Giselle Silva e Faria

COMPARAÇÃO DAS VARIÁVEIS DE ATIVIDADE FÍSICA FORNECIDAS PELO ACELERÔMETRO ACTIGRAPH GT3X E PELO APLICATIVO DE CELULAR GOOGLE FIT DURANTE A MARCHA DE INDIVÍDUOS PÓS-ACIDENTE VASCULAR ENCEFÁLICO

Belo Horizonte
Escola de Educação Física, Fisioterapia e Terapia Ocupacional da UFMG
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Orientadora: Profª Luci Fuscaldi Teixeira-Salmela, Ph.D., UFMG
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ATA DE NÚMERO 246 (DUZENTOS E QUARENTA E SEIS) DA SESSÃO DE ARGUIÇÃO E DEFESA DE DISSERTAÇÃO APRESENTADA PELA CANDIDATA **GISELLE SILVA E FARIA** DO PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS DA REABILITAÇÃO. .-

Aos 16(dezesseis) dias do mês de fevereiro do ano de dois mil e dezessete, realizou-se na Escola de Educação Física, Fisioterapia e Terapia Ocupacional, a sessão pública para apresentação e defesa da dissertação **"COMPARAÇÃO DAS VARIÁVEIS DE ATIVIDADE FÍSICA FORNECIDA PELO ACELERÔMETRO ACTIGRAPH GT3X E PELO APLICATIVO DE CELULAR GOOGLE FIT DURANTE A MARCHA DE INDIVÍDUOS PÓS-ACIDENTE VASCULAR ENCEFÁLICO".** A banca examinadora foi constituída pelas seguintes Professoras Doutoras: Luci Fuscaldi Teixeira-Salmela, Aline Alvim Scianni e Raquel de Carvalho Lana, sob a presidência da primeira. Os trabalhos iniciaram-se às 9h00min 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 Mestre, após a entrega da versão definitiva da dissertação.** 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, 16 de fevereiro de 2017.-

Professora Dra. Luci Fuscaldi Teixeira-Salmela LSalmela

Professora Dra. Aline Alvim Scianni Aline Alvim Scianni

Professora Dra Raquel de Carvalho Lana Raquel de Carvalho Lana Campelo

Marilane Soares 084190 ____________________

Secretária do Colegiado de Pós-Graduação em Ciências da Reabilitação

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PARECER

Considerando que a dissertação de mestrado de **GISELLE SILVA E FARIA** intitulada **"COMPARAÇÃO DAS VARIÁVEIS DE ATIVIDADE FÍSICA FORNECIDA PELO ACELERÔMETRO ACTIGRAPH GT3X E PELO APLICATIVO DE CELULAR GOOGLE FIT DURANTE A MARCHA DE INDIVÍDUOS PÓS-ACIDENTE VASCULAR ENCEFÁLICO",** defendida junto ao Programa de Pós-Graduação em Ciências da Reabilitação, nível mestrado, cumpriu sua função didática, atendendo a todos os critérios científicos, a Comissão Examinadora **APROVOU** a defesa de dissertação, conferindo-lhe as seguintes indicações:

Nome dos Professores/Banca	Aprovação	Assinatura
Luci Fuscaldi Teixeira-Salmela	Aprovada	LSalmela
Aline Alvim Scianni	Aprovada	Aline Alvim Scianni
Raquel de Carvalho Lana	Aprovada	Raquel de Carvalho Lana Campelo

Belo Horizonte, 16 de fevereiro de 2017.

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

UNIVERSIDADE FEDERAL DE MINAS GERAIS
COLEGIADO DE PÓS-GRADUAÇÃO EM CIÊNCIAS
DA REABILITAÇÃO / EEFFTO
AV. ANTÔNIO CARLOS, Nº 6627 - CAMPUS UNIVERSITÁRIO
CEP 31270-901 - BH / MG

Dedico esse trabalho àqueles que estão sempre ao meu lado, independente das circunstâncias, de maneira incondicional e inquestionável: Claiton Pereira de Faria (Papai) e Nilva Elena Silva Faria (Mamãe), meus amores dessa e de outras vidas.

“(...) É saber sonhar e, então, fazer valer a pena
cada verso daquele poema sobre acreditar.
Não é sobre chegar no topo do mundo e saber que venceu.
É sobre escalar e sentir que o caminho te fortaleceu (...)”

(Trecho de “Trem Bala” - Ana Vilela)

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Foram mais de dois anos intensos. Dores, perdas, quedas, sustos, insônia, desespero... Mas a cada momento superado, a alegria da vitória e a sensação de conquistar mais um degrau eram recompensadoras. Em cada uma dessas dificuldades, pude contar com diversas pessoas que teimam em não desistir de mim e em me levantar.

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PREFÁCIO

O presente estudo foi desenvolvido como requisito parcial à obtenção do título de Mestre em Ciências da Reabilitação, de acordo com as normas do colegiado de Pós-Graduação em Ciências da Reabilitação da Universidade Federal de Minas Gerais (UFMG) referentes ao formato opcional, que segue as normas da Associação Brasileira de Normas Técnicas (ABNT). Desta forma, a fim de atender as exigências da instituição de ensino, a presente dissertação é compreendida por cinco capítulos.

O **primeiro** capítulo se refere à introdução, onde são abordados os problemas até então existentes com relação ao tema estudado, a justificativa para a realização do estudo e os objetivos do trabalho.

O **segundo** capítulo se refere à metodologia desenvolvida, onde se detalha os caminhos percorridos para o desenvolvimento do presente estudo como a definição do local de realização do trabalho e da amostra populacional estudada, além de discorrer sobre os instrumentos utilizados, as variáveis de desfecho e as análises estatísticas utilizadas.

O **terceiro** capítulo apresenta os resultados, fazendo referência às características da amostra estudada e apresentando os principais achados relacionados às variáveis de desfecho.

O **quarto** capítulo consta de dois artigos elaborados, que serão encaminhados para publicação. O primeiro artigo segue as normas da revista *Disability and Health Journal e o* segundo artigo segue as normas da revista *Disability and Rehabilitation*.

O **quinto** capítulo contém as considerações finais, seguido das referências bibliográficas utilizadas, do mini currículo da autora e dos anexos e apêndices referentes a presente dissertação.

RESUMO

O uso da acelerometria e de aplicativos de celular tem ganhado cada vez mais importância no contexto da reabilitação de indivíduos pós-Acidente Vascular Encefálico (AVE), visto que permite a avaliação objetiva dos níveis de atividade física e o monitoramento de variáveis, como número de passos e gasto energético (GE). No entanto, não se sabe se os dados fornecidos por esses dispositivos representam o real nível de atividade física desses indivíduos. Para atender tais pressupostos, foram desenvolvidos dois estudos respondendo aos seguintes objetivos: **Estudo 1 -** Comparar o número de passos predito pelo acelerômetro *ActiGraph* GT3X e pelo aplicativo de celular Google Fit, com o número de passos observados pelo pesquisador durante a marcha rápida no solo de indivíduos pós-AVE crônicos; **Estudo 2 -** Comparar o GE estimado pelo acelerômetro *ActiGraph* GT3X e pelo aplicativo de celular Google Fit com o GE obtido através do ergoespirômetroMetamax 3B durante a marcha rápida em solo de indivíduos pós-AVE crônicos. Foi realizado um estudo transversal, onde indivíduos pós-AVE crônicos caminharam em um corredor reto e plano de 10 metros, em velocidade máxima, por cinco minutos. Durante o teste, os indivíduos utilizaram o acelerômetro *ActiGraph* GT3X, um celular contendo o aplicativo Google Fit e o ergoespirômetro portátil Córtex Metamax 3B, simultaneamente. A medida de critério para o número de passos foi o observado por um pesquisador previamente treinado. Para a análise estatística, foram realizados testes de normalidade (*Shapiro-Wilk*), seguido do cálculo de coeficientes de Pearson e Coeficiente de Correlação Intraclasse (CCI[2,1]) para todas as variáveis de desfecho. Nível de significância: 5%. Participaram do estudo 37 indivíduos com média de idade de 62 (±11,2) anos, e tempo pós-lesão de 91,3 (±90,4) meses. Foram encontradas associações positivas e estatisticamente significativas entre o número de passos determinado pelo pesquisador e o estimado pelo aplicativo de celular Google Fit (r=0,89; p<0,001), e pelo acelerômetro *ActiGraph* GT3X (r=0,56; p<0,001). A análise do CCI (2,1), por sua vez, demonstrou existir uma maior concordância entre os dados obtidos pelo aplicativo de celular Google Fit (CCI=0,93; p<0,001) com menor média de diferença entre o número de passos observado e o estimado (-8,3 passos; p=0,37), enquanto o acelerômetro *ActiGraph* GT3X demonstrou menor concordância (CCI=0,32; $p<0,001$) e média de diferença entre os valores observado e estimado de 191,8 ($p<0,001$) passos. Com relação ao GE, foram observadas associações positivas e estatisticamente significativas de magnitude fraca apenas entre o GE estimado pela fórmula combinada do *ActiGraph* GT3X e o GE convertido do ergoespirômetro ($r=0,37$; $p=0,04$). A análise do CCI (2,1) revelou não existir concordância entre os valores estimados pela fórmula combinada e pelo obtido através do ergoespirômetro. O presente estudo observou que, apesar de ser utilizado em indivíduos pós-AVE, o acelerômetro *ActiGraph* GT3X possivelmente não parece ser o monitor de atividade física mais adequado para essa população. Já o aplicativo de celular Google Fit demonstrou ter potencial para ser utilizado em indivíduos pós-AVE crônicos, visto que o número de passos estimados pelo dispositivo foi associado à medida de critério durante a marcha rápida no solo.

Palavras-chave: Acidente Vascular Cerebral. Atividade Física. Marcha. Estudo de Validação. Acelerometria. Telefones Móveis.

ABSTRACT

The objective evaluation of physical activity levels of individuals with stroke becomes very important for clinicians involved in stroke rehabilitation, once it guides the professionals to set more realistic and objective goals to improve physical conditioning of these individuals. In this scenario, the use of accelerometry and smartphone applications stands out, since theyprovide objective measures of different physical activity variables, such as the number of steps taken and energy expenditure (EE). However, although these devices have been frequently used in recent studies with individuals with stroke, it is not known if their data represent the actual physical activity levels of these individuals. Therefore, in the present dissertation, two studies were carried-out in an attempt to solve these issues. The **first study** aimed at comparing the number of steps predicted by the ActiGraph GT3X accelerometer and the Google Fit smartphone application, with the number of steps observed by the researcher during fast overground walking of chronic stroke individuals. The **second study** aimed at comparing the EE estimates from the ActiGraph GT3X accelerometer and the Google Fit smartphone application, with the EE obtained from the conversion of the oxygen consumption (VO_2) given by the Metamax 3B ergoespirometer during fast overground walking of chronic stroke individuals. Both studies had a cross-sectional design, in which individuals with chronic stroke were asked to walk on a 10-meter straight hallway over five minutes at their fast speeds, wearing the ActiGraph GT3X accelerometer, a smartphone containing the Google Fit application, and the Cortex Metamax 3B ergoespirometer. The criterion-standard measure for the variable related to the number of steps was thatcounted by a trained examiner. The inclusion criteria were: ages ≥20 years, time since stroke onset >6 six months, ability to walk at least 14m independently, ability to understand and follow verbal instructions, and absence of cognitive deficits, as determined by the cut-off scores on the Mini Mental State Exam. Individuals, who had any other neurological, orthopedic, and/or respiratory diseases, were excluded. Descriptive statistics, normality tests (Shapiro-Wilk) were carried-out for all outcomes, followed by the calculation of Pearson's correlation coefficients and intra-class correlation coefficient (ICC [2.1]). For all analyses, the significance level was established at

$\alpha \leq 0.05$. Thirty-seven individuals were included in the present study, who had a mean age of 62 (±11.2) years, and a mean time since the stroke onset of 91.3 (±90.4) months. Significant and positive associations were found between the number of steps observed by the researcher and the number of steps estimated by the Google Fit smartphone application (r=0.89, p<0.001), and the ActiGraph GT3X accelerometer (r=0.56; p<0.001). The ICC (2,1) analysis revealed that the Google Fit smartphone application showed greater agreement (ICC=0.93; p <0.001) and a lower mean difference between the observed and estimated number of steps (p=0.37), whereas the ActiGraph GT3X accelerometer data showed lower agreement (CCI=0.32, p<0.001) and a mean difference between the observed and estimated number of steps of 191.8 (p < 0.001) steps. Regarding the EE, significant, weak, and positive association was only found between the EE estimated from the combined formula from ActiGraph GT3X and that converted from the ergospirometer (r=0.37; p=0.04). The ICC analyses (2,1) found no agreement between these EE data. Therefore, the results of the present study demonstrated that, despite being frequently used in studies with stroke individuals, the ActiGraph GT3X accelerometer did not provide valid measures, and maynot be the most appropriate physical activity monitor for this population, since its variables did not show any association with the criterion-standard measure. On the other hand, the Google Fit smartphone application showed the potential to be used with individuals with chronic stroke, since the number of steps estimated by the device was associated with the criterion-standard measure during fast overground walking.

Keywords: Stroke. Physical Activity.Walking.Validation Studies.Accelerometry.CellPhones.

SUMÁRIO

1 INTRODUÇÃO

Além de ser a principal causa de morte no mundo, o Acidente Vascular Encefálico (AVE) também se destaca por ser a principal causa de incapacidade a longo prazo (LECIÑANA *et al.*, 2014). De acordo com a Organização Mundial de Saúde (OMS), 1,9 milhões de pessoas sobreviveram a um episódio de AVE apenas na América Latina em 2004 (LECIÑANA*et al.*, 2014). Além disso, de acordo com a Sociedade Brasileira de Doenças Cerebrovasculares, atualmente o AVE é a doença que mais mata brasileiros e mais incapacita pessoas em todo o mundo (SOCIEDADE BRASILEIRA DE DOENÇAS CEREBROVASCULARES, 2016).Nesse contexto, um grande número de sobreviventesao AVE apresenta déficits motores residuais (FLYNN; MACWALTER; DONEY, 2008), que ocasionam aumento nas demandas energéticas e favorecem uma redução dos níveis de deambulação (MICHAEL; ALLEN; MACKO, 2005) e limitações em atividadesdiárias (FLYNN; MACWALTER; DONEY, 2008).Assim, indivíduos pós-AVE necessitam de um trabalho constante de uma equipe de reabilitação, visando re-estabelecer o máximo de independência e funcionalidade desses indivíduos dentro dos contextos em que esses se encontram inseridos.

Visandofornecer uma estrutura de trabalho padronizada e de melhor qualidade aos atendimentos oferecidos pelos profissionais envolvidos nos processos de reabilitação,a OMS criou em 2001, a Classificação Internacional de Funcionalidade, Incapacidade e Saúde (CIF) considerado o principal modelo teórico a ser utilizado por esses profissionais (SAMPAIO *et al.*, 2005;ORGANIZAÇÃO MUNDIAL DA SAÚDE, 2004). Isso porque tal modelo considera que, em um processo de reabilitação, o indivíduo deve ser considerado como um sistema complexo, possuidor de diferentes níveis funcionais que interagem entre si e contribuem da mesma maneira para o quadro apresentado (ORGANIZAÇÃO MUNDIAL DA SAÚDE, 2004). Ao se avaliar a presença de alterações em estruturas e funções corporais, limitações durante a realização de determinadas atividades e restrições na participação social do indivíduo, a CIF modifica o foco do processo de reabilitação, antes centralizado na doença, e passa a considerar todas as variáveis que podem vir a contribuir para o quadro apresentado (ÜSTÜN*et al.*, 2003). Tal classificação apresenta, ainda, níveis funcionais que podem ser didaticamente divididos em fatores pessoais como história de vida, sentimentos, ideias, expectativas, etc., e fatores ambientais como contexto familiar, círculo de amizades, ambiente doméstico, local de trabalho, dentre outros (ORGANIZAÇÃO MUNDIAL DA SAÚDE,2004;DI NUBILA;BUCHALLA, 2008*)*. Cada um desses fatores pode atuar como um facilitador ou como uma barreira para o processo de reabilitação, cabendo ao profissionalclassificá-los (SAMPAIO *et al.* 2005). Assim, a CIF engloba todas as funções do corpo, bem como a capacidade de realização das atividades de vida diária (AVD), sem perder de vista a interferência que as alterações nesses domínios ocasionam na participação social do indivíduo (SAMPAIO *et al.* 2005).

A utilização da CIF no contexto do condicionamento cardiovascular em indivíduos pós-AVE é de extrema importância para a compreensão do impacto da diminuição dos níveis de atividade física na vida dos sobreviventes. Devido aos déficits em estrutura e função remanescentes da lesão, como por exemplo, alterações metabólicas e cardiovasculares (IVEY; HAFER-MACKO; MACKO, 2006; IVEY; HAFER-MACKO; MACKO, 2008; BILLINGUER *et al.*, 2012), além de uma marcha mais assimétrica (STANHOPE *et al.*, 2014),indivíduos pós-AVE geralmente apresentam predisposição a um estilo de vida mais sedentário e ao descondicionamento cardiorrespiratório, o que impacta diretamente no desempenho de AVD e pode contribuir não somente para um maior risco de recorrência de AVE, como também para a presença de demais doenças cardiovasculares (BILLINGER*et al.*, 2014).

