UNIVERSIDADE FEDERAL DE SÃO CARLOS

CENTRO DE CIÊNCIAS BIOLÓGICAS E DA SAÚDE

PROGRAMA DE PÓS-GRADUAÇÃO EM FISIOTERAPIA

"REPRODUTIBILIDADE E VALIDADE DO INCREMENTAL SHUTTLE WALKING TEST EM ADULTOS INDIVÍDUOS ADULTOS ASMÁTICOS"

IVANA GONÇALVES LABADESSA

São Carlos-SP
2017

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Tese apresentada ao Programa de Pós-Graduação em Fisioterapia do Centro de Ciências Biológicas e da Saúde da Universidade Federal de São Carlos como parte dos requisitos para a obtenção do título de Doutora em Fisioterapia. Área de concentração: Processo de Avaliação e Intervencão em Fisioterapia.

São Carlos-SP
2017

Estudo conduzido no Laboratório de Espirometria e Fisioterapia Respiratória (LEFiR) do Departamento de Fisioterapia da Universidade Federal de São Carlos UFSCar).

Projeto desenvolvido com apoio financeiro da Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP – Proc. nº 201123771-7)

UNIVERSIDADE FEDERAL DE SÃO CARLOS

Centro de Ciências Biológicas e da Saúde
Programa de Pós-Graduação em Fisioterapia

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DEDICATÓRIA

À DEUS, por ser a fonte de Amor, Fé e Luz da minha vida!

À minha Mãe Clarice, minha fortaleza, meu tudo, pelo apoio, compreensão, carinho e amor incondicional dedicados a mim, virtudes essas que foram fundamentais para que eu conseguisse vencer mais etapa essa da minha vida. Ao meu grande irmão Márcio, meu maior exemplo de superação, pelo amor, carinho e palavras de apoio nos momentos mais difíceis.

Ao meu amado pai Odair (in memorian) que está do outro lado da vida dando continuidade ao trabalho dedicado incondicionalmente em prol do amor e da caridade, mas que ainda se faz presente na minha vida dedicando todo amor e apoio incondicional, por todo orgulho que deva estar sentindo nesse momento onde quer que esteja e, sobretudo por ser minha fonte inesgotável de esperança, amor e sonhos!

Amo muito vocês!

AGRADECIMENTOS

À Deus por essa conquista, por ser sempre providencial na minha vida e me guiar até aqui, fortalecendo-me a cada desafio vivenciado, por me oferecer sempre toda coragem, paciência e sabedoria para aprender aceitar, compreender e transpor todas as dificuldades ao longo dessa jornada; e por me permitir estar aqui hoje sendo grata a todas essas pessoas!

À minha orientadora Profª Drª. Valéria Amorim Pires Di Lorenzo, por quem tenho respeito carinho e admiração, por me aceitar como sua orientanda, pela sensibilidade com as palavras, pelo apoio, amizade e carinho, por acreditar na minha pessoa desde o início e mais do que tudo, por ter possibilitado que esse sonho pudesse se tornar realidade! Por contribuir para o meu crescimento, pessoal e profissional!

Ao Prof. Dr. Mauricio Jamami, pela amizade, companheirismo e ensinamentos e por contribuir com o meu crescimento profissional e pessoal!

Aos professores da banca examinadora. Profª Drª Renata Gonçalves Mendes, Profº Drº Rodrigo Polaquini Simões, Profº Drº Victor Zuniga Dourado, ao médico Profº Drº Elcio dos Santos Oliveira Vianna, Profª Drª Flávia Cristina Rossi Caruso Bonjorno, Profº Drº Michel Silva Reis, Profª Drª Kamilla Tays Marrara e a Profª Drª Valéria Amorim Pires Di Lorenzo por terem contribuído e enriquecido esse estudo com suas valiosas considerações e sugestões!

À Profª Drª Audrey Borghi Silva pela parceria com esse estudo, pelos equipamentos e laboratório que foram cedidos para que as avaliações pudessem ser realizadas, por todas suas sugestões e contribuições para com esse estudo e aos alunos de sua orientação e apoios técnicos, Soraya Pilon Jürgensen, Bruno Archiza, Katiany Thays Lopes Zangrando, Camila Noji e Paula Ricci que puderem auxiliar ao longo desses anos, meu muito obrigado, pois sem vocês, esse estudo não seria possível!

Aos médicos Drº Marcos Miranda Araujo e Profª Drª Fabiola Paula Galhardo Rizzatti, por participar desse estudo, sendo sempre solícitos durante as avaliações, pois sem a presença de vocês não conseguiríamos realizar esse estudo!

À Cristiane Lubk Garbim, apoio técnico desse estudo a quem sou muito grata, pois muitas vezes você foi meus braços e minhas pernas, por todo suporte e contribuição ao longo dessa jornada de trabalho que pudemos dividir, pela sensibilidade, carinho, afeto, respeito e amizade dedicados a mim e principalmente por todo apoio e torcida!

À FAPESP, pelo apoio financeiro!

Aos secretários da PPG-FT Emerson e Vagner por serem sempre solícitos e prontos a ajudar!

À CAPES pelo Apoio Financeiro!

Aos meios de comunicação rádio UFSCar, EPTV São Carlos, e aos repórteres por toda dedicação e por serem solícitos na divulgação desse estudo, tornando esse projeto de pesquisa acessível a todos que por ventura ficaram interessados em participar e contribuir com esse trabalho!

À amiga Renata Pedrolongo Basso Vanelli, por demonstrar ao longo de todos esses anos de convivência o verdadeiro sentido da palavra amizade, nos momentos de tristeza e alegria, angústia e tranquilidade, por compartilharmos ensinamentos, conhecimentos, aprendizado pessoal e profissional, pela compreensão, respeito, afeto, carinho e todo auxílio e caridade despendidos a mim sem esperar nada em troca. Enfim, por tudo que hoje e sempre representará eternamente na minha vida!

À Profª Drª Adriana Sanches Garcia de Araujo pela parceria enquanto doutoranda ao longo desses anos durante a realização desse estudo e por podermos compartilhar conhecimentos!

Às amigas Anna Claudia Sentanin e Ivanize Mariana Masseli dos Reis pela amizade e companheirismo! Com vocês os momentos de trabalho foram muito mais harmoniosos e felizes!

Aos amigos Daniela Ohara e Maycon Sousa Pegorari, por toda amizade, carinho, respeito, compreensão, aprendizado, companheirismo e principalmente por toda torcida, apoio e ajuda dedicados a mim com tanta verdade e sinceridade!

Á toda da equipe de pesquisa do Laboratório de Fisioterapia Respiratória (LEFiR) pela fraternidade, carinho, amizade, descontração, união, disponibilidade e dedicação para a minha pessoa. Juliano Ferreira Arcuri, Julia Giangoppe dos Santos, Marina Sallum Barusso Grüninger, Maria Cecília Frade, Carolina Costa, Fernanda Sousa, Bruna Varanda Pessoa, Eloisa Maria Gatti Regueiro, Kamilla Tays Marrara, Diego Marmorato, Daniela Ike, Glaucia Nency Takara, Victor Fernando Couto, Cilso Dias Paes, Samantha Maria Nyssen, Camila Akemi Sakaguchi, Jacqueline Rodrigues de Freitas Vianna!

À todos os voluntários por participarem desse estudo, pelo carinho e respeito transmitidos a mim. Sem eles seria impossível a realização desse estudo!

À Iolanda querida, por todos esses anos de convivência, por todos os dias em que nos encontramos e você me diz "bom dia" cheio de carinho, de afeto, de luz e muito amor!

Às meninas da limpeza Maria e Gleides que sempre me desejam um bom dia repleto de carinho, sinceridade e felicidade!

Ás minhas queridas irmãs de coração Luana Guerreiro Pereira, Luna Guerreiro Pereira, Priscila Otaviano Treviso, Vanessa Marc e a minha mãe de coração Ana Maria Guerreiro por demonstrar o verdadeiro sentimento de fraternidade e amizade construído ao longo de 27 anos com muito carinho, cumplicidade, afeto, união e amor; por participarem das minhas dores e alegrias, das minhas conquistas e derrocadas e por simplesmente fazerem parte da minha existência!

À minha família. Meus avós Lourdes e Vicente (in memorian), Dolores e José (in memorian) pela compreensão nos momentos de ausência e, sobretudo pelo todo incentivo e amor!

Aos meus tios e primos pelo carinho, amor e torcida ao longo dessa jornada!

E por fim, mas principalmente....

Aos meus pais e ao meu irmão por acreditarem em mim e por sempre se fazerem presente na minha vida compreendendo, incentivando, apoiando e amando!

EPÍGRAFE

De tudo ficaram três coisas...
A certeza de que estamos começando...
A certeza de que é preciso continuar...
A certeza de que podemos ser interrompidos antes de terminar...

Mas é importante que façamos...

Da interrupção um novo caminho...
Da queda, um passo de dança...
Do medo, uma escada...
Do sonho, uma ponte...
Da procura, um encontro!

(Fernando Sabino)

LISTA DE ABREVIATURAS E SIGLAS

ATS	*American Thoracic Society*
ATS/ERS	*American Thoracic Society/European Respiratory Society*
BD	Broncodilatador
BIE	Broncoespasmo Induzido pelo Exercício
BMI	*Body Mass Index*
BP	*Blood Pressure*
bpm	*Beats per minute*
CCI	Coeficiente de Correlação Intraclasse
CCPET	*Constant Cardiopulmonary Exercise Test*
cm	*Centimeters*
COPD	*Chronic Ostructive Pulmonar Disease*
CPET	*Cardiopulmonary Exercise Test*
CVF	Capacidade Vital Forçada
CV	*Coefficient of Variation*
CWT	*Constant Workload Test*
DBP	*Diastolic Blood Pressure*
Δ	*Delta*
DP	Distância percorrida
DPOC	Doença Pulmonar Obstrutiva Crônica
EIB	*Exercise-Induced Bronchospasm*
ERS	*European Respiratory Society*
FET	*Field Exercise Test*
FEV_1	*Forced Expiratory Volume in the First Second*
FR	Frequência Respiratória
FVC	*Forced Vital Capacity*
HR	*Heart Rate*
ICC	*Intraclass Correlation Coefficient*
ICPET	*Incremental Cardiopulmonary Exercise Test*
ISWTD	*Walked Distance Incremental Shuttle Walking Test*
ISWT	*Incremental Shuttle Walking Test*
ISWT-2	*Second Incremental Shuttle Walking Test*
ISWT-3	*Third Incremental Shuttle Walking Test*

IWT	*Incremental Workload Test*
κ	*kappa index*
Kg	*Kilograms*
Km/h	*Kilometers per hour*
LET	*Laboratory Exercise Test*
LLF	*Lower Limbs Fatigue*
L	*Liters*
L min^{-1}	*Liters per minute*
MDD	*Minimal Detectable Difference*
M	*Meters*
ml Kg min^{-1}	Milliliters per kilogram per minute
ml min^{-1}	Milliliters per minute
MVV	*Maximal Voluntary Ventilation*
Pre-BD	*Pre Bronchodilator*
Post-BD	*Post Bronchodilator*
%	*Percentage*
RR	*Respiratory rate*
% Predicted	*Percentage of Predicted*
SBP	*Systolic Blood Pressure*
SD	*Subjective Dyspnea*
SEM	*Standard Error of Measurement*
SPSS	*Statistical Package for the Social Sciences*
SVC	*Slow Vital Capacity*
TC6	Teste de Caminhada de Seis Minutos
TECP	Teste de Exercício Cardiopulmonar
TECPC	Teste de Exercício Cardiopulmonar Constante
TECPI	Teste de Exercício Cardiopulmonar Incremental
VCO_2	*Carbon Dioxide Production*
V_E	Ventilação Minuto
V_E	Minute Ventilation
VEF_1	Volume Expiratório Forçado no primeiro segundo
VE/VCO_2	*Carbon Dioxide Ventilatory Equivalent*
V_E/VVM	*Ventilatory Demand*

V_E > 40% da VVM	Demanda Ventilátioria maior que 40% da ventilação voluntária máxima.
VO_2	Captação de Oxigênio
VO_2	Oxygen Uptake
VVM	Ventilação Voluntária Máxima
WD	*Walked Distance*
χ^2	*Chi squared test*

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RESUMO

Esta tese resultou na elaboração de dois estudos, cujos objetivos foram: Estudo I: avaliar a reprodutibilidade teste reteste do incremental Shuttle Walk Test (ISWT) para a distância percorrida no ISWT (DP-ISWT), respostas cardiorrespiratórias, metabólicas e percepção de esforço em adultos jovens asmáticos controlados. Estudo II – avaliar a reprodutibilidade e validade do ISWT em detectar o broncoespasmo induzido pelo exercício (BIE) em adultos jovens asmáticos controlados. Participaram 34 indivíduos asmáticos, sendo que para o segundo estudo, participaram 32 asmáticos. Foram submetidos no primeiro dia a um teste de função pulmonar pré e pós-broncodilatador (BD) e o primeiro ISWT para familiarização. No segundo dia, foi realizado um teste de exercício cardiopulmonar incremental (TECPI) e após um intervalo de 48 horas foi realizado no terceiro dia um teste de exercício cardiopulmonar constante (TECPC), ambos foram executados com temperatura e umidade do ar controlado segundo as recomendações para teste de exercício cardiopulmonar (TECP). No quarto dia, foi realizado o segundo ISWT (ISWT-2) em um corredor plano e coberto e após um intervalo mínimo de 48 horas e máximo de sete dias no quinto dia foi realizado o terceiro ISWT (ISWT-3) nas mesmas condições e ambos foram conduzidos pelo mesmo avaliador. Além disso, para realização de todos os testes foi utilizado um sistema portátil de telemetria para captação das variáveis ergoespirométricas respiração-a-respiração. Este sistema também foi utilizado para realizar o teste de função pulmonar por meio de uma máscara facial e também foram realizadas manobras de capacidade vital forçada (CVF) para obtenção dos valores de volume expiratório forçado no primeiro segundo (VEF_1) sendo três manobras reprodutíveis antes dos testes e uma manobra nos 5', 10', 15', 20' e 30' minutos após os testes, exceto para o TECPI, a fim de avaliar a ocorrência do BIE. Os valores do coeficiente de correlação intraclasse (CCI) foram maiores do que 0,75 ($p < 0,001$) para a DP-ISWT, a captação de oxigênio absoluto (ml/min) e corrigido pela massa corporal (ml/kg/min) (VO_2), produção de dióxido de carbono (ml/min) (VCO_2) e ventilação minuto (l/min) (V_E). Os gráficos de Bland-Altman apresentaram erro médio próximo de zero e limites de concordância dentro dos limites aceitáveis de variação com exceção da sensação de dispneia (SD) que apresentou um erro médio distante de zero e limites de concordância altos, mostrando que a SD foi maior no terceiro ISWT em relação ao segundo ISWT. A análise da reprodutibilidade para detecção do BIE foi fraca ($k=0,24$; $p>0,169$). Para as análises de validade encontramos um valor fraco entre o ISWT-2 e o TECPC ($k=0,059$; $p>0,618$) e um valor moderado entre o ISWT-3 e o TECPC (0,46; $p < 0,002$). Foi verificada também uma associação significativa moderada entre o ISWT-3 e o TECPC ($r=0,51$; $p<0,01$). Sobre as respostas fisiológicas, o tempo de ventilação durante os testes acima de 40% da ventilação voluntária máxima (VVM) foi menor no ISWT-2 e no ISWT-3 em relação ao TECPC ($p=0,000$; $p=0,000$), foi encontrada uma diferença significativa para o momento em que foi atingida uma $V_E > 40\%$ da VVM no grupo de BIE positiva ($p=0,000$; $p=0,000$) e BIE negativa ($p=0,044$; $p=0,028$) entre o ISWT-2 vs TECPC e ISWT-3 vs TECPC, respectivamente, ou seja, os indivíduos asmáticos levaram mais tempo para atingir a demanda ventilatória no ISWT-2 e ISWT-3 do que no TECPC e a frequência respiratória (FR) foi maior no ISWT-3 em relação ao TECPC para o grupo BIE positiva ($p=0,010$).

Palavras-chave: Asma induzida por exercício, fisioterapia, reprodutibilidade, validade, teste de esforço.

