening interventions.

What is already known on this topic: After a stroke, many people are unable to generate normal amounts of force, which restricts participation in daily activities. Cyclical electrical stimulation can be used to strengthen muscles, even when the patient cannot voluntarily generate adequate force for resistance exercise.
What this study adds: Cyclical electrical stimulation increases strength and activity in people who have had a stroke. These effects are maintained beyond the intervention period, suggesting that the increased strength is utilised in daily life and is therefore maintained by ongoing increased activity.

eAddenda: Figures 3a, 3b, 5a, 5b and Appendix 1 and 2 can be found online at doi:10.1016/j.jphys.2013.12.002

Competing interests: Nil.

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References

1. Norrving B, Kissela B. The global burden of stroke and need for a continuum of care. *Neurology*. 2011;80(3 Suppl. 2):S5–S12.
2. Faria-Fortini I, Michaelsen SM, Cassiano JG, Teixeira-Salmela LF. Upper extremity function in stroke subjects: relationships between the international classification of functioning, disability, and health domains. *J Hand Ther*. 2011;24(3):257–264.
3. Robinson CA, Shumway-Cook A, Matsuda PN, Ciol MA. Understanding physical factors associated with participation in community ambulation following stroke. *Disabil Rehabil*. 2007;33(12):1033–1042.
4. Ada L, Dorsch S, Canning CG. Strengthening interventions increase strength and improve activity after stroke: a systematic review. *J Physiother*. 2006;52(4):241–248.
5. Glinsky J, Harvey L, Van Es P. Efficacy of electrical stimulation to increase muscle strength in people with neurological conditions: a systematic review. *Physiother Res Int*. 2007;12(3):175–194.
6. de Kroon JR, Lee JH, IJzerman MJ, Lankhorst GJ. Therapeutic electrical stimulation to improve motor control and functional abilities of the upper extremity after stroke: a systematic review. *Clin Rehabil*. 2002;16(4):350–360.
7. Pomeroy VM, King L, Pollock A, Baily-Hallam A, Langhorne P. Electrostimulation for promoting recovery of movement or functional ability after stroke. *Cochrane Database Syst Rev*. 2006;19(2):CD003241.
8. Powell J, Pandyan A, Granat M, Cameron M, Stott D. Electrical stimulation of wrist extensors in poststroke hemiplegia. *Stroke*. 1999;30:1384–1389.
9. Bax L, Yu LM, Ikeda N, Tsuruta H, Moons KG. Development and validation of MIX: comprehensive free software for meta-analysis of causal research data. *BMC Med Res Methodol*. 2006;6:50.
10. Bax L, Ikeda N, Fukui N, Yaju Y, Tsuruta H, Moons KG. More than numbers: the power of graphs in meta-analysis. *Am J Epidemiol*. 2009;169(2):249–255.
11. Bakhtiary A, Fatemy E. Does electrical stimulation reduce spasticity after stroke? A randomized controlled study. *Clin Rehabil*. 2008;22:418–425.
12. Bowman BR, Baker LL, Waters RL. Positional feedback and electrical stimulation: an automated treatment for the hemiplegic wrist. *Arch Phys Med Rehabil*. 1979;60:497–502.
13. Heckmann J, Mokrusch T, Krockel A, Warnke S, Stockert T, Neundorfer B. EMG-triggered electrical muscle stimulation in the treatment of central hemiparesis after stroke. *Eur J Phys Med Rehabil*. 1997;7(5):138–141.
14. Hui-Chan C, Ng S, Mak M. Effectiveness of a home-based rehabilitation programme on lower limb functions after stroke. *Hong Kong Med J*. 2009;15(3 Suppl. 4):42–46.
15. Kobayashi H, Onishi H, Ihashi K, Yagi R, Handa Y. Reduction in subluxation and improved muscle function of the hemiplegic shoulder joint after therapeutic electrical stimulation. *J Electromyogr Kinesiol*. 1999;9:327–336.
16. Kraft G, Fitts S, Hammond M. Techniques to improve function of the arm and hand in chronic hemiplegia. *Arch Phys Med Rehabil*. 1992;73:220–227.
17. Sentandreu Mañó TS, Salom Terrádez JR, Tomás JM, Meléndez Moral JC, de la Fuente Fernández T, José CC. Electrical stimulation in the treatment of the spastic hemiplegic hand after stroke: a randomized study. *Med Clin*. 2011;137(7):297–301.

18. Rosewilliam S, Malhotra S, Roffe C, Jones P, Pandyan A. Can surface neuromuscular electrical stimulation of the wrist and hand combined with routine therapy facilitate recovery of arm function in patients with stroke? *Arch Phys Med Rehabil*. 2012;93:1715–1721.
19. Shin H, Cho S, Jeon H, Lee Y, Song J, Jang S, et al. Cortical effect and functional recovery by the electromyography-triggered neuromuscular stimulation in chronic stroke patients. *Neurosci Lett*. 2008;442:174–179.
20. Winchester P, Montgomery J, Bowman B, Hislop H. Effects of feedback stimulation training and cyclical electrical stimulation on knee extension in hemiparetic patients. *Phys Ther*. 1983;63(7):1096–1103.
21. Yan T, Hui-Chan C. Transcutaneous electrical stimulation on acupuncture points improves muscle function in subjects after acute stroke: a randomized controlled trial. *J Rehabil Med*. 2009;41:312–316.
22. Yan T, Hui-Chan C, Li L. Functional electrical stimulation improves motor recovery of the lower extremity and walking ability of subjects with first acute stroke: a randomized placebo-controlled trial. *Stroke*. 2005;36:80–85.
23. Kimberley T, Lewis S, Auerbach E, Dorsey L, Lojovich J, Carey J. Electrical stimulation driving functional improvements and cortical changes in subjects with stroke. *Exp Brain Res*. 2004;154:450–460.
24. Lima MO, Lima FPS, Takeshi S, de Freitas T, Regina-Ribeiro S, Tortoza C, et al. Efecto de la estimulacion electrica neuromuscular y de los ejercicios isotonicos en los musculos flexores y extensores de la rodilla en pacientes hemiplejicos. *Rev Neurol*. 2008;46(3):135–138.
25. de Kroon JR, IJzerman MJ. Electrical stimulation of the upper extremity in stroke: cyclic versus EMG-triggered stimulation. *Clin Rehabil*. 2008;22:690–697.