Um estudo de 2015 observou que o sedentarismo se instala ainda na fase aguda após o AVE, momento em que esses indivíduos tendem a passar até 94% do tempo do dia inativos (MATTLAGE *et al.*, 2015). Esse perfil tende a se perpetuar para a fase crônica da lesão, como foi identificado em um estudo de base populacional nos Estados Unidos, que observou que os níveis de atividade física de indivíduos pós-AVE comunitários são mais baixos que de idosos ou indivíduos com outras condições crônicas de saúde musculoesqueléticas ou cardiovasculares (ASHE*et al.*, 2009). Nesse sentido, estudos demonstraram que o tempo gasto em atividades sedentárias, por si só, pode contribuir para um risco maior de desenvolvimento de doenças cardiovasculares e de ganho excessivo de peso (MARTINEZ-GOMEZ*et al.*, 2009; WARREN *et al.*, 2010). Nesse contexto, a promoção da prática de atividade física diária tem se tornado um fator imprescindível e apoiado por guias clínicos, inclusive os direcionados ao AVE (BILLINGER *et al.*, 2014, GORDON *et al.*, 2004).

A importância da prática regular de atividade física com o objetivo de se ter uma melhor condição de saúde já é bem estabelecida em indivíduos pós-AVE (BILLINGER*et al.*, 2014; GORDON *et al.*, 2004; SAUNDERS; MPHIL; MEAD, 2014; GALLANAGH*et al.*, 2011). Além disso, tem sido reportados com cada vez mais frequência os benefícios de se manter um estilo de vida ativo, com melhoras no controle de sintomas da depressão (GRAVEN*et al.*, 2011), nos aspectos executivos e funcionais (CUMMING *et al.*, 2012), na memória, qualidade de vida (CHEN; RIMMER, 2011) e na fadiga (FARIA; TEIXEIRA-SALMELA; POLESE, 2015). Evidências apontam ainda para o fato de se recomendar a prática de exercícios aeróbicos regulares com o objetivo de se melhorar a capacidade aeróbica e a eficiência da marcha de indivíduos pós-AVE crônicos (BILLINGER *et al.*, 2014;WENDEL-VOSS *et al.*, 2004). A literatura reporta que indivíduos pós-AVE crônicos deambulando em uma maior cadência tendem a melhorarem o condicionamento cardiovascular mais do que indivíduos pós-AVE deambulando em velocidade habitual (MICHAEL; MACKO, 2007), o que geralmente é o principal objetivo de um programa de condicionamento. Nesse contexto, um estudo prévio observou que indivíduos pós-AVE crônicos aumentam o GE, quando deambulam em velocidade máxima (POLESE *et al.*, 2015). Dessa maneira, acredita-se que o risco de novos eventos cardiovasculares, bem como o risco de quedas e fraturas, seria reduzido através da prática de atividade física regular, além de favorecer a independência funcional desses indivíduos (BILLINGER*et al.*, 2014;WENDEL-VOSS *et al.*, 2004).

Estudos prévios observaram que indivíduos pós-AVE na fase crônica, classificados como moderadamente ativosde acordo com a pontuação obtida no Perfil de Atividade Humana (PAH), reportaram menores níveis de fadiga (FARIA; TEIXEIRA-SALMELA; POLESE, 2015), além de apresentarem menores discrepâncias de força em membros inferiores e funcionalidade (POLESE *et al.*, 2013). Nesse contexto, os benefícios para a saúde associados à prática de atividades físicas, mesmo de intensidade leve, também têm sido reportados como, por exemplo, um melhor controle da glicemia e um melhor controle do ganho de peso(HEALY*et al.*, 2007; LEVINE; EBERHARDT; JENSEN, 1999).

Dessa maneira, a avaliação objetiva da atividade física habitual de indivíduos pós-AVE torna-se importante para a prática clínica, uma vez que fornece informações essenciais sobre a recuperação das limitações de atividade vivenciadas por esses indivíduos (GEBRUERS*et al.*, 2010).Contudo, apesar da avaliação do nível de atividade física ser fundamental para o desenvolvimento de intervenções mais efetivas, tal prática ainda é pouco frequente no ambiente clínico (WANMIN *et al.*, 2012). Questionários de autorrelatopodem ser uma forma interessante de se avaliar tal parâmetro, porém estão sujeitos a viés de memória e erros de compreensão por parte dos pacientes (WANMIN *et al.*, 2012). Tal fato, associado ao desenvolvimento tecnológico, permite que métodos mais objetivos, como o uso de acelerômetros e aplicativos de celular, ganhem uma atenção cada vez maior (WANMIN *et al.*, 2012).

1.1 Acelerometria como método de mensuração dos níveis de atividade física

Acelerômetros são dispositivos capazes de medir a aceleração de um corpo qualquer de forma indireta (FIGUEIREDO *et al.*, 2007). Como a aceleração aplicada em um corpo é proporcional à rede de forças externas atuantes no mesmo, esta pode, portanto, ser usada para se estimar a intensidade e frequência da atividade física praticada pelo usuário do acelerômetro (CHEN; BASSET, 2005). Além disso, são dispositivos pequenos, nãoinvasivos, fáceis de serem utilizados e capazes de fornecer indicadores objetivos dos níveis de atividade física, durante maiores períodos de tempo (LEE; KIM; WELK, 2014).

Acelerômetros comerciais utilizados como monitores de atividade física têm a habilidade de medir objetivamente o número de passos dados e o gasto energético (GE) durante a realização de uma determinada atividade (MOTL; SNOOK; AGIOVLASITIS,2011; SERRA *et al.* 2016). Tais dispositivos geralmente produzem dados de saída (*outputs*) na forma de "*counts* de atividade" por um período de tempo definido (i.e., *counts*/min.$^{-1}$) (BORNSTEIN *et al.*, 2011). De acordo com o fabricante, *counts* são as somas dos valores absolutos da mudança de aceleração medidos durante um período de tempo. Essas unidades representam a estimativa da intensidade da atividade medida durante cada período de tempo (BORNSTEIN *et al.*, 2011). Uma vez gerados, é possível a conversão dos *counts* na unidade de medida padrão referente ao GE, i.e., quilocalorias por minuto (kcal/min), permitindo análise e interpretação coerente e padronizada dos dados fornecidos pelo dispositivo.

De acordo com uma revisão de literatura realizada em 2015, acelerômetros são os dispositivos mais frequentemente utilizados para se avaliar os níveis de atividade física em indivíduos pós-AVE (FINI *et al.*, 2015). Dispositivos como o *StepWatch Activity Monitor*(SAM), *SenseWear Armband Pro*e *ActivPal* foram considerados os mais utilizados, porém o primeiro fornece apenas o número de passos, enquanto os dois últimos fornecem informações referentes ao GE (FINI *et al.*, 2015).

O número de passos fornecido pelo SAM já foi comparado com diversas medidas de critério e em diferentes condições (FULK *et al.*, 2014;MUDGE.; STOTT; WALT, 2007; MACKO *et al.*, 2002).Fulk *et al.* (2014) objetivou comparar o número de passos fornecidos por quatro monitores de atividade física, sendo eles o *Nike Fuel*+, *Fitbit Ultra*, *Yamax Digi-Walker SW-701* (YDWP) e SAM, com o que foi observado através da filmagem de um teste de caminhada de dois minutos de 20 indivíduos com traumatismo crânio-encefálico e 30 indivíduospós-AVE crônicos. Dentre os dispositivos avaliados, o SAM apresentou melhor acurácia com ICC (2,1)=0,97 e média da diferença entre o número de passos real e o estimado de 4,7 (FULK *et al.*, 2014).

Já Mudge, Stott e Walt (2007) compararam o número de passos estimados pelo SAM com os resultados obtidos pelo *ThreeDimensional Gait Analysis* (3-DGA) e por um dispositivo de análise de marcha que funciona como um sensor de pressão (*Footswitch*) fixado na cabeça do primeiro metatarso de cada pé (MUDGE; STOTT; WALT, 2007). A marcha dos participantes foi avaliada tanto em laboratório como em ambiente aberto, em velocidades habitual e máxima, e em atividades, como caminhada em diferentes terrenos e subir e descer escadas (MUDGE.; STOTT; WALT, 2007). Foi observado que os valores estimados pelo SAM apresentaram correlações de magnitude boa a excelente, tanto para o membro inferior parético (3-DGA: r=0,896; *Footswitche*s: r=0,963), como para o não parético (3-DGA: r=0,963; *Footswitche*s: r=0,999), com os limites de confiança de 95% na análise de Bland-Altman variando de ±10 (3-DGA) a ±57 passos (*Footswitches)* para o membro inferior parético (MUDGE.; STOTT; WALT, 2007).

Macko *et al.* (2002) por sua vez, investigaram a acurácia e a confiabilidade do SAM e de um pedômetro mecânico convencional (*Elexis Trainer*, FM-180, *International Microtech*, Miami, FL)durante a marcha em ambiente fechado de indivíduos pós-AVE crônicos, sendo a medida de critério utilizada um contador manual de passos (MACKO *et al.*, 2002). Foram realizados dois testes de caminhada de um minuto cada, sendo, um em velocidade habitual e o outro em velocidade máxima (MACKO *et al.*, 2002). Observou-se que, durante os testes de caminhada, em ambas velocidades, o número de passos estimados pelo SAM foi mais acurado que o estimado pelo pedômetro: 98,7±1,2% e 89,0±11,93%, respectivamente($p<0.01$).

De forma geral, o SAM apresentou resultados promissores para indivíduos pós-AVE crônicos.No entanto, tal dispositivo apresenta elevado custo para ser adquirido e utilizado na prática clínica, além de necessitar de treinamento prévio para sua utilização (FULK *et al.*, 2014). Esses fatores associados podem dificultar a adesão do equipamento por parte dos profissionais clínicos. Além disso, na maioria dos estudos realizados até o presente momento, o SAM foi posicionado no membro inferior não parético, o que pode ter levado a uma possível superestimação do real nível de atividade física desses indivíduos. Isso porque, após o AVE, é comum a presença de alterações biomecânicas durante a marcha, devido, principalmente, aos déficits motores residuais presentes no membro inferior parético (YAVUZER, 2006). Dessa maneira, este possivelmente não seria o posicionamento mais adequado para se estimar o nível de atividade física desses indivíduos. Apesar de Mudge, Stott e Walt (2007) terem avaliado o uso do SAM também no membro inferior parético, sua acurácia foi testada com os indivíduos deambulando sem seuscalçados habituais, o que, muito provavelmente, não condiz com a realidade da prática de atividades físicas e também pode favorecer uma diferença no padrão de marcha observado. Além disso, o intervalo de confiança de 95% da análise de Bland-Altman demonstrou uma variabilidade muito grande no número de passos estimados pelo SAM, quando posicionado no membro inferior não parético, ao ser comparado ao *Footswitch* (MUDGE; STOTT; WALT, 2007). Ademais, por se tratar de um acelerômetro, o SAM possivelmenteteria o potencial para mensurar demais variáveis relacionadas à prática de atividade física,uma vez que já se sabe que tais dispositivos são capazes de fornecer variáveis como, por exemplo, o GE, auxiliando usuários e clínicos a terem acesso a um quadro mais completo do estado de saúde do indivíduo. Porém, tal dispositivo considera apenas o número de passos de usuário (FULK*et al.*, 2014).

Com relação ao GE, dentre os dispositivos que fornecem tal informação, apenas o *SenseWear Armband Pro*teve sua validade de critério testada (FINI *et al.*, 2015), ao ser comparado com água duplamente marcada (MOORE*et al.*, 2012),com o *Oxycon Metabolic Cart* (CareFusion Respiratory, Care, Yorba Linda, CA, USA) (MANNS; HAENNEL 2012) e com a calorimetria indireta (CardioVit CS-200 Ergo-Spiro, Schille) (VANROY*et al.*, 2014).Manns e Haennel (2012) compararam o GE de 12 indivíduos pós-AVE, obtido através do consumo de oxigênio, com o GE estimado pelo *SenseWear Pro Armband* (Body Media, Pittsburgh, PA, EUA), um acelerômetro frequentemente utilizado em indivíduos pós-AVE. Observou-se que, apesar de terem sido encontrados valores de concordância adequados entre os valores reais e preditos (ICC=0,59 braço parético; ICC= 0,70 braço não parético), o percentual médio da diferença absoluta observada entre os braços parético e não parético foi consideravelmente alto (aproximadamente 18%) (MANNS; HAENNEL, 2012). Por outro lado, Moore *et al.* (2012) também compararam o uso do *SenseWear Pro Armband* com a água duplamente marcada para se obter o GE total de nove indivíduos pós-AVE crônicos, com comprometimento motor leve (escore 2±2 em uma escala de 0 a 7 na *National Institute of Health Stroke Scale* – NIHSS), por um período de 10 dias. Foi observado que o acelerômetro não forneceu medidas fidedignas ao se estimar o GE desses indivíduos através de *"counts"*, o que corrobora as evidências prévias, onde o uso domesmo dispositivo não se mostrou válido para se medir o GE em indivíduos pós-AVE (VANROY*et al.*, 2014).

Embora se saiba da importância da mensuração do nível de atividade física pós-AVE, a literatura ainda é escassa em relação à validação e avaliação das propriedades de medidas de diferentes acelerômetros como métodos de mensuração dos níveis de atividade física.

1.1.1 Acelerômetro *ActiGraph* GT3X

Dentre os diversos tipos de acelerômetros existentes no mercado, o *ActiGraph* GT3X tem se destacado, por sercapaz de fornecer medidas da intensidade da atividade física realizada atravésda contagem do número de passos dados durante um determinado período de tempo e através de "*counts* de atividade" (ACTIGRAPH, LLC ENGINEERING/MARKETING, 2008), além de já ter sido utilizado em indivíduos pós-AVE (MATLAGE *et al.*, 2015).

Após a realização de qualquer atividade física em que o indivíduo esteja utilizando o acelerômetro *ActiGraph* GT3X, é possível obter, dentre outras variáveis, o número de passos dados pelo usuário (ACTIGRAPH, LLC ENGINEERING/MARKETING, 2008). Essa informação torna-se relevante para o contexto da reabilitação neurológica, uma vez que a literatura reporta que a utilização da acelerometria em um programa de monitoramento de passos é eficaz para aumentar o nível de deambulação de indivíduos pós-AVE crônicos (DANKS*et al.*, 2014). Contudo, assim como os acelerômetros já mencionados, o*ActiGraph* GT3X, também tem sido posicionadono membro inferior não parético (DANKS*et al.*, 2014).Nesse contexto, até o presente momento, apenas um estudo utilizou o *ActiGraph* GT3X no membro inferior parético, porém de indivíduos pós-AVE na fase aguda da lesão (MATLAGE *et al.*, 2015).Foi observado queesses indivíduos apresentaram um baixo nível de atividade física (MATLAGE *et al.*, 2015).No entanto, não se sabe seas variáveis fornecidas pelo acelerômetro *ActiGraph* GT3X, quando posicionado no membro inferior parético de indivíduos pós-AVE,são medidas válidas de níveis de atividade física.

Outra maneira de se mensurar os níveis de atividade física de usuários do acelerômetro *ActiGraph* GT3Xé através do GE obtido através da conversão dos "*counts* de atividade" fornecidos pelo dispositivoem quilocalorias (kcal), unidades-padrão de GE (EALIGER *et al.*, 2007). Para isso, são utilizadas as seguintes fórmulas previamente estabelecidas (FREEDSON; MELANSON; SIRAD, 1998):

(1) Equação do Teorema de Trabalho-Energia (TTE): $kcal/min_{TTE}$= 0,0000191**counts*/min*massa corporal, em kg.

(2) Equação de Freedson: $kcal/min_{Freedson}$=0,00094**counts*/min+ 0,1346*massa, em kg – 7,37418.

(3) Fórmula Combinada: Utiliza a equação do TTE quando os *counts*/min forem ≤1952 e a equação de Freedson, quando os *counts/*min forem >1952.

As fórmulasde conversão dos "*counts* de atividade" em kcal mencionadas, no entanto, foram inicialmente desenvolvidas para indivíduos saudáveis em atividades de marcha e corrida em esteira (FREEDSON; MELANSON; SIRAD, 1998). Issopossivelmente pode favorecer um erro na estimativa do GE de indivíduos com condições neurológicas durante a realização de uma determinada atividade, devido às diferenças biomecânicas (YAVUZER, 2006) e cardiovasculares (BILLINGUER *et al.* 2014).

