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Incremental shuttle walk test performed in a hallway and on a treadmill: are they interchangeable?

Shuttle walk teste incremental realizado no corredor e na esteira: eles são intercambiáveis?

La prueba incremental Shuttle walk realizada en el pasillo y la cinta caminadora: ¿son intercambiables?

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ABSTRACT | The performances of healthy individuals in an incremental shuttle walking test performed in a hallway (ISWT-H) and on a treadmill (ISWT-T) were compared to assess their physiological responses during aerobic training sessions with the speeds estimated from both tests. This was a cross-sectional study with 55 healthy subjects, who were randomized to perform the ISWT tests with 24 hours between them. Training sessions were held using a treadmill at 75% of the speeds obtained from the ISWT-H and ISWT-T. Measurements included walking distance, oxygen uptake (VO_2), carbon dioxide (VCO_2) production, heart rate (HR), and ventilation (VE). There was a significant difference between walking distances (ISWT-T: 823.9±165.2 m and ISWT-H:685.4±141.4 m), but similar physiological responses for VO_2 (28.6±6.6 vs. 29.0±7.3 ml^{-1}.kg^{-1}.min^{-1}), VCO_2 (1.9±0.7 vs. 1.9±0.5 1), HR (158.3±17.8 vs. 158.6±17.7 bpm), and VE (41.5±10.4 vs. 43.7±12.9 1). The estimated speeds were different for the training sessions (5.5±0.5 km/h and 4.9±0.3 km/h), as well as the VO_2, VCO_2, VE, and HR. It was concluded that in healthy young adults, ISWTs carried out in a hallway and on a treadmill are not interchangeable. Since the ISWT-H was determined to have lower speed, the training intensity based on this test may underestimate a patient's responses to aerobic training.

Keywords | Exercise Test; Exercise; Walking; Oxygen Consumption.

RESUMO | Comparou-se o desempenho no *shuttle walk* teste incremental realizado no corredor (SWTI-C) e na esteira (SWTI-E) em indivíduos saudáveis e comparar as respostas fisiológicas durante as sessões de treinamento aeróbio com as velocidades estimadas em ambos os testes. Trata-se de um estudo transversal com cinquenta e cinco participantes saudáveis. Os participantes foram randomizados para realizar os testes com 24 horas de intervalo. As sessões de treinamento foram realizadas na esteira com 75% da velocidade obtida no SWTI-C e no SWTI-E. As avaliações incluíram a distância da caminhada, consumo de oxigênio (VO_2), produção de dióxido de carbono (VCO_2), frequência cardíaca (FC) e ventilação (VE). Houve uma diferença significante entre as distâncias caminhadas (SWTI-E: 823,9 ± 165,2 m e SWTI-C: 685,4 ± 141,4 m), mas respostas fisiológicas semelhantes para o VO_2 (28,6 ± 6,6 vs. 29,0 ± 7,3 ml^{-1}.kg^{-1}.min^{-1}), VCO_2 (1,9 ± 0,7 vs. 1,9 ± 0,5 1), HR (158,3 ± 17,8 vs. 158,6 ± 17,7 bpm) e VE (41,5 ± 10,4 vs. 43,7 ± 12,9 1). As velocidades estimadas foram diferentes para as sessões de treinamento (5,5 ± 0,5xkm/h e 4,9 ± 0,3 km/h), assim como o VO_2, VCO_2, VE e FC. Concluiu-se que em adultos jovens saudáveis, SWTI realizados no corredor e na esteira não são intercambiáveis. Uma vez que o SWTI-E determinou uma menor velocidade, a intensidade do treinamento baseada neste teste pode subestimar as respostas de um paciente ao treinamento aeróbio.

Descritores | Teste de Esforço; Exercício; Caminhada; Consumo de Oxigênio.