Websites

26. www.pedro.org.au
27. www.meta-analysis-made-easy.com

ANEXO V- Carta de aprovação pelo Comitê de Ética em Pesquisa - UFMG

UNIVERSIDADE FEDERAL DE MINAS GERAIS
COMITÊ DE ÉTICA EM PESQUISA - COEP

Projeto: CAAE - 0254.0.203.000-11

Interessado(a): Profa. Luci Fuscaldi Teixeira-Salmela
Departamento de Fisioterapia
EEFFTO - UFMG

DECISÃO

O Comitê de Ética em Pesquisa da UFMG – COEP aprovou, no dia 13 de julho de 2011, após atendidas as solicitações de diligência, o projeto de pesquisa intitulado **"Avaliação de parâmetros metabólicos e cardiorrespiratórios de hemiparéticos crônicos durante a realização de atividades funcionais"** bem como o Termo de Consentimento Livre e Esclarecido.

O relatório final ou parcial deverá ser encaminhado ao COEP um ano após o início do projeto.

Profa. Maria Teresa Marques Amaral
Coordenadora do COEP-UFMG

ANEXO VI- Carta de aprovação pelo Comitê de Ética em Pesquisa-

Secretaria Municipal da Saúde de Belo Horizonte

Secretaria Municipal de Saúde de Belo Horizonte

Comitê de Ética em Pesquisa Envolvendo Seres Humanos

Parecer: 0254.0.203.000-11A

Pesquisadora responsável: Luci Fuscaldi Teixeira-Salmela

O Comitê de Ética em Pesquisa da Secretaria Municipal de Saúde de Belo Horizonte – CEP/SMSA/BH aprovou em 13 de fevereiro de 2013, o projeto de pesquisa intitulado "**Avaliação de parâmetros metabólicos e cardiorrespiratórios de hemiparéticos crônicos durante a realização de atividades funcionais**", bem como seu Termo de Consentimento Livre e Esclarecido.

O relatório final ou parcial deverá ser encaminhado ao CEP um ano após início do projeto ou ao final deste, se em prazo inferior a um ano.

Eduardo Prates Miranda

Coordenador do CEP/SMSA/BH

Avenida Afonso Pena, 2336, 9º andar. Funcionários - Belo Horizonte. 30.130-007 - MG.
coep@pbh.gov.br TEL.: (31) 3277-5309 FAX: (31) 3277-7768

ANEXO VII - Normas para publicação da Revista *Stroke*

Instructions for Authors

Stroke: A Journal of Cerebral Circulation publishes reports of clinical and basic investigation of any aspect of the cerebral circulation and its diseases from many disciplines, including anesthesiology, critical care medicine, epidemiology, internal medicine, neurology, neuro-ophthalmology, neuropathology, neuropsychology, neurosurgery, nuclear medicine, nursing, radiology, rehabilitation, speech pathology, vascular physiology, and vascular surgery.

Tips for Submissions

- The total word count of any article consists of the title page, abstract (if applicable), main body of text, acknowledgments, sources of funding, disclosures, references, figure legends, tables and appendices intended for print publication. Word count is calculated by the editorial office using the Microsoft Word tool. If the manuscript exceeds the total word count, authors must place a statement in the cover letter indicating the authors agree to pay the additional fees.
- The combined total number of figures and tables is limited to 6 (3 for Brief Reports).
- Each figure may contain up to 4 panels (i.e., Parts A to D).
- References with more than 6 authors should list the first 6 authors followed by et al and do not list the month/issue/day (the number in parentheses) in the reference.
- The corresponding author should collect Conflict of Interest information from all co-authors before submitting a manuscript. The initial submission must include a disclosure statement that lists all the conflicts. If there are no conflicts, please state "Disclosures: None."
- All authors listed on the title page of the manuscript must also be listed in the online submission system.
- The use of the online data supplement is strongly encouraged not only for additional tables and figures but for complex methodology, large tables, and complex figures. They must be clearly labeled as data supplement on the title page and in references throughout the paper and the file should be uploaded as a separate supplemental PDF.
- Consult the AMA Manual of Style 10th Edition, for style.

Article Categories

For preparation, see Tips for Submission and Instructions for New Submissions.

Original Contributions. Original research contributions are for manuscripts that encompass the broad range of innovative and impactful clinical and basic research in the field of cerebrovascular disorders. These manuscripts should present comprehensive with a robust methodology and results sections. The maximum length for original manuscripts is 4,500 words. Please note the publication fees in the Costs to Authors section. The total number of figures and/or tables is limited to 6. Each figure may contain up to *4 panels (i.e., parts A to D)* and must conform to the requirements for figures described in that section of the instructions to authors.

Brief Reports. Brief reports are for manuscripts with less complete data sets than would be appropriate for original contributions that present novel and impactful clinical and basic research of a more preliminary nature. Maximum length is 1,800 words. The total number of references is limited to 15. The total number of figures and/or tables is limited to 3.