O estudo de Agiovlasitis, Motl e Fernhall (2010), por exemplo, comparou os resultados obtidos com duas equações de predição de GE desenvolvidas para indivíduos jovens e saudáveis, com o obtido através do consumo de oxigênio emindivíduos com esclerose múltipla durante a marcha em esteira. Foi observado que ambas as fórmulas subestimaram o consumo de oxigênio para os indivíduos com esclerose múltipla, pelo fato desses indivíduos apresentarem menor economia energética, resultante da presença de déficits motores residuais(AGIOVLASITIS; MOTL; FERNHALL, 2010). Apesar desse aparente problema, devido ao fato de não haver uma equação de conversão específica para indivíduos com condições neurológicas, as fórmulas de predição de GE desenvolvidas para indivíduos saudáveis têm sido utilizadas pela literatura para populações com condições neurológicas, tais como esclerose múltipla, traumatismo crânio-encefálico e AVE (MOTL *et al.*, 2006; TWEEDY; TROST, 2005; MATLAGE *et al.*, 2015).

Dessa maneira, não se sabe se as fórmulas de predição utilizadas pelos acelerômetros estimam de forma acurada o real GE de indivíduos pós-AVE, uma vez que Zamparo *et al.* (1995), Plats, Rafferty e Paul(2006)ePolese *et al.* (2015) demonstraram graficamente que, apesar de indivíduos pós-AVE com velocidade de marcha comunitária (>0,8m/s) apresentarem um GE similar ao de indivíduos saudáveis, indivíduos com velocidade de marcha domiciliar (<0,4m/s) apresentaram um GE pelo menos quatro vezes maior, quando comparados com indivíduos saudáveis (PLATS; RAFFERTY; PAUL, 2006;POLESE *et al.*, 2015;ZAMPARO *et al.*, 1995). Uma possível explicação para tal fato seria a de que indivíduos saudáveis são capazes de selecionar baixas velocidades, enquanto indivíduos pós-AVE com maior comprometimento não o fazem com a mesma frequência, visto que a baixa velocidade apresentada por esses pode ser equivalente à máxima que os mesmos conseguem desenvolver.

1.2 Desenvolvimento da tecnologia móvel e o uso de aplicativos de celular para mensurar níveis de atividade física

O uso de aplicativos de celular tem se destacado uma vez que, devido ao avanço tecnológico, esses dispositivos têm apresentado sensores de alto nível para detecção de movimento, armazenamento e compartilhamento de informações (GOOGLE DEVELOPERS, 2016). Além disso, devido ao fácil acesso a aparelhos celulares e às interfaces de simples compreensão voltadas especialmente ao público em geral, o uso de aplicativos de celular para avaliação e monitoramento dos níveis de atividade física tem se tornado cada vez mais popular (LEE, 2013). Nesse contexto, diversos programas têm sido desenvolvidos exclusivamente para auxiliar na recuperação de indivíduos com comprometimento neurológico (GOODNEY *et al.*, 2010), tais como:aplicativos com a função de educar pacientes e cuidadores a respeito de exercícios domiciliares, posicionamentos adequados e controle da medicação utilizada

(ZHANG; YEO; HO, 2015), e aplicativos capazes de estimular a realização de exercícios com o membro superior parético (LAWSON *et al.*, 2016). Visando a melhoria do condicionamento cardiovascular de indivíduos pós-AVE, recentemente foi desenvolvido um aplicativo de célula, *StarFish* que objetiva aumentar o número de passos/dia dado pelo indivíduo (PAUL; RAFFERTY; PAUL, 2016).No entanto, o *StarFish* fornece apenas o número de passos/dia e não informações referentes ao GE durante uma determinada atividade. O aplicativo Google Fit, por sua vez, fornece variáveis como o número de passos, o GE, a distância percorrida e o tipo de atividade física praticada pelo usuário (GOOGLE DEVELOPERS, 2016). Assim, o Google Fit fornece uma visão mais completa do estado de saúde do usuário e da atividade física praticada, permitindo um melhor monitoramento.

1.2.1 Aplicativo Google Fit

Aplicativos como o Google Fit, por exemplo, fornecem as principais informações referentes ao nível de atividade física de um indivíduo, como o número de passos dados em um determinado período de tempo, o GE obtido após determinada atividade e o tempo em que o indivíduo se manteve ativo (GOOGLEDEVELOPERS 2016).

Porém, assim como acontece com os acelerômetros convencionais, os aplicativos de celular disponíveis atualmente foram desenvolvidos para indivíduos saudáveis em atividades de marcha e corrida na esteira (LEE, 2013; CASE *et al.*, 2015; WU*et al.*, 2012).Dessa maneira, é possível questionar se tais dispositivos seriam válidos para a monitorização do nível de atividade física de indivíduos pós-AVE.

Nesse sentido, uma vez que não se sabe se o acelerômetro*ActiGraph* GT3X e o aplicativo de celular Google Fit fornecem estimativas válidas do número de passos dados por indivíduos pós-AVE crônicos, e as fórmulas utilizadas para se estimar o GE de indivíduos pós-AVE foram desenvolvidas para indivíduos saudáveis, foram desenvolvidos dois estudos na presente dissertação, envolvendo as seguintes questões de pesquisa:

Estudo 1

Existem diferenças entre o número de passos estimado pelo acelerômetro *ActiGraph* GT3X e aplicativo de celular Google Fit, com o número de passos observado pelo pesquisador durante a marcha rápida no solo de indivíduos pós-AVE crônicos?

Estudo 2

Existem diferenças entre o GEobtido através do ergoespirômetro Cortex Metamax 3B e o GE predito pelos dispositivos *ActiGraph* GT3X e Google Fit de indivíduos pós-AVE crônicos durante a marcha rápida no solo?

1.3 Objetivos

Estudo 1

Comparar o número de passosestimado pelo acelerômetro *ActiGraph* GT3X e aplicativo de celular Google Fit, com o número de passos observados pelo pesquisador durante a marcha rápida no solo de indivíduos pós-AVEcrônicos.

Estudo 2

Comparar o GE estimado pelo acelerômetro *ActiGraph* GT3X e pelo aplicativo de celular Google Fit com o GEobtido através do padrão-ouro (ergoespirometro Cortex Metamax 3B) de indivíduos pós-AVE crônicos durante a marcha rápida no solo.

2 MATERIAIS E MÉTODO

2.1 Delineamento do Estudo

Trata-se de um estudo metodológico, onde os indivíduos foram selecionados através de uma amostra de conveniência.

2.2 Local de realização

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

2.3 Amostra

Indivíduos com diagnóstico de AVE foram recrutados na comunidade, de acordo com os seguintes critérios de inclusão: (1) idade ≥20 anos; (2) tempo de lesão >6 meses; (3) habilidade para deambular pelo menos

14 m com ou sem a utilização de dispositivos auxiliares; (4) capacidade para compreender e seguir instruções verbais, além de ausência de déficits cognitivos, determinado pelos pontos de corte no Mini Exame do Estado Mental baseado na escolaridade (para analfabetos: 13 pontos; educação básica: 18 pontos) (BERTOLUCCI *et al.*,1994). Indivíduos diagnosticados com quaisquer outras disfunções neurológicas, ortopédicas e/ou respiratórias foram excluídos.

O cálculo amostral foi realizado *a posteriori* através do *software GPower* 3.1 e indicou que a análise dos dados referentes ao número de 30 indivíduos obteve um poder de 0,98.

2.4 Instrumentação e Medidas

Características dos participantes, como idade, sexo, tempo pós-AVE, lado da hemiparesia, rastreio de alterações cognitivas (MEEM) (BERTOLUCCI*et al.*,1994), tônus muscular dos extensores de joelho (Escala de *Ashworth* Modificada) (BOHANNON; SMITH, 1987), recuperação motora dos membros inferiores (Escala de *Fugl-Meyer* seção para membros inferiores) (MAKI *et al.*, 2006), força muscular de extensores de joelho e flexores dorsais/ plantares do tornozelo obtida através do dinamômetro manual *Hand Held* (DORSH *et al.*, 2012), nível funcional (teste de velocidade de marcha em 10 metros) (NASCIMENTO *et al.*, 2012) e capacidade funcional (*Duke Activity Status Index* – DASI) (COUTINHO-MYRRHA *et al.*, 2014), foram coletadas para caracterização da amostra (ANEXO I).

2.4.1 Medidas de desfecho

As seguintes medidas de desfecho foram obtidas durante a marcha rápida no solo:

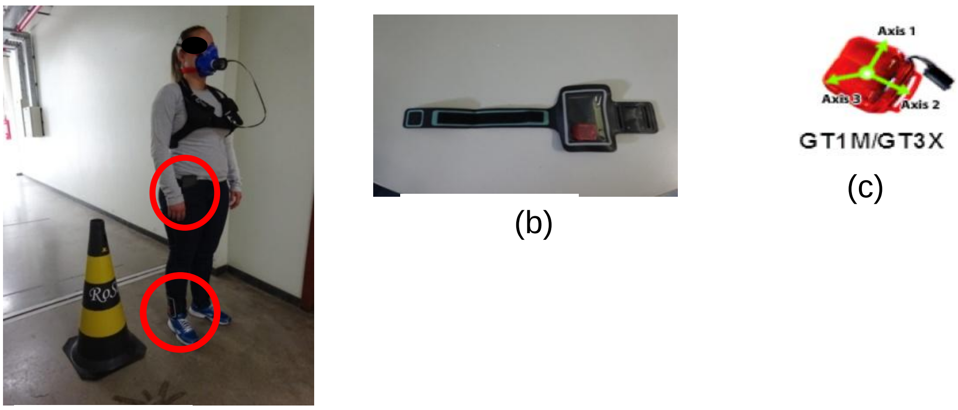
(a)O número de passos estimado através doacelerômetro *ActiGraph* GT3X,do aplicativo de celular Google Fit e o observado pelo pesquisador;

(b) O GE, em kcal, obtido através de um ergoespirômetro Córtex Metamax 3B (padrão-ouro), e o estimado pelo acelerômetro *ActiGraph* GTX3 e aplicativo de celular Google Fit;

2.4.1.1 Número de passos estimado através do acelerômetro *ActiGraph* GT3X, do aplicativo de celular Google Fit e observado pelo pesquisador-observador

O acelerômetro *ActiGraph* GT3X (*ActiGraph*, *Pensacola*, Flórida, EUA), foi utilizado para se avaliar o número de passos dados pelo indivíduo durante a marcha rápida no solo.Trata-se de um acelerômetro triaxial (i.e., mede a aceleração nos eixos ântero-posterior, médio-lateral e vertical) capaz de registrar mudanças de aceleração com magnitudes que englobam aproximadamente 0,05 e 2,5g (g=9,8m/s^2) dentro de uma faixa de frequência de 0,25 a 2,5 Hertz, em uma taxa de 30 vezes por segundo (30 Hertz) (BUONANI *et al.*, 2013). Esse foi posicionado no tornozelo do membro inferior parético, como estabelecido pelo fabricante e utilizado em um estudo prévio com indivíduos pós-AVE (MATTLAGE *et al.*, 2015) (FIGURA 1).

Figura 1: (a) Acelerômetro *ActiGraph* GT3X posicionado no membro inferior parético; (b) *ActiGraph* GT3X, em detalhe, demonstrando a forma como o dispositivo foi acoplado ao membro inferior do participante; (c) Demonstração de como o *ActiGraph* GT3X foi posicionado a fim de padronizar os dados brutos coletados: *axis* 1= eixo y ou vertical (VT), *axis* 2= eixo z ou médio-lateral (ML), *axis* 3=eixo x ou ântero-posterior (AP).

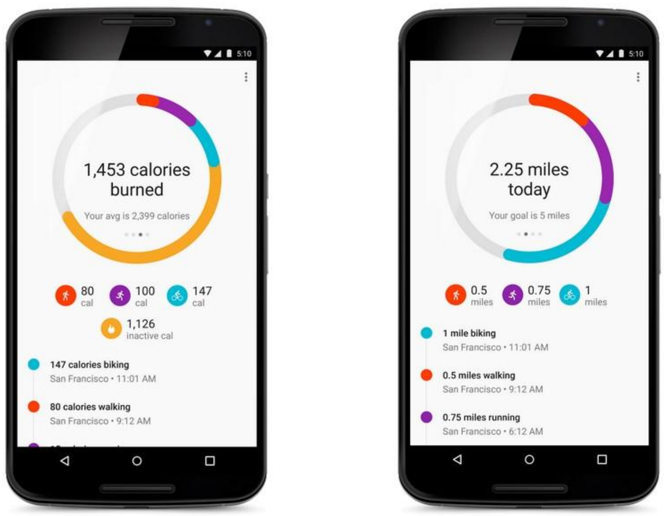


(a) (b) (c)

Já o Google Fit, permite medir, monitorar e armazenar as informações de condicionamento físico de seus usuários. Está disponível gratuitamente para computadores, dispositivos móveis (sistema *Android* versão a partir de 4.0) e dispositivos *AndroidWear*, tornando possível o acesso aos dados em qualquer lugar e por diferentes aplicativos e dispositivos. Além de ser de fácil utilização e leitura por parte do usuário, o aplicativo encontra-se disponível para qualquer celular com tecnologia *Android*, sendo de fácil acesso, tanto por parte de profissionais da saúde, quanto por pacientes.

O Google Fit é formado por um conjunto de sensores de alto nível, como acelerômetro, giroscópio e GPS, capaz de detectar mudanças de posicionamento (i.e. posição sentada para posição de pé, etc), diferentes formas de movimento (ie. caminhada, corrida, andar de bicicleta, etc), diferentes tipos de dados (i.e. contagem de passos, frequência cardíaca, etc) e diferentes sessões de atividade (i.e. intervalo em que a atividade foi realizada) (GOOGLE DEVELOPERS, 2016) (FIGURA 2).

Figura 2: Ilustração da interface do aplicativo de celular Google Fit, após a prática de uma atividade física. É possível discriminar quais atividades foram praticadas, por quanto tempo, além da distância percorrida e o GE de cada uma.



Todas essas informações são armazenadas em um repositório central *online*, ao qual o usuário tem acesso direto e pode utilizar para sincronizar com diferentes aplicativos e dispositivos, tanto para acompanhar a evolução, quanto para incrementar o treinamento (GOOGLE DEVELOPERS, 2016).

Antes de cada utilização do aplicativo, o mesmo foi calibrado através do fornecimento de dados pessoais do usuário, como sexo, massa corporal (em quilogramas - kg) e altura (em centímetros - cm). Além disso, é possível personalizar as unidades de medida em que se deseja coletar os dados: para distância, é possível optar entre quilômetros ou milhas; para altura, centímetros ou pés/polegadas; para massa corporal, pode-se decidir entre kg, libras ou *stones* e para o gasto energético, é possível optar entre calorias (cal) ou quilojoules. Para o presente estudo, foram utilizadas as variáveis referentes ao sistema métrico brasileiro definido pelo Sistema Internacional de Unidades (SI) sendo elas: quilômetros, cm e kg (INSTITUTO NACIONAL DE METROLOGIA, QUALIDADE E TECNOLOGIA, 2012). Por se tratar de um aplicativo de celular, possui as mesmas dimensões e peso do dispositivo no qual está instalado, no caso, um celular LG Nexus 5 de dimensões 69,17mm (largura) x 137,84mm (comprimento) x 8,59mm (profundidade) e 130 gramas, respectivamente. O mesmo foi posicionado no bolso anterior do membro inferior parético (CAPELA; LEMAIRE; BADDOUR, 2015) (FIGURA 1).

Ainda, o número real de passos foi determinado através da observação de um pesquisador-avaliador, experiente e previamente treinado, durante o teste de marcha rápida em solo. Um segundo pesquisador ficou responsável pela filmagem do teste. A filmagem fez-se necessária para que uma nova contagem fosse feita com uma semana de diferença a fim de se obter a confiabilidade intra-examinador (ICC [3,1]=0,98; $p<0,001$) e de se evitar a possibilidade de viés de memória por parte do pesquisador-avaliador. Dessa maneira, as medidas observadas no momento do teste de caminhada foram utilizadas como medida de critério do número de passos dados pelos participantes.

2.4.1.2 Gasto energético estimado pelo acelerômetro *ActiGraph* GTX3 e aplicativo de celular Google Fit, e o obtido através de um ergoespirômetro Cortex Metamax 3B (padrão-ouro)

O acelerômetro *ActiGraph* GT3X (*ActiGraph*, *Pensacola*, Flórida, EUA), foi utilizado para se avaliar também o GE durante a marcha rápida no solo. Para a análise do GE, foi calculada a média dos *counts* coletados durante todo o período de teste, e este foitransformado em kcal através do software *ActiLife Data AnalysisSoftware* versão 4.1.0. As equações utilizadas para se estimar o GE foram indicadas pelo fabricante (ACTIGRAPH, LLC ENGINEERING/MARKETING, 2008):

(4) Equação do Teorema de Trabalho-Energia (TTE):

$kcals/min_{TTE}$=0,0000191*counts/min*massa corporal, em kg

(5) Equação de Freedson:

$kcals/min_{Freedson}$=0,00094*counts/min+ 0,1346* massa, em kg – 7,37418

(6) Fórmula Combinada: Utiliza a equação do TTE quando os counts/min forem ≤1952 e a de Freedson quando os counts/min forem >1952.