RESUMEN | Se trata de una comparación del rendimiento en la prueba incremental shuttle walk llevado a cabo en el pasillo (SWPI-P) y en la cinta caminadora (SWPC) entre individuos sanos, para evaluar las respuestas fisiológicas durante las sesiones de entrenamiento aeróbico con

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velocidades estimadas en ambas pruebas. Estudio transversal con 55 individuos sanos. A los participantes se les eligieron al azar para realizar las pruebas con intervalo de 24 horas. Se llevaron a cabo sesiones de entrenamiento en la cinta caminadora con el 75 % de la velocidad obtenida en SWPI-P y en SWPC. Se incluyen entre las evaluaciones la distancia de la caminata, el consumo de oxígeno (VO_2), la producción de dióxido de carbono (VCO_2), la frecuencia cardiaca (FC) y la ventilación (VE). Hubo una diferencia significativa entre las distancias recorridas (SWPC: 823,9 ± 165,2 m y SWPI-P: 685,4 ± 141,4 m), pero similares a las respuestas fisiológicas del VO_2 (28,6 ± 6,6 vs. 29,0 ± 7,3 $ml^{-1}.kg^{-1}.\ min^{-1}$), VCO_2 (1,9 ± 0,7 vs. ± 1,9 0,5 1), HR (158,3 ± 17,8 vs. 158,6 ± 17,7 bpm) y VE (41,5 ± 10,4 vs. 43,7 ± 12,9 1). Las velocidades estimadas fueron diferentes en las sesiones de entrenamiento (5,5 ± 0,5 km/h y 4,9 ± 0,3 km/h), así como VO_2, VCO_2 VE y FC. Se concluyó que, en los adultos jóvenes sanos, la SWPI llevada a cabo en el pasillo y en la cinta caminadora no pueden ser intercambiables. Dado que la SWPC determinó una menor velocidad, la intensidad de entrenamiento de esta prueba puede subestimar las respuestas de un paciente en el entrenamiento aeróbico.

Palabras clave | Prueba de Esfuerzo; Ejercicio; Caminata; Consumo de Oxígeno.

INTRODUCTION

The incremental shuttle walking test (ISWT) was designed to evaluate exercise capacity in patients with chronic pulmonary diseases[1]. The ISWT is a reproducible test with established reference values, and it is responsive to interventions[2,3]. In addition, previous studies have estimated the training intensity on a treadmill based on the peak speed reached during an ISWT[4]. However, a common disadvantage in relation to walking-based tests is the need for an appropriate physical space (10 m long in the case of the ISWT), which may not be available in hospitals, offices or clinics, or for patients receiving outpatient care. In addition, the need for continuous monitoring and oxygen supplementation in some of these patients makes performing the test difficult.

The six-minute walk test (6MWT) has similar limitations; for example, it requires a bigger hallway (30 m)[2]. To overcome this issue, the 6MWT has been performed on a treadmill; however, this strategy has led to a substantial decrease in walking distance[5,6]. One explanation for this finding was the time spent adjusting the speed of the treadmill[6], since the rhythm of the 6MWT is self-paced. It is possible that the ISWT, an externally-paced test, promotes similar walking distances and physiological responses when performed on a treadmill (ISWT-T) and in a hallway (ISWT-H). This assumption is based on a previous study that found no differences in walking distance, heart rate, dyspnea, or perception of effort when compared to the endurance shuttle walking test, another externally-paced test, performed on a treadmill and in a hallway[7]. Although some differences do occur in the patterns of muscle activation and joint movements between walking in a hallway and on a treadmill, the overall patterns of the two modes are fairly similar[8], as is the energy expenditure[9].

A few studies have compared the ISWT-H and the ISWT-T; however, their findings were controversial due to the small size of the samples of patients with cardiovascular disease (n=8)[10], post-myocardial infarction (n=10)[9], and idiopathic pulmonary disease (n=19)[11], which may have incurred a type-II error. Moreover, there have been no previous studies including patients with chronic pulmonary disease. Before considering this specific population, it was helpful to test the replacement of the hallway with the treadmill, and perform the ISWT in healthy subjects to evaluate the safety and concordance of their physiological responses during both tests. Then, these individuals were evaluated during physical training sessions based on the velocities obtained from the ISWT-H and ISWT-T.

Our hypothesis was that the performance of healthy subjects in the ISWT on a treadmill would be similar to their performance in the hallway. Therefore, the prescription of physical training through an ISWT-H or ISWT-T would result in similar cardiac demands, ventilatory demands, and metabolic loads. If proven, the hypothesis would show that a treadmill is a good alternative when an ISWT-H is not possible. Given the above, the aim of this study was to compare the safety, performance, and physiological responses of the ISWT-H and ISWT-T in healthy individuals, and to evaluate their acute physiological responses during training sessions with the intensities (speed percentages) determined by these two tests.