ABSTRACT

The present thesis has a result two studies in which the aims were: Study I – to evaluate the reliability test retest of the incremental Shuttle Walk Test (ISWT) for the walked distance in ISWT (ISWTD), cardiorespiratory responses, metabolic responses and effort perception in young adults with asthma control. Study II – to evaluate the reliability and validity of the ISWT in detecting exercise-induced bronchospasm (EIB) in young adults with asthma control. Thirty-four asthmatic subjects participated in this study, and for the second study, 32 asthmatics participated. On the first day, a pre-and post-bronchodilator (BD) lung function test was performed and the first ISWT for familiarization. On the second day, an incremental cardiopulmonary exercise test (ICPET) was performed and after a 48-hour interval on the third day a constant cardiopulmonary exercise test (CCPET) was performed, both were performed with temperature and humidity of the controlled air according to recommendations for cardiopulmonary exercise (CPET). On the fourth day, the second ISWT (ISWT-2) was performed in a flat and covered corridor and after a minimum interval of 48 hours and a maximum of seven days on the fifth day the third ISWT (ISWT-3) were performed under the same conditions and both were conducted by the same evaluator. In addition, a portable telemetry system was used to capture the breath-to-breath ergospirometry variables. This system was also used to perform the pulmonary function test using a facial mask and forced vital capacity maneuvers (FVC) were also performed to obtain forced expiratory volume values in the first second (FEV_1), with three reproducible maneuvers before Tests, and a maneuver at 5', 10', 15', 20' and 30' minutes after the tests, except for the ICPET, in order to evaluate the occurrence of EIB. The values of the intraclass correlation coefficient (ICC) were higher than 0.75 ($p < 0.001$) for ISWTD, the absolute oxygen uptake (ml/min) and corrected by body mass (ml / kg / min) (VO_2), carbon dioxide (ml/min) and minute ventilation (l/min) (V_E). The Bland-Altman plots presented mean error and limits of agreement within acceptable limits of variation with the exception sensation of dyspnea (SD), which presented a mean error far from zero and high agreement limits, showing that SD was higher in the third ISWT compared to the second ISWT. Reliability analysis for EIB detection was weak ($k=0.24$; $p>0.169$). For the validity analyzes we found a weak value between ISWT-2 and CCPET ($k=0.059$; $p>0.618$) and a moderate value between ISWT-3 and CCPET (0.46; $p<0.002$). There was also a significant moderate association between ISWT-3 and CCPET ($r=0.51$; $p<0.01$). Regarding the physiological responses, the ventilation time during the tests above 40% of the maximum voluntary ventilation (MVV) was lower in ISWT-2 and ISWT-3 than in CCPET ($p=0.000$; $p=0.000$), a significant difference was found for the moment when an $V_E >$ 40% of the MVV was reached in the positive EIB group ($p=0.000$; $p=0.000$) and negative EIB ($p=0.044$; $p=0.028$) between the ISWT-2 vs CCPET and ISWT-3 vs CCPET, respectively, in other words, asthmatic individuals took longer to achieve ventilatory demand in ISWT-2 and ISWT-3 than in CCPET and the respiratory rate (RR) was higher in the ISWT-3 compared to the CCPET for the positive EIB group ($p=0.010$).

Key Words: Asthma, exercise-induced, physical therapy, reproducibility, validity, exercise test

Sumário

1. CONTEXTUALIZAÇÃO

A asma é uma doença heterogênea, geralmente caracterizada por uma inflamação crônica das vias aéreas e afeta 1-18% da população em diferentes países, atingindo valores superiores a 10% no Brasil, Austrália e Canadá. Estima-se, atualmente, que 300 milhões de indivíduos sejam acometidos pela doença, com uma projeção global para 400 milhões em 2025. É definida pela história de sintomas respiratórios como chiado, falta de ar, aperto no peito e tosse que variam ao longo do tempo e intensidade, juntamente com a limitação do fluxo aéreo expiratório variável. Estas variações são muitas vezes desencadeadas por fatores como exposição à alérgenos ou irritantes, mudanças no tempo, infecções respiratórias virais e exercício físico (GINA, 2016).

O exercício físico é um grande estímulo aos sintomas da asma para muitos pacientes, caracterizados por um estreitamento das vias aéreas que ocorre tipicamente durante ou após a cessação do exercício, mais comumente conhecido como broncoespasmo induzido pelo Exercício (BIE) (GINA, 2016, DE FUCCIO et al., 2005). A prevalência do BIE varia de aproximadamente 5% a 20% na população em geral, para talvez 30% a 70% em atletas de elite de inverno e atletas que participam de esportes de resistência no verão e em pelo menos 90% dos indivíduos com asma persistente (WEILER et al., 2007).

Ainda, é provável que quase todos os indivíduos que têm asma crônica serão induzidos a ter um ataque da asma com um teste de exercício adequado, embora alguns estudos sugerem uma prevalência do BIE de apenas 50% a 90% nesta população (ANDERSON et al., 2010; RUNDELL e JENKINSON, 2002), além disso, o BIE tem sido demostrado em indivíduos sem diagnóstico de asma com uma prevalência de 20% (PARSONS et al., 2013).

Embora a patogênese do BIE não esteja completamente elucidada, provavelmente é causada pela hiperventilação induzida pelo exercício e alterações correspondentes na

fisiologia das vias aéreas (McFADDEN, 1999; RUNDELL et al., 2000; WEILER et al., 2007).

Um aumento da taxa ventilatória é necessário para atender às exigências de oxigênio muscular durante o exercício. Este aumento da taxa ventilatória desafia a capacidade das vias aéreas para condicionar o ar inalado para a umidade correta e níveis de calor antes que o ar chegue aos alvéolos. O exercício vigoroso resulta na inalação de um volume aumentado de ar relativamente frio e seco e na perda de calor da mucosa respiratória, o que induz mudanças de osmolaridade na superfície das vias aéreas que, por sua vez, podem ativar mastócitos e células epiteliais para liberar mediadores pró-inflamatórios tais como histamina, leucotrienos e quimiocinas (WEILER et al., 2007).

O BIE é um grande fator de risco para morte súbita na população asmática, principalmente em atletas. Um estudo retrospectivo (AMITAL et al., 2004) realizado com 151 jovens militares que tiveram morte súbita inexplicada, encontraram que os eventos cardíacos são a principal causa de morte súbita nesta população, seguida pela asma e hemorragia cerebral. Outro estudo de revisão (BECKER et al 2004), identificou que 61 mortes por asma ao longo de um período de sete anos ocorreram em associação ao exercício físico e 10% das mortes ocorreram em indivíduos sem história de asma ou do BIE.

Os sintomas do BIE são variáveis e inespecíficos, e a presença ou ausência de sintomas respiratórios específicos tem um valor preditivo muito baixo para confirmar objetivamente o BIE. Para tanto, o diagnóstico do BIE é estabelecido pelas mudanças na função pulmonar após o exercício e não baseado nos sintomas (PARSONS et al., 2007; HALLSTRAND et al., 2002). Medições da função pulmonar em série após um exercício físico específico são utilizadas para determinar se há presença de BIE e quantificar a gravidade do distúrbio, e para isso recomenda-se avaliar o volume expiratório forçado no

primeiro segundo (VEF_1) uma vez que essa variável tem melhor repetibilidade (ENRIGHT et al., 2004).

Normalmente são realizadas manobras de VEF_1 nos 5, 10, 15 e 30 minutos após o exercício físico, mas pode ser extendido para mais de 30 minutos a monitoração se for esperada uma reposta severa. A diferença entre o valor do VEF_1 pré-exercício e o menor valor do VEF_1 registado dentro de 30 minutos após o exercício é expressa como uma porcentagem do valor pré-exercício. O critério para a queda percentual do VEF_1 usado para diagnosticar o BIE é $\geq$ 10% em algumas diretrizes (CARLSEN et al., 2008; NEDER e NERY, 2002; CRAPO et al., 2000; ROCA et al., 1997; STERK et al., 1993). Esse valor foi baseado na média, mais dois desvios padrões (DPs) da queda percentual do VEF_1 em indivíduos saudáveis normais sem história familiar de asma, atopia ou infecção recente do trato respiratório superior (ANDERSON et al., 2010).

A gravidade do BIE pode ser classificada como leve, moderada ou grave se a queda percentual do VEF_1 no nível pré-exercício for $\geq$ 10% mas < 25%, $\geq$ 25% mas < 50% e $\geq$ 50%, respectivamente (FREED e ANDERSON, 2008; ANDERSON e BRANNAN, 2003). Esta classificação baseou-se na gama de valores medidos para o BIE e antes do uso generalizado de esteróides inalados. Atualmente, um declínio no $VEF_1 \geq 30\%$ em uma pessoa tomando esteroides inalatórios é considerado grave. Normalmente a queda do VEF_1 ocorre dentro de 5 a 10 minutos após o exercício, embora em algumas ocasiões ocorra até 30 minutos após a cessação deste (IV DIRETRIZES PARA O MANEJO DA ASMA, 2006; CRAPO et al., 2000). A recuperação do BIE geralmente é espontânea e o VEF_1 retorna para 95% do valor basal em 30-90 minutos.

Os testes de broncoprovocação são frequentemente utilizados para avaliar indivíduos com asma. O estímulo usado para induzir a obstrução das vias aéreas pode ser categorizado como direto ou indireto. Os testes diretos de broncoprovocação atuam nos receptores do

músculo liso das vias aéreas (por exemplo, acetilcolina e análogos muscarínicos nos receptores muscarínicos, histamina nos receptores H_1) para induzir a broncoconstrição, independente da inflamação das vias aéreas, tendo como método a inalação de metacolina (PAUWELS et al., 1988; COCKCROFT e DAVIS, 2009).

Já os testes indiretos envolvem uma via intermediária, como a liberação de mediadores osmóticos ou não-osmóticos de células inflamatórias, estimulação nervosa sensorial entre outros, e os métodos utilizados são: exercício físico, hiperpneia voluntária eucapnica, adenosina monofosfato e manitol. Os autores que inicialmente desenvolveram o conceito direto-indireto sugerem que a hiper-reatividade das vias aéreas avaliada pelos testes diretos pode induzir a um resultado falso-positivo e ressaltam a eficiência dos métodos indiretos para a confirmação do BIE (PAUWELS et al., 1988; COCKCROFT e DAVIS, 2009).

Tem sido sugerido na literatura que o treinamento físico aeróbio reduz a atividade inflamatória das vias aéreas e consequentemente o BIE em asmáticos (MENDES et al, 2011), sendo necessária avaliação da presença do BIE em todos os pacientes com diagnóstico de asma. Dessa forma, a avaliação do BIE permite monitorar o controle da asma, determinar a eficácia e as dosagens ideais dos medicamentos prescritos para prevenir o BIE, diagnosticar a asma ocupacional e a relacionada ao exercício físico, evitando eventos graves.

Nesse contexto, o protocolo ideal para detectar o BIE envolve um rápido aumento da intensidade do exercício ao longo de aproximadamente 2-4 minutos para atingir um elevado nível de ventilação. A maioria dos protocolos recomenda a respiração de ar seco (<10 mg H_2O/L) com um clipe nasal no local durante a corrida ou ciclismo em uma carga suficiente para elevar a frequência cardíaca para 80-90% do máximo previsto (frequência cardíaca máxima prevista ≈ 220 – idade em anos) ou ventilação para alcançar 17,5 – 21 vezes VEF_1. Uma vez que este nível de exercício físico é alcançado, o sujeito deve sustentar o exercício a esse nível elevado por mais 4-6 minutos (PARSONS et al., 2013; ANDERSON et al., 2010).

Dessa forma, o tipo, a duração, a intensidade do exercício, a temperatura e teor de água do ar inspirado são determinantes importantes da resposta das vias aéreas ao exercício (BAR-OR et a., 1977; ANDERSON et al., 1979). O tempo do exercício também é importante, porque alguns indivíduos tornam-se refratários a outro estímulo de exercício por até 4 horas (ANDERSON et al., 1982). Além disso, os dois determinantes mais importantes do BIE são a ventilação alcançada e sustentada num alto nível durante o exercício e o teor de água do ar inspirado (KIVITY e SOUHRADA, 1980; PARSONS et al., 2013). Com isso, a mensuração da ventilação durante os testes para detectar o BIE permite comparar o efeito do mesmo estímulo ao longo do tempo e entre os indivíduos (ANDERSON et al., 2001).

Sabe-se que a ocorrência do BIE associado ao grau de obstrução das vias aéreas no repouso, a diminuição da capacidade ventilatória e a maior sensação de dispneia vivenciada ao exercitar-se ou o medo de vivenciá-la são fatores que limitam a prática de exercício físico regular e determinam uma interrupção precoce do exercício nos indivíduos asmáticos, fazendo com que estes adotem um estilo de vida mais sedentário e consequentemente tenham uma menor tolerância ao exercício (RUBIN et al., 2002; PIANOSI e DAVIS, 2004). Além disso, a diminuição da capacidade de exercício e a gravidade da doença podem afetar a vida social e emocional, fazendo com que os indivíduos asmáticos tenham significativamente menor qualidade de vida quando comparado aos indivíduos não asmáticos (EVERHART e FIESE, 2008).

Nesse sentido, além dos tratamentos farmacológicos, a exercício físico pode ser considerado relevante, pois ajuda a melhorar o controle dos sintomas e/ou reduzir riscos futuros. Para tanto, os indivíduos asmáticos devem ser incentivados a praticar exercício físico regular devido aos seus benefícios como a prevenção e controle do BIE e melhora da capacidade aeróbia (GINA, 2016). Outros estudos demonstram ainda, que quando esses indivíduos estão clinicamente estáveis, o nível de atividade física parece ser o fator

determinante para que os indivíduos asmáticos alcancem intensidades semelhantes de exercício que os não asmáticos, mesmo para aqueles que ocorre o BIE (CLARK e COCHRANE, 1988; LAMAR-FILHO et al., 2001).

Dessa forma, torna-se indispensável à avaliação da capacidade de exercício, bem como do BIE em indivíduos com asma, a fim de identificar a real influência dos fatores clínicos, físicos e fisiológicos frente à realização das atividades físicas.

‘ Nesse contexto, estudos sobre a avaliação da capacidade de exercício em indivíduos asmáticos por meio do teste de exercício cardiopulmonar (TECP), em relação ao comportamento das variáveis fisiológicas, em especial da captação de oxigênio (VO_2), têm demonstrado resultados conflitantes (VERMEULEN et al., 2016), mas alguns estudos (KOCH et al., 2009; LAVENEZIANA et al., 2006) têm demonstrado que o valor do VO_2 pico tem se mostrado normal para os indivíduos asmáticos classificados de leve a moderado.

Quanto aos asmáticos mais graves existem poucos estudos, mas BARREIRO et al., 2004 demonstraram que o valor do VO_2 foi baixo num grupo de indivíduos asmáticos com história de asma quase fatal. Sobre o comportamento da ventilação durante o teste de exercício em cicloergômetro em indivíduos com asma persistente MAHLER et al., 2007 observaram que um rápido aumento da ventilação minuto (V_E) durante o teste está relacionada a cessação precoce do exercício.

OCHMANN et al., 2013 encontraram que a distância percorrida (DP) no teste de caminhada de seis minutos (TC6) apresentou uma correlação significativa com a carga máxima obtida no TECP em um grupo de indivíduos asmáticos e com isso, verificaram que uma variação de 50 metros está relacionada com uma mudança de carga máxima num total de 11,6 watts. Outro estudo (MARCON et al., 2013) verificou que a DP no TC6 foi significativamente menor no grupo de indivíduos com asma leve (-17,1; IC95%: -28,3 a -5,8 m) quando comparado a um grupo controle (604 ± 68 metros em média) (p=0,01).

Diante do exposto e para melhor avaliar os indivíduos asmáticos, medidas objetivas são importantes para determinar a capacidade de exercício, e assim, orientar na prescrição de um programa de reabilitação adequado as limitações individuais e a gravidade da asma. Para tanto, os testes de exercício cardiopulmonar incremental máximo (TECPI) em esteira ou cicloergômetro são os mais utilizados por permitir determinar a intensidade necessária para a realização de exercícios prolongados e quantificar os fatores limitantes do exercício, como o BIE (SOUZA e PEREIRA, 2005).

Nesse contexto, embora não haja um consenso sobre os protocolos de testes de exercício já citados na literatura (NEDER e NERY, 2002), preconiza-se que o teste adequado para avaliação do BIE seja realizado em esteira ou cicloergômetro (CROPP, 1979; CRAPO et al., 2000), sendo o teste convencional em esteira preferível por aumentar mais rapidamente a V_E (CRAPO et a., 2000), além disso, foi mostrado que os testes incrementais rápidos são igualmente eficazes aos testes com carga constante quando a questão é a avaliação do BIE (DE FUCCIO, 2005).

Porém, como são onerosos e requer equipe treinada e capacitada, uma alternativa seria a utilização dos testes de campo, e um deles é o teste de caminhada com velocidade controlada e progressiva, o Incremental Shuttle Walking Test (ISWT) que é um teste simples, reprodutível, pode ser realizado em qualquer local plano, não necessita de ergômetro específico e avalia respostas diferentes da capacidade de exercício quando comparado ao TC6 (SINGH et al., 1992, MORALES et al., 2000).

O ISWT foi desenvolvido usando um formato incremental como possível substituto para o teste de exercício máximo limitado por sintoma e tem sido utilizado para avaliar a capacidade de exercício na reabilitação pulmonar para pacientes com doença pulmonar obstrutiva crônica (DPOC) e em outras condições (PARREIRA et al., 2014; DOURADO et al., 2010). Além disso, os testes de campo são capazes de detectar o BIE e permitir o

diagnóstico precoce das limitações no exercício físico (BATTILANI et al., 2004; DAL CORSO et al., 2007).

Dessa forma, o ISWT desempenha papel fundamental na avaliação da capacidade de exercício funcional, na avaliação de prognóstico, na determinação de resultados de ensaios clínicos e na avaliação da resposta ao tratamento de uma ampla gama de doenças respisratórias (SINGH et al., 2014), exceto para asma, onde encontramos apenas o estudo de DYER et a., 2002 que tiveram por objetivo testar a reprodutibilidade da distância caminhada no ISWT com idosos asmáticos.

SINGH et al., 2014 afirmam que de sete estudos com DPOC, quatro destes (LUXTON et al., 2008; ARNARDÓTTI et al., 2006; TUNER et al., 2004; ONORATI et al., 2003) apresentaram uma correlação forte entre o VO_2 ou a carga de trabalho entre o TECP e o ISWT (r=0.75 – 0,88), e três estudos não apresentaram diferença para o VO_2 entre os testes (HILL et al., 2012; ZAINULDIN et al., 2012; PALANGE et al., 2000).

Nesse sentido, HILL et al., 2012 desenvolveram um estudo com pacientes portadores de doença pulmonar obstrutiva crônica (DPOC), e verificaram por meio de uma análise minuto a minuto que tanto o ISWT como o teste de exercício cardiopulmonar (TECP) demostraram uma resposta linear para a captação de oxigênio (VO_2) no pico dos testes, sugerindo que os dois testes provocam uma resposta cardiopulmonar similar.