Progress or Topical Reviews. This category presents a review of advances related to important research and clinical topics relevant to some aspect of cerebrovascular disease. They will generally be invited by the editors but unsolicited reviews will also be accepted for editorial review. Invited reviews will also undergo peer review but except in rare circumstances will not be subject to rapid triage and early rejection. Manuscripts should not exceed 4,500 words with 6 figures/tables. **Please do NOT include an abstract in review papers. An introduction or background section will suffice.**

Comments and Opinions. In this category, authors summarize the present state of knowledge in some aspect of cerebrovascular disease without the objectivity required in a Progress Review. Maximum length is 4,500 words with a total of 6 figures/tables. **Please do NOT include an abstract in review papers. An introduction or background section will suffice.**

Special Reports. These articles may summarize an event or a topic of interest to the readers of *Stroke*. Authors must query the editors before writing Special Reports to determine possible interest in such articles. Maximum length is 4,500 words with a total of 6 tables/figures.
Clinical and Research Innovations (Online-Only Publication). These articles provide a broad opportunity to communicate innovative new ideas that comprise solutions to problems in acute stroke that are currently viewed as impediments to progress in stroke research and clinical care. Submissions may cover a wide spectrum of potential advances including new technologies that accelerate progress; articles delineating the need for new potential collaborations; solutions to workflow problems; as well as solutions and innovations related social, ethical and legal matters impacting stroke care and research.

Format: Please do NOT include an abstract. The initial paragraph should center on the specific problem that is being addressed. It may contain a limited amount of literature review related to the problem itself in order to clearly set out the issues at hand. The rest of the article should focus on the solution but not on the problem. Please structure the manuscript using these subheadings as guidelines. You may modify or omit subheadings as appropriate: Brief description on the problem/challenge; Description of the innovation/solution; Results of pilot testing; and Conclusion/Limitations/next steps. Articles are not limited to innovations that can result in intellectual property or other assets with commercial potential. However, in the process of describing the solution, the generation of intellectual property, filing for patents, of the development of products and/or companies and industry collaborations are recognized to be natural aspects of innovation, and are welcome attributes and should be mentioned if applicable. (Please note that the journal is not responsible for protection of intellectual property). Subheadings may be used as necessary. Please include a Conclusion that comments on the implications of this latest work on the overall stroke and research are encouraged. In addition, authors may consider discussing future plans, expectations of collaboration etc.

Maximum length for this article is 2,000-2500 words. The word limit includes title page, main body of text, acknowledgments, sources of funding, disclosures, references, figure legends, and tables. Subheadings may be used as appropriate. Please see the recent editorial introducing this new article type: "Bottlenecks in Acute Stroke Care and Research: Solutions and Innovations."
Letters to the Editor (Online-Only Publication). This forum expresses views about articles published in *Stroke* or presents ideas or findings of scientific interest that do not constitute original research. Letters must reference a*Stroke* article published in print within the past 4 weeks. The maximum length is 750 words including no more than 5 references and 3 authors. Tables, figures, and data supplements are prohibited. ***Please use the journal formatting for titles of Letters to the Editor.*** Example: Letter by Author et al. Regarding Article, "Article Title." Letters may be shortened or edited by the Editorial Office. The editor invites responses to letters as appropriate. Response Letter titles use this format: Response to Letter Regarding Article, "Article Title."
Case Reports (Online-Only Publication). The editors will in *very rare* circumstances consider case reports for publication only if they present important and unique clinical experience. Authors should limit descriptions of negative and normal findings. Maximum length is 1,500 words with only the most relevant references. **Please use the abstract headings Background and Purpose, Summary of Case, and Conclusion.** Authors should limit figures to those that enhance the study.

Instructions for New Submissions

To submit your manuscript online, please visit the journal's online manuscript submission site (http://stroke-submit.aha-journals.org), and follow the instructions for creating an author account and submitting a manuscript. Access can also be gained by visiting *Stroke* online at http://stroke.ahajournals.org and selecting the Online Submissions button. If you have any questions about the online submission process, contact the Editorial Office by e-mail at stroke@strokeahajournal.org or by telephone at 617-542-5100 ext 8796.

Initial Review Process

Submitted manuscripts will be evaluated initially by an associate editor or guest editor. During initial review, the associate editor will determine whether or not the manuscript is appropriate for a full review based on the quality, originality, scientific rigor and data presentation/analysis of the manuscript. In some instances, the associate editor may reach out to a second reviewer (assistant editor, section editor, member of the editorial board, or invited reviewer with topic-related expertise) for this quick assessment. It is anticipated that approximately 50% of the submitted manuscripts will undergo formal review and 50%

will be rejected without evaluation by external reviewers. This policy reflects the stringent requirements for the acceptance of manuscripts submitted to *Stroke*.

Expedited Publication

The editors invite submission of manuscripts that have major importance to the scientific community. To be considered for expedited publication, an article must be unique and contain information that could make a significant difference in medical practice or constitute an important advance in basic knowledge. The authors must clearly state reasons for the request in the cover letter. If the editors agree that an article should be an expedited publication, they will arrange an accelerated review and, if accepted, accelerated publication.

Guest Editors

To avoid actual or perceived conflict of interest, the journal uses guest editors to handle certain manuscripts. For more details, see the Editor Conflict-of-Interest Policy text below.