METHODOLOGY

Study design

This was a cross-sectional study performed in two visits (24 hours apart). During the first visit, spirometry was performed, and each subject's body mass index (BMI) was calculated (weight/height^2)[12]. The subjects were randomized to perform the ISWT-H or ISWT-T first. Thirty minutes after the ISWT-H or ISWT-T, a training session was held on a treadmill at 75% of the speed obtained from either the ISWT-H or ISWT-T (whichever one was performed that day). The flowchart of the selection of participants and the procedures are shown in Figure 1.

Sample

Through convenience sampling, 62 adult healthy individuals of both sexes, with normal lung function and a sedentary lifestyle (self-reported, individuals who performed physical activity less than 150min per week having been considered as sedentary) were studied. Individuals with a history of smoking, neuromuscular or musculoskeletal diseases, cardiopulmonary disease, acute respiratory infection, or a BMI indicating obesity (BMI≥30 kg/m^2) were excluded. This study was approved by the Local Research Ethics Committee (process number 418704), and all of the participants signed an informed consent form before the assessments.

Assessments

Spirometry

Spirometry was performed using an ULTIMA CPX (Medical Graphics, St. Paul, Minnesota, USA). The acceptability and reproducibility criteria adopted for the technical procedures were those recommended by the Brazilian guidelines for testing lung function[13]. The forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1), and FEV_1/FVC ratio were expressed in absolute values and as percentage of the predicted value for the Brazilian population[14].

Incremental shuttle walking test – hallway

The ISWT-H was performed according to the original description[1] in a 10 m-long hallway. This distance was marked by two cones that were placed 0.5 m from each edge. The individual followed this route at a predetermined speed imposed by an audible prerecorded rhythm. The ISWT was composed of 12 levels lasting one minute each, with an initial 0.5 m/s speed and 0.17 m/s increments each minute, reaching a maximum 2.37 m/s speed. The test was interrupted if the individual did not successfully reach one of the cones at the time of the sound stimulus (0.5 m before the cone) twice. Other reasons for discontinuing the test were chest pain, intolerable dyspnea, leg cramps, staggering, diaphoresis, or a pale or ashen appearance[2].

Heart rate (HR) (Polar Precision Performance; Polar Electro, Kem-skin, Finland) and oxygen pulse saturation (9500; Nonin, Plymouth, Minnesota, USA) were continuously measured during the test. The blood pressure and Borg Rating of Perceived Exertion for dyspnea and lower limb fatigue[15] were obtained at rest and immediately after the end of the exercise. The walking distance was expressed as an absolute value and as percentage of the predicted value[3].

Incremental shuttle walking test – treadmill

The ISWT-T was performed on a treadmill without incline (Millennium Classic; Inbrasport, Porto Alegre, RS, Brazil) following the same protocol as the ISWT-H (above). The criterion for the interruption of the ISWT was a patient being 0.5 m from the cone at the time of the sound stimulus during two consecutive attempts. Then, a demarcation was established with masking tape fixed to the treadmill's bearing bar in parallel with the lower limb on each side of the treadmill for a similar test interruption parameter. In this context, the ISWT-T was interrupted if a patient did not keep the position of the lower limbs parallel to the masking tape two consecutive times during the sound stimulus. The handrail support was used by all subjects. The reasons for discontinuing the test were the same as those for the ISWT-H. The same variables described for the ISWT-H were measured during the ISWT-T.

Aerobic training session

A subgroup of 18 out of 55 participants selected through convenience sampling was evaluated to compare the acute physiological responses to the training sessions. For this test, the aerobic training speed was set to 75% of the maximum speed obtained from the ISWT-H or the ISWT-T[16]. The session lasted 20 minutes: 5 minutes of warm up (50% of the target speed), 15 minutes at the target speed, and 5 minutes of slowdown. The handrail support was used by all subjects. The variables measured during the training session were the same as those measured during the ISWT-H and ISWT-T tests.