Vale ressaltar que apesar de tais fórmulas terem sido estabelecidas para indivíduos saudáveis durante a marcha e corrida em esteira, as mesmas tem sido utilizadasem estudos em indivíduos com disfunções neurológicas (MATTLAGE*et al.*, 2015; MOTL *et al.*, 2006;TWEEDY; TROST, 2005).

Já para o GE estimado pelo aplicativo de celular Google Fit (Google *Inc., Mountain View*, Califórnia, EUA),optou-se pela utilização de cal como forma de facilitar a conversão dos dados em kcal, com consequente padronização das informações obtidas pelos diferentes instrumentos utilizados no estudo. A transformação dos dados coletados para kcal foi feita através da seguinte fórmula:

(7) $kcal/min_{GoogleFit}$= ($cal_{GoogleFit}$/1000)

A Tabela 1 apresenta as principais características técnicas do*ActiGraph* GT3X e do aplicativo de celular Google Fit.

Tabela 1-Especificações técnicas do acelerômetro *ActiGraph* GT3X e do celular LG Nexus 5 contendo o aplicativo Google Fit.

Especificações	***ActiGraph* GT3X**	**LG Nexus 5 contendo o Google Fit**
Frequência	30Hz	ND
Armazenamento de dados	16MB	16GB
Tempo de duração da bateria	31 dias	De 17 horas a 12,5 dias
Sensor do acelerômetro	acelerômetro triaxial ADXL335 (Analog Devices, USA)	Acelerômetrotriaxial + giroscópio MPU6515 (Invense Inc., USA)
Amplitude de aceleração registrada	±3g	ND
Medidas de desfecho (dados brutos)	Aceleração dos três eixos e a magnitude do vetor	Aceleração dos três eixos
Medidas estimadas	Número de passos, GE (kcal) e duração da atividade física	Tipo de atividade física praticada, distância percorrida (milhas ou km), número de passos e GE (cal ou kJ) e duração da atividade física

ND= Não disponível

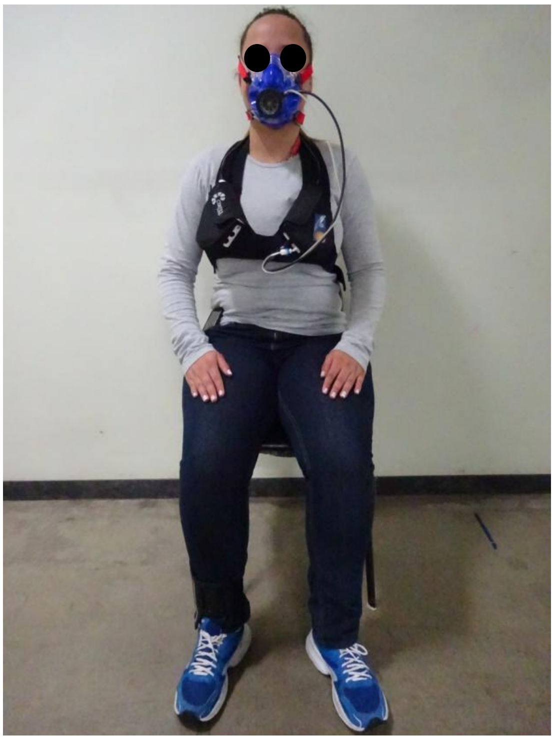
Para a determinação do GE através do consumo de oxigênio, foi utilizado o ergoespirômetro portátil de sistema aberto Córtex MetaMax 3B®, Alemanha (padrão-ouro). O consumo de oxigênio, determinado pelo VO_2 médio e expresso em mL/kg/min foi mensurado durante a marcha rápida, de acordo com os critérios estabelecidos por Polese *et al.* (2015). Os gases foram coletados a cada respiração a partir de uma máscara facial que possui baixo volume de espaço morto e duas válvulas inspiratórias com baixa resistência inspiratória, que permitem a remoção dos gases exalados durante o teste, proporcionando uma melhor qualidade na análise dos gases (CÓRTEX 2010b). O sistema possui 650 gramas e permite a transmissão de dados para a base em uma distância de até 800 metros (CÓRTEX 2010b),permitindo assim, explorar as respostas fisiológicas humanas em atividades funcionais (FIGURA 3).

Figura 3. Cortex Metamax 3B inserido no colete, juntamente com a máscara de silicone.

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. Antes de cada coleta, o equipamento, 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% O_2, 50% CO_2, *balance* N_2: ±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, EUA). Isso possibilitou que as medidas durante as coletas fossem 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 (POLESE *et al.*, 2015). O equipamento apresenta adequada validade e confiabilidade, quando utilizado para avaliação de diversas atividades em indivíduos pós-AVE crônicos (BRANDES *et al.*, 2012; POLESE *et al.*, 2015).

Após a calibração, o ergoespirômetro foi colocado no tórax do participante, 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 fossem captados(FIGURA 4).

Figura 4: Participante com o colete contendo o ergoespirômetro durante a coleta de dados no minuto anterior ao início do teste



Para as análises relativas ao GE, foram consideradas askcal transformadas a partir da média do consumo de oxigênio relativo (mL/kg/min) durante os cinco minutos de coleta através da seguinte equação (POWERS; HOWLEY, 2009):

(8) $kcal/min_{Metamax3B}$= (VO_2 em mL/kg/min*massa corporal, em kg)/1000

Tal medida foi tomada, uma vez que o objetivo do estudo foi avaliar a validade dos instrumentos para se monitorar a prática de atividade física de forma geral, e não apenas o momento em que o GE atingisse a condição de estado estável. Assim, foram captadas informações referentes às alterações metabólicas dos momentos inicial (adequações metabólicas ao início da prática de atividade física), intermediário (onde o metabolismo do indivíduo atinge o estado estável) e final (adequações metabólicas à interrupção da prática).Além disso, o aplicativo de celular Google Fit fornece apenas o GE estimado durante toda a atividade, não sendo possível ter acesso aos dados a cada minuto. Dessa maneira, a comparação dos dados foi possível.

2.5 Procedimentos

As coletas dos dados aconteceram em um único dia. No momento do agendamento, foram repassadas ao participante por telefone as seguintes orientações: comparecer para a coleta com uma roupa confortável, calça ou bermuda que contenha bolsona frente e calçado habitual, continuar tomando os medicamentos rotineiros e não ingerir alimentos ou bebidas que contenham estimulantes, tais como chocolate, café e chá preto.

Inicialmente o participante foi esclarecido com relação aos objetivos do estudo, com posterior assinatura do Termo de Consentimento Livre e Esclarecido (TCLE) (APÊNDICE I). Em seguida, foi realizada uma entrevista previamente estruturada, com o objetivo de se coletar dadosdemográficos e clínicos, comoidade, sexo, massa corporal, altura, tempo pós-lesão, lado parético, número de comorbidades, número de medicamentos em uso e rastreio de possíveis alterações cognitivas (MEEM) (BERTOLUCCI *et al.*, 1994). Posteriormente, foramobtidas as medidas de força muscular dos extensores de joelho, flexores dorsais e flexores plantares bilateralmente(dinamômetro manual) (DORSH *et al.*, 2012), tônus muscular dos extensores de joelho (Escala de *Ashworth* Modificada) (BOHANNON; SMITH, 1987), recuperação motora dos membros inferiores (Escala de *Fugl-Meyer*) (MAKI *et al.*, 2006), nível funcional (velocidade de marcha de 10 metros: velocidade habitual e máxima) (NASCIMENTO *et al.*, 2012) e capacidade funcional (DASI) (COUTINHO-MYRRHA *et al.* 2014) (ANEXO I).

Logo em seguida, foram realizadas as medidas do GE basal, com o indivíduo deitado, em decúbito dorsal, 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 cinco minutos nesta posição. 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.

Finalmente, foi realizado o teste de marcha na velocidade máxima, durante cinco minutos, em um corredor reto e plano de 10 metros, de acordo com os critérios estabelecidos por Polese *et al.* (2015). Optou-se pela realização do teste na velocidade máxima, uma vez que um dos objetivos do presente estudo foi comparar o GE estimado por diferentes monitores durante a prática de atividade física, o que, geralmente, implica no aumento do GE por parte do praticante.

Previamente à realização do teste foi dado o seguinte comando padronizado aos participantes:

“Você deverá caminhar até o outro cone e voltar o mais rápido que conseguir, porém sem correr e em segurança. Você ficará indo e voltando durante cinco muntos, sendo que, a cada ida e a cada volta, você deverá caminhar como se fosse pegar o último ônibus do dia que está passando. Caso sinta-se desconfortável, fique marchando no lugar e volte a caminhar quando se sentir melhor. Caso queira interromper, permaneça marchando no lugar e levante a mão que vamos até você.”

Durante a realização do teste, um avaliador previamente treinado forneceuestímulos verbais nos minutos um, três e quatro, seguindo critérios previamente estabelecidos (BRITTO, SOUZA, 2006; BRITTO *et al.*, 2013).

Além disso, o participante utilizou o acelerômetro *ActiGraph* GT3X e o celular contendo o aplicativo Google Fit, bem como o ergoespirômetro portátil Metamax 3B, simultaneamente (FIGURA 5).

Figura 5: Participante preparado para iniciar o teste de caminhada de cinco minutos,portando o ergoespirômetro Cortex Metamax 3B (máscara e colete), o celular contendo o aplicativo Google Fit (círculo do bolso anterior do membro inferior parético) e o acelerômetro *ActiGraph* GT3X (círculo do tornozelo do membro inferior parético).

2.6 Aspectos éticos

O projeto foi aprovado pelo Comitê de Ética em Pesquisa da UFMG, sob o parecer CAAE–47256815.9.0000.5149 (ANEXO II).

2.7 Análise estatística

Estatísticas descritivas e testes de normalidade (*Shapiro-Wilk*) foram realizados para todas as variáveis, utilizando o pacote estatístico SPSS (versão 19.0). Coeficientes de correlação de Pearson foram calculados para avaliar o grau de associação entre as medidas de GE obtidas com os dispositivos e o ergoespirômetro portátil, bem como entre o número de passos estimado pelos dispositivos e o observado pelo pesquisador,considerando os valores estabelecidos por Portney e Watkins (2009): 0,00 a 0,25 pouca ou nenhuma correlação; 0,26 a 0,50 correlação fraca; 0,51 a 0,75 correlação de moderada a boa; acima de 0,75 correlação de boa a excelente. O Coeficiente de Correlação Intraclasse (CCI [2,1])foi utilizado para se observar a existência de concordâncias entre os instrumentos, tanto para as análises referentes ao GE quanto para as análises referentes ao número de passos, além da análise do grau de concordância entre os mesmos. Os valores considerados foram os mesmos estabelecidos por Portney e Watkins (2009),mencionados anteriormente.O nível de significância para todas as análises foi de 5%.

3 RESULTADOS

3.1 Participantes

Foram recrutados 38 indivíduos pós-AVE crônicos na comunidade. No entanto, um participantefoi excluído devido ao diagnóstico de doença de Parkinson. Dessa maneira, foram incluídos 37 indivíduos que foram avaliados e participaram do presente estudo. Para a análise do GE, uma subamostra de 30 indivíduos foi avaliada,devido à intercorrências com o ergoespirômetro, que impossibilitaram a coleta do GE de todos os participantes (TABELA 2).A média de idade dos 37 indivíduos participantes foi de 62 (±11,2) anos, 91,3 (±90,4)meses pós-lesão e sendo 27 homens. Dezenovepossuíam hemiparesia à esquerda e 31 sofreram AVE isquêmico. A média do índice de massa corporal (IMC) da amostra foi de 27,4 (±5,5)Kg/m^2, com apenas 12 indivíduos (31,6%) relatando serem praticantes de atividade física regular. A atividade físicamais frequentemente praticada reportada por esses, foi a caminhada (15,8%). Todos os participantes relataram fazer uso de medicamentos para outras comorbidades, sendo que a média da presença dessas foi de 4,6 (±2,5). Dez indivíduos relataram fazer uso de beta bloqueador.

Tabela 2 - Características dos participantes

Características	***n*=30**
Idade (anos), média±DP, (min–máx)	62±11,2(24–82)
Tempo pós-lesão (meses), média±DP, (min–máx)	91± 90,4(9–412)
Sexo, homens (n)%	27 (71,1)
Lado parético, esquerdo (n)%	19 (51,4)
Tipo de AVE, isquêmico (n)%	31 (83,8)
IMC (Kg/m^2), média±DP	27,4±5,5
MEEM (0 – 30), média ±DP	26,1± 3,3
Fugl Meyer-membros inferiores (0–34), média ± DP	20,4± 5,9
DASI (0–58,2), média±DP	33,7±15,1
Distância percorrida no teste de caminhada de cinco minutos (m), média ±DP	293,7± 158,9
Velocidade de marcha do teste de caminhada de cinco minutos (m/s), média ±DP, (min–max)	1,0±0,5 (0,3– 2,4)
Velocidade de marcha (m/s), média±DP, (min–max.)	
Habitual	0,8±0,3 (0,3 – 1,4)
Máxima	1,4±0,9 (0,5 –2,4)
Força muscular (Nm), média±DP,membro inferior parético/não parético	
Extensores de joelho	13,9±6,3/15,2±8,2
Flexores dorsais	5,7±2,8/6,6±3,2
Flexores plantares	8,2±4,6/8,9±5,1
Tônus dos extensores de joelho, escala modificada de *Ashworth,* (n)%	
0	18(60,0)
1	8(26,8)
1+	0(0)
2	2(6,6)
3	1(3,3)
4	1(3,3)

DP: desvio-padrão; IMC: índice de massa corporal; MEEM: Mini-Exame do Estado Mental; DASI: *Duke Activity Status Index*

3.2 Número de passos estimado através do acelerômetro *ActiGraph* GT3X, do aplicativo de celular Google Fit e observado pelo pesquisador-observador

As médias do número de passos estimados pelo acelerômetro *ActiGraph* GT3X e pelo aplicativo Google Fit foram 276,7±98,8 e 481,0±119,6, respectivamente, enquanto a média observada determinada pelo pesquisador foi de 472,0±93,0.

3.3 Gasto energético estimado pelo acelerômetro *ActiGraph* GTX3 e aplicativo de celular Google Fit, e o obtido através de um ergoespirômetro Cortex Metamax 3B (padrão-ouro)

A média do GE estimado pelo *ActiGraph* GT3X, utilizando a equação de Freedson foi 8,0±4,9 kcal/min, o Teorema de Trabalho e Energia 8,6±6,5kcal/min e a fórmula combinada foi 8,0±4,8 kcal/min. A média do GE estimado pelo aplicativo de celular Google Fit foi de 0,0±0,0 kcal/min.A média do GE obtido com o ergoespirômetro portátil no repouso foi de 3,3±0,5 mL/kg/min, enquanto no teste de marcha foi 3,6±1,2kcal/min. A Tabela 3 apresenta as medidas de GE estimado pelos três instrumentos.

Tabela 3– Gasto energético (Kcal/min e cal/min) estimado pelos três instrumentos utilizados durante o teste de marcha rápida no solo (n=30)

Instrumento	Kcal (média ± DP)	cal (média ± DP)
Metamax 3B	3,6±1,2	3573,5±1193,6
ActiGraph GT3X:		
- Equação de Freedson	8,0±4,9	8001,7±4907,6
- Teorema de Trabalho e Energia	8,6±6,5	8605,4±6509,2
- Fórmula Combinada	8,0±4,8	8048,3±4750,7
Google Fit	0,0±0,0	6,4±3,7

3.4 Associações e concordâncias entre as medidas

Associações positivas e estatisticamente significativas foram observadas entre o número de passos observado pelo pesquisador com o estimado pelo acelerômetro *ActiGraph* GT3X (r=0,56; p<0,001) e pelo aplicativo de celular Google Fit (r=0,89; p<0,001). A análise do CCI (2,1), por sua vez, demonstrou existir uma maior concordância entre os dados obtidos pelo aplicativo de celular Google Fit (CCI=0,93; p<0,001; IC95%=0,86 a 0,96) com menor média de diferença entre o número de passos observado e o estimado (-8,3 passos; p=0,37), enquanto o acelerômetro *ActiGraph* GT3X demonstrou menor concordância (CCI=0,32; p<0,001; IC95%=-0,16 a 0,67) e média de diferença entre o observado e o estimado de 191,8 (p<0,001) passos.

Com relação ao GE, foram observadas associações positivas, significativas e de magnitude fraca apenas entre o estimado pela fórmula combinada do *ActiGraph* GT3X e o obtido pelo ergoespirômetro. A análise do CCI (2,1)revelou não existir concordância entre os valores estimados pelo*ActiGraph* GT3X e ergoespirômetro. A Tabela 4 apresenta os resultados das correlações de Pearson para todas as equações utilizadas para estimativa do GE.

