UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL

ESCOLA SUPERIOR DE EDUCAÇÃO FÍSICA, FISIOTERAPIA E DANÇA

PROGRAMA DE PÓS GRADUÇÃO EM CIÊNCIAS DO

MOVIMENTO HUMANO

A DANÇA COMO ESTRATÉGIA DE PROMOÇÃO DA SAÚDE CARDIOMETABÓLICA E INDEPENDÊNCIA FUNCIONAL NO ENVELHECIMENTO

Proponente: Josianne da Costa Rodrigues Krause

Porto Alegre, dezembro de 2018.

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TESE DE DOUTORADO

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Documento apresentado para defesa de tese de Doutorado no Programa de Pós Graduação em Ciências do Movimento Humano (PPGCMH) da Escola de Educação Física, Fisioterapia e Dança (ESEFID) da Universidade Federal do Rio Grande do Sul (UFRGS).

Proponente: Josianne da Costa Rodrigues Krause

Prof. Orientador: Alvaro Reischak de Oliveira

Porto Alegre, dezembro de 2018.

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Eu vou tentar, eu vou me esforçar, e eu vou conseguir!

Miguel Rodrigues Krause (5 anos)

RESUMO

RESUMO

INTRODUÇÃO: O envelhecimento biológico é caracterizado, dentre outros fatores, por uma diminuição de massa muscular concomitante a um aumento de tecido adiposo visceral, elevando o risco do desenvolvimento de doenças cardiovasculares e dependência física. A dança tem sido sugerida como uma intervenção de exercício potencial para melhorias cardiometabólicas e funcionais com o envelhecimento. Além disso, é uma atividade amplamente praticada pelos idosos como lazer, sendo uma intervenção de baixo custo e grande aderência por essa população. Entretanto, conclusões acerca dos efeitos da dança como forma de exercício para saúde ainda são limitadas, principalmente devido à falta de comparação com outros tipos de exercício físico, bem como ao número limitado de ensaios clínicos randomizados controlados analisando marcadores de risco cardiovascular (RCV).

OBJETIVO GERAL: Verificar os efeitos de uma intervenção de dança, comparada a um exercício aeróbio tradicional (caminhada) e a um grupo controle (alongamento), sobre marcadores RCV e capacidade funcional de mulheres idosas, em um ensaio clínico randomizado controlado (ECRc). Adicionalmente, verificar as respostas cardiorrespiratórias agudas de uma aula de dança para idosas, em um estudo de respostas agudas (antes e depois).

MÉTODOS: Trinta mulheres sedentárias (65±5 anos, índice de massa corporal (IMC) 27±4) foram randomizadas em três grupos de intervenção (n=10/grupo): dança, caminhada e alongamento (controle ativo) com duração de oito semanas (grupos dança ou caminhada 3x/sem, 60 min; grupo alongamento 1x/sem, 60 min). *Intervenções:* Dança: elementos técnicos (ballet, jazz, etc), estilos variados (danças latinas, dança aeróbica, etc), sem par. Caminhada: esteira, intensidade 60% VO_2pico. Alongamento: grandes grupos musculares, sem desconforto. Intervenções incluíam aquecimento, parte principal (35-40 min), e volta à calma. Foram avaliados no período pré e pós intervenção: consumo de oxigênio de pico (VO_2pico, desfecho primário); insulina, CRP, TNF-α, circunferências da cintura e quadril, tecido adiposo visceral, colesterol total, HDL-C, LDL-C, glicose, espessura muscular do quadríceps, força máxima e potência muscular, equilíbrio estático e dinâmico, marcha, flexibilidade, habilidade de sentar e levantar, e nível de atividade física. Os resultados estão descritos em média e IC (95%). As comparações intra e entre grupos foram realizadas pelo método de Equações de Estimativas Generalizadas, *post hoc LSD* ($p<0{,}05$), utilizando o software SPSS 22.0 Tamanho de efeito (TE) da intervenção de dança *vs*. alongamento (D *vs*. A) e caminhada *vs*. alongamento (C *vs*. A) também foram calculados.