Gas exchange analysis

During the two tests and training sessions, a portable metabolic system (VO2000; Medical Graphics, St. Paul, MN, USA) was used to measure the oxygen uptake (VO_2), carbon dioxide production (VCO_2) and ventilation (VE). Before every test, a system calibration was performed according to the recommendations of the manufacturer. The measurements were taken at rest in the sitting position, throughout the entire test, and during the two-minute recovery period. For the metabolic and ventilatory analyses, the peak of the average of the test's last 30 seconds and the peak of the average of the training session's last three minutes were considered.

Statistical analysis

The data analysis was performed using the SPSS 20.0 software (SPSS, Chicago, Illinois, USA). The Shapiro-Wilk test was used to determine the normality of the data, and the data were expressed as means and standard deviations according to the adherence to the Gaussian curve. A Student's paired t-test was performed to compare the variables at the peak of the exercise between the two tests, and to compare the variables between the two training sessions. Comparisons of the VO_2, VE, and HR were performed every minute by using the analysis of variance (ANOVA) for repeated measures, with a *post hoc* Bonferroni analysis. The level of significance was $p<0.05$, and effect size was calculated using Cohen's test. The statistical power of the sample size was calculated *a posteriori* using the G*Power software (Universität Düsseldorf, Germany).

RESULTS

Sixty-two healthy subjects were recruited for this study. After seven exclusions, 55 subjects were surveyed (Figure 1). The baseline characteristics are shown in Table 1.

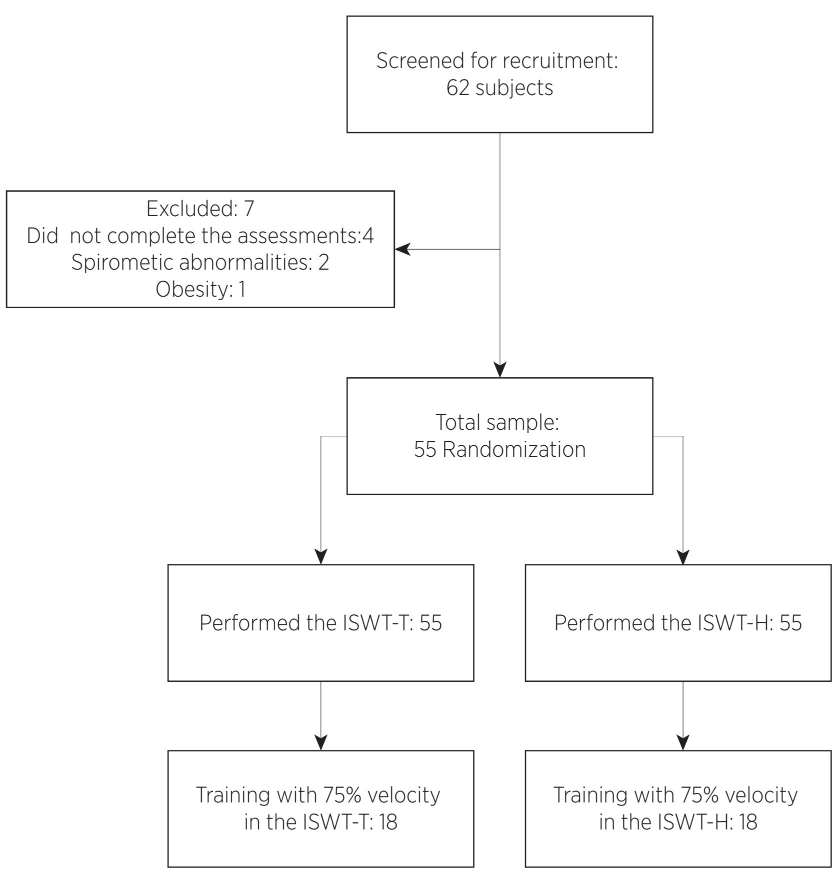


Figure 1. Flowchart of selection of participants and procedures

Table 1. Baseline characteristics

Variables	ISWT Group n=55	Training Group N=18
Age, years	24.8±8.3	25.3±12.7
Male/Female	26/29	4/14
Weight, kg	64.5±10.9	58.9±7.9
Height, m	1.7±0.1	1.6±0.7
Body Mass Index, kg/m^2	23.1±3.0	22.1±2.8
FVC, L	4.1±0.8	3.7±0.6
FVC, % pred	97.6±13.6	98.3±9.4
FEV_1, L	3.5±0.7	3.2±0.7
FEV_1, % pred	95.0±13.8	96.5±12.7
FEV_1/FVC	0.9±0.1	0.7±0.1