Diante de todo o contexto explorado, embora existam estudos que avaliam a capacidade de exercício em diversas populações de doenças respiratórias crônicas, bem como, a ocorrência do BIE nos indivíduos com asma por meios testes diretos e indiretos, há uma escassez de estudos que utilizaram o teste de campo com velocidade controlada, como ISWT, para testar a reprodutibilidade na avaliação da capacidade de exercício, e além da reprodutibilidade, também a validade na detecção do BIE nessa população. Além disso, os estudos de validação são mais escassos, talvez devido ao fato de que o ISWT é um

instrumento que foi desenvolvido mais recentemente, em comparação ao TC6. Com isso também verificar se o ISWT traria benefícios em termos de aplicabilidade clínica, como mais um instrumento para avaliar a capacidade de exercício dessa população em especial e com isso permitir o desenvolvimento de novas estratégias terapêuticas para melhorar o condicionamento físico bem promover adaptações para os asmáticos.

Dessa forma, a realização desse estudo permitiu avaliar e testar a reprodutibilidade do ISWT quanto a sua eficiência para avaliar a capacidade de exercício de adultos asmáticos e testar também a reprodutibilidade e validade desse mesmo teste quanto ao seu papel clínico e verificar sua eficiência comparado ao padrão-ouro referenciado na literatura para detectar o BIE nessa população.

Sendo assim, foram elaborados dois estudos que compõem a presente tese de doutorado e que serão descritos nas sessões subsequentes, cujos possibilitaram a elaboração de dois estudos, cujos títulos são:

Estudo I: **Reliability of the Walked Distance, Cardiorespiratory, Metabolic and Perceptual Responses in Incremental Shuttle Walk Test in Asthmatics Adult.**

Estudo II: **Is Incremental Shuttle Walking Test reliable and valid to detect exercise-induced bronchospasm in adult asthmatics?**

2.OBJETIVOS

1- Avaliar a reprodutibilidade teste reteste da distância caminhada no Incremental Shuttle Walk Test (ISWT), respostas cardiorrespiratórias, metabólicas e percepção de esforço em adultos jovens asmáticos controlados.

2- Avaliar a reprodutibilidade e validade do ISWT em detectar o BIE em adultos jovens asmáticos controlados.

ESTUDO I

Reliability of the Walked Distance, Cardiorespiratory, Metabolic and Perceptual Responses in Incremental Shuttle Walk Test in Asthmatics Adult.

Manuscrito submetido ao periódico Physical Therapy Journal (Anexo II).

ABSTRACT

Background: Incremental Shuttle Walking Test (ISWT) is reliable and valid to evaluate the exercise capacity in particular of patients with respiratory diseases. However, there are no studies evaluating the clinical applicability of ISWT in young adults with controlled asthma. **Objective:** The aim of this study was to assess the test-retest reliability of ISWT for the walked distance (ISWTD) and cardiorespiratory, metabolic and perceived exertion responses in young adults with controlled asthma. **Design:** A reliability assessment was conducted. **Methods:** 34 subjects diagnosed with asthma participated in the study. They performed three ISWT on different days, with a minimum interval of 48 hours and up to one week between second and third ISWT. For the reliability analysis, the values of the second and third ISWT were used, eliminating the influence learning effect of the first test. **Results:** The intraclass correlation coefficient values were higher than 0.75 ($P < 0.001$) for ISWTD, speed (km/h), absolute oxygen uptake (ml/min) and adjusted for body mass (ml/ kg/min), carbon dioxide production (mL/min) and minute ventilation (l/min) in the ISWT peak. The Bland-Altman plot presented a mean error close zero and the distributions of the measurements were within acceptable limits of variation.

Limitations: We find difficulty comparing our results with other findings, because some studies conducted two ISWTs with 30-minute intervals, but our experimental procedure did not allow two tests to be conducted on the same day, because we could not predict whether the first test would trigger the exercise-induced bronchospasm.

Conclusion: The ISWT presented excellent reliability for the ISWTD and the metabolic responses. Nevertheless, the cardiorespiratory exertion and perceived responses presented moderate to excellent reliability. Thus, we conclude that ISWT presented test-retest reliability for in young adults with controlled asthma.

Key words: Asthma, cardiopulmonary response, physiotherapy, exercise test, walking, reliability

INTRODUCTION

Asthma is a major chronic disease characterized by airways' inflammation, which is associated with expiratory flow limitation and bronchial hyperresponsiveness.[1] Subjects with chronic lung diseases are more likely to have lower exercise tolerance, not only by previous airflow limitation, but also due to systemic manifestations that commonly coexist in these subjects, as peripheral muscle dysfunction.[2] In this context, subjects start to adopt a more sedentary lifestyle, predisposing them to early fatigue and exercise intolerance.[1]

However, regular physical training seems to be the cornerstone in the rehabilitation process, suggesting that increased exercise capacity plays an important modulatory role in reducing the degree of systemic inflammation, with a potential to reduce the severity of the disease,[3] as well as the use of corticosteroids[4] acting beneficially in improving of the psychosocial factors[5] and reducing the risks of exacerbation.[6]

In this context, exercise capacity assessment is fundamental to determine the systemic consequences in asthmatics, as well as to propose intervention strategies to promote positive adaptations. Although cardiopulmonary exercise test is the gold standard for determining exercise intolerance, it is expensive and requires skilled staff and also presents risks inherent in its implementation because it is a maximal test.[7,8]

Therefore, field tests have been widely used because they are less expensive, they requires minimal staff for their execution and are safer since they induce submaximal stress.[9] The Incremental Shuttle Walking Test (ISWT)[10] is an alternative, which is considered a reliable, valid and safe instrument for assessing exercise capacity in subjects with chronic obstructive pulmonary disease (COPD)[11] and it can be considered maximum[12] or

submaximal[13] depending on the assessed population. In addition, it was developed using an incremental format as a possible surrogate for laboratory-based symptom-limited maximal exercise tests.[10] Some studies show that oxygen uptake peak VO_2 showed moderate to strong correlations with measures of maximal exercise performance on cardiopulmonary exercise test (CPET) (SINGH et la., 2014). Dyer and colleagues[14] studied a small sample of asthmatic elders with other associated comorbidities, in addition, some volunteers were smokers and ex-smokers, and they verified that the reliability for walking distance on the ISWT was weak.

However, there are no studies yet that has evaluated the reliability of the ISWT as well as its efficacy in assessing the exercise capacity of asthmatic adult. Therefore, the aim of present study was to analyze the test-retest reliability of the walked distance, cardiorespiratory, metabolic and perceived exertion responses in young adults with controlled asthma. The authors admitted as hypothesis that the ISWT presented good reliability for the walked distance, cardiorespiratory, metabolic and perceived exertion responses in an asthmatic adult sample.

MATERIAL AND METHODS

Study Design and Participants

This is an observational, comparative, inter-methodological study conducted by the Spirometry and Respiratory Physiotherapy Laboratory (LEFiR) and the Cardiopulmonary Physiotherapy Laboratory (LACAP) from the Federal University of São Carlos. The study included 34 asthmatic individuals' men or women, who were 18 to 45 years old during the period March 2012 to December 2015 and were allocated or contacted through physician referral, posters in the University, on local radio, television and newspapers. Contacts were made by telephone and email, and if they would fit the inclusion criteria they were invited to participate.

Subjects were eligible to participate in the study if they presented clinical and functional diagnosis of asthma, classified according to its severity as intermittent and as its level of control as controlled. The subjects had less than two daytime symptoms per week, no use of medicines prophylactically, only for the relief of symptoms. The subjects had no limitations during mild exertion, no nocturnal symptoms and normal spirometry, according the criteria established by the Global Initiative for Asthma.[3] Furthermore, the subjects should present an absence of an exacerbation (unscheduled medical appointment) during the past three weeks (PEREIRA et al., 2002), with a regular follow-up by the pneumologist. They were not considered eligible for the study when they presented other respiratory, metabolic or cardiovascular diseases, that could cause or aggravate the sensation of dyspnea during efforts as well as those who presented any other contraindications to perform cardiopulmonary exercise test,[7] such as musculoskeletal diseases, neurological, artery diseases, inflammatory diseases, kidneys, liver, diabetes mellitus with diabetic neuropathy, difficulty of understanding and/or adherence to the study procedures, declared users of illegal drugs and pregnancy. All volunteers were informed of all experimental procedures and signed a consent form of a broader study, which included all evaluations and analyzes used in present study. The study was approved by the university human ethics committee (decision number 018/2012).

Experimental Procedure

All asthmatic subjects underwent three assessment days in the afternoon period, with a minimum interval of 48 hours between the first and second day. On the first day clinical and physiotherapeutic evaluation, pre and post bronchodilator (BD) pulmonary function test were conducted. Moreover, in the same day they underwent the first ISWT, in order to become familiar with the test. Additionally, they received recommendations prior to the test, such as

avoiding consumption of stimulating beverages 48 hours before the test, not performing physical activity 24 hours before the test, light meals and sleeping properly in the night before the test (at least 8 hours). In this study, short-acting BD were suspended for at least 6 hours and long acting BD were suspended for 12 hours before all the assessments because the same subjects were examined for heart rate variability, which had already been published by our group.[15] On the second day, the second ISWT was conducted and, after a minimum of 48 hours and a maximum of one week, subjects underwent the third ISWT. All tests were conducted by the same assessor in a plan hallway, and used a cardiopulmonary exercise testing portable system (Oxycon Mobile®, Mijnhardt/Jäger, Würzburg, German), and an oronasal mask as interface (**Figure 1. A and 1. B)**, which was used to capture the ventilatory, cardiorespiratory and metabolic responses. The equipment collected the variables breath-by-breath. Furthermore, subjects' responses were collected at rest, during the tests and in the recovery period. In order to eliminate the learning effect, only the parameters from the second and third ISWT were used in the reliability analysis.

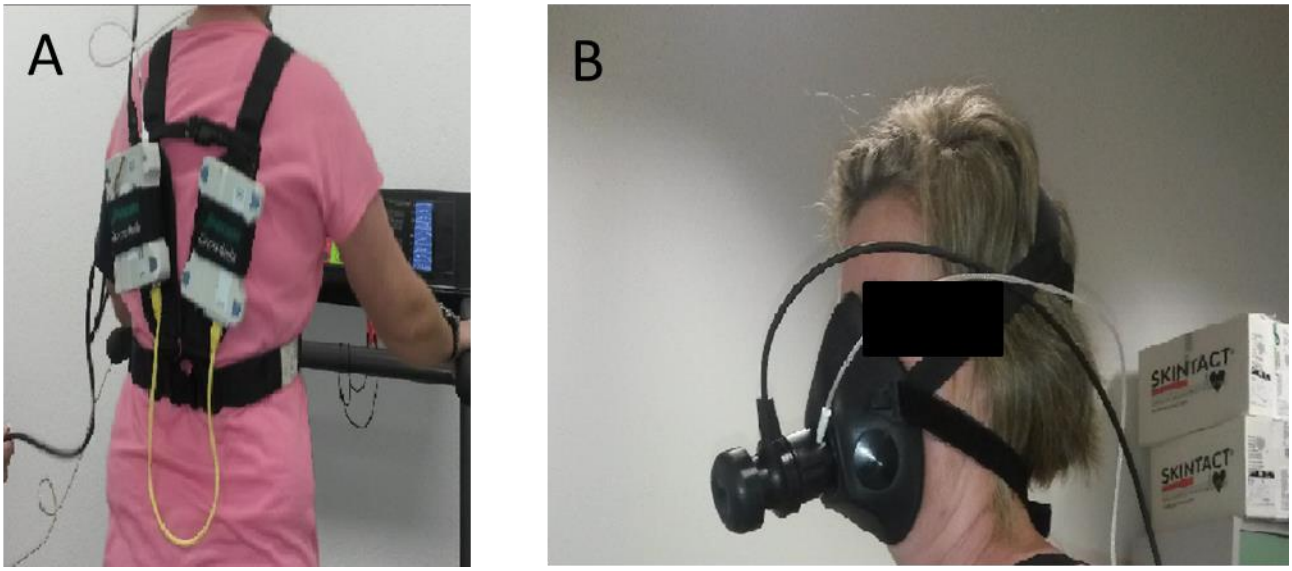

Figure 1. A: Portable ergospirometry system for cardiopulmonary testing. **B:** Oronasal mask as interface.

Incremental Shuttle Walking Test (ISWT)

The ISWT consists of walking on a 10-meters corridor, which was delimited by two cones **(Figure 2)**. The walking was in a progressive speed, which increased 0,17m/s every minute via beep. The subjects were instructed, every minute, to increase walking speed during the 12 stages of the test, so that reached maximum effort. The test end was determined by interruption the subjects, when they reported intense sensation of dyspnea (SD), pain, lower limbs fatigue (LLF) and/or any other symptoms that prevent them from continuing the tests.

In addition, the assessor interrupted the test when the subject could no longer maintain the required speed for two consecutive laps, in which was considered a criteria to be more than 0.5 meters away from the cone when the beep sounded.[10] If subjects had reached the cone before the beep, they were instructed to remain close to the cone and wait for the signal.

The subjects were monitored at rest, immediately after the testing and on the fourth minute of passive recovery. The monitored variables were heart rate (HR) using a cardiofrequencimeter (Polar®, RS800 CX), blood pressure (BP) by auscultation, oxygen saturation pulse (Portable oxymeter, Nonin® 8500A) and subjective sensation of dyspnea and LLF by the Borg scale.[16] In addition, the following cardiorespiratory and metabolic variables were recorded at rest, during the test and at the recovery period: minute ventilation (V_E), VO_2 peak (Maximum oxygen consumption in absolute value and corrected for body weight), VCO_2 (carbon dioxide production) and V_E/VCO_2 (ventilatory equivalent carbon dioxide). In addition, we selected for analysis of the variables mentioned in the paragraph above the highest values recorded in the last six seconds of the peak of all the tests. The maximum HR was calculated using the equation 220 - age (men) and 210 - age in years (women). The total distance was recorded in meters and the data of the second and third tests were used for reliability analysis. The percentage of walked distance during the ISWT (ISWTD) was

determined by the following predictive equation: [347.7 – (7.2 x age) - (3 x weight) + (472.3 x height) + (137.2 x gender)].[17]

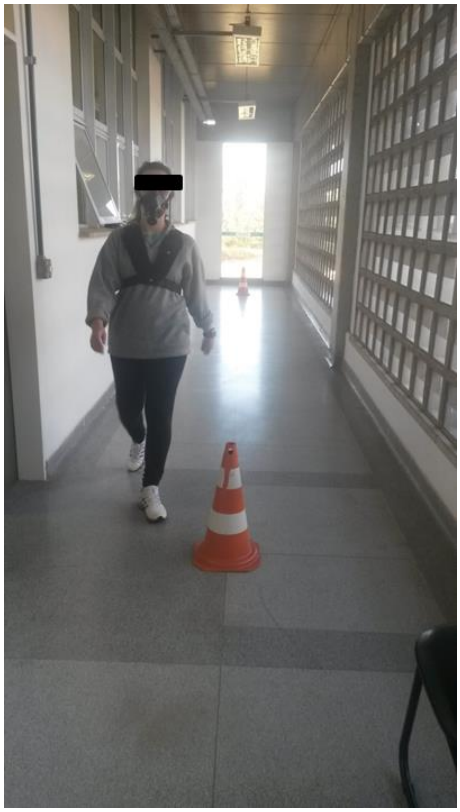

Figure 2: It illustrates the location and layout of the Incremental Shuttle Walking Test.

Spirometry

We performed the pulmonary function test using a portable ergoespirometry system (Oxycon Mobile®, Mijnhardt/Jäger, Würzburg, German). Slow vital capacity (SVC), forced vital capacity (FVC) and maximal voluntary ventilation (MVV) maneuvers were performed. Pre and post bronchodilator forced expiratory volume in the first second (FEV_1) and FEV_1/FVC were used to verify airway obstruction Technical procedures, acceptability and reliability criteria followed the guidelines of the American Thoracic Society/European Respiratory Society (ATS/ERS).[18] Spirometric indices were presented in absolute values and as a percentage of the reference values.[19]

Statistical Analysis

Approximately 19 asthmatic subjects were required as the minimum sample size to perform the proposed reliability analysis,[20] considering $\alpha<0.05$ and $\beta<0.2$, two tests as the number of repetitions, the null hypothesis as intraclass correlation coefficient (ICC) <0.7 and the expected hypothesis as ICC=0.9. In addition, a sample with 30 individuals to perform these analyzes is considered moderate and acceptable according to the COSMIN checklist (Consensus-based Standards for the selection of health status Measurement Instruments).[21] The expected ICC value was consistent with the ICC Mean value for the walked distance in ISWT verified in third studies that tested its reliability, which ranged from 0.80 to 0.99.[22–24]

The Shapiro-Wilk test was performed in order to verify the normality of data. Data were organized in tables and graphs. Moreover, they were presented as mean±standard deviation or median (interquartile range) for parametric variables and nonparametric respectively. The significance level was $p<0.05$ and the statistical program Statistical Package for Social Sciences (SPSS) for Windows, version 17.0 were used.

Firstly, we conducted a variance analysis comparing ISWTD, cardiorespiratory, metabolic and perceived exertion responses between the second and third ISWT using the t test paired or its corresponding nonparametric test, the Wilcoxon test.