RESULTADOS: ECRc (pré *vs.* pós): Efeito de interação grupo *vs.* tempo mostrou aumentos no VO_2pico ($mL.kg^{-1}.min^{-1}$) após a intervenção de dança 23,3 (20,8-25,8) *vs* 25,6 (23,4-27,8), e caminhada 23,4 (21,3-25,5) *vs* 27,0 (25,4-28,6), sem diferenças no grupo alongamento 23,5 (21,3-25,7) *vs* 23,0 (21-24,9). Não houve diferença entre os grupos dança e caminhada. O grupo caminhada foi superior ao grupo alongamento no momento pós-intervenção. TE: D *vs.* A = 0,72, C *vs.* A = 1,28. Altura do salto vertical (cm) também melhorou para os grupos dança 11,2 (9,3-13,1) *vs* 12,2 (10,3-14), e caminhada 10,3 (9-11,6) *vs* 11,3 (9,7-13), sem diferença para o grupo alongamento 9,8 (8,6 to 11,3) *vs* 9,3 (7,8 to 10,7). Não houve diferença entre os grupos dança e caminhada.

O grupo dança foi superior ao grupo alongamento no momento pós-intervenção. TE: D *vs.* A = 1,00, *C vs.* A = 0,74. Equilíbrio estático (s) também melhorou para os grupos dança 5,44 (2,34-8,55) *vs* 11,07 (6,53-15,62) e caminhada 5,67 (2,91-8,42) *vs* 14,46 (9,09-19,84), sem diferença para o grupo alongamento 4,05 (2,28-5,82) *vs* 4,04 (3,12-4,97). Não houve diferença entre os grupos dança e caminhada. Ambos os grupos dança e caminhada foram superiores ao grupo alongamento no momento pós-intervenção. TE: D *vs.* A = 1,22, C *vs.* A = 1,55. Habilidade de marcha e equilíbrio dinâmico melhoraram apenas para o grupo caminhada. Efeito tempo (efeitos agrupados) mostrou melhoras em relação aos marcadores inflamatórios CRP (mg/L)1,65 (1,56-1,73) *vs* 1,55 (1,44-1,65) e TNFα (pg/mL) 6,69 (6,36-7,02) *vs* 6,04 (5,82-6,25), LDL-C (mg/dL) 139,1 (126,6-151,7) *vs* 130,7 (117,1-144,4), HDL-C (mg/dL) 43,3 (38,9-47,7) *vs* 47,4 (42,6-52,3), gordura visceral (mm) 48,1 (40,1-56,0) *vs* 42,9 (35,9-50,0), habilidade de sentar e levantar (s) 10,23 (9,71-10,75) *vs* 8,32 (7,88-8,76), flexibilidade (cm) -0,60 (-2,44-1,24) *vs* 1,71 (-0,51-3,92), e nível de atividade física (tempo de caminhada em min.semana) 85 (39-131) *vs* 233 (154-313). Não foram encontradas diferenças para perfil glicêmico, triglicerídeos, colesterol total, força e espessura muscular do quadríceps. **Estudo de respostas agudas** (n=10 participantes do grupo dança, resultados em média ± desvio padrão): Teste de esforço máximo: VO_2 ($mL.kg^{-1}. min^{-1}$): VO_2pico (23,3 ± 4,3), primeiro limiar ventilatório (LV1) (17,2 ± 3,5) e segundo limiar ventilatório (20,9 ± 3,4). Aula de dança; VO_2 ($mL.kg^{-1}. min^{-1}$, %VO_2pico): aquecimento (12,8 ± 2,4, 55%), deslocamento (14,2 ± 2,4, 62%), coreografia (14,6 ± 3,2, 63%) e show (16,1 ± 3,3, 69%). A parte do show (coreografia aprendida) foi igual ao LV1 das participantes.

CONCLUSÕES: Os resultados do ECRc mostraram que a intervenção de dança foi capaz de induzir ganhos cardiorrespiratórios, potência de membros inferiores e equilíbrio estático iguais à caminhada, enquanto o grupo alongamento não apresentou mudanças. Ganhos adicionais em marcha e equilíbrio dinâmico foram verificados após a intervenção de caminhada. O engajamento em quaisquer das intervenções (alongamento, dança ou caminhada) foi capaz de atenuar marcadores inflamatórios e perfil lipídico, bem como induzir mudanças positivas na composição corporal. Os resultados do estudo de respostas cardiorrespiratórias agudas mostraram que a aula de dança elaborada para idosas foi de baixa intensidade aeróbia (LV1).

PALAVRAS-CHAVE: envelhecimento, exercício aeróbio, dança, caminhada, risco cardiovascular, capacidade funcional, condicionamento cardiorrespiratório.