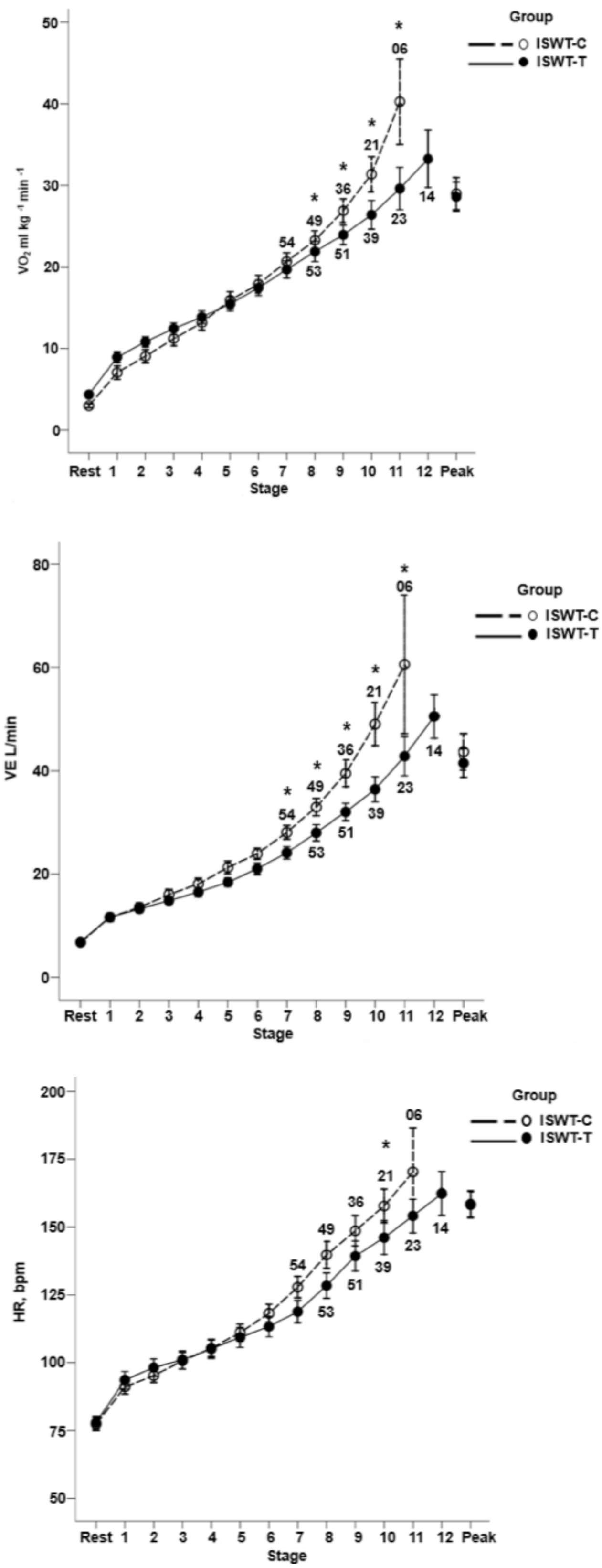
ISWT: incremental shuttle walk test, kg: kilogram, m: meters, kg/m^2: kilogram per square meter, FVC: forced vital capacity, L: liters, % pred: percentage predicted, FEV_1: forced expiratory volume in 1 second

A better performance (walking distance, speed, and test stage) was observed in the ISWT-T when compared to the ISWT-H (Table 2). For the distance walked, effect size was 0.89 and sample power was 0.99. A higher VO_2 (l/min) also occurred in the ISWT-H when compared to the ISWT-T (Table 2). The performances at each stage of the ISWT-H and ISWT-T showed linear increases in HR, VO_2, and VE in both tests. The results showed significant differences between the two tests during the same stages of the ISWT: the VO_2 of the 8th stage, the ventilation of the 7th stage, and the HR of the 10thstage (Figure 2).