Manuscript Formatting

- Only Microsoft Word files will be accepted for review.
- Manuscripts must be double-spaced, including references, figure legends, and tables.
- We recommend using Times New Roman 12-point font.
- Leave 1-inch margins on all sides. Number every page, beginning with the abstract page, including tables, figure legends, and figures.
- Manuscripts should be presented in the following sequence:
    1. Title page
    2. Abstract
    3. Text, including Introduction, Methods, Results, Discussion and Summary/Conclusions
    4. Acknowledgments
    5. Sources of Funding
    6. Conflict(s)-of-Interest/Disclosure(s)
    7. References
    8. Figure Legends
    9. Tables
    10. Figures
- Cite each reference in the text in numerical order and list in the References section. In text, reference numbers may be repeated but not omitted. Do not duplicate references either in text or in the reference list.
- Cite each figure and table in the text in numerical order.
- Upload one copy of any in-press article that is cited in the references, if applicable.
- Upload one copy of any abstracts published or submitted for publication, if applicable.
- Use SI units of measure in all manuscripts. For example, molar (M) should be changed to mol/L; mg/dL to mmol/L; and cm to mm. Units of measure previously reported as percentages (e.g., hematocrit) are expressed as a decimal fraction. Measurements currently not converted to SI units in biomedical applications are blood and oxygen pressures, enzyme activity, H+ concentration, temperature, and volume. The SI unit should be used in text, followed by the conventionally used measurement in parentheses. Conversions should be made by the author before the manuscript is submitted for peer review.
- **NEW:** Provide $US dollar equivalents if you include other currency amounts in the manuscript.
- Please provide sex-specific and/or racial/ethnic-specific data, when appropriate, in describing outcomes of epidemiologic analyses or clinical trials; or specifically state that no sex-based or racial/ethnic-based differences were present. See the Uniform Requirements for Manuscripts Submitted to Biomedical Journals for more details.
- **Please review the correct usage "sex" and "gender." "Gender" is a social construct and "sex" describes a biological status.** Please use the terms appropriately.
- Authorship Responsibility and Copyright Transfer Agreement Forms (and Licensing Agreements for Original Contributions) are ONLINE ONLY. Forms will be required PRIOR to

resubmission, or if the manuscript has only one version (e.g., a letter to the editor) after acceptance. Each author will be sent an email containing a link to the form at the appropriate time.

- Consult the *AMA Manual of Style: A Guide for Authors and Editors*, 10th ed, Oxford: Oxford University Press; 2007, for style.
- Consult current issues for additional guidance on format.

Cover Letter

Please upload a cover letter that includes the following statement: "All authors have read and approved the submitted manuscript, the manuscript has not been submitted elsewhere nor published elsewhere in whole or in part, except as an abstract (if relevant)." The cover letter may include the names of up to 3 potential reviewers whom the authors would like to suggest, especially members of the editorial board. The authors may also include the names of up to 3 reviewers whom they would like to not evaluate their submission. The editor ultimately decides who reviews the manuscript. Lastly, please note any potential overlapping content submitted or accepted to another journal or conference.

Title Page

The first page of the manuscript should be the title page. This page must include:

- Full title of the article, limited to 120 characters.
- Authors' names, highest academic degree earned by each, authors' affiliations, name and complete address for correspondence, and address for reprints if different from address for correspondence. Please also include any study group or collaboration in the author list, i.e., " . . .Last Author, on behalf of the Stroke Study Group."
- Fax number, telephone number, and e-mail address for the corresponding author.
- Cover title (total characters must not exceed 50, including spaces) to be typeset on the top of the journal page.
- Itemized list of the tables and figures
- 3 to 7 key words for use as indexing terms
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- Specify the number of words on your title page. Word count should include all parts of the manuscript (i.e., title page, abstract, main body of text, acknowledgments, sources of funding, disclosures, references, figure legends, tables, and appendices intended for print publication). Over-length manuscripts will **NOT** be accepted for publication without an additional page charge. See the Costs to Authors below.

Abstract

- Do not cite references in the abstract.
- Limit use of acronyms and abbreviations.
- Be concise (250 words, maximum).
- The abstract should have the following headings:
    1. Background and Purpose (description of rationale for study)
    2. Methods (brief description of methods)
    3. Results (presentation of significant results)
    4. Conclusions (succinct statement of data interpretation)
    5. When applicable, include a fifth heading: "Clinical Trial Registration." Please list the URL, as well as the Unique Identifier, for the publicly accessible website on which the trial is registered. If the trial is not registered, please indicate the reason in the heading.
    Example 1: Clinical Trial Registration-URL: http://www.clinicaltrials.gov. Unique identifier: NCT00123456.
    Example 2: Clinical Trial Registration-URL: http://www.controlled-trials.com. Unique identifier: ISRCTN70000879.
    Example 3: Clinical Trial Registration-URL: http://www.chictr.org. Unique identifier: ChiCTR-RCH-14004884.

Example 4: Clinical Trial Registration-This trial was not registered because enrollment began prior to July 1, 2005.