Tabela 4–Coeficientes de correlação de Pearson (r) e valores de p entre as medidas de GE estimadas pelos dispositivos (acelerômetro *ActiGraph* GT3X e aplicativo de celular Google Fit) com o GE obtido através do ergoespirômetro (Cortex Metamax 3B)

Maneira em que o GE foi estimado	**Coeficiente de Correlação (r)**	**Valor de p**
ActiGraph GT3X:		
• Equação de Freedson	0,04	0,06
• Teorema de Trabalho e Energia	0,04	0,06
• Fórmula Combinada	0,37*	0,04
Google Fit	0,0	0,97

*=p<0,05

4 ARTIGOS

4.1 Artigo 1

COVER LETTER

To: The editors of Disability and Health Journal.

Dear Dr. McDermott and Dr. Turk,

You will find attached a submission of a original research, entitled: “Validity of the ActiGraph GT3X accelerometer and the Google Fit smartphone application in detecting stepping activity in stroke individuals” for possible publication in the Disability and Health Journal. The authors of the manuscript are Giselle Silva e Faria, Janaine Cunha Polese, Giane Amorim Ribeiro-Samora, Lorena Pereira Lima, Christina Danielle Coelho de Morais Faria, Aline Alvim Scianni e Luci Fuscaldi Teixeira-Salmela. The area of expertise is on “Evaluative research on new interventions, technologies, and programs”. The present work validates an easy-to-use, free-access smartphone application for monitoring physical activity levels of stroke individuals, by giving objective measures of step count.

We declare that this work is unpublished. It strictly followed all ethical procedures and it has not been submitted to any other journal for publication.

Yours sincerelly,

Luci Fuscaldi Teixeira-Salmela
Corresponding author

VALIDITY OF THE ACTIGRAPH GT3X ACCELEROMETER AND THE GOOGLE FIT SMARTPHONE APLLICATION IN DETECTING STEPPING ACTIVITY OF STROKEINDIVIDUALS

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ABSTRACT

Background: Because devices, such as regular accelerometers, may be relatively expensive, not easily incorporated within clinical settings, and may not provide valid measures of stepping activity for individuals with neurological conditions, the use of smartphone applications may be a better alternative to encourage people to get engaged in more active lifestyles. However, these applications have not been validated for individuals with stroke. **Objective:** To examine the validity of the Google Fit smartphone application and the ActiGraph GT3X accelerometer in estimating stepping activity in people with stroke. **Methods:** Thirty-seven community-dwelling individuals with stroke were asked to walk on a 10-meter straight hallway over five minutes at their fast speeds, wearing the ActiGraph GT3X accelerometer and a smartphone on the paretic lower limb. The criterion-standard measure consisted of the actual number of steps, determined by a trained examiner. **Results:** The mean estimated steps by the ActiGraph GT3X and Google Fit were 276.7±97.6 and 481.0±119.8, respectively, whereas that determined by the examiner was472.0±93.9. Statistically significant associations were found between the actual steps and those estimated by the ActiGraphGT3X ($r=0.56$; $p<0.001$) and Google Fit ($r=0.89$; $p<0.001$).The Google Fit application demonstrated the highest reliability coefficient (ICC[2,1]=0.93; $p<0.001$; mean difference=-8.3 steps; $p=0.37$), compared with the ActigraphGT3X (ICC[2,1]=0.32; $p<0.001$; mean difference=191.8; $p<0.001$). **Conclusions:** The ActiGraphGT3X tended to underestimate the data and may not be appropriate to estimate stepping activity for individuals with stroke. The findings support the validity of a smartphone application in estimating stepping activity of individuals with stroke.

Key words: HEMIPLEGIA, AMBULATION, VALIDATION, CELL PHONE, ACCELEROMETRY.

INTRODUCTION

The adoption of active lifestyles is of paramount importance for individuals with stroke, to prevent additional comorbidities and new stroke episodes[1]. However, the activity levels of individuals with stroke tend to be lower than those observed for sedentary healthy subjects[2]. In this sense, more active behaviors should be encouraged, byassessing and monitoring the patients' levels of daily walking activities. One way to do it is by encouraging the use of stepping activity monitors,to increase the total walking time and the amount of daily medium and long walking bouts[3].

The use of pedometers in step activity monitoring programs was found to be associated with significant increases in physical activity levels of individuals with chronic stroke[4].Previous studies hypothesized the number of steps should be considered the preferred method to assess and monitor the levels of daily activity of individuals with chronic stroke[5,6], since step counts are considered natural units of walking activity[6]. In addition, step counting has been considered the gold-standard measure of mobility and walking activity for these individuals[5]. In this sense, there is a great variety of step monitors available on the market, which allows people to keep track of their amount of achieved daily steps.

Step monitors usually use accelerometry-based technology, which has been frequently employed to measure ambulatory activity after stroke[7-9]. These devices are small, non-invasive, and have small microprocessors, which work continuously[8], allowing the users to have trustworthy information regarding their activity levels. The ActiGraph GT3X is an example of a frequently used tri-axial accelerometer, which can objectively measure the number of steps taken over a period of time and has been used in various neurological conditions[10-12].

However, devices, such as the ActiGraph GT3X,have been mainly usually used for research purposes, since they are relatively expensive and not easily incorporated within clinical settings.

In an attempt to solve these issues, consumer-based activity monitors have been developed to monitor activity parameters, such as the number of steps taken over a period of time, calories burnt, and walked distance[13]. A promising and cost-effective method in this scenario is the use of smartphone applications, since these devices have built-in accelerometers, gyroscopes, and global positioning systems (GPS)[14], which allow the users to have real-time access to their data[13]. In addition, the data provided by smartphone applications may be compared with those of other people in social medias[13].Althoughthe use of smartphone applications was validated for healthy young subjects[13,15], there is no available data for individuals with neurological conditions, including those with stroke. Therefore, the aim of the present study was to examine the validity of a smartphone application (Google Fit) and the ActiGraph GT3X accelerometer in estimating stepping activity in people with stroke. The estimated steps provided by both devices were compared with the actual steps, which were counted from videotapes. This information may be useful to recommend these devices for monitoring stepping activity.

METHODS

Participants

Individuals, who had a single unilateral stroke, were recruited from the general community, from August, 2015 to August, 2016, according to the following criteria: Were older than 20 years; had a time since the onset of the stroke of at least six months; were able to walk independently with or without assistive devices; had residual weakness or increased tonus of the knee extensor and/or ankle plantar flexor muscles; and showed no cognitive impairments, as determined by the following education-adjusted cut-off scores on the Mini Mental State Examination: 13 for the individuals with illiteracy and 18 for those with basic education[16].Participants were excluded if they had any other non-stroke related conditions.

All participants provided written consent, based upon previous approval from the Institutional Ethical Review Board (#CAAE–47256815.9.0000.5149).

Instruments and Procedures

Initially, the participants underwent an interview and physical examination for the collection of their demographic, anthropometric, and clinical data, which included age, sex, body mass, height, time since the onset of the stroke, paretic side, cognitive assessment (Mini Mental State Examination), functional status, which was evaluated by the 10-meter walking test (10MWT), and motor recovery of the lower limb (Fugl-Meyer lower-extremity section scores).

Then, they were asked to walk back and forth on a 10-meter flat and straight hallway over five minutes, at their maximum speeds, following previously recommended procedures[17], wearing the ActiGraph GT3X accelerometer on their paretic ankle[10] and a smartphone in the front pockets of their paretic lower limb, following previously recommended procedures[18]. A research assistant also videotaped the participants, as they walked. The actual steps were determined by a trained researcher, who counted the steps taken by the participants from the video recordings, on two occasions, with at least one week apart. This period of time was chosen, to avoid memory bias. The researcher had five years of research and clinical experience in the area of stroke rehabilitation. Excellent test-retest reliability (ICC [3,1]=0.98; $p<0.001$) was found. Then, the actual number of steps, which was identified by the examiner, was used as a criterion-standard measure.

ActiGraph GT3X accelerometer

The ActiGraph GT3X is a small, commercially available triaxial accelerometer, which captures changes in acceleration in the anteroposterior, lateral, and vertical axes[19] and predicts, amongst other variables, the number of steps taken over a period of time. It can be positioned on different body regions and, on the present study, it was placed distally on the paretic ankle, as recommended by the manufacturer and previously used with individuals with stroke[10]. This positioning was chosen once it was observed that the accelerometer is more reliable when placed on the ankle versus the hip or spine to measure step count in older adults with or without assistive device[20] .The collected data were analyzed by the the ActiLife data analysis software 4.1.0.

Google Fit smartphone application

The Google Fit is an open platform developed by Google Inc., which allows the users to control their fitness data. It is also available as a free application for smartphones, which works with versions above 4.0 in Android systems[14]. The Google Fit consists of a set of high level sensors, such as accelerometer, gyroscope, and GPS, which can detect changes in position (for example, moving from sitting to standing), various types of movement (walking, biking, and others), several kinds of data (number of steps, walked distance, heart rate, and others), and different bouts of activity (time of each bout)[14]. The smartphone with the application used in the present study was the LG Nexus

5,which weighted 130 grams and had the following dimensions: width of 69.17mm, height of 137.84mm, and depth of 8.59mm.

Prior to the test, the smartphone was positioned on the participants' front pocket of their paretic lower limb, as previously used with individuals with stroke[18] and calibrated with the following user data: sex, body mass (Kg), and height (cm).

Statistical analyses

Descriptive statistics and tests for normality (Shapiro-Wilk) were carried-out with the SPSS software (version 19.0) by an independent researcher. Pearson's correlation coefficients were calculated to examine the associations between the criterion-standard measures (actual steps) and those estimated by the Google Fit application and the ActiGraphGT3X accelerometer, considering the following cut-offvalues[21]:0-0.25: little or no relationship; 0.26-0.50: fair; 0.51-0.75: moderate to good; and >0.75: good to excellent relationship. Intra-class correlation coefficients (ICC [2,1]) were calculated to investigate the relative reliability between the actual steps and those estimated by the Google Fit application and the ActiGraph GT3Xaccelerometer. The significance level was set at 5%.

RESULTS

Participant's characteristics

Initially,38 individuals volunteered to participate, but one was excluded, due to the diagnosis of Parkinson's disease. Thus, 37 participants, 28 men, who had a mean age of 62±11years and a mean time since the onset of the stroke of 91±91 months, participated. The participants showed different functional levels, since their walking speed ranged from 0.3 to 1.4m/s. Their characteristics are reported in Table 1.

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

Concurrent Validity

The mean (SD) number of the steps estimated by the Google Fit application and the ActiGraph GT3X accelerometer was 481.0±119.6 and276.7±98.8, respectively, whereas the mean actual step was 472.0±93.0. Significant and positive associations were found between the actual steps and those estimated by the Google Fit application (r=0.89; p<0.001)and the ActiGraph GT3X accelerometer (r=0.56; p<0.001).

The ICC (2,1) analyses revealed that the Google Fit application showed the highest agreement (ICC=0.93; p<0.001; 95%CI=0.86 to 0.96) and the lowest mean difference between the actual and estimated steps(-8.3steps;p=0.37),whereas the ActiGraph GT3X accelerometer showed the lowest agreement (ICC=0.32; p<0.001; 95%CI=0.16 to 0.67) and a mean difference of 191.8 (p<0.001) (Table 2).

------------------------------- INSERT TABLE2 ABOUT HERE ---------------------------

DISCUSSION

This study aimed at examining the validity of a smartphone application (Google Fit) and the ActiGraph GT3X accelerometer in individuals with chronic stroke, by comparing the data estimated by these devices with those determined by the examiner. The results showed that the measures estimated by the Google Fit application were similar and highly associated with those identified by the examiner. However, the measures estimated by the ActiGraphGT3X tended to be lower and showed moderate associations with those determined by the examiner. The ICC (2,1) revealed that the data estimated by the Google Fit application showed better agreement and lower relative bias than those estimated by the ActiGraph GT3X, when compared with the actual steps.

Corroborating the present findings, a previous study, which examined the accuracy of the ActiGraph AM7164accelerometer for estimating the number of steps in individuals with multiple sclerosis, also found that the accelerometer showed a tendency to underestimate the number of steps during walking, mainly when walking speed was lower than 0.9m/s[22]. Although the version of the ActiGraph accelerometer used in the present study was more recent, the results were similar and could be partially explained by the mean walking speed of the participants (0.9m/s), which was similar to that of Motl *et al.*[22]. A possible reason for this relies on the fact that regular accelerometers usually do not consider gait asymmetries, which are typical features of individual with stroke[23,24]. It is important to notice that the algorithms used to estimate the data from the ActiGraph accelerometers are based upon studies developed with healthy individuals[25], who usually do not have any marked gait asymmetries. However, previous studies found that ActiGraph accelerometers can also underestimate step counts with healthy middle aged adults[22] and community-dwelling elderly[26].Another important point to mention is that, even though there are different triaxial accelerometers available from the ActiGraph, the algorithms used by the manufacturer were developed by taking into account only the vertical axis[25]. The vertical axis would probably not be the best axis to be considered while analyzing the number of steps taken by individuals with stroke, once they usually tend restrict the vertical movement of their paretic lower limb as a compensatory strategy[23,24]. In this scenario, the medio-lateral axis would probably be the best component to explain the gait pattern presented by individuals with stroke, since they usually tend to abduct their paretic lower limb to perform a circumduction[23,24], and the abduction movement happens in the medio-lateral axis.

There are different activity monitors currently commercially available, such as the Fitbit Ultra, Fitbit One and Nike Fuel+, which have been used for estimating stepping activity of individuals with chronic stroke[27,28]. However, all of them have shown some limitations. For instance, although the number of steps estimated by the Fitbit Ultra showed good association with those obtained by video recordings (ICC=0.70)[27], a tendency for underestimation of the data for individuals with gait speeds lower than 0.58m/s was found[27]. The Fitbit One also showed considerably higher mean errors in estimating stepping activity (15.8%) in individuals with chronic stroke, who walked at lower speeds[28]. Finally, the data estimated by the Nike Fuel+ showed the lowest association with those determined by observation in individuals with chronic stroke (r=0.19)[27]. In this scenario, the sample of the present study presented their gait speed ranging from 0.3 – 2.4 m/s during the five minute walking test, which also included individuals with lower gait speeds.

Smartphone applications were found to provide accurate measures of stepping activity in healthy young subjects[13,15] and, to the best of our knowledge, this is the first study which investigated its validity with individuals with chronic stroke. The results supported the use of the Google Fit application as a good alternative to estimate stepping activity, since the data showed higher association with those determined by the examiner, than those estimated by the

ActiGraph GT3X accelerometer. It is important to point-out that it might be difficult to have access to some consumer-based activity monitors, because they could be relatively expensive. On the other hand, the Google Fit application is an open platform, which is freely available for mobile phones[14],making it more accessible to people to keep track of their walking activity. Thus, the findings that the Google Fit application provides valid measures of stepping activity may have important clinical implications. This would allow rehabilitation professionals and patients to monitor the exact amount of step activity over a period of time and stimulate the users to have more active and healthier life styles. In addition, opposite to other consumer-based activity monitors, the Google Fit application does not require a computer to process the information, since it provides instantaneous information using an easy-to-read interface, and therefore, is more practical and less time consuming to be employed within clinical environments.

Even though the participants of the present study had different functional status and presented different gait speeds during the five minutes walking test, it is also important to mention that they were at the chronic stages of stroke and walked in a closed environment, therefore, the results should not be extrapolated for individuals with different characteristics and in different conditions. Future studies should examine other measurement properties of smartphone applications in individuals with other characteristics and in different environments.

CONCLUSIONS

The findings of the present study support the validity of the Google Fit application in estimating stepping activity of individuals with chronic stroke during fast overground walking. In addition, its cost-effectiveness makes it an interesting alternative to be incorporated within clinical contexts. The ActiGraph GT3X accelerometer tended to underestimate the data and did not show to be valid for estimating stepping activity in individuals with chronic stroke.

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INSTITUTIONAL REVIEW BOARD APPROVAL

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

Projeto: CAAE – 47256815.9.0000.5149

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 15 de setembro de 2015, o relatório final do projeto de pesquisa anterior à Plataforma Brasil intitulado **"Comparação do gasto energético predito com o gasto energético real obtido durante a marcha de indivíduos pós-acidente vascular encefálico crônicos com diferentes níveis funcionais".**

Telma Campos Medeiros Lorentz

Profa. Dra. Telma Campos Medeiros Lorentz
Coordenadora do COEP-UFMG

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Table 1: Participants' characteristics

Characteristic	***n*=37**
Age (years), mean±SD, (range: min–max)	62±11 (24–82)
Sex (men) n	28
Body mass (kg), mean±SD (range:min–max)	74.5±14.9 (50–117)
Height (cm), mean±SD (range:min–max)	164.7±8.6 (142-184)
Time since stroke (months), mean±SD, (range:min–max)	91±91 (9–412)
Side of paresis (left), n	19
MMSE (scores 0–30), mean±SD	25.6±4.9
Gait speed (m/s), mean±SD, (range: min-max)	
Comfortable	0.9±0.3 (0.3-1.4)
Fast	1.3±0.6 (0.5-2.1)
Fugl-Meyer Lower Limbs (scores 0-34), mean±SD	20.3±5.8
Walking distance (m), mean±SD	294.1 ± 156.7
Gait speed during the walking test (m/s), mean±SD, (range: min-max)	1.0±0.5 (0.3-2.4)
Estimated steps by the Actigraph GT3X (number), mean±SD	276.7±98.8
Estimated steps by the Google Fit (number), mean±SD	481.0±119.6
Actual steps determined by the examiner (number), mean±SD	472.0±93.0

MMSE= Mini-mental state examination; SD= Standard deviation.