To test the reliability we use the following analyzes: the ICC, and its results were classified as low reliability when values were less than 0.4, good reliability when values were between 0.4 and 0.75 and excellent when values were above 0.75.[25] Furthermore, we calculated the coefficient of variation (CV)[26] which is the standard deviation expressed as a percentage of the mean (CV = ISWTD / mean). The error analysis between the second and third test was conducted using the mean error and its 95% limits of agreement presented in a Bland-Altman plot expressed as a percentage of the mean (Error%: [(ISWT-3 –ISWT-2)/(ISWT-3 + ISWT-2)/2] x 100, the standard error of measurement (SEM) [SEM = SD x

√(1-ICC)], the minimal detectable difference (MDD) [MDD = 1.64 x √(2) x SEM] and the 95% confidence interval of the mean ISWTD by the formula [95% CI-mean = $ISWT_{(meters)}$ ± (SEM x 1,96 x √2)].[27]

RESULTS

The sample characteristics are shown in **Table 1.** The **figure 3** is a flowchart illustrating the number of individuals who were contacted, ineligible, excluded, with the final sample of 34 asthmatics (20 women). Medications received included short-acting β2-adrenergics (n = 13), long-acting β2-adrenergics (n = 8), anticholinergic (n = 2), inhaled corticosteroids (n = 1), oral corticosteroid (n = 1), theophylline (bronchodilator action) (n = 1), and nine subjects did not receive any type of medication.

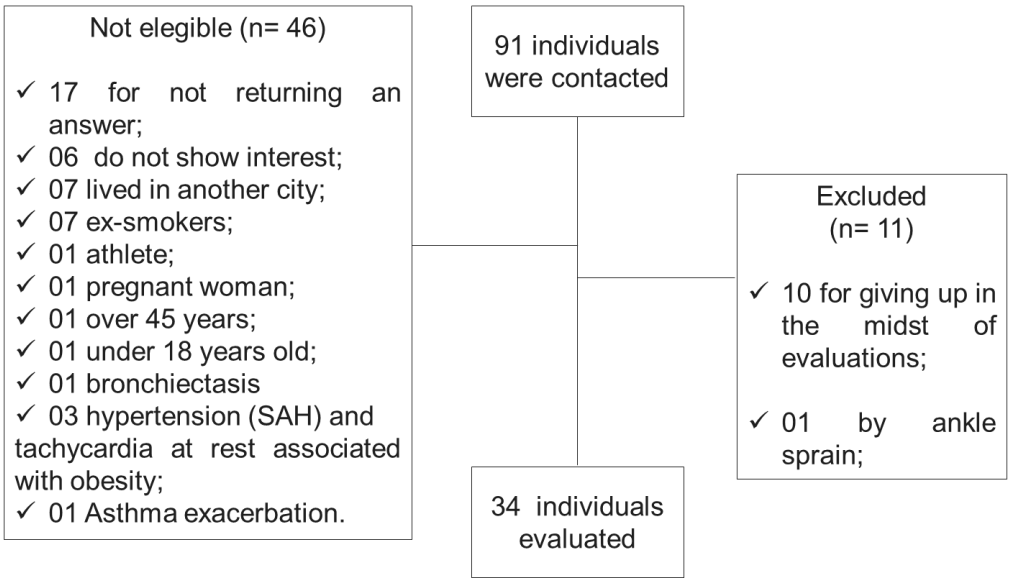

Figure 3: Study Flowchart.

Table 1: Demographic, anthropometric and spirometric characteristics of the assessed asthmatic subjects.

Characteristics	Asthmatic Subjects (N=34)
Age (years)	27 (24.0 – 38.3)
Height (cm)	1.69 (1.62 – 1.77)
Body Mass (kg)	72.7±14.7
BMI (Kg/m^2)	25.0 (21.7 – 29.4)
ISWTD (predicted, m)	762.0±102.8
FEV_1 pre-BD (l)	3.3±0.9
FEV_1 pre-BD (% predicted)	92.5±19.2
FEV_1 post-BD (l)	3.5±0.9
FEV_1 post-BD (% predicted)	97.4±16.6
FVC pre-BD (l)	5.1±1.4
FVC pre-BD (% predicted)	116.4 (95.1 – 127.1)
FEV_1/FVC pre-BD (% predicted)	71.8±18.5
FEV1/CVF post-BD (% predicted)	91.4 (83.2 – 100.6)
MVV (l)	102.0 (84.4 – 148.8)
MVV (% predicted)	71.8±18.5

Results expressed as mean ± SD or median (interquartile range). BMI: Body mass index; ISWTD: incremental shuttle Walking test distance; FVC: forced vital capacity, FEV_1: forced expiratory volume in the first second; MVV: Maximum voluntary ventilation; pre-BD: pre-bronchodilator; post-BD: post-bronchodilator.

ISWT was reliable to measure ISWTD in meters and some cardiorespiratory, metabolic and perception effort responses. The variables that presented ICC values greater than 0.75 (P<0.001) were walked distance, speed, absolute VO_2, VCO_2, VO_2 corrected by the body mass and V_E, which was classified as excellent reliability. Furthermore, some variables presented ICC values greater than 0.4 and lower than 0.75 (P<0.001), such as HR, dyspnea and lower limb fatigue, which is classified as good reliability **(Table 2).**

Table 2: Reliability Analysis for ISWTD, cardiorespiratory, metabolic and perceived exertion responses between the second and third Incremental Shuttle Walking Test.

Variables	ICC (95% CI)	*CV**
ISWTD, m	0.85 (0.72 – 0.82)	0.08
Speed, km/h	0.86 (0.74 – 0.93)	0.04
VO_2, ml min^{-1}	0.95 (0.89 – 0.97)	0.08
VCO_2, ml min^{-1}	0.94 (0.89 – 0.97)	0.10
VO_2, ml kg^{-1} min^{-1}	0.88 (0.76 – 0.94)	0.09
Ventilation, l min^{-1}	0.88 (0.77 – 0.94)	0.12
HR (bpm)	0.68 (0.45 – 0.83)	0.12
SD	0.48 (0.17 – 0.70)	0.46
LLF	0.62 (0.36 – 0.79)	0.44

ICC: Intra-class correlation coefficient; 95% CI: 95% confidence interval; *CV: Coefficient of variation; ISWTD; incremental shuttle walking test distance; VO_2, oxygen uptake; VCO_2, carbon dioxide production; VO_2, oxygen uptake; VCO_2, carbon dioxide production; HR: Heart rate; SD: Sensation of dyspnea; LLF: lower limbs fatigue.

Considering other reliability aspects, no significant difference between the ISWTD on the ISWT-2 and ISWT-3 and between the percentage of predicted ISWTD for ISWT-2 and ISWT-3 ($P>0.05$) were found. A statistically significant difference in heart rate at rest was verified, as well as for dyspnea at peak between ISWT-2 and ISWT-3, however, these results were clinically less relevant **(Table 3).**

The walked distance in ISWT presented as error values DMD = 91.08 meters, SEM = 39.3 meters. On mean, subjects walked 541.7 m (95% CI 432.8 to 650.6) in ISWT-2 and 540.0 m (95% CI 431.1 to 648.9) in ISWT-3. In the Bland Altman plot expressed as a percentage of the mean the ISWTD showed a mean error in the test-retest comparison of 0.03% m with limits of agreement of -23.0% m to 23.1% m. This indicates that in the retest, 95% of subjects should be able to walk a distance ranging from less 23.0% to more 23.1%, than ISWT-2 **(Figure 4).**

Table 3: Comparative assessment of the second and third Incremental Shuttle Walking Test (ISWT-2 and ISWT-3) for ISWTD, cardiorespiratory and metabolic responses and perceived exertion.

Variables	ISWT-2	ISWT-3	*P*
ISWTD, m	541.7 ± 102.5	540.0 ± 101.9	0.90
ISWTD% predict,%	71.0 ± 10.1	70.8 ± 8.9	0.88
Speed, km/h	6.1 (5.5 – 6.7)	6.1 (5.5 – 6.7)	0.51
VO_2, ml min^{-1}	1870.8 ± 552.9	1849.3 ± 556.4	0.50
VCO_2, ml min^{-1}	1933.4 ± 607.9	1920.2 ± 703.7	0.63
VO_2, ml kg^{-1} min^{-1}	25.9 ± 5.9	25.3 ± 7.0	0.28
Ventilation, l min^{-1}	61.1 ± 17.5	61.6 ± 21.9	0.97
Heart rate rest, bpm	86.2 ± 12.1	82,4 ± 12.0*	0.05
Heart rate peak, bpm	151.9 ± 21.2	148.2 ± 23.8	0.24
Heart rate max, predict, %	83.9 ± 10.7	81.1 ± 1	0.13
SD rest	0.0 (0.0 – 0.0)	0.0 (0.0 – 0.5)	0.30
SD peak	2.0 (0.9 – 3.0)	2.8 (1.0 – 3.3)ǂ	0.04
LLF rest	0.0 (0.0 – 0.0)	0.0 (0.0 – 0.0)	0.45
LLF peak	2.5 (1.0 – 3.5)	2.5 (0.5 – 5.0)	0.21

Results expressed as mean ± SD or median (interquartile range). ISWTD: incremental shuttle Walking test distance; VO_2: oxygen uptake; VCO_2: carbon dioxide production; HR: Heart rate; SD: Sensation of dyspnea; LLF: lower limbs fatigue. *: different compared to the mean value of the ISWT-2 by the paired *t* de *Student* ($p \leq 0.05$); ǂ: different compared to the median value of the ISWT-2 by the Wilcoxon test ($p \leq 0.05$).

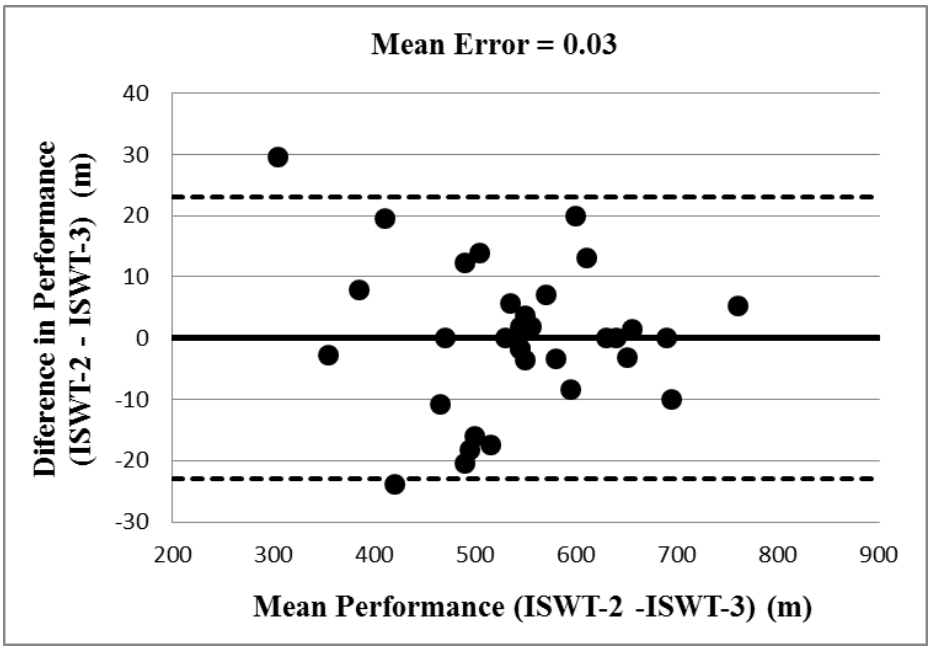

Figure 4: Reliability by Bland-Altman plot for asthmatic subjects. Performance expressed as percentage of the mean (walking distance) in meters between the second and third ISWT. ISWT-2: Second Incremental Shuttle Walking Test; ISWT-3: Third Incremental Shuttle Walking Test; Bias: Mean differences between the means.

The mean error and the limits of agreement by Bland Altman plot for heart rate, VO_2 corrected for body mass, sensation of dyspnea and perceived exertion in the lower limbs at the peak of ISWT-2 and ISWT-3 are shown in **(Figure 5)**.

HR at the peak of ISWT was in Mean 151.9 bpm (95% CI 116.6 to 187.2) in ISWT-2 and 148.2 bpm (95% CI 113.0 to 183.5) in ISWT-3. A mean error expressed in percentage of -5.7 bpm with limits of agreement -46.8 to 35.3 bpm was found, namely, it indicates that in the retest, 95% of subjects who underwent ISWT, will present a mean LLF value in a range of 46.8 lower to 35.3 higher than the mean ISWT-2 HR.

Regarding the VO_2 peak in ISWT, its Mean value was 25.9 ml/kg/min (95% CI: 19.7 to 32.1) in ISWT-2 and 25.3 ml kg/min (95% CI: 19. 1 to 31.5) in ISWT-3. A mean error expressed in percentage of -3.9 ml kg^{-1} min^{-1} in percentage with limits of agreement of -37.8

to 30.1 ml kg^{-1} min^{-1} was found, which indicates that in the retest, 95% of subjects who underwent ISWT, will present a man VO_2 value in a range of 37.8 ml kg/min lower to 30.1 ml kg/min higher than the mean ISWT-2 VO_2.

The SD peak ISWT was in mean of 2.0 (95% CI: -1.20 - 5.20) in ISWT-2 and 2.6 (95% CI: -0.60 - 5.80) in ISWT-3. A mean error expressed in percentage of 19.2 with limits of agreement of -156.2 to 194.7 was found, which indicates that in the retest, for 95% of subjects who underwent ISWT, it is expected that SD is assessed as 156.2 lower to 194.7 higher than the mean ISWT-2 SD.

Lastly, LLF at peak ISWT presented a mean value of 2.5 (95% CI: -1.09 - 6.09) in ISWT-2 and 2.9 (95% CI: -0.69 - 6.49) in ISWT-3. A mean error expressed in percentage of 5.4 with limits of agreement of -146.2 to 157.0 was found, which indicates that in the retest, 95% of subjects who underwent ISWT, will present a mean LLF value in a range of 146.2 lower to 157.0 higher than the ISWT-2 LLF.

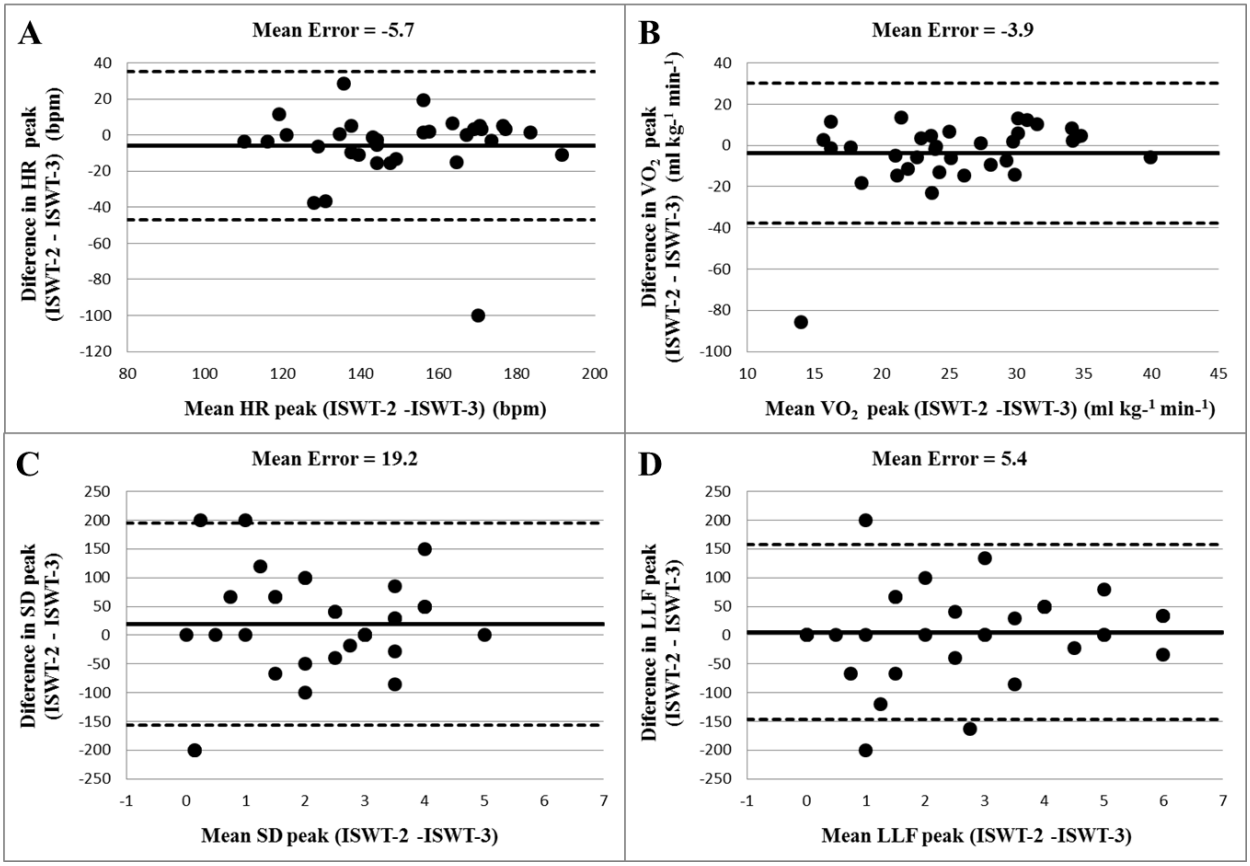

Figure 5: Reliability by Bland-Altman plot expressed as percentage of the mean for asthmatic subjects. A: HR peak for ISWT. B: VO_2 (ml kg-^{1} min-^{1}) peak for ISWT. C: SD peak for ISWT. D: LLF peak for ISWT.

ISWT-2: Second Incremental Shuttle Walk Test; ISWT-3: Third Incremental Shuttle Walk Test; Bias: Mean differences between the means.