Table 2. Comparison between the cardiopulmonary variables at the end of the ISWT-H and of the ISWT-T

Variables	n=55		
	ISWT-H	ISWT-T	P
Distance, m	685.4±141.4	823.9±165.2	<0.001
Dist, % pred	60.1±8.9	73.0±16.7	<0.001
Velocity, km/h	6.8±0.7	7.3±0.6	<0.001
Stages	10.1±1.3	10.9±1.1	<0.001
HR, bpm	158.3±17.7	158.6±17.8	0.88
HR, % pred	81.1±8.4	81.2±8.6	0.88
SpO_2, %	97.0±1.3	97.2±1.0	0.30
Borg dyspnea	2.1±1.9	1.8±1.7	0.31
Borg lower limb	2.9±2.5	2.9±2.3	0.88
VO_2, L/min	1.9±0.6	1.8±0.5	0.01
VO_2, ml kg^{-1} min^{-1}	29.0±7.3	28.6±6.6	0.67
VO_2, % pred	81.2±13.9	85.3±13.9	0.79
VCO_2, L	1.9±0.7	1.9±0.5	0.10
RQ	1.0±0.1	1.0±0.1	0.42
VE, L/min	43.7±12.9	41.5±10.4	0.19
VE/MVV	0.3±0.1	0.3±0.1	0.24

ISWT-H: incremental shuttle walk test in hallway; ISWT-T: incremental shuttle walk test on treadmill; m: meters: % pred: percentage predicted; HR: heart rate; bpm: beats per minute; SpO_2%: pulse oxygen saturation; VO_2: oxygen uptake; ml.kg^{-1} min^{-1}: milliliters per kilogram per minute; L: liters; VCO_2: carbon dioxide production; VE: ventilation; L/min: liters per minute; VE/MVV: ventilation/maximum voluntary ventilation; RQ: respiratory quotient



Values are expressed as mean and with 95% confidence interval; ISWT-H: incremental shuttle walk test in hallway; ISWT-T: incremental shuttle walk test on treadmill (ISWT-T). N=55 until 7th stage. *Significant difference between tests (P<0.05)

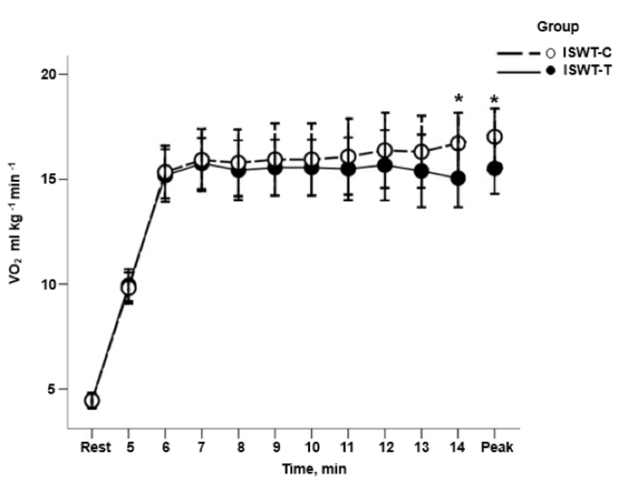
Figure 2. Oxygen consumption (VO_2, A), ventilation (VE, B) and heart rate (HR, C) per stage

During the training sessions, significant differences in the metabolic, ventilatory, and cardiorespiratory responses were observed between the ISWT-T and ISWT-H. The percentages of the speeds determined from both tests was higher in the ISWT-T than in the ISWT-H, with 1.38 effect size and 1.0 sample power (Table 3). The changes in VO_2 ($ml.kg^{-1}.min^{-1}$) during each minute of the training session can be seen in Figure 3.