Table 2: Intra-class correlation coefficients and 95% confidence intervals between the actual steps and those estimated by the Google Fit application and the Actigraph GT3X accelerometer (*n*=37)

Device	ICC [2, 1] (95%CI)	Mean difference (95%CI) between the actual and the estimated steps
Google Fit application	0.93 (0.86 to 0.96)	-8.29 (-26.76 to 10.18)
ActigraphGT3X accelerometer	0.32 (-0.18 to 0.68)	191.82 (160.79 to 222.84)

4.2 Artigo 2

VALIDITY OF THE ACTIGRAPH GT3X ACCELEROMETER AND THE GOOGLE FIT SMARTPHONE APPLICATION INESTIMATING ENERGY EXPENDITURE DURING FAST OVERGROUND WALKING OF INDIVIDUALS WITH CHRONIC STROKE

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ABSTRACT

Purpose: To examine the validity of the ActiGraph GT3X accelerometer and the Google Fit smartphone application in estimating energy expenditure in people with stroke, during fast overground walking. The energy expenditure, in kilocalories (kcal), estimated by both devices was compared with that obtained with the Cortex Metamax 3B ergoespirometer (gold-standard measure). **Materials and Methods:** Thirty community-dwelling individuals with stroke walked on a 10-meter hallway over five minutes at their fast speeds, wearing the Cortex Metamax 3B ergoespirometer, the ActiGraph GT3X accelerometer, and a smartphone with the Google Fit application. **Results:** A fair relationship was found only between the values estimated from the combined formula of the ActiGraph GT3X and those obtained with the gold-standard measure (*r*=0.37; p=0.04). However, no significant agreement between these measures was observed (ICC[2,1]= 0.18; p=0.17). There were not found any significant associations between the energy expenditure values estimated by the Google Fit application and those provided by the ergoespirometer. **Conclusions:** The findings demonstrated that both the ActiGraph GT3X accelerometer and the Google Fit smartphone application did not provide valid energy expenditure measures for chronic stroke individuals during fast overground walking.

Keywords:stroke; energy expenditure; validity; monitoring;

accelerometry; cell phones.

INTRODUCTION

After a stroke, individuals tend to adopt sedentary behaviors, which usually perpetuate during the chronic stages [1,2]. However, the paramount importance of an active lifestyle for individuals with stroke has already been reported [3,4], since it helps, amongst other aspects, to prevent deconditioning and new cardiovascular events [3]. Besides, it is also recommended that stroke individuals should be involved in regular aerobic exercise programs targeted to enhance their aerobic capacity and walking efficiency, in order to improve functional independency [3,5]. The reason for these recommendations relies on the fact that individuals with stroke have metabolic abnormalities [6,7] and cardiovascular adaptations, which are not observed in healthy individuals [8]. Therefore, these abnormalities increase the risk of recurrent cardiovascular events [7]. In this scenario, the objective assessment and monitoring of energy expenditure during physical activity practice becomes of great importance.

Devices, such as regular accelerometers, objectively measure energy expenditure [9,10] and are the most frequently used monitors with stroke individuals, as reported in a recent systematic review 2015[11]. One example of a triaxial accelerometer commonly used in various neurological conditions is the ActiGraph GT3X (ActiGraph, Pensacola, Flórida, USA) [1,12,13]. Nonetheless, its energy expenditure prediction equations were developed based upon data of healthy individuals during walking and running on a treadmill [14]. Considering the constellation of impairments in body functions and structures observed after stroke, it is reasonable to question if accelerometers could be reliable devices to measure energy expenditure in this population. Also, these devices are mainly used for research purposes, once they are relatively expensive and difficult to be used within clinical settings [15].

In this sense, a promising way of assessing and monitoring physical activity of individuals with stroke is by using smartphone applications [16], since they provide real-time information and are freely accessible and easy-to-use [15,17]. One example of this technology is the Google Fit (Google Inc., Mountain View, Califórnia, EUA) application, which is an open platform also available as a smartphone application [17]. It provides information regarding step counts, walked distance, and burnt calories during physical activity practice [17]. However, since the Google Fit is a relatively new application, released on 2014 [17], its validity has not been evaluated in individuals with neurological conditions, including individuals with stroke. Moreover, information regarding the prediction equations for the estimation of energy expenditure is not available. Therefore, it is neither known how they were developed, nor if the smartphone application would be reliable to monitor energy expenditure in chronic stroke individuals.

Therefore, the aim of the present study was to examine the validity of the ActiGraph GT3X accelerometer and the Google Fit smartphone application in estimating energy expenditure in people with stroke, during fast overground walking. The estimated energy expenditure, in kilocalories (kcal), provided by both devices was compared with that, obtained with the Cortex Metamax 3B ergoespirometer (gold-standard measure).This information may be useful to recommend these devices for monitoring energy expenditure.

MATERIALS AND METHODS

Participants

Individuals, who had a single unilateral stroke, were recruited from the general community, from August to December 2015. To be included, the participants should be above 20 years of age; had a mean time since the onset of the stroke of at least six months; be able to walk independently with or without assistive devices; had residual weakness of the paretic knee extensor, plantar flexor and/or dorsal flexor muscles (strength deficit >10% compared to the non-paretic side) [18], assessed by a hand-held dynamometer, and/or increased tonus of the paretic knee extensor muscles, determined by scores different from zero on the modified Ashworth scale; and had no cognitive impairments, as determined by the following education-adjusted cut-off scores on the Mini Mental State Examination: 13 for the individuals with illiteracy and 18 for those with basic education [19]. Participants were excluded if they had any other associated neurological, respiratory and/or orthopedic conditions.

The number of at least 30 participants was based upon a previous study with similar objective [20].All participants provided written consent, based upon previous approval from the Institutional Ethical Review Board (CAAE–47256815.9.0000.5149).

Instruments and Procedures

Initially, the participants underwent an interview and physical examination for the collection of their demographic, anthropometric, and clinical data, which included age, sex, body mass, height, time since the onset of the stroke, functional level (10 Meter Walking Test - 10MWT – habitual and fast speeds), functional capacity (Duke Activity Status Index - DASI), motor recovery of the paretic lower limb (Fugl-Meyer lower-extremity section scores), strength and tonus of the knee extensor muscles. Following, they were asked to walk back and forth on a 10-meter, flat, and straight hallway over five minutes, at their maximum speeds, following previously recommended procedures [21]. The reason that maximum speed was chosen was because we wanted to know if these devices would provide reliable measures of energy expenditure during physical activity practice, which usually involves increased energy demands. Besides, it is reported that walking at higher cadences improves cardiovascular health, more than walking at comfortable speeds for chronic stroke individuals [22], which is usually the main goal of a conditioning program.

During the walking test, participants wore the ActiGraph GT3X accelerometer on their paretic ankle, a smartphone with the Google Fit application in the front pocket of their paretic lower limb, and the Cortex Metamax 3B ergoespirometer (gold-standard measure), following previously recommended procedures [1,23].

The ActiGraph GT3X accelerometer

The ActiGraph GT3X accelerometer is a small (3.8cm width x 3.7cm length x 1.8cm depth; 27 grams), commercially available triaxial accelerometer, which captures changes in accelerations ranging in magnitudes from 0.05 to 2.5 G's, with and samplerate of 30Hz in three individual axes: Anterior-posterior (AP) or X axis, medial-lateral (ML) or Z axis, and vertical (VT) or Y axis) [24,25], as well as a composite vector magnitude (VM) of the three axes [25]. The accelerometer gives its outputs as counts per period of time, called epochs, and in the present study, these were set at 60-second epochs, as previously applied with individuals with stroke[1]. The ActiGraph GT3X estimates the energy expenditure by converting its counts/min from the VT axis into kcal, by applying two different previously established equations and one combined formula, as follows [26]:

Work-energy theorem (WET) equation: $kcals/min_{WET}$=0.0000191* counts/minute* body mass, in kg

(1)

Freedson equation: $kcals/min_{Freedson}$=0.00094*counts/minute+ 0.1346*body mass, in kg -7.37418

(2)

Combined formula: It uses the WET equation for counts/min ≤1,952 and the Freedson

equation for counts/min >1,952. (3)

The accelerometer can be positioned on different body regions and, in the present study, it was placed on the paretic ankle, as recommended by the manufacturer and previously used with individuals with stroke[1]. Energy expenditure estimates, in kcal, from the ActiGraph GT3X equations, over the five-minute monitoring test were averaged and used for analyses. The collected data were analyzed by the ActiLife data analysis software 4.1.0.

Google Fit smartphone application

The Google Fit is an open platform developed by Google Inc., that allows the users to control their fitness data. It is also available as a free application for smartphones, which works on versions above 4.0 in Android systems [17]. The Google Fit consists of a set of high level sensors, such as accelerometer, gyroscope, and global positioning system, which can detect changes in position and distinguish amongst various types of movements, several kinds of data, and different bouts of activity [17]. The smartphone with the application used in the present study was the LG Nexus 5, which weighted 130 grams and had the following dimensions: 69.17mm width x 137.84mm length x 8.59mm depth.

The Google Fit application provides energy expenditure estimates in calories (cal) and in the present study, the data were transformed into kcal, to be able to make comparisons, as follows:

$$kcal/min_{GoogleFit}=cal_{GoogleFit}/1000 \quad (4)$$

The data of the five-minute monitoring test were also averaged and used for analyses, because the Google Fit software gives energy expenditure output as total burnt calories, and not on a minute-by-minute basis.

Prior to the walking test, the smartphone was positioned on the participants' front pocket of their paretic lower limb, as previously reported [23] and calibrated, according the following users' data: sex, body mass (kg), and height (cm). Table 1 shows the technical specifications of both devices.

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

Gold-standard measure

The Cortex Metamax 3B ergoespirometer gives real-time corrected measures of $VO_{2,}$ in Kg/ml/mint [27]. The VO_2 was measured minute by minute by using an open circuit ergoespirometry, which provide reliable measures during overground walking with individuals with stroke (ICC: 0.76 to 0.97) [21] and was used as gold-standard measure. The gases were collected at each breathing cycle through a silicone mask adapted to the individual's face [27]. For analyses, the VO_2 values of the entire five-minute monitoring test were averaged and converted into kcal, by applying the following formula [28]:

$$kcal/min_{Metamax3B}=(VO_{2,}\text{ in Kg/ml/min*body mass, in kg})/1000 \quad (5)$$

The ergoespirometer was calibrated in three steps, following the manufacturer recommendations: 1) barometric; 2) gas, by using verified gases of known concentration (12% O_2, 5% CO_2,and balance N_2: ±0.02% absolute); and 3) volume, by using a 3L syringe (Hans Rudolph Inc.) [27].

Statistical analyses

Descriptive statistics and tests for normality were carried-out with the SPSS software (version 19.0). Pearson's correlation coefficients were calculated to examine the associations between the energy expenditure values (in kcal) estimated by the equations from the ActiGraph GT3X accelerometer and the Google Fit smartphone application, with those provided by the gold-standard measure. Intra-class correlation coefficients (ICC [2,1]) were employed to examine the agreement between the energy expenditure (in kcal) values estimated by the ActiGraph GT3X accelerometer and the Google Fit smartphone application, with those obtained from the gold-standard measure. All analyses considered the following cut-off values [29]: 0-0.25: little or no relationship; 0.26-0.50: fair relationship; 0.51-0.75: moderate to good relationship; and >0.75 good to excellent relationship. The significance level was set at 5% for all analyses.

RESULTS

Thirty individuals with stroke (21 men), with a mean age of 62 (±12) years and a mean time since the onset of stroke of 98 (±96) months, were included. Twenty-one participants reported not being engaged in any kind of physical activity, 24 had ischemic stroke, and the mean distance covered during the test was 258.9 (±155.2) meters. Out of the nine individuals who were physically active, five reported walking as the most frequently practiced activity, with bouts of activity ranging from 30 minutes to one hour, three times a week. The characteristics of the participants are given in Table 2.

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

Validity of the devices for estimating energy expenditure

The ActiGraph GT3X accelerometer

Out of the three equations used to estimate the energy expenditure from the ActiGraph GT3X accelerometer, a fair relationship with the gold-standard measure was found only for the values estimated by the combined formula (r=0.37; p=0.04). However, no agreement between these measures was observed. In addition, there were not found any other statistically significant associations between the values estimated by the other equations (WET and Freedson equations)and those provided by the gold-standard measure(r= 0.04; p=0.06).

Google Fit smartphone application

There were not found any significant associations between the energy expenditure values estimated by the Google Fit application and those provided by the gold-standard measure (Table 3). Therefore, agreement analysis was not performed.

---------------------------- INSERT TABLE 3 ABOUT HERE --------------------

DISCUSSION

This study aimed at examining the validity of the ActiGraph GT3Xaccelerometer and the Google Fit smartphone application in estimating energy expenditure in people with stroke, during fast overground walking. For this, the energy expenditure data estimated by both devices were compared with those provided by the gold-standard measure (Cortex Metamax 3B ergoespirometer).A fair association with the gold-standard measure was found only with the data estimated by the combined formula of the ActiGraph GT3X. However, the ICC (2,1) analyses found no agreement between these measures.

The fair association observed between the energy expenditure data estimated by the ActiGraph GT3X combined formula and those provided by the gold-standard measure, may be due to the fact that the equations used by the ActiGraph GT3X accelerometer to estimate energy expenditure (in kcal) were developed for healthy young individuals, during walking/running on a treadmill [14]. Previous studies reported that individuals with stroke, who had higher functional levels, i.e., walk at speeds >0.8m/s, have energy expenditure values similar to healthy individuals [30-32]. However, the results of the present study with a sample, who had a mean walking speed of 0.8m/s, showed that the energy expenditure values estimated by all of the ActiGraph GT3X equations were about 55% higher, than those provided by the gold-standard measure. Even though the sample of the present study consisted of community-dwelling individuals with few residual deficits, this overestimation suggests that the equations usually used to predict energy expenditure of healthy individuals during treadmill walking, may not be the most appropriate for predicting energy expenditure of stroke individuals during fast overground walking.

A previous study also compared the energy expenditure data estimated by the ActiGraph GT3X equations with those measured by a metabolic cart (Oxycon Pro) with healthy adolescents, young adults, and elderly walking and running on a treadmill in six different conditions [33]. When the data of the elderly were analyzed separately, there was found that out of the three equations from ActiGraph GT3X, the WET one worked the best [33]. However, in the present study, the data estimated by the WET equation showed no association with those provided by the gold-standard measure. These differences may be due to the sample characteristics and walking condition. Besides, it is important to point-out that even though a triaxial accelerometer was used, only the data estimated from the vertical axis (VT) was considered for analysis [33]. The vertical axis would probably not be the best axis to be considered while analyzing the number of steps taken by individuals with stroke, once they usually tend to restrict the vertical movement of their paretic lower limb as a compensatory strategy for their residual weakness [34,35]. The present study corroborates with this hypothesis, once it observed a relatively high percentage of residual weakness in the muscles considered the main contributors to the gait performance of stroke individuals [34,35].

Moreover, the ActiGraph GT3X equations were based on the ActiGraph GT1M previous model [14]. In this scenario, Sasaki *et al.* [34] observed that the raw data measured by the ActiGraph GT1M and the ActiGraph GT3X were not comparable even for healthy young subjects (anteroposterior axis [AP]: mean bias of -515$\pm$640 counts; vector magnitude [VM] for the two axis: mean bias=-231$\pm$28 counts). When both ActiGraph devices were compared, the main difference was that the GT1M model works as uniaxial or biaxial accelerometer and does not take into account the mediolateral axis (ML) [14]. In the present study, however, the raw data from the ML axis were the only ones that showed some association with those provided by the gold-standard measure (VO_2, in mL/kg/min). These findings could be explained by the gait patterns of the individuals with stroke, who show residual motor impairments and gait asymmetries [34]. It is well known that, in order to regain ability to walk, they tend to abduct their paretic lower limb to perform a circumduction [34,35], which is a movement that has a lot of the ML axis component and is not usually adopted by healthy individuals while walking. In this scenario, since energy estimations by the ActiGraph GT3X do not take into account the ML axis, it would be expected that these estimations would also be different from the real energy expenditure values provided by the gold-standard measure. To confirm this hypothesis, the correlation between the raw data provided by both the ActiGraph GT3X and the gold-standard measure was analyzed. Significant associations were found only between the ML axis raw data (0.53; p=0.002) and VM (0.71; p<0.001).

Since the equations given by the ActiGraph GT3X accelerometer were not considered the most appropriate for measuring energy expenditure in the elderly, Santos-Lozano *et al.* [33] suggested the use of age-specific equations for estimating energy expenditure measures. Thus, it is reasonable to argue that the determination of specific equations for the prediction of energy expenditure is also necessary and would be a better alternative for individuals with neurological conditions.