DISCUSSION

The present study aimed to assess the test-retest ISWT values reliability, such as distance cardiorespiratory, metabolic and perceived exertion responses in asthma patients. Thus we find as outcomes that most of the assessed variables were highly reliable. ISWT has

been used to assess the exercise capacity of patients with COPD. In addition, there are several studies tested its reliability in other populations.[28–35]

However, our study was the first to test the ISWT reliability in asthmatic adults using as methods of analysis the ICC, SEM, DMD, CV and the mean error, with their limits of agreement by Bland-Altman. Only the study Dyer, et al[14] tested the ISWT reliability in elderly asthmatic, but their results were presented only by comparing means using an analysis of variance, and with a small sample.

The ISWT test-retest reliability presented ICC values higher than 0.75 for walked distance, which indicate excellent reliability. Third studies tested the test-retest reliability for walked distance in ISWT, and the ICC ranged between 0.80 to 0.99.[22–24] Thus, this confirms our study findings in other chronically ill populations. In this context, we can say that the ISWT is a reliable instrument to evaluate exercise capacity based on the results found in our study regarding the walked distance in the ISWT and the cardiorespiratory, metabolic and perceived exertion responses of controlled asthmatics.

Among the above mentioned studies, two conducted two tests, and of these, one was with an interval of 30 minutes between them,[23] other was carried out with an interval of 8 weeks between tests.[24] Other study[22] conducted three tests on different days, two tests on the same day with 30-minute interval, and the third test with an interval of 2 to 7 days.[22]

Furthermore, we found low CV values (0.08 or 8.0%), which indicates that the variability between means are homogeneous and dependent on the application method over time. One study verified the ISWT reliability in subjects with chronic heart failure[36] and found CV values similar to those found in our study (6.9).

However, the error value, which is another form of analysis to determine the reliability, was high in the test-retest analysis of the ISWT, since MDD was greater than the minimum clinically important difference 36.7m,[37] 47.5m.[38] When assessed by SEM, the

walked distance error (ISWTD) found by other authors was lower for one study (12m)[39] and higher for another one (109m)[40] when compared to our results.

PEPERA, et al[24] when studying subjects with clinically stable cardiovascular disease, found a mean error -7m with limits of agreement (Bland-Altman analysis) -203 to 189m. Hence the magnitude of these values 386m was higher than the ones found in the present study, which was 60.1m. Moreover, Jürgensen, et al[22] conducted a study with obese women and found a mean error of -5.9 with limits of agreement of -82.0 to 70.2m, and the values' amplitude were between them was 148.2m, which is higher than the value found by our study (60.1m).

Another study[23] conducted with subjects with bronchiectasis without cystic fibrosis found a mean error of -4.4m and limits of agreement between -57 to 48 m, which were lower values than those found in our study. Furthermore the tests were performed on the same day with 30-minute interval between them. Van Bloemendaal, et al[40] conducted a study with subjects after stroke and found a mean error of 27.4 error and limits of agreement -272.3 to 327.0m, however, the authors do not make clear how long was the time interval between tests.

Regarding the comparisomed by analysis of variance, there was no significant difference between test-retest for the ISWTD. Additionally, we found only one study[22] that found similar findings to our study and also performed the reliability analysis with a week as maximum interval.

The ISWT speed reliability was excellent (ICC=0.86), which was similar to the study Jürgensen, et al[22] that presented (ICC=0.84). In addition, the CV value was low (0.04 or 4.0%), indicating that the mean of the two measures are homogeneous, however, we were not able to find any other study that had conducted this analysis. Moreover, there was no statistically significant difference (p=0.50) in the comparison of the speed in the two tests, which was also similar to the study Jürgensen, et al[22] (p=0.85).

Regarding the cardiorespiratory responses during the ISWT, the HR presented good reliability (ICC=0.68). However, Camargo, et al[23] found excellent values test-retest reliability (ICC=0.92). Nevertheless, in that study, the tests were performed on the same day, different from the experimental procedure of our study. The found CV value in the present study was low (0.12 or 12.0%), which indicates low dispersion of the mean. Thus, our results were homogeneous. Green, et al[36] also found low CV values (5.2%).

We found a HR mean error value of -5.7 bpm, which is close to zero, and limits of agreement ranging from -46.8 to 35.3 bpm. These values, were similar to other two studies[22,41] which found a mean error closer to zero and lower limits of agreement compared to our results. However, the distribution of measures was similar to our study since heterogeneity of the data was also found. Moreover, the expected HR was in a range of 110-190 bpm, which is similar to the one found by Jürgensen, et al[22] (120 a 180 bpm), but was different from the one of Booth & Adams[41] (80 to 140 bpm). In addition, in the present study, the distributions occurred within acceptable limits of variation, which allows us to state that the two measures showed similar behavior, and therefore, are reliable.

The subjective feeling of SD during the ISWT presented moderate reliability (ICC = 0.48), however, the value of the CV was high (0.46 or 46.0%), which indicates that the variability between the measurements was higher than the acceptable. Moreover, no studies were found that had assessed the reliability of this measure. The test-retest comparison between the means revealed no significant difference (p=0.88) between them, which agrees with the findings of other study (p=0.38).[36] Regarding the mean error, we find a value fairly far from zero (19.2%), and the agreement limits were high ranged from -156.2 to 194.7, so we can say that the two measures did not agree among themselves, in other words, they were not reliable, since the individuals presented a higher SD in ISWT-3 than ISWT- 2, but the

distributions occurred within acceptable limits of variation, except for one of the points that is close to the acceptable lower limit.

The subjective LLF report showed moderate reliability (ICC=0.62), but the CV values were high (0.44 or 44.0%), which indicates a high variability between the measurements, which was different of another study[36] that found low value (4.5%). However, the test-retest comparison between means verified no significant difference for rest and peak LLF. In the agreement analysis, we found a mean error close to zero (5.4%) and the limits of agreement were high, ranging from -146.2 to 157.0, but the distributions occurred within acceptable limits of variation except one point that is near the acceptable upper limit and two points that are close to the acceptable lower limit. However, there is a lack of studies that have already assessed this variable reliability during the ISWT.

Regarding the metabolic variables, VO2 (ml kg^{-1} min^{-1}) had excellent reliability (ICC=0.88) in the test-retest comparison, similar to the study of Jürgensen, et al[22] (ICC=0.90). Moreover, the CV value was low (0.09 or 9.0%), which indicates homogeneity of the measures. About the analysis variance there was no significant difference (p = 0.28), which was also similar to the study that was previously cited (p = 0.86). Furthermore, we found a mean error close to zero (-3.9%), indicating that measures agree one with each other, and the limits of agreement were low ranging from -37.8 to 30.1 and although our Bland Altman has been plotted by percentage, we believe that our results were similar to those found by Jürgensen, et al[22] (mean error=-0.5 and limits of agreement = -4.5 to 3.5) in terms of interpretation. Nonetheless, in present study the distributions occurred within acceptable limits of variation, except one point that is below the acceptable lower limit, showing that the two measures have similar results.

The VO_2 **(**ml/min^{-1}) during the ISWT showed excellent reliability (ICC=0.95), which was similar to the study Jürgensen, et al[22] (ICC=0.89), and the CV value was low (0.08 or

8.0%) indicating homogeneity between measurements. As for VCO_2 **(**ml/min^{-1}) the reliability was also excellent (ICC = 0.94) and also similar to that study[22] (ICC = 0.86). In addition, the measures were homogeneous since CV was low (0.10 or 10.0%). Regarding the ventilation ($l\ min^{-1}$) the reliability was also excellent (ICC = 0.88), which was similar to the above cited study[22] (ICC = 0.77). Additionally, CV value was low (0.12 or 12.0%), which indicates that the measures were homogeneous. Lastly, the comparison of the means presented no statistically significant differences between test-retest for any of the above mentioned measures (p=0:50; p=0.63; p=0.97) respectively. This was similar to the findings of Jürgensen, et al[22] (p=0.60; p=0.62; p=0.33).

Thus, the clinical relevance of our results is clear, since it presents that walked distance, cardiorespiratory, metabolic and perceived exertion responses were reliable during ISWT the test retest analysis. However, we assume that the tests may be compared after one week interval. Moreover, the strong point of our study was testing the ISWTD, the cardiorespiratory, metabolic and perceived exertion responses reliability during the ISWT in adult asthmatic, which, in our knowledge, was the first time it was done.

Study Limitations

We find difficulty comparing our results with other findings, because some studies conducted two ISWTs with 30-minute intervals, but our experimental procedure did not allow two tests to be conducted on the same day, because we could not predict whether the first test would trigger the exercise-induced bronchospasm (EIB).

CONCLUSION

The ISWT presented excellent reliability for walked distance and for metabolic responses. Nevertheless, cardiorespiratory responses and perceived exertion presented moderate to excellent reliability. Thus, we conclude that the ISWT presented test-retest reliability in young adults with controlled asthma.

ACKNOWLEDGMENTS

The authors thank all the subjects who participated in this study and therefore contributed to that this was closed of the best possible way. We are also very grateful for the contributions made by Juliano Ferreira Arcuri.

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ESTUDO II

Is Incremental Shuttle Walking Test Reliable and Valid to Detect Exercise-Induced Bronchospasm in Adult Asthmatics?

Manuscrito submetido ao periódico Brazilian Journal of Physical Therapy. (Anexo III).

ABSTRACT

Background: Exercise-induced bronchospasm (EIB) presents an elevated prevalence in asthmatic patients. Its diagnosis is done considering the clinical history and EIB-inducing exercise tests. Nevertheless, EIB assessment reliability and validity by the Incremental Shuttle Walk Test (ISWT) has not been assessed yet. **Objective:** To verify the EIB assessment reliability and validity using the ISWT in young adults with controlled asthma. **Methods:** 32 individuals with asthma diagnosis were enrolled in the study. An incremental cardiopulmonary exercise test (ICPET) was conducted, followed by a constant cardiopulmonary exercise test (CCPET) after 48 hour. Three ISWTs were conducted by the same assessor, with between tests interval time varying from 48h to a week. **Results:** EIB detection reliability was considered weak ($k=0.24$; $p>0.169$). The validity analysis revealed a weak value between the ISWT-2 and the CCPET ($k=0.059$; $p>0.618$) and a moderate value between the ISWT-3 and the CCPET ($r=0.51$; $p<0.01$). When analysing the physiologic responses we found a significant difference in the time with ventilation above the 40% of the maximum voluntary ventilation (MVV) inter-tests in the positive EIB and negative EIB between the ISWT-2 and ISWT-3 vs. CCPET ($p=0.000$ e $p=0.000$). Moreover, there was a difference in the moment when the V_E> 40%MVV was achieved during the tests in the positive EIB group between the ISWT-2 vs CCPET and ISWT-3 vs CCPET ($p=0.000$; $p=0.000$) and in the negative EIB group between the ISWT-2 vs CCPET and ISWT-3 vs CCPET ($p=0.044$; $p=0.028$). **Conclusion:** We conclude that the ISWT was not reliable and valid to assess EIB in young adults with controlled asthma.

Key Words: Exercise test, reproducibility, validity, asthma exercise-induced, walking.

INTRODUCTION

Asthma is a chronic respiratory condition, which affects 1-18% of the population of different countries and is characterized as wheezing, breathlessness, chest tightness and/or cough symptoms. Moreover, asthma presents varied airflow limitation[1]. Thus, asthmatic individuals may present lower exercise tolerance due to factors such as diminished ventilator capacity, increased dyspnea and the occurrence of exercise-induced bronchospasm (EIB), which determine early exercise interruption and a sedentary life-style[2,3].

Around 90% of the asthmatic individuals suffer with EIB, who are mostly young-adult athletes, and 10% of EIB occurrences affect individuals without asthma diagnosis[4]. Airways narrowing and their increased resistance during and after the exercises may be a result of a low airway's humidity, causing a hyperosmolar environment, which releases cellular mediators. Nevertheless, regular exercise is known to reduce the systemic inflammatory state Hence, it potentially improves exercise capacity and quality of life[5].

Therefore, objective measures are necessary to determine EIB occurrences, aiming at assessment and exercise-prescription improvements in an exercise program fitted to individual limitations and the severity of the disease[2]. The use of the incremental (ICPET) and constant cardiopulmonary exercise tests (CCPET) are indicated to assess this condition, since they are valid and reliable in EIB detection[6].

Nevertheless, these tests present high cost and demand a specialized team, and an alternative would be the use of a walk test with controlled and progressive speed, such as the Incremental Shuttle Walk Test (ISWT), since it leads to a symptom limited maximum response and was created to assess exercise capacity of patients with chronic obstructive pulmonary disease (COPD)[7,8].

The ISWT is a reliable, valid and safe test to assess exercise capacity of individuals with diverse health conditions, especially respiratory diseases[9]. Additionally, ISWT was developed in an incremental protocol as a possible replacement of the symptom-limited maximum effort tests as well as presenting low cost, easy applicability and few equipments[10]. However, until this moment, there is a lack of studies testing the validity and reliability of the ISWT to detect EIB.

Thereafter, the aim of the present study was to assess the reliability and validity of EIB detection by the ISWT. Our hypothesis was that ISWT was reliable in the test-retest analysis and valid to diagnose EIB in young adults with controlled asthma.

METHOD

Individuals and Study Design

This was an observational cross-sectional study, conducted in the Spirometry and Respiratory Physiotherapy Laboratory and in the Cardiopulmonary Rehabilitation Laboratory. This study had as purpose to verify the clinimetrics characteristics (reliability and validity) of the ISWT in assessing EIB occurrence.

32 asthmatic individuals (men and women) were included in the study with their age ranging from 18-45 years. The enrolment period was from March 2012 to December 2015 and they were contacted by advertisements on the university, local radio, television and newspapers. The contact was established using telephone and email, and if they met the inclusion criteria they were invited to participate in the study.

Individuals were considered apt to participate in the study when (1) they presented clinical and spirometric asthma diagnosis, and classified as symptom controlled and without exacerbation risk factors according to the criteria established by the Global Initiative for Asthma[1]; (2) absence of exacerbation (non-scheduled medical visit) during the past three weeks before their inclusion[11], and with a regular follow-up with a pneumologist; (3) they were not current or previous smokers and did not present pregnancy or skeletal muscle, neurologic, arterial, renal, hepatic disorders, as well as diabetes mellitus with diabetic neuropathy. Moreover, the individuals were excluded when were drug users or the ones who presented other respiratory, metabolic or cardiovascular diseases that could lead to dyspnea during effort; those individuals who presented any contraindications to undergo a cardiopulmonary exercise test[6], as well as the individuals who presented comprehension and adherence difficulties. The study was approved by the university ethics committee (n 018/2012).

Experimental Procedure

The asthmatic individuals underwent a five-day assessment (Figure 1), with a minimum interval of 48h between the first and second day. In the first day, clinical, physiotherapy assessments, pulmonary function test and a familiarization first ISWT were conducted. Moreover, they received instructions to avoid drink caffeinated beverages, do not

perform physical activities and to have light meals and have an eight-hour sleep in the day prior to the test. Furthermore, short action bronchodilators were suspended six hours, and the long-actions bronchodilators were suspended 12 hours prior to the tests, since they were also assessed regarding the heart rate variability, which was published by our group elsewhere[12]. In the second day the individuals underwent an ICPET and after an interval (minimum 48 hours – maximum a week) they performed a CCPET in the third day. In the fourth day patients performed a second ISWT and after an interval (minimum 48 hours – maximum a week) the individuals performed a third ISWT (figure1).

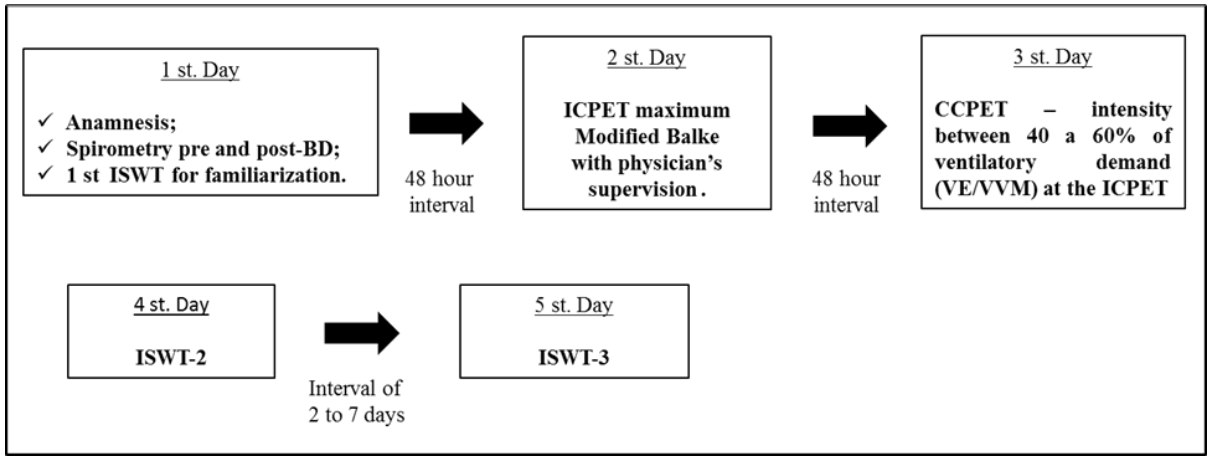

Figure 1. Experimental procedure timeline

Post-BD: post bronchodilatador; ISWT-2: second incremental Shuttle Walking Test; ISWT-3: third incremental Shuttle Walking Test; ICPET: incremental cardiopulmonary exercise test; VE/MVV: ventilator demand; CCPET: constant cardiopulmonary exercise test.

Pulmonary function test

We conducted the pulmonary function tests according to the recommendations American Thoracic Society/European Respiratory Society guideline[13] using a portable ergospirometric system (Oxycon Mobile®, Mijnhardt/Jäger, Würzburg, German) with oronasal mask **(Figure 2. A and 2. B)**. Slow vital capacity (SVC), forced vital capacity (FVC) and maximum voluntary ventilation (MVV) manoeuvres were performed to determine the pre and post bronchodilator forced expiratory volume in the first second (FEV_1) and FEV_1/FVC ration and the MVV. The spirometric values were presented in absolute and percentage of the predicted values[14]. Individuals also performed three acceptable FVC manoeuvres before each exercise test and after the 5^{th}, 10^{th}, 15^{th}, 20^{th}, 30^{th} recovery minute.