Text

- The following are typical main headings: Materials and Methods, Results, Discussion, and Summary.
- Abbreviations must be defined at first mention in the text, tables, and figures.
- **Introduction:** This section should briefly introduce the context of the results to be presented and should duplicate what is contained elsewhere in the manuscript
- **Methods:**
  - For any apparatuses used in Methods, the complete names of manufacturers must be supplied.
  - For human subjects or patients, describe their characteristics.
  - For animals used in experiments, state the species, strain, number used, and other pertinent descriptive characteristics.
  - When describing surgical procedures on animals, identify the preanesthetic and anesthetic agents used, and state the amount or concentration and the route and frequency of administration for each. The use of paralytic agents, such as curare or succinylcholine, is not an acceptable substitute for anesthetics.
  - For other invasive procedures on animals, report the analgesic or tranquilizing drugs used. If none were used, provide justification for such exclusion.
  - Manuscripts that describe studies on humans must indicate that the study was approved by an institutional review committee and that the subjects gave informed consent.
  - Manuscripts involving animals must indicate that the study was approved by an institutional animal care and use committee.
  - Reports of studies on both animals and humans must indicate that the procedures followed were in accordance with institutional guidelines.
  - All drugs should be referred to by their generic names rather than trade names. The generic chemical identification of all investigational drugs must be provided.
  - A statistical subsection must be provided at the end of the Methods section describing the statistical methodology employed for the data presented in the manuscript.
  - The Methods section should provide essential information related to the conduct of the study presented in the manuscript. For methodology previously published by the authors, the prior publication should be referenced and a copy of the paper provided to the reviewers, if necessary.
  - The Methods section should only contain material that is absolutely necessary for comprehension of the results section. Additional (more detailed) methods can be provided as a data supplement.
  - **Updated October 2014: Prevention of bias is important for experimental stroke research (see Macleod et al, *Stroke.* 2009;40:e50–e52). For studies where the primary objective is the preclinical testing of therapies, the following checklist items must be adhered to and clearly documented in the manuscript:**
    1. *Animals:* Species, strains and sources must be defined. For genetically modified animals, wildtype controls including background and back-crossing must be defined.
    2. *Statistics and sample size:* Specific statistical methods must be defined, including parametric versus nonparametric and multigroup analyses, and sample size powering based on expected variances and differences between groups.
    3. *Inclusions and exclusions:* Specific criteria for inclusions and exclusions must be specified. For example, only animals where blood flow reductions fall below a certain threshold are included. Or only animals with a certain degree of neurological deficits are included. Once animals are randomized (see below), all excluded animals must be reported, including explicit presentation of mortality rates.
    4. *Randomization, allocation concealment and blinding:* All animals must be randomized. Investigators responsible for surgical procedures or drug treatments must

be blinded. End point assessments must be performed by investigators blinded to the groups for which each animal is assigned.

- **Results:** This section should succinctly report the results of experimental studies and clinical research or clinical series/observations.
- **Discussion:** This section should not reiterate the results but put the results in appropriate context regarding relevant literature and the importance of new observations contained in the manuscript.
- **Summary/Conclusions:** A brief paragraph summarizing the results and their importance may be included but is not required.

Acknowledgments

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Sources of Funding

Authors must list all sources of research support relevant to the manuscript in this location. All grant funding agency abbreviations should be completely spelled out, with the exception of the NIH. Note that funding should be listed separately from disclosures.

Disclosures

Authors must state disclosures in the manuscript text prior to first review and provide disclosures online when submitting a revision or upon request after acceptance. **Disclosures stated in the text must match the online disclosures.** If you have no disclosures, please state "Disclosures: None" in the manuscript text before the references. Conflicts of interest pertain to relationships with pharmaceutical companies, biomedical device manufacturers, or other corporations whose products or services are related to the subject matter of the article. Such relationships include, but are not limited to, employment by an industrial concern, ownership of stock, membership on a standing advisory council or committee, being on the board of directors, or being publicly associated with the company or its products. Other areas of real or perceived conflict of interest could include receiving honoraria or consulting fees or receiving grants or funds from such corporations or individuals representing such corporations. The corresponding author should collect Conflict of Interest information from all co-authors before submitting a manuscript online.

References

- *Accuracy of reference data is the author's responsibility.* Verify all entries against original sources, especially journal titles, inclusive page numbers, publication dates, accents, diacritical marks, and spelling in languages other than English.
- Do not list the month/issue/day (the number in parentheses) in the reference.
- References with more than 6 authors should list the first 6 authors followed by et al.
- Cite references in numerical order according to first mention in text.
- Personal communications, unpublished observations, and submitted manuscripts must be cited in the text, not in the references, as "([name(s)], unpublished data, 20XX)."
- References must be from a full-length publication in a peer-reviewed journal.
- Abstracts may be cited only if they are the sole source and must be identified in the references as "Abstract."

- "In-press" citations must have been accepted for publication and the name of the journal or book publisher included. Please provide a copy of any potentially overlapping manuscript that has been submitted to another journal or is in press or published elsewhere.
- Example of a journal reference:
  Mith AR, Asai Y, Kim M, Dirk TR, Karrus HF, Yang YS, et al. This is the title. *Stroke.* 2014;30:2407–2408.
- Examples of online journal references:
  Nakagawa T, Hasegawa Y, Uekawa K, Ma M, Katayama T, Sueta D, et al. Renal Denervation Prevents Stroke and Brain Injury via Attenuation of Oxidative Stress in Hypertensive Rats. J Am Heart Assoc. 2013;2:e000375.
- Stroke Unit Trialists' Collaboration. Organised inpatient (stroke unit) care for stroke. Cochrane Database of Systematic Reviews 2013,9:CD000197.
- Example of a publish-ahead-of-print reference:
  Authors. Article Title. [published online ahead of print November 8, 2014]. *Stroke.* 2014. URL. Accessed November 20, 2014.
- Example of a book chapter reference:
  Amstand RR, Smithy RS, Kim LY. Chapter Title. In: Wong YT, Khan S, eds. *Book Title.* 3rd Ed. New York, NY: Publisher Name; 2009:456–464.
- Example of a website reference:
  CDC Chronic Disease Indicators: Indicator Definition. Hospitalization for cerebrovascular accident or stroke. National Center for Chronic Disease Prevention and Health Promotion web site. http://apps.nccd.cdc.gov/cdi/IndDefinition.aspx?IndicatorDefinitionID=83. Accessed November 23, 2010.
- Web sites generally follow this format: Author names (if any). Title of information or page. Name of website. URL. Publication date (if any). Access date.
- Example of a Software Manual Reference:
  StataCorp. Stata statistical software: Release 12. College Station, TX: StataCorp LP; 2011.
- Example of a Government Bulletin:
  Author. Title of bulletin. Place of publication: Name of issuing department or agency; publication date. Page numbers (if any). Publication number (if any). Series number (if any).
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—TOP—

Tables

- Each table must be typed on a separate sheet and double-spaced, if possible. The table number should be Arabic, followed by a period and a brief informative title.
- Use the same size type as in text.
- Tables should be cell-based (i.e., constructed using Microsoft Word tables or Excel). Do not use tabs or hard returns. Do not supply tables as graphics.
- Tables should be used to present comparisons of large amounts of data at a glance. Tables with only 1 or 2 rows of data should be incorporated into the text.