Regarding the data estimated by the Google Fit smartphone application, the energy expenditure measures were not associated with those from the gold-standard measure. The Google Fit smartphone application provided energy expenditure values in calories and, when those values were converted into kilocalories, it gave estimates close to zero. This finding could be explained by the fact that physical activity monitoring from smartphone applications is a relatively new field of technology, meaning that it is still under development, and it is usually used by healthy individuals [37-39]. In this sense, manufacturers tend to take into consideration only the target population, when developing the applications' software. Wu *et al.* [39], for example, reported that the use of smartphones with built-in accelerometer and gyroscope is beneficial for classifying activities of healthy individuals from 19 to 60 years of age. It was also observed that smartphone applications estimate energy expenditure of healthy young individuals during walking and running on a treadmill with better accuracy than the ActiGraph GT3X+ accelerometer (a newer version of GT3X) [37]. However, one of the limiting factors while trying to validate the use of smartphone applications is that not all of the software applications allow users to have access neither to the raw data, nor to the energy expenditure prediction equations, such as the Google Fit. Thus, in the present study, it is impossible to know if there was a probable error in the collected data (raw data) or in the equations used to transform the data into energy expenditure outputs (in kcal).

Generally, several smartphone applications have been developed for different purposes, such as to administer functional tests, by providing audio and visual instructions [40]; help general rehabilitation of individuals with stroke, by educating patients and caregivers regarding home-based exercises, postures, and medicine control [41]; and stimulate the practice of rehabilitation exercises for upper limb recovery [42]. Concerning post-stroke conditioning goal, there was found only one smartphone application, named Starfish, which has been recently developed to monitor and increase the number of daily steps of individuals with chronic stroke[16]. Even though the Starfish demonstrated potential to increase physical activity levels [16], it does not take into account other forms of physical activity, nor the user's energy expenditure (in kcal), while practicing physical activities. Thus, future studies should focus on the development of smartphone applications with the goal of assessing and monitoring energy expenditure, since these devices have shown to be effective for supporting changes in health behaviors and physical activity levels [43,44].

One could argue that the walking test was conducted in a closed environment and activity monitors should also be validated in outdoor environments, in order to try to reproduce community settings. However, both devices, which were assessed in the present study, did not show to provide valid measures of energy expenditure, not even in a closed environment. This suggests that they would also not be valid to monitor outdoor activities. Moreover, other activities with different metabolic demands, such as stair climbing and upper limb activities should also be monitored. Nonetheless, walking is of great importance for individuals with stroke, since decreased walking function is one of the main causes of physical dependency for stroke individuals [45].

In summary, the findings of the present study demonstrated that both the ActiGraph GT3X accelerometer and the Google Fit smartphone application did not provide valid energy expenditure measures (in kilocalories) for chronic stroke individuals during fast overground walking. Future studies should focus on the development physical activity monitors based on group-specific energy expenditure equations, given that they are free or cheap, easy to use, and provides real-time information of physical activity parameters.

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Table 1.Technical specifications of the Actigraph GT3X accelerometer and the smartphone LG Nexus 5

Specification	Actigraph GT3X	LG Nexus 5 with Google Fit
Sample rate	30Hz	NA
Data storage	16MB	16GB
Battery life	31 days	17 hours to 12.5 days
Accelerometer sensor	ADXL 335 triaxial accelerometer (Analog Devices, USA)	MPU6515 triaxial accelerometer+gyroscope (Invense Inc., USA)
Registered range of acceleration	±3g	NA
Measured outcomes	Acceleration around the three axes and vector magnitude	Acceleration around the three axes
Estimated outcomes	Number of steps taken Energy expenditure (kcal) Duration of physical activity (min)	Number of steps taken Type of activity Travelled distance (miles or km) Energy expenditure (cal or kJ) Duration of physical activity (min)

NA= Not Available

Table 2.Participants' characteristics

Characteristics	n=30
Age (yrs), mean±SD, (range: min–max)	62±12 (24–82)
Sex (men/women), n	21/9
Body mass (kg), mean±SD (range:min–max)	75.0±12.2 (50–99)
Height (cm), mean±SD (range:min–max)	164.7±8.6 (142-184)
Time since stroke (months), mean±SD (range:min–max)	98.5.0±96.1 (9–412)
Side of paresis (L/R)	17/13
MMES (scores 0–30), mean±SD	26.1±3.3
Gait speed (m/s), mean±SD, (range: min-max)	
– Comfortable	0.8±0.3 (0.3-1.4)
– Fast	1.3±1.0 (0.5-2.3)
DASI (score 0-58.2), mean±SD	31.0±14.8
Fugl-Meyer lower-limb section (score 0-34), mean±SD	19.1±5.3
Tonus of the knee extensor muscles (MAS score:0-4), n	
– 0	18
– 1	8
– 2	2
– 3	1
– 4	1
Residual Weakness (%±SD)	
- Knee extensors	8.3±4.8
- Ankle plantarflexors	20.0±3.3
- Ankle dorsiflexors	19.4±3.9

SD=Standard Deviation, min=minimum, max=maximum, yrs=years, DASI=Duke Activity Status Index

Table 3.Pearson's correlation coefficients and p values between the energy expenditure measures (in kcal) from the Actigraph GT3X and Google Fit estimations, and the gold-standard measure.

Instruments		**Energy expenditure measures (mean±SD)**	**Correlation coefficients**	**P value**
Cortex Metamax 3B		3.6±1.2	-	-
ActiGraph GT3X				
	WET equation	8.6±6.5	0.04	0.06
	Freedson equation	8.0±4.9	0.04	0.06
	Combined formula	8.0±4.8	0.37*	0.04
Google Fit		0.0±0.0	0.02	0.97
Instruments and it's raw data		**Raw data measured (mean±SD)**	**Correlation coefficients**	**P value**
Cortex Metamax 3B				
(mL/kg/min)	VO_2	9.5±3.0	-	-
ActiGraph GT3X				
axes (counts)	VT	5975.9±4317.3	0.28	0.14
	AP	3693.9±2242.5	0.12	0.51
	ML	3525.4±2374.9	0.53*	0.00
	VM	8412.5±4568.9	0.71*	0.00

WET= Work-Energy Theorem; VT= vertical axis; AP= antero-posterior axis; ML= medio-lateral axis; VM= vector magnitude.
*p<0.01

Implications for rehabilitation

- Individuals with stroke should be encouraged to practice safe physical activity, to prevent deconditioning and recurrence of stroke.
- Objective measures are necessary to monitor energy expenditure of stroke individuals during their physical activity practice.
- Although it has been frequently used, the ActiGraph GT3X accelerometer does not provide valid measures of energy expenditure for individuals with chronic stroke.
- The Google Fit smartphone application also does not provide valid measures of energy expenditure for individuals with stroke.

5 CONSIDERAÇÕES FINAIS

5.1 Limitações dos estudos

Os resultados apresentados no presente estudo devem ser interpretados com cautela devido à presença de algumas limitações. Dentre elas destaca-se o fato das avaliações terem ocorrido em um ambiente controlado de laboratório. Dispositivos desenvolvidos com o objetivo de monitorar os níveis de atividade física devem ser validados inclusive em ambientes externos e variados, na tentativa de se reproduzir os ambientes reais da vida comunitária. No entanto, se considerarmos apenas o GE fornecido pelo acelerômetro *ActiGraph* GT3X e pelo aplicativo de celular Google Fit, os monitores avaliados no presente estudo não apresentaram validade aceitável mesmo no ambiente controlado. Isso nos leva a hipotetizar que eles possivelmente também podem não ser adequados para monitorar níveis de atividade física de indivíduos pós-AVE crônicos em ambientes externos.

Além disso, esforços foram feitos na tentativa de se recrutar indivíduos com diferentes níveis funcionais classificados pela velocidade de marcha habitual.No entanto, uma vez que o presente estudo foi realizado em um ambiente de pesquisa, a participação de indivíduos pós-AVE crônicos com melhores níveis funcionais foi mais frequente, já que esses são capazes de se transportarem ao local da coleta de dados com maior facilidade.Todavia, o presente estudo incluiu uma variedade considerável de indivíduos com diferentes níveis funcionais (velocidade de marcha variando entre 0,3 a 1,4m/s).

Ademais, o fato de terem sido considerados apenas indivíduos na fase crônica após o AVE impede que os resultados observados sejam extrapolados para indivíduos nas fases aguda ou subaguda da lesão, ou ainda para indivíduos com diferentes características.

Finalmente, demais atividades com diferentes demandas metabólicas, como subir e descer escadas e atividades utilizando os membros superiores poderiam ter sido consideradas no presente estudo, por também serem consideradas atividades físicas. Porém optou-se por priorizar a atividade de marcha uma vez que, mudanças na deambulação estão entre as principais causas de dependência física para essa população (MASIERO *et al.*, 2007), sendo considerada uma atividade de extrema importância para indivíduos pós-AVE.

5.2 Conclusão

Os resultados observados no presente estudo permitem concluir que as variáveis de atividade física fornecidas pelo acelerômetro convencional *ActiGraph* GT3X não se mostraram ser adequadas para se avaliar e/ou monitorar a atividade física de indivíduos pós-AVE crônicos durante a marcha rápida no solo. Isso porque as variáveis fornecidas pelo acelerômetro, como o número de passos, o GE e seus dados brutos mensurados nos eixos AP e VT, não apresentaram associações ou concordância com as medidas de critérios estabelecidas.

Já o aplicativo de celular Google Fit apresentou resultados promissores, uma vez que uma das variáveis de atividade física fornecidas pelo dispositivo demonstrou boa associação e excelente concordância com a medida de critério. O número de passos estimado pelo aplicativo demonstrou ser uma medida válida para se avaliar e monitorar o nível de atividade física de indivíduos pós-AVE crônicos, enquanto o GE, por sua vez, teve resultados similares ao observado no *ActiGraph* GT3X.

Tais resultados demonstram a necessidade do desenvolvimento de equações de predição do GE específicas para indivíduos pós-AVE crônicos.

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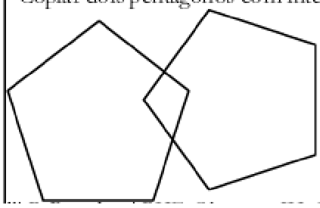
ANEXO I: Escalas e testes utilizados nas avaliações

Mini Exame do Estado Mental

Orientação temporal (5 pontos)	Qual a hora aproximada?
	Em que dia da semana estamos?
	Que dia do mês é hoje?
	Em que mês estamos?
	Em que ano estamos?
Orientação espacial (5 pontos)	Em que local estamos?
	Que local é este aqui?
	Em que bairro nós estamos ou qual é o endereço daqui?
	Em que cidade nós estamos?
	Em que estado nós estamos?
Registro (3 pontos)	Repetir: CARRO, VASO, TIJOLO
Atenção e cálculo (5 pontos)	Subtrair: 100-7 = 93-7 = 86-7 = 79-7 = 72-7 = 65
Memória de evocação (3 pontos)	Quais os três objetos perguntados anteriormente?
Nomear 2 objetos (2 pontos)	Relógio e caneta
REPETIR (1 ponto)	"Nem aqui, nem ali, nem lá"
Comando de estágios (3 pontos)	Apanhe esta folha de papel com a mão direita, dobre-a ao meio e coloque-a no chão
Escrever uma frase completa (1 ponto)	Escrever uma frase que tenha sentido
Ler e executar (1 ponto)	Feche seus olhos
Copiar diagrama (1 ponto)	Copiar dois pentágonos com interseção 

Ashworth Modificada

Grau	Observação clínica
0	Tônus normal.
1	Aumento do tônus no início ou no final do arco de movimento.
1+	Aumento do tônus em menos da metade do arco de movimento, manifestado por tensão abrupta e seguido por resistência mínima.
2	Aumento do tônus em mais da metade do arco de movimento.
3	Partes em flexão ou extensão e movidos com dificuldade.
4	Partes rígidas em flexão ou extensão.

Fugl-Meyer (MMII)

AVALIAÇÃO DA FUNÇÃO MOTORA

TESTE DE FUGL- MEYER

Parte II - Membro Inferior

Identificação
Nome:
Data: Sessão: 1 2 3 4

Lado acometido: Esquerdo O Direito O

I. Atividade Reflexa	0	1	2
Flexores (aquileo)	O		O
Extensores (reflexo rotuliano)	O		O

Total [ ] 4

0: Ausência de reflexos;
2: Presença de reflexos.

II. Sinergias de

Flexão		0	1	2
Coxo-femoral	Flexão	O	O	O
Joelho	Flexão	O	O	O
Tornozelo	Dorsi-flexão	O	O	O

0: Nenhum movimento;
1: Movimento parcialmente realizado;
2: Movimento normal.

Extensão		0	1	2
Coxo-femoral	Extensão	O	O	O
	Adução	O	O	O
Joelho	Extensão	O	O	O
Tornozelo	Flexão Plantar	O	O	O

0: Nenhum movimento;
1: Movimento com pequena resistência;
2: Movimento comparável ao lado bom.

Total [ ] 14

TESTE DE FUGL- MEYER

III. Movimentos combinando a sinergia de flexão e de extensão

	0	1	2
a. Flexão do joelho além de 90°	O	O	O

0: Nenhum movimento
1: Movimento parcial (até 90°)
2: Movimento normal (além de 90°)

b. Dorsi-flexão do tornozelo	O	O	O

0: Nenhum movimento
1: Movimento parcial (amplitude parcial e/ou inversão do tornozelo)
2: Movimento normal (amplitude normal sem inversão do tornozelo)

Total [ ] 4

IV. Movimentos voluntários com pouca ou fora das sinergias

a. Flexão do joelho > 90° sem flexão da coxo-femoral	O	O	O

0: Nenhum movimento
1: Movimento parcial (amplitude parcial e/ou coxo-femoral flexiona)
2: Movimento normal

b. Dorsi-flexão do tornozelo	O	O	O

0: Nenhum movimento
1: Movimento parcial (amplitude parcial e/ou inversão do tornozelo)
2: Movimento normal

Total [ ] 4

TESTE DE FUGL- MEYER

V. Atividade Reflexa Normal

	0	1	2
Aquileo, rotuliano	O	O	O

0: *2 reflexos são hiperativos*
1: *um reflexo hiperativo*
2: *nenhum está hiperativo*

Total [ ] **2**

VI. Coordenação/velocidade (tornozelo-joelho lado oposto, 5 vezes)

a. Tempo para 5 repetições **Esquerda** [ ] **Direita** [ ]

b. Tremor	O	O	O
c. Dismetria	O	O	O

0: *incoordenação marcada*
1: *ligeira incoordenação*
2: *movimento coordenado*

d. Velocidade	O	O	O

0: *6 segundos a mais do que no lado não afetado*
1: *2 _ 5 segundos a mais do que no lado não afetado*
2: *< 2 segundos de diferença*

Total [ ] **6**

Grande total [ ] **34**

Duke Activity Status Index - DASI

Duke Activity Status Index Versão Brasileira Coutinho-Myrrha MA et al			
Você consegue	**Peso (MET)**	**Sim**	**Não**
1. Cuidar de si mesmo, isto é, comer, vestir-se, tomar banho ou ir ao banheiro?	2,75		
2. Andar em ambientes fechados, como em sua casa?	1,75		
3. Andar um quarteirão ou dois em terreno plano?	2,75		
4. Subir um lance de escadas ou subir um morro?	5,50		
5. Correr uma distância curta?	8,00		
6. Fazer tarefas domésticas leves como tirar pó ou lavar a louça?	2,70		
7. Fazer tarefas domésticas moderadas como passar o aspirador de pó, varrer o chão ou carregar as compras de supermercado?	3,50		
8. Fazer tarefas domésticas pesadas como esfregar o chão com as mãos usando uma escova ou deslocar móveis pesados do lugar?	8,00		
9. Fazer trabalhos de jardinagem como recolher folhas, capinar ou usar um cortador elétrico de grama?	4,50		
10. Ter relações sexuais?	5,25		
11. Participar de atividades recreativas moderadas como vôlei, boliche, dança, tênis em dupla, andar de bicicleta ou fazer hidroginástica?	6,00		
12. Participar de esportes extenuantes como natação, tênis individual, futebol, basquetebol ou corrida?	7,50		
Pontuação total: _________			

***Pontuação DASI**: o peso das respostas positivas são somados para se obter uma pontuação total que varia de 0 a 58.2. Quanto maior a pontuação, maior a capacidade funcional.*[1]

ANEXO II – Parecer de aprovação no Comitê de Ética em Pesquisa da Universidade Federal de Minas Gerais

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

Projeto: CAAE – 47256815.9.0000.5149

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 15 de setembro de 2015, o relatório final do projeto de pesquisa anterior à Plataforma Brasil intitulado **"Comparação do gasto energético predito com o gasto energético real obtido durante a marcha de indivíduos pós-acidente vascular encefálico crônicos com diferentes níveis funcionais".**

Telma Campos Medeiros Lorentz

Profa. Dra. Telma Campos Medeiros Lorentz
Coordenadora do COEP-UFMG

Av. Pres. Antonio Carlos, 6627 – Unidade Administrativa II - 2º andar – Sala 2005 – Cep:31270-901 – BH-MG
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ANEXO III – Normas de publicação da revista*Disability and Health Journal* (Artigo 1)

Disability and Health Journal

Introduction

Disability and Health Journal is a scientific, scholarly, and multidisciplinary journal for reporting original contributions that advance knowledge in disability and health. Topics may be related to global health, quality of life, and specific health conditions as they relate to disability. Such contributions include reports on:

• Empirical research on the characteristics of persons with disabilities, environment, health outcomes, and determinants of health;
• Systematic or other evidence-based reviews and tightly conceived theoretical interpretations of research literature;
• Evaluative research on new interventions, technologies, and programs;
• Issues or policies affecting the health and/or quality of life for persons with disabilities, using a scientific base.