An EIB occurrence was considered positive when there was at least a 10% decrease on the after test FEV_1 baseline values[6].

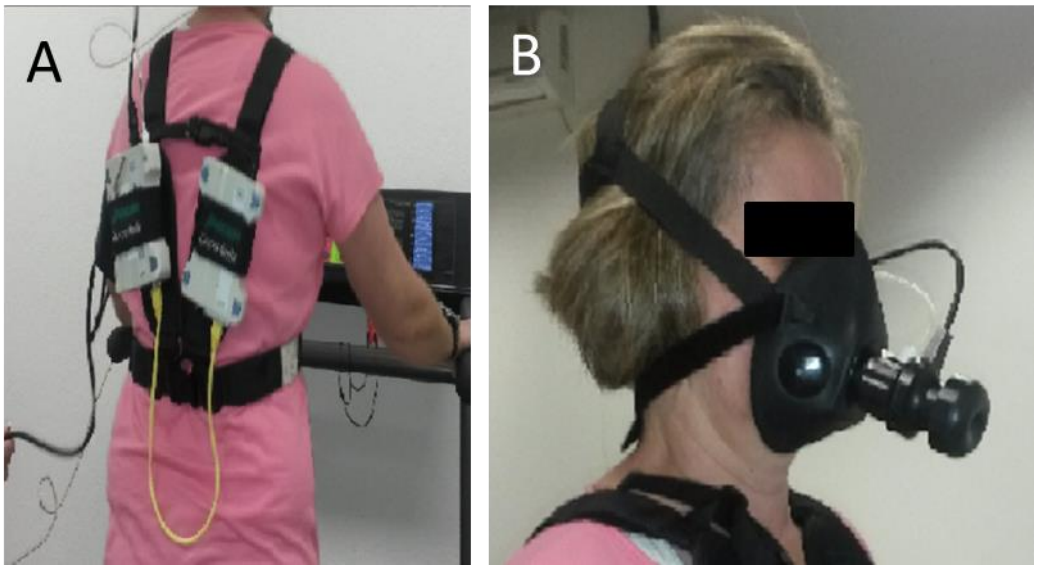

Figure 2. A: Portable ergospirometry system for cardiopulmonary testing. **B:** Oronasal mask as interface.

Incremental Shuttle Walk Test (ISWT)

The ISWT was conducted according to Singh et al.[7] **(Figure 3)**. The physiological responses were monitored at rest, immediately after the test and in the fourth passive-recovery minute. The assessed responses were heart rate (HR) using a cardiofrequencimeter, systolic and diastolic blood pressure (SBP and DBP) by auscultatory method, pulse oximetry was obtained by a pulse oximeter, subjective dyspnea (SD) and lower limb fatigue (LLF) was assessed by the Borg CR-10 scale[16] In order to perform the reliability and validity analysis, the EIB determination using the change on FEV_1 was assessed in the second and third test. The first ISWT was used to diminish the learning effect.

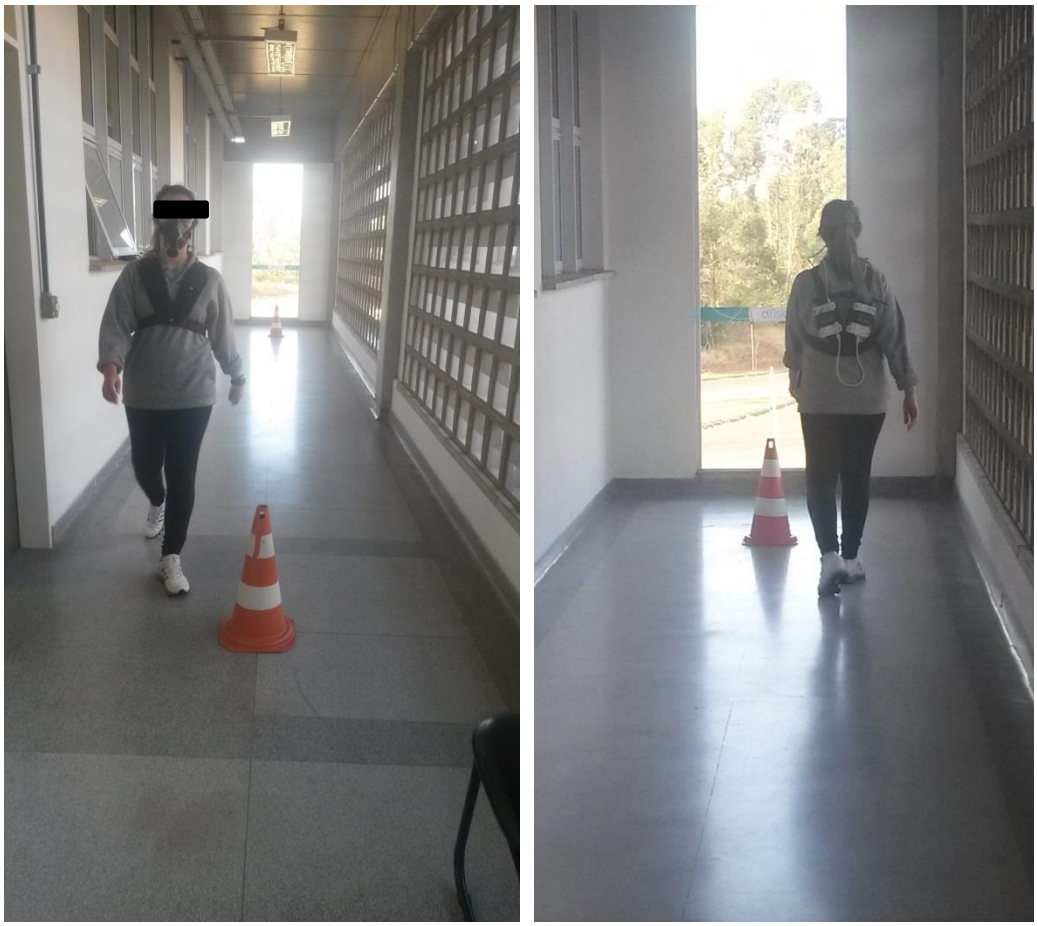

Figure 3: It illustrates the location and layout of the Incremental Shuttle Walking Test.

Incremental Cardiopulmonary Exercise Test (ICPET)

The ICPET was conducted in a treadmill (Inbrasport ATL, Inbramed, Porto Alegre, RS, Brazil) by a physiotherapist and a physician. The individuals were instructed to walk in the speed and inclination determined by the assessor according to the Modified Balke Protocol[6,15]. After the fourth minute of the test, the treadmill speed was maintained constant and the inclination was increased 2% each two minutes **(Figure 4)**. The individuals were familiarized with the treadmill and the Borg scale prior to the test. The test was interrupted in the appearance of limiting symptoms, such as LLF, general tiredness, dizziness, nausea, cyanosis, arrhythmia, angina, oximetry lower than 90% or reaching the maximum predicted HR.

During the test, the individuals were monitored by an electrocardiogram using CM5, modified DII and V2 leads; HR; SBP; DBP; pulse oximetry; SD and LLF. These variables were monitored at rest, each three minutes during the test, immediately after the test and at the first active recovery minute and at the fourth passive recovery minute.

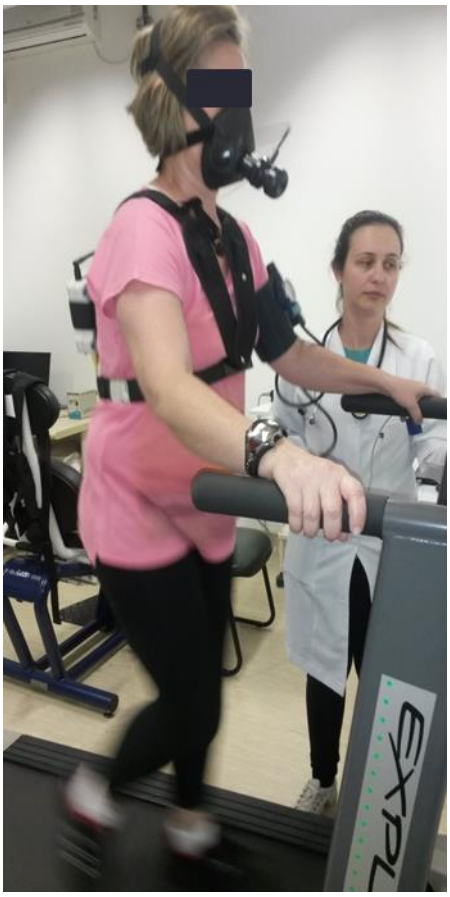

Figure 4: Illustrates the incremental cardiopulmonary exercise test on the treadmill.

Constant Cardiopulmonary Exercise Test (CCPET)

This test was conducted aiming to detect EIB by a physiotherapist. The individuals were instructed to walk in the treadmill according the specific constant workload protocol to assess EIB[7,18] **(Figure 5)**. The intensity of the CCPET was determined maximum workload achieved in the ICPET using the ventilatory demand (VE/MVV) between 40% and 60%. The test was sustained during 4-6 minutes in the pre-determined load (with a total test time of 7-9 minutes), thus the determined load was gradually introduced in a 3 minutes period. The

interruption and the cardiorespiratory-variable monitoring were the same as the ICPET, except for the electrocardiogram.

The ICPET and the CCPET were conducted in a controlled environment[18], while the ISWT was conducted without environmental control. A portable ergospirometric systems was used in all exercise tests (Oxycon Mobile®, Mijnhardt/Jäger, Würzburg, German) to obtain the minute ventilation (V_E), oxygen consumption (VO_2) and carbon dioxide production (VCO_2) breath-by-breath, during the period of the test, including the register in the moment of each load increment and at recovery time.

Figure 5: Illustrates the constant cardiopulmonary exercise test on the treadmill.

Statistical Analysis

Regarding the reliability analysis, an α: 0.05, a power (1- β error): 0.80 and one as liberty degree were considered to verify the sample size. A critical value of χ^2 =3.84 and a noncentrality parameter λ of 7.84 was found. Thereafter, if we had found a χ^2 higher than the

critical value, this condition indicated that the sample size was sufficient. The statistical package software used was the GPower 3.1. Moreover, a sample with 30 individuals was considered a moderate sample size, which was fair assessed by the COSMIN checklist (Consensus-based Standards for the selection of health status Measurement Instruments)[19].

The Shapiro-Wilk test was used to assess the normality of the data. The descriptive statistics were conducted to characterize the sample, in which the data was expressed as mean±standard deviation or median (25-75% interquartilic range) for the parametric and non-parametric data, respectively. The adopted significance level was $p<0.05$, and the statistical software used was the *Statistical Package for the Social Sciences* (IBM SPSS) for Windows, version 23.0.

An intra-test comparison (ISWT2, ISWT3 e CCPET) between the individuals with positive and negative EIB was performed to compare the physiological responses using the independent T Student test and its corresponding non-parametric test, the Mann-Whitney test. In the inter-tests analysis (ISWT2 vs ISWT3, ISWT2 vs CCPET and ISWT3 vs CCPET), for the individuals with positive EIB and negative EIB, the ANOVA One-way with *post hoc* de Scheffe, and its non-parametric equivalent (Kruskal-Wallis test) was used for the comparison of the physiologic responses.

Comparisons between the proportions of EIB detection found in the second Incremental Shuttle Walk Test (ISWT-2) and the third Incremental Shuttle Walk test (ISWT-3), in the ISWT-2 and the CCPET and in the ISWT-3 and CCPET were done. The differences were assessed by the Chi squared test (χ^2), using the FEV_1 decrease as a dichotomized variable (10% decrease of the absolute FEV_1 value) in positive and negative EIB occurrence.
In addition, the kappa coefficient was used to assess the agreement level to detect EIB and assess the test-retest agreement, which was classified as weak (0.0-0.2), reasonable (0.21-0.4), moderate (0.41-0.6), substantial (0.61-0.8) and almost perfect (0.81-1)[20].

The validation to detect EIB was verified using the concurrent criteria validity. In order to do so, Spearman correlation coefficient was used to verify the association between the highest level of FEV_1 decrease on ISWT and on CCPET[21,22]. The classification of this coefficient adopted the criteria $r>0.7$ as indicating validity[23].

RESULTS

The general sample characteristics are in **table 1**. The **figure 6** is a flowchart illustrating the number of individuals who were contacted, ineligible, excluded, with the final sample of 32 asthmatics (19 women).

The asthmatic individuals reported at least two day symptoms per week, used the medication only to relieve symptoms, except for two individuals who did a profilatic drug treatment. Moreover, they were not limited during light effort, did not present night symptoms and had normal spirometric values. The drug treatment they received were short-acting β_2-adrenergic (n=11), long-acting β_2-adrenergic (n=7), anticholinergic (n=2), inhaled corticoid (n=16), nasal corticoid (n=3), anti-histaminic (n=1), oral corticoid (n=1) and nine individuals had not undergone in any drug treatments.

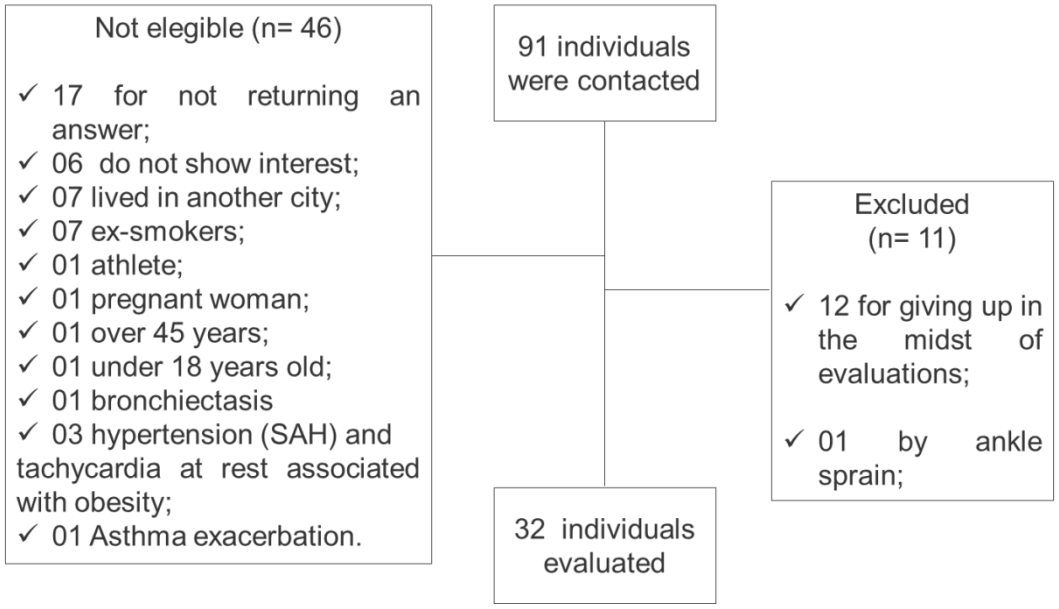

Figure 6: Study Flowchart.

Table 1: Demographic, anthropometric, exercise capacity and spirometric characteristics the total sample and the individuals with positive EIB and negative EIB in the CCPET*.

	TECPC		
Characteristics	**Total sample (n=32)**	**Positive EIB (n=24)**	**Negative EIB (n=08)**
Age, years	31.1±8.8	29.0±8.1	35.5±9.3
Height, m	1.69±0.0	1.69±0.1	1.71±0.1
Weight, kg	72.7±14.7	71.1±15.2	75.4±13.9
BMI, kg/m^2	25.2±4.0	24.9±4.3	25.7±3.6
FEV_1 pre-BD (% predicted)	92.5±19.2	90.3±19.1	103.0±15.5
FEV_1 post-BD (% predicted)	97.4±16.6	98.0±15.3	102.3±14.8
FEV_1/FVC post-BD (%)	87.1±17.9	88.7±15.4	87.1±15.7
MVV (l/min)	115.6±39.7	113.6±35.4	122.6±50.0
Δ FEV_1 % CCPET	13.3±10.6	17.0±8.9†	2.0±6.8

*Data was expressed as mean ± SD; BMI: body-mass index; CCPET: constant cardiopulmonary exercise test; ICPET: incremental cardiopulmonary exercise test; FVC: forced vital capacity; FEV_1: Forced expiratory volume in the first second; MVV: maximum voluntary ventilation; pre-BD: pre-bronchodilator; post-BD: post-bronchodilator; Δ FEV1 % CCPET: highest decrease of the FEV_1 in percentage of the absolute value in the CCPET; †: difference compared the the median value of negative EIB group using the Mann-Whitney test ($p<0.05$).

Reliability tests of EIB provoking

Twenty one individuals (65.6%) presented EIB in the ISWT-2 or ISWT-3. Among them, eight presented EIB in both tests [$\chi^2 = 1.05$; $\kappa = 0.18$ $p > 0.305$, with (95%CI -0.160 – 0.522)] presenting reasonable agreement **(Table 2)**. Six individuals presented EIB only after the ISWT-2 and seven only after the ISWT-3.

Table 2: Test-retest reliability of EIB occurrence (10% decrease on post-test FEV_1 compared to pre-test) after the ISWT-2 and ISWT-3.

	ISWT-3		
ISWT-2	Positive EIB	Negative EIB	Total
Positive EIB	8*	6	14
Negative EIB	7	11*	18
Total	15	17	32

*Kappa, 0.18 ($p>0.305$).