- Tables should be as compact as possible. Avoid unnecessary rows and columns.
- Use indenting within the stub column to indicate subgroups. Do not use bold, shading, rules, etc.
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- Any abbreviations or symbols used in the figures must be defined in the figure or figure legend.
- Follow AMA 9th edition for footnote style in legends.
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APÊNDICE A - Termo de Consentimento Livre e Esclarecido

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO Nº_____

Investigadoras: Profª Luci Fuscaldi Teixeira-Salmela, Ph.D.
Janaine Cunha Polese, Doutoranda do Programa de Ciências da Reabilitação

TÍTULO DO PROJETO

AVALIAÇÃO DE PARÂMETROS METABÓLICOS E CARDIORRESPIRATÓRIOS DE HEMIPARÉTICOS CRÔNICOS DURANTE A REALIZAÇÃO DE ATIVIDADES FUNCIONAIS.

INFORMAÇÕES

Você está sendo convidado a participar de uma pesquisa a ser desenvolvida no Departamento de Fisioterapia da Escola de Educação Física, Fisioterapia e Terapia Ocupacional da Universidade Federal de Minas Gerais.

Este projeto de pesquisa tem como objetivo avaliar os gases da respiração durante algumas atividades cotidiana de indivíduos que sofreram derrame.

Para realizá-lo você será convidado a responder alguns questionários e realizar uma avaliação dos gases da sua respiração por meio do uso de uma máscara muito confortável.

DESCRIÇÃO DOS TESTES A SEREM REALIZADOS

Avaliação

Este estudo será dividido em duas fases.

Na primeira, serão coletadas informações específicas para a sua identificação, além de alguns parâmetros clínicos e físicos. A sua capacidade funcional será avaliada a partir do seu desempenho em testes muito utilizados na prática clínica e em estudos científicos. Todos esses testes são constituídos de tarefas que você realiza corriqueiramente no seu dia a dia. O tempo utilizado para a realização destes testes será de aproximadamente duas horas.

Na segunda fase, você realizará uma análise de gases da sua respiração por meio do uso de uma máscara muito confortável e com monitorização contínua da pressão arterial, da freqüência cardíaca, do seu grau de cansaço e da saturação de oxigênio durante a realização de atividades que você realiza no dia a dia, tais como: caminhar em um corredor plano e subir e descer escadas. Você terá um período de descanso entre todas as atividades até que se sinta descansado, e será monitorado também durante o descanso. O tempo utilizado para a realização destes testes será de aproximadamente duas horas.

Riscos

Os testes e procedimentos adotados não apresentam riscos específicos além daqueles presentes no seu dia-a-dia. Durante o teste, você pode vir a sentir-se fadigado. Poderá também ocorrer durante os testes uma respiração mais rápida, sensação de falta de ar ou cansaço nas pernas e o coração bater mais rápido. Estas alterações são normais durante o

exercício. O teste será imediatamente interrompido ao seu pedido ou diante de qualquer sinal e sintoma diferente do normal, sendo tomada às providências necessárias. Sua freqüência cardíaca e sua pressão arterial serão monitoradas durante todos os testes, e caso você sinta algum desconforto, a SAMU será chamada para prestar atendimento. Qualquer tipo de desconforto vivenciado durante os testes deve ser revelado para que os pesquisadores tomem as devidas providências com o objetivo de minimizá-lo. Você poderá se desequilibrar enquanto caminha. Portanto, todos os testes serão acompanhados por duas pessoas posicionadas ao seu lado.

Benefícios

Você não obterá benefícios imediatos por participar desta pesquisa. Na realidade, você estará contribuindo para a nossa melhor compreensão dos prováveis benefícios da intervenção com atividades aeróbicas. A partir daí, poderemos indicá-las com maior segurança.

Confidencialidade

Você receberá um código que será utilizado em todos os seus testes e não será reconhecido individualmente.

Natureza voluntária do estudo

A sua participação é voluntária e você tem o direito de se retirar por qualquer razão e qualquer momento.

Pagamento

Você não receberá nenhuma forma de pagamento pela participação no estudo. Custos de transporte para o local dos testes e seu retorno poderão, se necessários, ser arcados pelas pesquisadoras.

Depois de ter lido as informações acima, se for de sua vontade participar, por favor, preencha o consentimento abaixo.

DECLARAÇÃO E ASSINATURA

Eu, _____li e entendi toda a informação repassada sobre o estudo, sendo que os objetivos, procedimentos e linguagem técnica satisfatoriamente explicados. Tive tempo suficiente, para considerar as informações acima e tive a oportunidade de tirar todas as minhas dúvidas. Estou assinando este termo voluntariamente e tenho direito de agora, ou mais tarde, discutir qualquer dúvida que venha a ter com relação à pesquisa com:

Janaine Cunha Polese (31) 3055-3217
Prof. Luci Fuscaldi Teixeira-Salmela (31) 3409-7403

Comitê de Ética em Pesquisa da UFMG (31) 3409-4592
Endereço: Avenida Antônio Carlos, 6627,
Pampulha, BH/MG Campus – UFMG –
Unidade Administrativa II – 2º andar.