Disability and Health Journal describes and analyzes health and health related states using conceptual frameworks, including the International Classification of Functioning (ICF), and the social and medical models of disability. The Journal provides a forum for peer reviewed articles that identify, evaluate and promote existing and emerging models of healthcare delivery and/or health promotion that contribute to the improvements of health across the lifespan.

The Journal focuses on individual health, public health, health promotion, health education, wellness, community participation (e.g., employment, recreation, personal relationships and access to services) and tertiary prevention (e.g., rehabilitation, reducing the incidence of secondary conditions).

Types of Articles

Original Research. Original Articles are scientific reports of the results of original epidemiologic (including secondary data analysis) and clinical research. The text is limited to 4000 words (not including abstract, acknowledgments, figure legends, tables, references, and ancillary online-only material), with a structured abstract of 250 words or less (see instructions below for structure), and a maximum of 6 tables and/or figures, and no more than 40 references (unless this is waived by the Editor). Research reports must contain sufficient information to allow readers to understand how a study was designed and conducted, including variable definitions, instruments and other measures, and analytic techniques. We recommend reviewing guidelines and checklists related to specific research at the EQUATOR Network to ensure sufficient detail is provided in the manuscript (http://www.equator-network.org). **NEW**: Submitting a checklist such as that from STROBE is now a requirement for submission (see editorials published in the April 2014 issue). Download the checklist through http://www.equator-network.org/reporting-guidelines/strobe/, complete it by adding a column that specifies where in the manuscript each component has been followed, and upload it with your submission.

Brief Reports. Brief Reports can provide their results clearly in a shorter format or represent pilot work, small number of subjects (including a case report if it represents a unique circumstance or experience), new methodology, or nonstandardized measurements. The text is limited to 2500 words (not including abstract, acknowledgments, figure legends, tables, references, and ancillary online-only material) and a maximum of 3 tables and/or figures total. A structured abstract of 250 words or less is required (see instructions below for structure).

Evidence-based Review Articles. Review manuscripts are valuable within the relatively new but growing field of Disability and Health, and DHJO welcomes such submissions. DHJO supports the international agenda to advance review research that provides knowledge synthesis about the present state of research, gaps in research or implementation, evidence to support or change practice, and guidance for policy. There are many types of reviews,[1-3] and the body of science and protocols to inform effective reviews is increasing.[4-11] Literature or narrative reviews that cite multiple references found through a library search are not considered evidence-based reviews. Clear definitions and specific criteria for rating articles are important for the users of the review articles, be they researchers, clinicians, policy-makers, or consumers.[7] To provide consistency and to maintain the expectations of our readers, DHJO has developed more specific guidance for authors.

At a minimum, the submission should include the following key components:

- A manuscript title that reflects the review type
- Clear definition of the review aims and the reason the review type was chosen[6]
- Systematized search/selection process description
- Flowchart of search/selection process
- Appraisal of the articles at some level (recognizing inherent difficulties)[4,9-13] and acknowledging the biases within studies with appropriate descriptions
- Table of selected and reviewed articles (including extracted data) with some organization based on study design, condition, utility, or other relevant factor
- Table (may be the same Table as above) that includes a summary of articles' elements: research design, sample size, study method, and statistical approach as appropriate
- Additional tables or graphs may portray reference to unifying concepts and underlying framework; narrative reporting of results should summarize the findings related to study aims or other defined concepts
- Interpretation of results in the Discussion should consider quality, strength of evidence, applicability, relevance to stakeholders, support/refutation in existing literature, and limitations
- Whenever possible a rating system should be used to quantify the importance of each manuscript in the final review
- Conclusions should be carefully derived

A structured abstract of 250 words or less is required (see instructions below). The text is limited to a maximum of 5000 words of text (not including abstract, acknowledgments, figure legends, tables, references, and ancillary online-only material), with no more than a total of 6 tables and/or figures.

Systematic reviews must have PRISMA[4] completed and submitted. If Tables of selected articles are large/long, they may be published as ancillary online-only appendices.

1. Grant MJ & Booth A. (2009). A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Info Libr J*. 26: 91-108.
2. Hartling L, Vandermeer B, Fernandes RM. (2014). Systematic reviews, overviews of reviews and comparative effectiveness reviews: a discussion of approaches to knowledge synthesis. *Evid.-Based Child Health* 9: 486-494.
3. Whittemore R, Chao A, Jang M, Minges KE, Park C. (2014). Methods for knowledge synthesis: an overview. *Heart & Lung*. 43 (2014) 453-461.
4. EQUATOR Network. http://www.equator-network.org/ Last accessed April 28, 2016.
5. stlund U, Kidd L, Wengstrm Y, Rowa-Dewar N. (2011). Combining qualitative and quantitative research within mixed method research designs: A methodological review. *Int J Nurs Stud* 48: 369-383.
6. Gough D, Thomas J, Oliver S. (2012). Clarifying differences between review designs and methods. *Systematic Reviews*. 1:28.
7. Colquhoun HL, Levac D, O'Brien KK, Straus SE, Tricco AC, *et al.* (2014). Scoping reviews: time for clarity in definition, methods, and reporting. *J Clin Epidemiol.* 67:1291-1294.
8. Peters MD, Godfrey CM, Khalil H, McInerney P, Parker D, Soares CB. (2015). Guidance for conducting systematic scoping reviews. *Int J Evid Based Healthc*. 13(3):141-146.
9. Khalil H, Peters M, Godfrey CM, McInerney P, Soares CB *et al.* (2016). An evidence-based approach to scoping reviews.*Worldviews on Evidence-Based Nursing*, 2016; 13:2, 118-123.
10. Tricco AC, Lillie E, Zarin W, O'Brien K, Colquhoun H, *et al.* (2016). A scoping review on the conduct and reporting of scoping reviews. *BMC Med Research Method*. 16:15.
11. Tricco AC, Tetzlaff J, Moher D. (2011). The art and science of knowledge synthesis. *J of Clin Epi*. 64:11-20.
12. Crowe M & Sheppard L. (2011).A review of critical appraisal tools show they lack rigor: alternative tool structure is proposed. *J Clin Epidemiol* 64: 79-89.
13. Tabak RG, Khoong EC, Chambers D, Brownson RC (2012).Bridging research and practice: models for dissemination and implementation research. *Am J Prev Med*. 43(3): 337-350.

Commentary. Manuscripts are editor-solicited or negotiated after correspondence with Editors.

Topics relate to articles within the issue, timely perspectives on emerging issues in the field, or opinions and judgments on trends or new perceptions. Presentations may cover such areas as policy, ethics, current events, or controversies. A point/counterpoint format would also be of interest. The text is limited to a maximum of 3000 words of text (not including abstract and references). It is expected that there will be references to support the manuscript content. An Abstract that is a brief narrative summary without subheadings that does not exceed 150 words is required.

Authors wishing to submit an unsolicited Commentary should send proposals with a brief, 250-word synopsis of the planned Commentary to disabilityandhealthjnl@gmail.com for pre-submission approval by the Editors. Authors of approved proposals will receive instructions for submission from the Editorial Office.

Editorial. Editorials are solicited by the Editors.

Letters to the Editor. Letters discussing a recently published article in the Journal should be received within 4 weeks of the article's publication. The text is limited to a maximum of 500 words of text, one table and/or figure, and 5 references; no abstract is needed. Ensure that the article about which you are writing is included in the list of references. Letters not meeting these specifications are generally not considered.

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If the work involves the use of human subjects, the author should ensure that the work described has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans; Uniform Requirements for manuscripts submitted to Biomedical journals. Authors should include a statement in the manuscript that informed consent was obtained for experimentation with human subjects. The privacy rights of human subjects must always be observed.

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   Example 1: Leprosy
   - Leprosy is a disabling disease which not only impacts physically but restricts quality of life often through stigmatisation.
   - Reconstructive surgery is a technique available to this group.
   - In a relatively small sample this study shows participation and social functioning improved after surgery.

   Example 2: Multiple Sclerosis

   - Exercise is an effective means of improving health and well-being experienced by people with multiple sclerosis (MS).
   - People with MS have complex reasons for choosing to exercise or not.
   - Individual structured programmes are most likely to be successful in encouraging exercise in this cohort.
6. **Acknowledgement**. Please supply all details required by your funding and grant-awarding bodies as follows: *For single agency grants*: This work was supported by the under Grant . *For multiple agency grants*: This work was supported by the under Grant ; under Grant ; and under Grant .
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Updated May 2016

APÊNDICE A - Termo de Consentimento Livre e Esclarecido

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO Nº_______

Investigadoras: Profª Luci Fuscaldi Teixeira-Salmela, Ph.D.
Giselle Silva e Faria, Mestranda do Programa de Ciências da Reabilitação

TÍTULO DO PROJETO

COMPARAÇÃO DO GASTO ENERGÉTICO PREDITO COM O GASTO ENERGÉTICO REAL OBTIDO DURANTE A MARCHA DE INDIVÍDUOS PÓS-ACIDENTE VASCULAR ENCEFÁLICO CRÔNICOS COM DIFERENTES NÍVEIS 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 comparar a energia gasta durante a caminhada de indivíduos que sofreram derrame, com o que é esperado para esses indivíduos.

Para participar, você será convidado a responder alguns questionários e a realizar a avaliação do quanto você se moveu durante a sua caminhada e dos gases da sua respiração. Isso será feito por meio do uso de um aparelho pequeno colocado em seu tornozelo, um telefone celular colocado em seu bolso e uma máscara muito confortável, ajustada em seu rosto.

DESCRIÇÃO DOS TESTES A SEREM REALIZADOS

Avaliação

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.

Você realizará ainda uma análise de gases da sua respiração por meio do uso de uma máscara muito confortável e com monitorização contínua da pressão arterial, da frequência cardíaca, do seu grau de cansaço e da saturação de oxigênio durante uma caminhada de cinco minutos. A sua aceleração será medida por dois aparelhos pequenos, sendo o primeiro preso em seu tornozelo por uma fita elástica com velcro, e o segundo, um aparelho celular que será colocado no bolso de sua calça. 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 de todos os testes será de aproximadamente uma hora.

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 frequência 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:

Giselle Silva e Faria (31) 3334-264 / (31) 8436-8711
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

_____________________________ _____________________________
Giselle Silva e Faria Luci Fuscaldi Teixeira-Salmela
Pesquisador **Orientadora**

APÊNDICE B–Ficha de Avaliação

FICHA DE AVALIAÇÃO Código: __________

Data: _____________

DADOS DE IDENTIFICAÇÃO:

Nome:____

Sexo:____ Idade: __________ Data de nascimento: ____________

Estado civil:___________ Escolaridade:_______________________________

Endereço:____

____

Cidade:________________________________ CEP:___________________

Tel: ______________________________________

Vive com: ( ) Cônjuge ( ) Filhos ( ) Sozinho(a) ( ) Outros______

Ocupação: _____________________________________

Patologias associadas:

____

____

Medicações em uso (nome, dosagem, horário e duração): _______________

____

____

Número de episódios de AVE:_____________ Data do último AVE:____________

Tempo de evolução da doença (meses): ____________________

Hemicorpo acometido: ( )D ( )E Tipo de AVE:__________________

Utiliza DA? _________ Qual?_________________

Pratica atividade física regularmente? ( )não ( )sim

Se sim, que tipo e qual a frequência?__________________________________

____

Praticava atividade física antes do AVE? ( )não ( )sim

Se sim, que tipo e qual a frequência?__________________________________

____

MEEM: _________ DASI:_________

DADOS ANTROPOMÉTRICOS:

Altura:_______________ Peso:________________ IMC:________________

DADOS REPOUSO:

	INICIAL	FINAL
PA		
$SatO_2$		
FC		
Borg		

DADOS FUNCIONAIS:

Força Muscular:

	D	E
Extensores de Joelho		
Flexores Plantares		
Flexores Dorsais		

Tônus de Extensores de Joelho (Ashworth): _____ Fugl-Meyer: ______

Velocidade da Marcha:

	Uso de DA	Tempo
Habitual		
Máxima		

Capacidade de marcha (caminhada):

	INICIAL	FINAL
PA		
$SatO_2$		
FC		
Borg		

Uso de DA	Distância

Número de passos

MINI CURRÍCULUM VITAE

Dados pessoais

Giselle Silva e Faria
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Endereço para acessar CV: http://lattes.cnpq.br/8992573925184882

Formação acadêmica/titulação

2015 Mestrado em Ciências da Reabilitação. Universidade Federal de Minas Gerais, UFMG, Brasil

2014 – 2015 Especialização em Fisioterapia Neurológica Adulto e Infantil.Faculdade de Ciências Médicas (MG), FCMMG, Brasil.

2008 – 2013 Graduação em Fisioterapia. Universidade Federal de Minas Gerais, UFMG, Brasil.

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Carga horária: 20
Regime: Dedicação exclusiva.

2014 – 2015 Vínculo: Colaborador
Enquadramento Funcional: Colaboradora em projetos de pósgraduação
Carga horária: 10
Regime: Parcial

2011 – 2013 Vínculo: Bolsista
Enquadramento Funcional: Aluna de iniciação científica
Carga horária: 20
Regime: Dedicação exclusiva.

2011 – 2012 Vínculo: Estagiária voluntária em projeto de extensão
Enquadramento Funcional: Estagiária
Carga horária: 8
Regime: Parcial

2010 – 2011 Vínculo: Bolsista
Enquadramento Funcional: Monitora em Cinesiologia
Carga horária: 20
Regime: Dedicação exclusiva

2009 – 2010 Vínculo:Voluntário
Enquadramento Funcional: Monitora em Cinesiologia
Carga horária: 20

Regime: Parcial

Centro de Ortopedia e Fraturas do Eldorado

2010 – 2010 Vínculo: Estagiária Bolsista
Enquadramento Funcional: Estagiária
Carga horária: 20
Regime: Parcial

Atividades

2015 – atual Pesquisa e desenvolvimento, Escola de Educação Física, Fisioterapia e Terapia Ocupacional. Linhas de pesquisa COMPARAÇÃO DO GASTO ENERGÉTICO PREDITO COM O GASTO ENERGÉTICO REAL OBTIDO DURANTE A MARCHA DE INDIVÍDUOS PÓS-ACIDENTE VASCULAR ENCEFÁLICO CRÔNICOS COM DIFERENTES NÍVEIS FUNCIONAIS.

2012 – 2015 Pesquisa e desenvolvimento, Escola de Educação Física, Fisioterapia e Terapia Ocupacional. Linhas de pesquisa AVALIAÇÃO DOS PARÂMETROS METABÓLICOS E CARDIORRESPIRATÓRIOS DE HEMIPLÉGICOS CRÔNICOS DURANTE A REALIZAÇÃO DE ATIVIDADES FUNCIONAIS.

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2010 – 2011 Pesquisa e desenvolvimento, Escola de Educação Física, Fisioterapia e Terapia Ocupacional. Linhas de pesquisa DESEMPENHO MUSCULAR ISOCINÉTICO DO COMPLEXO DO OMBRO DE INDIVÍDUOS COM HEMIPARESIA CRÔNICA.

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Produção bibliográfica

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Participação em eventos

2016 Apresentação de pôster no IV Congresso Brasileiro de Fisioterapia Neurofuncional - COBRAFIN.

2015 Apresentação de palestra na I Semana Acadêmica da Faculdade Pitágoras.

2015 Apresentação de Mini-Curso na II Semana Acadêmica da Faculdade Pitágoras

2015 Apresentação de pôster no X Congresso Brasileiro de Doenças Cerebrovasculares.

2014 Apresentação de pôster no III Congresso Brasileiro de Fisioterapia Neurofuncional - COBRAFIN.

2014 Ouvinte no Seminário WILEY: Publication ethics and optimizing yours chances of acceptance in journal.

2013 Apresentação de pôster no VII Simpósio Internacional de Neurociências da UFMG.

2013 Apresentação de pôster no XIV Congresso Mineiro de Neurologia.

2012 Apresentação de pôster no 8th World Stroke Congress.

2012 Apresentação de pôster na XXI Semana de Iniciação Científica – UFMG Conhecimento e Cultura.