ISWT-2 and ISWT-3 performance in detecting EIB

Twenty six individuals (79.4%) presented EIB on the ISWT-2 or CCPET. EIB was detected in both tests in 11 individuals [χ^2 = 0.17; κ = 0.059 p > 0.681, (95CI% -0.218 – 0.336)], which was classified as weak agreement. Thirteen individuals only presented EIB after the CCPET and three only after the ISWT-2.

A total of twenty four individuals (70.5%) presented EIB on ISWT-3 or CCPET. EIB was detected in both tests in 15 individuals [χ2 = 9.41; κ = 0.46 p <0.002 (95%IC 0.201 – 0.708)], which was classified as moderate agreement. Among the disagreements, nine individuals presented EIB only after the CCPET **(Table 3)**.

The absolute values of the highest decrease of the FEV_1 presented a positive moderate correlation between the ISWT-3 and the CCPET (r=0.51; p<0.01).

Table 3: Inter-tests agreement on EIB detection (10% decrease on post-test FEV_1 compared to pre-test) between ISWT-2 and CCPET and between ISWT-3 and CCPET.

	CCPET		
ISWT-2	Positive EIB	Negative EIB	Total
Positive EIB	11*	3	14
Negative EIB	13	5*	18
Total	24	8	32
ISWT-3			
Positive EIB	15†	0	15
Negative EIB	9	8†	17
Total	24	8	32

*Kappa, 0.059 (p>0.681).

†Kappa, 0.46 (p < 0.002).

Physiological responses in the different exercise tests

A significant statistical difference was found for the period of time with VE > 40% of the MVV in both positive EIB and negative EIB in the comparisons ISWT-2 vs CCPET and

ISWT-3 vs CCPET (p=0.000; p=0.000 respectively). Furthermore, a difference was also found in the moment when VE/VVM reached a value above 40% in positive EIB for the comparisons ISWT-2 vs CCPET and ISWT-3 vs CCPET (p=0.000; p=0.000 respectively) and in the negative EIB group for the comparisons ISWT-2 vs CCPET and ISWT-3 vs CCPET (p=0.044; p=0.028 respectively). Additionally, a significant difference was found for the respiratory rate in positive EIB group between the ISWT-3 and the CCPET (p=0.010). Absolute and weight-corrected VO_2 behaviour showed similar exercise intensity between ISWT-2, ISWT-3 and CCPET. Lastly, the tests increased HR in a similar way, reaching up to 80% of the maximum predicted HR **(Table 4)**.

Table 4: Physiologic responses on peak ISWT-2, ISWT-3 and CCPET with asthmatic individuals grouped by the presence or absence of EIB (10% decrease on post-test FEV1 compared to pre-test)*

Variable	ISWT-2		ISWT-3		CCPET	
	Positive EIB (n = 14)	**Negative EIB (n = 18)**	**Positive EIB (n = 15)**	**Negative EIB (n = 17)**	**Positive EIB (n = 24)**	**Negative EIB (n = 8)**
Total time, min	7.9±0.9	8.2±0.8	8.1±0.9	8.1±1.02	10.8±1.4	10.9±1.3
Time with V_E >40% of MVV, min	1.4±1.4	1.3±1.3	1.4±1.1	1.0±1.2	5.2±2.6‡	5.5±2.5‡
Moment V_E>40% of MVV, min	6.5±1.2	6.2±1.6	6.0±1.3	6.4±1.7	4.2±1.4‡	4.3±1.8‡
VO_2, ml/min	1790.9±389.5	1903.3±631.2	1726.9±399.6	1933.3±685.6	1720.3±471.5	1876.4±629.5
VO_2, ml kg^{-1} min^{-1}	25.02±5.2	26.5±6.5	24.2±5.2	26.2±8.6	24.4±4.9	24.7±5.8
V_E, L/min	59.0±16.5	64.1±18.9	60.9±18.6	63.4±25.8	59.8±19.9	67.3±19.3
V_E/MVV, %	55.2±16.8	56.3±15.1	61.2±18.7	50.5±11.0	53.6±11.8	57.9±11.1
RR, rpm	35.6±7.9	38.8±7.9	41.0±5.7	35.6±9.2	34.1±6.2†	35.3±6.3
HR, % of predicted	81.9±10.6	86.0±10.9	83.0±11.2	79.3±12.2	82.2±19.6	87.4±13.7
WD, meters	527.9±95.9	567.8±88.4	544.7±89.7	546.5±109.7	----------	----------

*Data expressed as mean±SD; Time with VE >40% of MVV: period of time (in minutes) with ventilatory demand above 40% of the maximum voluntary ventilation; Moment VE>40% of MVV: moment when ventilatory demand started being above 40% of the maximum voluntary ventilation; VO_2: Absolute and weight-corrected oxygen consumption; V_E: minute ventilation; V_E/MVV ventilator demand; RR: respiratory rate; %HR: percentage of the predicted heart rate; WD: walked distance; † difference when compared to the mean ISWT-3 (ANOVA one-way test) ($p<0.05$); ‡:difference when compared to the median value of the ISWT-2 and ISWT-3 for positive EIB and negative EIB (Kruskal-Wallis test).

DISCUSSION

Our study was the first to test the test-retest reliability and validity of the ISWT for the EIB detection (10% decrease on post-test FEV_1 compared to pre-test). We found only a study[24] which assessed the reliability and the clinical role in assessing EIB of an incremental workload test (IWT) using as a standard a constant workload test (CWT), both conducted in ergometric bicycle. However, based in our results, we may affirm the ISWT was not reliable and valid to detect EIB.

EIB is a common clinical condition and contributes to a sedentary health style, social isolation and deficiency[25]. Therefore, the symptoms relieve is an important characteristic of most drugs available to asthma treatment, and there is great interest in the development of new therapeutic strategies to this condition[26]. Considering this context, we decided to assess the clinical role of the ISWT with the purpose to verify if this field test was as effective as the gold standard test to detect EIB presence.

In the reliability analysis, we found six individuals presented EIB after the ISWT-2 and seven presented this condition after the ISWT-3, of a total sample of 32 individuals. The reliability presented a kappa index of 0.18 ($p>0.305$), even though our post-test spirometric measures were executed following the necessary standards to EIB diagnosis using a cardiopulmonary exercise test (CPET).

In the validity analysis, we assumed the CCPET as standard test and, in this test, 24 individuals presented positive EIB. We verified 11 individuals presented positive EIB in the ISWT-2 and CCPET and 15 individuals in the ISWT-3 and CCPET. Hence, we found a weak value between the ISWT-2 and CCPET with a kappa index of 0.059 ($p>0.618$) and a moderate value between the ISWT-3 and CCPET with a kappa index of 0.46 ($p<0.002$). However, De Fuccio et al.[24] had as aim to assess if the IWT would be as effective as the CWT to determine EIB in susceptible individuals. They verified IWR presented similar results to detect EIB and was reliable, in comparison to the CWT.

Regarding the correlations results, we found a moderate value between the ISWT-3 and the CCPET considering the highest FEV_1 decrease ($r=0.051$, $p<0.01$). Nevertheless, in order to consider the ISWT as a valid test, an $r > 0.7$ was necessary[23].

Furthermore, in the present study, EIB was detected in three asthmatic individuals only in the ISWT-2. Taking this result into consideration, we infer the CCPET may not be the gold standard to detect EIB in these individuals. Thus, we suggest future studies should be conducted with the Endurance Shuttle Walking Test in an intensity to maintain the V_E/VVM > 40% in the ISWT, with a constant workload, aiming to investigate this test may be valid and reliable to detect EIB.

Moreover, some tests were developed to replace the exercise test to detect EIB. Some include dry-air voluntary hyperpnea and hyperosmotic inhaling (4.5% of physiological solution) or dry-powder mannitol. Nevertheless, none of this substitutes bronchoprovoking tests are completely sensitive and specific to EIB, but all of them had the utility to detect airways' hyperresponsiveness, which would be consistent to an EIB diagnosis[27].

In this context, a study verified mannitol, metacholine, exercise test and clinical diagnosis sensitivity and specificity to detect EIB in individuals with normal FEV_1, mild symptoms and hyperreactivity and the authors concluded all the methods were equivalent[28]. In addition, although there is no consensus about the exercise protocols described in literature, the available evidence indicates a specific exercise test (incremental or constant) should be conducted to an adequate EIB detection, since they allow the precise ventilator stress[6].

We verified, in the present study, all variables in table 4, presented similar behaviour in the comparisons between the positive EIB vs negative EIB (intra-test) for the ISWT-2, ISWT-3 and CCPET. An important issue stated in our study was the intensity of the tests lead to similar VO_2 on ISWT-2, ISWT-3 and CCPET. Moreover, the tests were capable of increasing similarly the HR to a value of 80% of the maximum predicted HR, which promoted a similar workload. Hence, this confirms the importance in assessing exercise capacity in controlled asthmatic adults.

On the inter-tests comparisons, to both positive EIB and negative EIB groups, we found a significant difference in the time of V_E/VVM > 40% on the CCPET when compared to ISWT-2 and ISWT-3 and a significant difference of respiratory rate in EIB positive group between ISWT-3 and CCPET.

All three tests were able to generate V_E/VVM > 40%, which is similar to what was found by De Fuccio et al.[24]. Nevertheless, the time with maintained V_E/VVM > 40% in the ISWTs were lower than two minutes for the time of maintained V_E/VVM > 40% on the

CCPET both to positive and negative EIB groups. De Fuccio et al.[24] affirmed that and quick-incremented test, which do not last more than 12 minutes may induce at least two high-intensity ventilation.

We also found a significant difference to the moment the V_E started being >40% during the tests, both in positive and negative EIB groups between the ISWT-2 vs CCPET and ISWT-3 and CCPET. Furthermore, as soon as they achieved V_E/VVM > 40%, all assessed individuals (except one man, who did not achieved a V_E/VVM > 40% during the ISWT-2 and ISWT-3), did not sustained constantly this V_E/VVM throughout the tests, and this condition was more evident during the ISWT-2 and ISWT-3.

Therefore, these results may be explained by the ISWT-speed increment characteristics that occurs every minute, corresponding to the test stage, since the first five levels do not impose a quick speed increment to generate a V_E/MVV > 40% to detect EIB. In the present study, we verified individuals reached the necessary V_E/VVM after the sixth ISWT stage of the tests.

Considering this situation, two studies affirm[27,29,30] the achieved and sustained V_E at a high level during exercise and the water content of inspired air are a primary determinant to identify EIB. Considering this, we believe the moment the V_E/VVM > 40% achieved, the non-sustentation of this ventilation for a minimum period of time during the tests, added to the fact that environmental conditions were not controlled were the contributors to ISWT validity and reliability were not acceptable to detect EIB.

RUNDELL et al.[31] assessed two running exercise modalities, one conducted in the a laboratory (LET) and other field exercise test (FET) and verified FET lasted for a range period of 1.5-60 minutes, and LET maintained a constant time of eight minutes. They considered the intensity (high ventilation ratios and not total ventilations during the test) and environmental conditions determined EIB occurance. Another study[27] also affirmed that the ideal EIB detection protocol involves a rapid exercise intensity increase, which should last for 2-4 minutes to achieve an elevated ventilation level.

Although our experimental procedure followed a rigorous standardization, we believe our study presented as limitation the fact that we did not assess EIB during the ICPET, since this test is also considered as gold standard to detect EIB. Because of that, we were not able to compare it with the ISWT. Additionally, we were not able to control temperature and humidity during the ISWT since it is a field test, even though it was conducted in a roofed corridor.

Nevertheless, although the ISWT did not present validity and reliability for detecting EIB, the obtained results regarding the other test variables do not diminish its role in the assessment of exercise capacity of asthmatic individuals. In addition, we believe that the ISWT can be considered an excellent instrument and a safe method to assess the exercise capacity of young adults with controlled asthma.

CONCLUSION

We conclude the ISWT was not reliable and valid to detect exercise-induced bronchospasm in young adults with controlled asthma.

ACKNOWLEDGMENTS

The authors thank all the individuals who participated in this study and therefore contributed to it. This work was funded by Fundação de Amparo à Pesquisa do Estado de São Paulo – FAPESP (grant nº 2011/23771-7) and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

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3. CONSIDERAÇOES FINAIS E DESDOBRAMENTOS FUTUROS

Embora o presente estudo não tenha comprovado a hipótese central do projeto maior, que foi avaliar a reprodutibilidade e validade do Incremental Shuttle Walking Test (ISWT) para detectar o broncoespasmo induzido pelo exercício (BIE) em adultos asmáticos, este trouxe importantes contribuições no que diz respeito à capacidade de exercício da população estudada.

Sendo assim, é importante considerar que: o ISWT e o Teste de Exercício Cardiopulmonar Constante (TECPC) apresentaram comportamentos semelhantes em termos de capacidade de exercício, ou seja, ambos os testes foram capazes de gerar uma mesma intensidade de exercício (VO_2) e estresse cardíaco (até 80% da frequência cardíaca máxima prevista) nos indivíduos avaliados nesse estudo, e com isso, pudemos concluir que o ISWT é um excelente método para avaliar a capacidade de exercício de adultos asmáticos controlados.

Diante destas considerações e questionamentos que ainda cercam o presente estudo, acreditamos que a continuidade do mesmo é extremamente válida. Assim futuros desdobramentos serão importantes:

Nesse contexto, sugerimos que estudos futuros sejam conduzidos com o Endurance Shuttle Walking Test (ESWT) em uma intensidade de exercício que faça com que o indivíduo mantenha uma demanda ventilatória > 40% da ventilação voluntária máxima (VVM) alcançada no ISWT e assim permitir avaliar se essa demanda ventilatória será alcançada e sustentada por um período de tempo de 4-6 minutos durante o ESWT, pois sabe-se que essas duas condições são determinantes primários para avaliar o BIE e com isso verificar se esse instrumento é confiável. Além disso, tendo o TECPC como teste padrão, avaliar se o ESWT é válido para detectar o BIE em indivíduos adultos asmáticos controlados.

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5. ANEXOS

ANEXO I

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Parecer Nº. 018/2012

CAAE: 0203.0.135.000-11
Título do projeto: AVALIAÇÃO DA REPRODUTIBILIDADE E DA VALIDADE DO TESTE DE CAMINHADA COM VELOCIDADE CONTROLADA (SHUTTLE WALK TEST). PARA DETERMINAÇÃO DA BRONCOCONSTRIÇÃO INDUZIDA PELO EXERCÍCIO
Pesquisadores (as): ADRIANA SANCHES GARCIA DE ARAUJO

Conclusão
As pendências apontadas no Parecer nº. 469/2011 foram satisfatoriamente resolvidas. **Projeto aprovado.** Atende as exigências contidas na Resolução 196/96, do Conselho Nacional de Saúde.

Normas a serem seguidas
• O sujeito da pesquisa tem a liberdade de recusar-se a participar ou de retirar seu consentimento em qualquer fase da pesquisa, sem penalização alguma e sem prejuízo ao seu cuidado (Res. CNS 196/96 – Item IV.1.f) e deve receber uma cópia do Termo de Consentimento Livre e Esclarecido, na íntegra, por ele assinado (Item IV.2.d).

• O sujeito de pesquisa ou seu representante, quando for o caso, deverá rubricar todas as folhas do Termo de Consentimento Livre e Esclarecido – TCLE– apondo sua assinatura na última página do referido Termo.

• O pesquisador responsável deverá da mesma forma, rubricar todas as folhas do Termo de Consentimento Livre e Esclarecido – TCLE– apondo sua assinatura na última página do referido Termo.

• O pesquisador deve desenvolver a pesquisa conforme delineada no protocolo aprovado e descontinuar o estudo somente após análise das razões da descontinuidade pelo CEP que o aprovou (Res. CNS Item III.3.z), aguardando seu parecer, exceto quando perceber risco ou dano não previsto ao sujeito participante ou quando constatar a superioridade de regime oferecido a um dos grupos da pesquisa (Item V.3) que requeiram ação imediata.

• O CEP deve ser informado de todos os efeitos adversos ou fatos relevantes que alterem o curso normal do estudo (Res. CNS Item V.4). É papel do pesquisador assegurar medidas imediatas adequadas frente a evento adverso grave ocorrido (mesmo que tenha sido em outro centro) e enviar notificação ao CEP e à Agência Nacional de Vigilância Sanitária – ANVISA – junto com seu posicionamento.

• Eventuais modificações ou emendas ao protocolo devem ser apresentadas ao CEP de forma clara e sucinta, identificando a parte do protocolo a ser modificada e suas justificativas. Em caso de projetos do Grupo I ou II apresentados anteriormente à ANVISA, o pesquisador ou patrocinador deve enviá-las também à mesma, junto com o parecer aprobatório do CEP, para serem juntadas ao protocolo inicial (Res. 251/97, item III.2.e).

• Relatórios parciais e final devem ser apresentados ao CEP, inicialmente dentro de 1 (um) ano a partir desta data e ao término do estudo.
São Carlos, 27 de Janeiro de 2012.

Prof. Dr. Daniel Vendrúscolo
Coordenador do CEP/UFSCar

ANEXO II

From: karendarley@apta.org

To: ivlabadessa@gmail.com

CC:

Subject: Manuscript Submitted -- PTJ-2016-0421

Body: This e-mail acknowledges that PHYSICAL THERAPY (PTJ) has received your manuscript, "RELIABILITY OF THE WALKED DISTANCE, CARDIORESPIRATORY, METABOLIC AND PERCEPTUAL RESPONSES IN INCREMENTAL SHUTTLE WALK TEST IN ASTHMATICS ADULTS.." We recognize that authors have many journals to consider when deciding where to submit their manuscripts. Thank you for your submission!

After the editorial office completes the initial processing of your submission, all of the authors/co-authors of the manuscript will receive an e-mail with instructions and a link for submitting the electronic Copyright and Disclosure form online. These forms are now combined as one form. (DO NOT e-mail or fax forms.)