Assinando esse termo de consentimento, estou indicando que concordo em participar deste estudo.

_____ _____
Assinatura do Participante Assinatura da Testemunha
Data: _____ Data: _____

Responsáveis

_____ _____
Janaine Cunha Polese Luci Fuscaldi Teixeira-Salmela
Pesquisador **Orientadora**

MINI CURRICULUM VITAE

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FORMAÇÃO ACADÊMICA

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Projeto 501765/201-0-
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Bolsista do(a): Conselho Nacional de Desenvolvimento Científico e Tecnológico, CNPq, Brasil.

2011 -
Doutorado em andamento em Ciências da Reabilitação/Health Sciences.
Universidade Federal de Minas Gerais/ University of Sydney.
com **período co-tutela** em The University of Sydney (Orientador: Louise Ada).
Título: Gasto energético de hemiparéticos crônicos durante a realização de atividades funcionais, Ano de obtenção: 2015.
Orientador: Luci Fuscaldi Teixeira Salmela.
Bolsista do (a): Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, CAPES, Brasil.

2009 - 2011
Mestrado em Ciências da Reabilitação
Universidade Federal de Minas Gerais, UFMG, Brasil.
Título: Parâmetros biomecânicos e percepção de hemiparéticos crônicos com o uso de dispositivos auxiliares na marcha., Ano de Obtenção: 2011.
Orientador: Luci Fuscaldi Teixeira Salmela.
Bolsista do(a): Conselho Nacional de Desenvolvimento Científico e Tecnológico, CNPq, Brasil.

2003 - 2008
Graduação em Fisioterapia.
Universidade de Passo Fundo, UPF, Brasil.

ATUAÇÃO PROFISSIONAL

Universidade Federal de Minas Gerais
2014 - 2014: Professora Assistente Substituta; Carga horária: 40 horas; Regime Parcial

Disciplinas Ministradas: 1) Fisioterapia Clínica I (Estágio supervisionado em Neurologia); 2) Ética e Deontologia.

University of Sydney
2012- 2012: Professora Assistente (PG Fellow); Carga horária: 8 horas; Regime Parcial
Disciplina Ministrada: 1) Tutorial na disciplina de Neurological Physiotherapy.

REVISOR DE PERIÓDICO

1. Clinical Biomechanics (Bristol)
2. Neurology and Therapy
3. Topics in Stroke Rehabilitation
4. Journal of Physical Therapy and Rehabilitation
5. Brazilian Journal of Physical Therapy
6. Revista de Neurociências
7. Fisioterapia em Movimento (PUCPR. Impresso)
8. Revista Panamericana de Salud Pública
9. Fisioterapia e Pesquisa

PRODUÇÃO BIBLIOGRÁFICA (2011 – 2014)

1. **POLESE, J. C.** ; SCIANNI, A. A. ; KUYS, S. ; ADA, L. ; TEIXEIRA-SALMELA, L. F. . Cardiorespiratory stress is not achieved during routine physiotherapy in chronic stroke. International Journal of Physical Medicine & Rehabilitation, v. 02, p. 211-216, 2014.

2. PINHEIRO, M. B. ; **POLESE, J. C.** ; Faria, Christina D.C.M. ; MACHADO, G. C. ; PARREIRA, V. F. ; BRITTO, R B. ; TEIXEIRA-SALMELA, L. F. . Inspiratory muscular weakness is more evident in stroke subjects with lower functional levels. European Journal of Physical and Rehabilitation Medicine (Testo Stampato), v. 50, p. 301-307, 2014.

3. ANDRADE, A. G. P. ; **POLESE, J. C.** ; PAOLUCCI, L. A.; MENZEL, H. K. ; TEIXEIRA-SALMELA, L. F. . Functional Data Analyses for the Assessment of Joint Power Profiles During Gait of Stroke Subjects. Journal of Applied Biomechanics, v. 30, p. 348-352, 2014.

4. NASCIMENTO, L. R. ; MICHAELSEN, S. M. ; ADA, L. ; **POLESE, J. C.** ; TEIXEIRA-SALMELA, L. F. . Cyclical electrical stimulation increases strength and improves activity after stroke: a systematic review. Journal of Physiotherapy, p. 22-30, 2014.

5. LIMA, R. C. M. ; MICHAELSEN, S. M. ; NASCIMENTO, L. R. ; **POLESE, J. C.** ; PEREIRA, N. D. ; TEIXEIRA-SALMELA, L. F. . Addition of trunk restraint to home-based modified constraint-induced movement therapy does not bring additional benefits in chronic stroke individuals with mild and moderate upper limb impairments: A pilot randomized controlled trial. NeuroRehabilitation (Reading, MA), v. 34, p. 1-8, 2014.

6. NASCIMENTO, L. R. ; TEIXEIRA-SALMELA, L. F. ; **POLESE, J. C.** ; ADA, L. ; FARIA, C. D. C. M. ; LAURENTINO, G. E. C. . Strength deficits of the shoulder complex during isokinetic testing in people with chronic stroke. Revista Brasileira de Fisioterapia (Impresso), v. 00, p. 00-00, 2014.

7. PINHEIRO, M. B. ; **POLESE, J. C.** ; MACHADO, G. C. ; SCIANNI, A. A. ; HIROCHI, T. L. ; TEIXEIRA-SALMELA, L. F. . Balance analysis during the sit-to-stand movement of chronic hemiparetic individuals based upon their functional levels.. Revista Terapia Manual, v. 12, p. 656-670, 2014.