Table 3. Comparison between groups at the peak of the training session

Variables	N=18		
	ISWT-H	ISWT-T	P
Velocity 75 %	4.9±0.3	5.5±0.5	<0.001
VO_2 L/min	0.9±0.1	0.9±0.2	0.12
VO_2 ml kg^{-1} min^{-1}	14.9±2.5	16.4±3.0	0.008
VO_2 % pred	44.4±8.8	48.5±10.3	0.008
VCO_2, L	0.7±0.1	0.8±0.1	0.03
RQ	0.8±0.1	0.9±0.1	0.40
VE, L/min	18.3±3.1	20.2±4.1	0.03
VE/MVV	0.1±0.0	0.2±0.5	0.03
HR, bpm	110.3±11.7	115.4±11.9	0.04
HR, % pred	56.7±5.6	59.5±6.5	0.03
SpO_2 %	97.4±1.4	97.2±0.9	0.45
Borg dyspnea	0.3±0.5	0.2±0.4	0.75
Borg lower limb	0.3±0.6	0.4±0.5	0.36
SBP, mmHg	129.4±16.9	125.6±12.5	0.13
DBP, mmHg	77.7±7.3	76.1±6.9	0.48

ISWT-H: incremental shuttle walk test in hallway; ISWT-T: incremental shuttle walk test on treadmill; $ml.kg^{-1}.min^{-1}$: milliliters per kilogram per minute; VO_2: oxygen uptake; % pred: percentage predicted; VE: ventilation; L/min: liters per minute; RQ: respiratory quotient; HR: heart rate; bpm: beats per minute; SpO_2: pulse oxygen saturation; SBP: systolic blood pressure; mmHg: millimeters per mercury; DBP: diastolic blood pressure



Values are expressed as mean and with 95% confidence interval. n=18. *Significant difference between tests (P<0.05)

Figure 3. Oxygen consumption (VO_2 ml kg^{-1} min^{-1}) during training with loads obtained in the Incremental Shuttle Walk Test in Hallway (ISWT-H) and in the Incremental Shuttle Walk Test on Treadmill (ISWT-T)

Overall, the tests and the training sessions were safe for the participants. No adverse effects were observed during the procedures, and all of the subjects completed them without reporting any difficulties.

DISCUSSION

This study compared the cardiopulmonary and metabolic performance of healthy subjects during an ISWT-H and ISWT-T, and evaluated their physiological responses during aerobic training sessions with the intensities obtained from the ISWT-T and ISWT-H. The main findings of this study may be summarized as follows: (i) the ISWT-T showed greater walking distance and speed, but similar cardiorespiratory and metabolic demands in relation to the ISWT-H at the peaks of the tests; (ii) during the different stages of the ISWT, the ISWT-H showed superior demand (VO_2, VE, and HR) when compared to the ISWT-T in the 7th stage; (iii) during the training session, greater metabolic and ventilatory requirements were observed with the speed obtained in the ISWT-T when compared to the ISWT-H; and (iv) performing the ISWT on a treadmill was a safe procedure. Considering these findings, we can say that the tests were not interchangeable, thus negating our hypothesis.

A substantial reduction in walking distance [51.2±85.3m[6] and 102 m (95% CI 65–139)[5] has been described when the 6MWT was performed on a treadmill. Additionally, when the 6MWT was performed on a non-motorized treadmill, the walking distance was even lower (-153 m)[17]. Similar results also occurred in the comparison between the 12-minute walk test in a hallway (12MWT-H) and on a treadmill (12MWT-T), with 82m[18] and 49m[19] differences between tests, respectively. One of the hypotheses for this finding is the lack of familiarity with the treadmill[20]. Therefore, conducting field tests on a treadmill has is recommended for the assessment of functional capacity[20].

Some previous studies have compared the ISWT-H with the ISWT-T; however, the findings were controversial. For example, a pilot study with heart disease patients (n=8) showed a higher energy cost per meter, indirectly calculated, in the ISWT-T (3.22±0.55 J/kg/m) when compared to the ISWT-H (3.00±0.41 J/kg/m), but this pattern was reversed at 1.52 m/s and 1.69 m/s walking speeds when the shuttle walking test had a greater energy cost per meter than the treadmill walking test[10].

Thus, the metabolic cost of walking on a treadmill did not reflect that of walking on the ground[10]. Moreover, the current equations used to estimate the metabolic energy cost in the ISWT-H should not be applied when the ISWT is performed on a treadmill[10]. However, in a study with idiopathic pulmonary fibrosis patients (n=10), the ISWT-T showed better performance than the ISWT-H (mean difference: 43m)[11], while the control group in another study with healthy subjects (n=19) did not show differences in the energy expenditure between the ISWT-H and ISWT-T (mean difference: -1.1±1.96 METs)[9]. It is possible that the small sample sizes of these studies may have caused a type-II error.