PTJ accepts a manuscript for review and for consideration for exclusive publication with the understanding that the manuscript--including any original research findings or data reported in it--has not been published and is not under consideration for publication elsewhere, whether in print or electronic form. Reports of secondary analyses of data sets should specify the source of the data.

Manuscripts published in PTJ become the property of the APTA and may not be published elsewhere, in whole or in part, without the written permission of APTA.

ANSWERS TO FREQUENTLY ASKED QUESTIONS:

HOW LONG WILL THE REVIEW TAKE?

As of April 1, 2014, the average number of days from submission to first decision = 44.7. The review process may take less time for some manuscripts and more time for others, depending on a variety of factors.

HOW CAN AUTHORS CHECK ON THE STATUS?

Log into your Author Center and click on "Submitted Manuscripts" to check the status of your manuscript(s).

HOW CAN AUTHORS GET HELP?

If you have any problems with PTJ Manuscript Central, click on "Get Help Now." If your problem is urgent, you may call Editorial Tracking Manager Karen Darley at 800-999-2782,

ext 3187; however, we ask that you call only if your problem is urgent. Please refer to your manuscript number, PTJ-2016-0421, when contacting the Editorial Office.

Please Note: The PTJ Authorship and Copyright Transfer and the ICMJE Uniform Disclosure combined form for Potential Conflicts of Interest (COI) form needs to be received from ALL authors & co-authors prior to the review process. This e-mail acknowledges that PHYSICAL THERAPY (PTJ) has received your manuscript, "RELIABILITY OF THE WALKED DISTANCE, CARDIORESPIRATORY, METABOLIC AND PERCEPTUAL RESPONSES IN INCREMENTAL SHUTTLE WALK TEST IN ASTHMATICS ADULTS.."

PTJ accepts a manuscript for review and for consideration for exclusive publication with the understanding that the manuscript--including any original research findings or data reported in it--has not been published and is not under consideration for publication elsewhere, whether in print or electronic form. Reports of secondary analyses of data sets should specify the source of the data.

Manuscripts published in PTJ become the property of the APTA and may not be published elsewhere, in whole or in part, without the written permission of APTA.

On behalf of Editor in Chief Rebecca Craik, thank you for your interest in publishing your work in PTJ.

PTJ Editorial Office

Date Sent: 02-Sep-2016

ANEXO III

31-Jan-2017

Dear Ms. Labadessa:

Your manuscript entitled "IS INCREMENTAL SHUTTLE WALKING TEST RELIABLE AND VALID TO DETECT EXERCISE-INDUCED BRONCHOSPASM IN ADULT ASTHMATICS?" has been successfully submitted online and is presently being given full consideration for publication in the Brazilian Journal of Physical Therapy.

Your manuscript ID is RBFIS-2017-0041.

Please mention the above manuscript ID in all future correspondence or when calling the office for questions. If there are any changes in your street address or e-mail address, please log in to ScholarOne Manuscripts at https://mc04.manuscriptcentral.com/rbfis-scielo and edit your user information as appropriate.

You can also view the status of your manuscript at any time by checking your Author Center after logging in to https://mc04.manuscriptcentral.com/rbfis-scielo.

Thank you for submitting your manuscript to the Brazilian Journal of Physical Therapy.

Sincerely,
Brazilian Journal of Physical Therapy Editorial Office

6. APÊNDICES

APÊNDICE I

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Consentimento informado de participação no projeto intitulado "AVALIAÇÃO DA REPRODUTIBILIDADE E DA VALIDADE DO TESTE DE CAMINHADA COM VELOCIDADE CONTROLADA (*SHUTTLE WALK TEST*). PARA DETERMINAÇÃO DA BRONCOCOSTRIÇÃO INDUZIDA PELO EXERCÍCIO"

Responsáveis:

Pesquisadora: Ms. Adriana Sanches Garcia de Araújo

Orientadora: Profa. Dra. Valéria Amorim Pires Di Lorenzo

Eu _____,
RG _____, Estado Civil, _____, idade _____anos,
residente na _____, n° _____,
Bairro _____, Cidade _____, Telefone _____,
concordo voluntariamente em participar do projeto de pesquisa "**AVALIAÇÃO DA REPRODUTIBILIDADE E DA VALIDADE DO TESTE DE CAMINHADA COM VELOCIDADE CONTROLADA (*SHUTTLE WALK TEST*). PARA DETERMINAÇÃO DA BRONCOCOSTRIÇÃO INDUZIDA PELO EXERCÍCIO"**

O trabalho tem o objetivo de avaliar e comparar as variáveis cardiorrespiratórias e a sensação de dispnéia e cansaço de membros inferiores em indivíduos com e sem Asma.

Comparar estas variáveis durante um teste de caminhada com velocidade controlada com as respostas apresentadas no teste de esforço máximo realizado em esteira ergométrica.

O programa constará de um teste de esforço em esteira, três testes de caminhada no solo em dias diferentes com intervalos de dois dias no mínimo e cinco no máximo entre cada teste, e quatro testes de função pulmonar. Este teste consta de pelo menos três manobras expiratórias forçadas aceitáveis e reprodutíveis antes e após os testes no 5º, 15º e 30º minutos de recuperação. A minha participação como voluntário deverá ter a duração de aproximadamente 40 minutos por teste, e ao participar dessa pesquisa o risco de vida é mínimo sendo que receberei um acompanhamento e monitorização constante, com critérios de segurança. Serão questionados, antes do treinamento físico, possíveis sinais clínicos (falta de ar, cansaço em membros inferiores, palpitações (batedeira), como também durante e após os testes. Durante os testes será realizada monitorização constante da frequência cardíaca, saturação periférica de oxigênio (SpO2), e será aferida pressão arterial antes e após os testes. O teste será interrompido na iminência de sinais e ou sintomas limitantes tais como: fadiga de membros inferiores, cansaço físico geral, tonturas, náuseas, cianose, presença de arritmias, angina, ou queda na SpO2. Ao participar desse trabalho estarei contribuindo para proporcionar maiores esclarecimentos sobre a eficácia de um teste de caminhada detectar asma induzida pelo exercício. Entretanto, sei que estou sujeito a riscos momentâneos como aumento da frequência cardíaca, respiratória, da falta de ar, bem como chiado do peito, e que serei prontamente assistido se caso ocorrer alguns destes sintomas. Eu entendo que não existe

nenhum tipo de seguro de saúde ou de vida, bem como qualquer outra compensação financeira que possa vir a me beneficiar em função da minha participação neste estudo.. Estou ciente ainda, de que as informações obtidas durante todo o tratamento serão mantidas em sigilo e não poderão ser consultadas por pessoas leigas, sem a minha autorização. As informações assim obtidas, no entanto, poderão ser usadas para fins de pesquisa científica, desde que minha privacidade seja sempre resguardada. Li e entendi as informações precedentes, bem como, eu e os responsáveis pelo projeto já discutimos todos os riscos e benefícios decorrentes deste, sendo que as dúvidas futuras que possam vir a ocorrer, poderão ser prontamente esclarecidas, bem como o acompanhamento dos resultados obtidos durante a coleta dos dados. E, além disso, todas as dúvidas que me ocorreram já foram esclarecidas por completo. Estou ciente também que poderei desistir de participar do projeto a qualquer momento, mediante aviso prévio ao pesquisador e sem qualquer tipo de ônus a minha pessoa.

Eu estou de acordo com a minha participação neste estudo de livre e espontânea vontade e entendo sua relevância. Comprometo-me, na medida das minhas possibilidades, prosseguir com as avaliações até a sua finalização, visando além dos benefícios trazidos com estes, colaborar para um bom desempenho do trabalho científico dos responsáveis por este projeto.

Julgo que é meu direito manter uma cópia deste consentimento.

Para questões relacionadas a este estudo, contate:

Adriana Sanches Garcia de Araújo: Fone: (16) 3351-8343, (16)81587480
e-mail: **garciadrica@hotmail.com**

Valéria Amorim Pires Di Lorenzo: Fone: (16) 3371-3444; (16) 3351-8343.
e-mail: **vallorenzo@power.ufscar.br**

_____

Assinatura do Voluntário

Pesquisadores Responsáveis

_____ _____

Adriana Sanches Garcia de Araújo **Profa. Dra. Valéria Amorim Pires Di Lorenzo**

São Carlos, ...de.....de 20.....

APÊNDICE II

Universidade Federal de São Carlos

Departamento de Fisioterapia

Laboratório de Espirometria Fisioterapia Respiratória

Laboratório de Fisioterapia Cardiovascular

Ficha de Avaliação Fisioterapêutica Grupo:_____

Data ____/____/_____ **Hora:**_____:_____

Nome:_____ **Data Nasc:**_____

Idade:_____ **Sexo:**_____ **Peso:**_____ **Altura:**_____ **IMC:**_____

Profissão:_____ **Procedência:**_____

Endereço:_____

_____**Telefone:**_____

Unidade de Referência:_____**Médico:**_____

Data Diagnóstico Asma:_____

Tem crises de Asma?_____**Frequência:**_____

Fatores relacionados às crises:_____

As crises estão associadas ao esforço físico?_____

Doenças Anteriores:_____

Tabagismo ( ) maço/ dia/ anos _____Alergias ( )_____
Medicações em uso:_____
_____

EXAME FÍSICO

Sinais Vitais: FC:_____bpm FR:_____ rpm PA_____x_____ mmHg
Dispneia: Não ( ) Sim ( ) _____
Padrão Ventilatório:_____ Ritmo Respiratório:_____
Expansibilidade:_____Deformidades:_____
Simetria Torácica:_____Percussão Torácica:_____
Presença de Tosse: Não ( ) Sim ( )_____
Presença de Secreção: Não ( ) Sim ( )_____
Ausculta Respiratória:_____
Espirometria – Data:_____/_____/_____

	Pré-BD	**Pós-BD**	**Pred%**
CVF			
VEF_1			
VVM			

_____

Fisioterapeuta/carimbo

APÊNDICE III

Universidade Federal de São Carlos

Departamento de Fisioterapia

Laboratório de Espirometria Fisioterapia Respiratória

Laboratório de Fisioterapia Cardiovascular

Teste de Exercício Cardiopulmonar Incremental

Data:

Nome: **Idade :** **Sexo:**

D. Nascimento:

Grupo de Pesquisa:

Medicamentos:

FC máx prevista idade:

FC submáxima 80 - 90%:

Polar:

VVM: **Carga para 60% VVM:**

VE/ VVM	Estágio	Tempo	Velocidade	Inclinação	SpO_2	FR	FC	PA	IPE		
		(min)	(Km/h)	(%)	(%)	(rpm)	(bpm)	(mmHg)	Cansaço	Fadiga MMII	Dor no peito
	Repouso										
	Recuperação	1′									
		2′									
		3′									
		4′									

Umidade do ar: Temperatura:

Teste Interrompido por:

_____

_____

APÊNDICE IV

Universidade Federal de São Carlos

Departamento de Fisioterapia

Laboratório de Espirometria Fisioterapia Respiratória

Laboratório de Fisioterapia Cardiovascular

Teste de Exercício Cardiopulmonar Constante

Data:

Carga: **Km/h:** **Inclinação:**

VE/ VVM	Estágio	Tempo	Velocidade	Inclinação	SpO_2	FR	FC	PA	IPE		
		(min)	(Km/h)	(%)	(%)	(rpm)	(bpm)	(mmHg)	Cansaço	Fadiga MMII	Dor no peito
	Repouso										
	Recuperação	1′									
		2′									
		3′									
		4′									

Umidade do ar: **Temperatura:**

Teste Interrompido por:

_____

_____

	5’	10’	15’	20’	30’		PRÉ	PICO
VEF_1						**ALÇA-FLUXO VOLUME**		

Universidade Federal de São Carlos

Departamento de Fisioterapia

Laboratório de Espirometria Fisioterapia Respiratória

Laboratório de Fisioterapia Cardiovascular

APÊNDICE V

Protocolo - Incremental Shuttle Walk Test (ISWT)

Nome: _____

Avaliador: _____

FC máx prevista: _____

ISWT 1 Data: ____/_____/_____

Nivel	Veloc.	Veloc	Voltas por nivel	Tempo de volta	Distancia
	(m/s)	(Km/h)		(s)	(m)
1	0.5	1,8	3	20.0	30
2	0.67	2,4	4	115.0	70
3	0.84	3,0	5	12.0	120
4	1.01	3,6	6	10.0	180
5	1.18	4,2	7	8.6	250
6	1.35	4,85	8	7.5	330
7	1.52	5,5	9	6.7	420
8	1.69	6,1	10	6.0	520
9	1.86	6,7	11	5.5	630
10	2.03	7,3	12	5.0	750
11	2.2	7,9	13	4.6	880
12	2.37	8,5	14	4.3	1020

SHUTTLE 1				
	Basal		Final	
SpO_2		(%)		(%)
FC		(bpm)		(bpm)
PA		(Mm Hg)		(mmHg)
Dispneia		(Borg)		(Borg)
FadigaMMII		(Borg)		(Borg)
Distancia total caminhada				(m)
Último Nivel Completado				

Nivel	**SHUTTLE 1**																	
	Voltas (10m cada uma)														Distância	PA	FC	Borg D	Borg MMII
1	1	2	3	Acompanhar o paciente															
2	1	2	3	4															
3	1	2	3	4	5														
4	1	2	3	4	5	6													
5	1	2	3	4	5	6	7												
6	1	2	3	4	5	6	7	8											
7	1	2	3	4	5	6	7	8	9										
8	1	2	3	4	5	6	7	8	9	10									
9	1	2	3	4	5	6	7	8	9	10	11								
10	1	2	3	4	5	6	7	8	9	10	11	12							
11	1	2	3	4	5	6	7	8	9	10	11	12	13						
12	1	2	3	4	5	6	7	8	9	10	11	12	13	14					
Final																			
Recuperação 1’																			
Recuperação 2’																			
Recuperação 5’																			

Nome: _____

ISWT 2 Data: ____/_____/_____

SHUTTLE 2				
	Basal		Final	
SpO		(%)		(%)
FC		(bpm)		(bpm)
PA		(Mm Hg)		(mmHg)
Dispneia		(Borg)		(Borg)
FadigaMMII		(Borg)		(Borg)
Distancia total caminhada				(m)
Último Nivel Completado				

Nivel	Veloc.	Veloc	Voltas por nivel	Tempo de volta	Distancia
	(m/s)	(Km/h)		(s)	(m)
1	0.5	1,8	3	20.0	30
2	0.67	2,4	4	115.0	70
3	0.84	3,0	5	12.0	120
4	1.01	3,6	6	10.0	180
5	1.18	4,2	7	8.6	250
6	1.35	4,85	8	7.5	330
7	1.52	5,5	9	6.7	420
8	1.69	6,1	10	6.0	520
9	1.86	6,7	11	5.5	630
10	2.03	7,3	12	5.0	750
11	2.2	7,9	13	4.6	880
12	2.37	8,5	14	4.3	1020

Nivel	SHUTTLE 2																	
	Voltas (10m cada uma)														Distância	PA	FC	Borg D	Borg MMII
1	1	2	3	Acompanhar o paciente															
2	1	2	3	4															
3	1	2	3	4	5														
4	1	2	3	4	5	6													
5	1	2	3	4	5	6	7												
6	1	2	3	4	5	6	7	8											
7	1	2	3	4	5	6	7	8	9										
8	1	2	3	4	5	6	7	8	9	10									
9	1	2	3	4	5	6	7	8	9	10	11								
10	1	2	3	4	5	6	7	8	9	10	11	12							
11	1	2	3	4	5	6	7	8	9	10	11	12	13						
12	1	2	3	4	5	6	7	8	9	10	11	12	13	14					
Final																			
Recuperação 1’																			
Recuperação 2’																			
Recuperação 5’																			

Nome: _____

ISWT 3 Data: ____/_____/_____

SHUTTLE 3				
	Basal		Final	
SpO		(%)		(%)
FC		(bpm)		(bpm)
PA		(Mm Hg)		(mmHg)
Dispneia		(Borg)		(Borg)
FadigaMMII		(Borg)		(Borg)
Distancia total caminhada				(m)
Último Nivel Completado				

Nivel	Veloc.	Veloc	Voltas por nivel	Tempo de volta	Distancia
	(m/s)	(Km/h)		(s)	(m)
1	0.5	1,8	3	20.0	30
2	0.67	2,4	4	115.0	70
3	0.84	3,0	5	12.0	120
4	1.01	3,6	6	10.0	180
5	1.18	4,2	7	8.6	250
6	1.35	4,85	8	7.5	330
7	1.52	5,5	9	6.7	420
8	1.69	6,1	10	6.0	520
9	1.86	6,7	11	5.5	630
10	2.03	7,3	12	5.0	750
11	2.2	7,9	13	4.6	880
12	2.37	8,5	14	4.3	1020

Nivel	SHUTTLE 3																	
	Voltas (10m cada uma)														Distância	PA	FC	Borg D	Borg MMII
1	1	2	3	Acompanhar o paciente															
2	1	2	3	4															
3	1	2	3	4	5														
4	1	2	3	4	5	6													
5	1	2	3	4	5	6	7												
6	1	2	3	4	5	6	7	8											
7	1	2	3	4	5	6	7	8	9										
8	1	2	3	4	5	6	7	8	9	10									
9	1	2	3	4	5	6	7	8	9	10	11								
10	1	2	3	4	5	6	7	8	9	10	11	12							
11	1	2	3	4	5	6	7	8	9	10	11	12	13						
12	1	2	3	4	5	6	7	8	9	10	11	12	13	14					
Final																			
Recuperação 1’																			
Recuperação 2’																			
Recuperação 5’																			