8. LIMA, R. C. M. ; NASCIMENTO, L. R. ; MICHAELSEN, S. M. ; **POLESE, J. C.** ; PEREIRA, N. D. ; TEIXEIRA-SALMELA, L. F. . Influences of hand dominance on the maintenance of benefits after home-based modified constraint-induced movement therapy in individuals with stroke. Revista Brasileira de Fisioterapia (Impresso), v. 00, p. 00-00, 2014.

9. **POLESE, J. C.** ; PINHEIRO, M. B. ; MACHADO, G. C. ; FARIA, C. D. C. M. ; HIROCHI, T. L. ; TEIXEIRA-SALMELA, L. F. . Chronic Hemiparetic Subjects with Higher Physical Activity Levels Report Better Quality of Life. Revista de Neurociências (EPM. Impresso), v. 22, p. 221-226, 2014.

10. **POLESE, J. C.** ; TEIXEIRA-SALMELA, L. F. ; FARIA, L. M. ; VELLOSO, M. ; PARREIRA, V. F. . Ergospirometric assessment: Relevance for rehabilitation of stroke subjects. Terapia Manual, v. 12, p. 36-42, 2014.

11. **POLESE, J. C.** ; ADA, L. ; DEAN, C. M. ; NASCIMENTO, L. R. ; TEIXEIRA-SALMELA, L. F. . Treadmill training is effective for ambulatory adults with stroke: a systematic review. J PHYSIOTHER, v. 59, p. 73-80, 2013.

12**. POLESE, J. C.** ; PINHEIRO, M. B. ; FARIA, C. D. C. M. ; BRITTO, R B. ; PARREIRA, V. F. ; TEIXEIRA-SALMELA, L. F. . Strength of the respiratory and lower limb muscles and functional capacity in chronic stroke survivors with different physical activity levels. Revista Brasileira de Fisioterapia (Impresso), v. 17, p. 487-493, 2013.

13. **POLESE, J. C.** ; PINHEIRO, M. B. ; BASILIO, M. L. ; PARREIRA, V. F. ; BRITTO, R B. ; TEIXEIRA-SALMELA, L. F. . Estudo de seguimento da função motora de indivíduos pós-acidente vascular encefálico. Fisioterapia e Pesquisa, v. 20, p. 222-227, 2013.

14. PINHEIRO, M. B. ; **POLESE, J. C.** ; MACHADO, G. C. ; FARIA, C. D. C. M. ; HIROCHI, T. L. ; TEIXEIRA-SALMELA, L. F. . The ability to manage stairs increases with physical activity levels in chronic stroke survivors. Journal of Novel Physiotherapies, v. 3, p. 159, 2013.

15. NASCIMENTO, L. R. ; **POLESE, J. C.** ; CAETANO, L. G, ; Miranda, D. C. ; MORAES, T. M. ; TEIXEIRA-SALMELA, L. F. . Different instructions during the ten-meter walking test determined significant increases in maximum gait speed in individuals with chronic hemiparesis. Revista Brasileira de Fisioterapia (Impresso), v. 16, p. 122-127, 2012.

16. NASCIMENTO, L. R. ; **POLESE, J. C.**; FARIA, D.C.M; TEIXEIRA-SALMELA, L. F. Isometric hand grip strength correlated with isokinetic data of the shoulder stabilizers in individuals with chronic stroke. Journal of Bodywork and Movement Therapies, v.16, p. 275-80, 2012.

17**.** BRAGA, I. R. ; RAMOS, L. M. M. ; SILVA, M. C. L. ; NASCIMENTO, L. R. ; **POLESE, J. C.** ; TEIXEIRA-SALMELA, L. F. . Correlações de força isométrica de elevação de ombro no plano escapular e de preensão palmar com medidas de capacidade e desempenho dos membros superiores em indivíduos com hemiparesia crônica. Terapia Manual, v. 10, p. 12-18, 2012.

18. **POLESE, J. C.** . Efeito da Hidroterapia na Força Muscular e Capacidade Respiratória em Indivíduos com Síndrome de Down. Revista Neurociências (Online), v. 20, p. 343-344, 2012.

19**. POLESE, J. C.** ; NASCIMENTO, L. R. ; FARIA, C. D. C. M. ; LAURENTINO, G. E. C. ; RODRIGUES-DE-PAULA, F. ; ADA, L. ; TEIXEIRA-SALMELA, L. F. . Percepção de hemiplégicos crônicos sobre o uso de dispositivos auxiliares na marcha.. Revista Panamericana de Salud Publica (Print), v. 30, p. 204-208, 2011.

20. **POLESE, J. C.;** TEIXEIRA-SALMELA, L. F.; NASCIMENTO, L. R.; FARIA, C. D. M.; KIRKWOOD, R. N.; LAURENTINO, G. C.; ADA, L. The effects of walking sticks on gait kinematics and kinetics with chronic stroke survivors. Clinical Biomechanics (Bristol), v. 27, p. 131-137, 2011.

Capítulos de livros publicados

POLESE, J. C. Cerebrovascular Disorders. In: Michalos AC. (Org.). Encyclopedia of Quality of Life and Well-Being Research. 1ed.Dordrecht: Springer, 2014,p. 642-644.

TEIXEIRA-SALMELA, L. F. ; FARIA, C. D. C. M. ; **POLESE, J. C.** ; SCIANNI, A. A. . Evidências científicas de intervenções fisioterapêuticas em pacientes pós-AVE. In: Garcia CSNB, Fachinetti LD. (Org.). (Org.). Associação Brasileira de Fisioterapia Neurofuncional. PROFISIO Programa de Atualização em Fisioterapia Neurofuncional. Ciclo 1. 1ed.Porto Alegre: Artmed/Panamericana, 2014, v. 1, p. 49-86.