No differences were found in walking distance, HR, dyspnea, or perception of effort when patients with chronic obstructive pulmonary disease (COPD) performed endurance tests with the same speeds on a treadmill and in a hallway[7]. However, during an incremental test, differences may occur between workloads that require increasingly greater effort, as demonstrated in our study. The physiological responses of the VO_2, VE, and HR began to show significant differences in the phases with an increased load when compared to the same iso stage (Figure 2). The same behavior has been shown in healthy subjects at higher speeds in the ISWT (3mph)[9].

Contrary to a variety of studies[5,6,10,18-19], better performance was found on the treadmill in our study. The demands were higher for the ISWT-H at the same stage (speed) as the ISWT-T, and the variables at the peak of the exercise were similar, despite the ISWT-T having resulted in greater walking distance and longer duration. We hypothesized that this was due to the arms being supported during the ISWT-T. It is known that the primary mechanism for balance maintenance during walking is the width of the step[21] and the swinging of the arms[22-23]. With regard to the first mechanism, it has been shown that no differences exist in the intervals of time and the distance of the steps between walking in a hallway and on a treadmill[19,24]. However, eliminating the movement of the arms while walking results in a decrease in the interval between steps[21], as does allowing the individuals to support themselves with their hands[21,24]. This support increases the side body balance during walking, reducing energy consumption and the demand required to maintain balance[22-24]. A similar effect occurs when manual support (using the hands) is allowed during step-based exercises, reducing VO_2 and the HR[25].

The role of the arms significantly affects the responses related to exertion while walking. Overall, allowing manual support reduces variability in the steps by 12%[21], HR by 18 bpm, energy expenditure by 2.81 kcal/min, perception of effort in the lower limb measured using the Borg scale by 1.92 points[26] and VO_2 expressed as l/min by 0.175[27] and as $ml.kg^{-1}.min^{-1}$ by 7.75[26]. Due to this effect, and as demonstrated in our study, the exercise's maximum time duration is different, depending on whether the hands are or are not used for support (9.9±4.1 min vs 8.0±2.9 min)[28].

The responses to exercise are also influenced by the intensity of the support provided by the hands. Significant differences exist when the hands are free and when they are used only as support (8.4% reduction in the VO_2 and 3.5% in the HR) versus when they are used with a strong grip (21% reduction in the VO_2 and 14.8% in the HR)[29]. The same effect occurs in the perception of exertion, which decreases as the hands are free, with support and with a strong grip, respectively[29]. These findings are consistent with our study in which, although the maximum load achieved in the ISWT-T was greater, a similar perception of effort existed between the tests, because the support provided by the hands decreased this exertion.

Given these findings, the swinging of the arms and the support provided by the hands are important factors to consider during the evaluation and prescription of exercise on a treadmill[22,23], demonstrating the need to standardize the position of the hands during prescription exercises, or to study the comparative effects of this support after the interventions[27,28,30].

As expected, our study demonstrated that during training, the cardiorespiratory and metabolic demands were higher with the load obtained by the ISWT-T; therefore, if the training intensity on the treadmill is estimated from the ISWT-H, the aerobic training is possibly being underestimated. However, even using the workload determined by the ISWT-T, the training intensity corresponded to 59.5% of the maximum HR predicted, reinforcing sub-training. The greatest benefits obtained by aerobic training are related to training intensity (moderate-to-intense), which is directly related to better improvement in the exercise capacity and a reduction of symptoms in individuals with chronic diseases[31].

Study limitations

The ISWT-T was conducted while allowing the use of the hands for support, which was relevant in changing the responses to the exercise. However, all of the participants underwent the same protocol, allowing the conclusions of this study to be valid for these tests, given that they were performed in the same way. Considering that the responses to training were underestimated, we could have used the modified ISWT, which allows running, but the objective of this study was to compare the classic protocols of the ISWT, which was developed for patients with chronic lung diseases. Finally, another limitation of the study is its convenience sample; however, the *a posteriori* statistical power showed a sample power higher than 80%.

CONCLUSION

The performances of healthy young adults in ISWTs carried out in a hallway and on a treadmill are not interchangeable. Since the ISWT-H was determined to have lower speed, the training intensity based on this test may underestimate a patient's responses to aerobic training.

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