ABSTRACT

INTRODUCTION: Biological aging is characterized, among many factors, by reductions in lean mass simultaneously to increases in visceral adipose tissue. This is connected to the development of cardiovascular diseases and physical dependence. Dancing has been suggested as a potential exercise intervention for cardiometabolic and functional improvements with aging. Moreover, it is a low-cost leisure activity, widely practiced among the older, with great adherence rates. However, conclusions on the effects of dancing as a type of exercise for improving health are still limited, mainly due to the lack of comparisons with other types of exercise. There is also a limited number of randomized controlled trials analyzing cardiovascular risk (CVR) markers as result of dance practice by the elderly.

AIMS: Verifying the effects of a dance intervention, compared to a traditional aerobic exercise (walking), and to a control group (stretching), on CVR markers and functional capacity of older women, in a randomized controlled trial (RCT). Additionally, verifying the acute cardiorespiratory responses of a dance session for older women, in a study of acute cardiorespiratory responses (before and after).

METHODS: Thirty sedentary women (65±5 yrs, BMI 27±4 kg/m^2) were randomized into three groups (n=10/group): dancing, walking or stretching (active control). All interventions lasted 8 weeks (60 min sessions): dancing/walking 3x/wk, stretching 1x/wk. Dancing: technical elements (ballet, jazz, etc), several styles (latin dances, aerobics, etc), no partner. Walking: treadmill, 60% peak oxygen consumption (VO_2peak). Stretching: large muscle groups, no discomfort. Interventions included a warm-up, main part (35-40 min) and cool-down. Before and after interventions assessments: VO_2peak (primary outcome), insulin, CRP, TNF-α, waist and hip circumferences, visceral adipose tissue (VAT), total cholesterol, HDL-C, LDL-C, glucose, quadriceps thickness, maximal muscle strength/power, static and dynamic balance, gait ability, flexibility, chair-raise and level of physical activity. Results are described as mean and CI (95%). Statistics: Generalized estimating equations, *post-hoc* LSD ($p<0.05$), SPSS 22.0. Effect sizes (ES) of dancing *vs*. stretching (D *vs.* S) and walking *vs*. stretching (W *vs.* S) were also calculated.

RESULTS (mean-CI): **RCT** (before *vs* after): Group *vs* time interaction showed increases in VO_2peak (mL.kg^{-1}.min^{-1}) for dancing 23.3 (20.8-25.8) *vs.* 25.6 (23.4-27.8), and walking 23.4 (21.3-25.5) *vs* 27.0 (25.4-28.6), with no differences for stretching 23.5 (21.3-25.7) *vs* 23.0 (21.0-24.9). There was no difference in between dancing and walking groups. Walking was superior to stretching after the interventions. ES: D *vs.* S = 0.72, W *vs.* S = 1.28. Lower body muscle power also improved for dancing 11.2 (9.3-13.1) *vs* 12.2 (10.3-14), and walking 10.3 (9-11.6) *vs* 11.3 (9.7-13), but not for stretching 9.8 (8.6 to 11.3) *vs* 9.3 (7.8 to 10.7). There was no difference in between dancing and walking groups. Dancing was superior to stretching after the interventions. ES: D *vs.* W = 1.00, W *vs.* S = 0.74. Static balance (s) also improved for dancing 5.44 (2.34-8.55) *vs* 11.07 (6.53-15.62) and walking groups 5.67 (2.91-8.42) *vs* 14.46 (9.09-19.84), with no differences for the stretching group 4.05 (2.28-5.82) *vs* 4.04 (3.12-4.97). There was no difference in between dancing and walking. Both dancing and walking were superior to stretching after the interventions. ES: D *vs.* S = 1.22, W *vs.* S = 1.55. Gait ability and dynamic balance improved only for the walking group. Main time effect (polled effects) showed improvements in CRP (mg/L)1.65 (1.56-1.73) *vs* 1.55 (1.44-1.65) and TNFα (pg/mL) 6.69 (6.36-7.02) *vs* 6.04 (5.82-6.25), LDL-C (mg/dL) 139.1 (126.6-151.7) *vs*

130.7 (117.1-144.4), HDL-C (mg/dL) 43.3 (38.9-47.7) *vs* 47.4 (42.6-52.3), visceral fat (mm) 48.1 (40.1-56.0) *vs* 42.9 (35.9-50.0), chair raise (s) 10.23 (9.71-10.75) *vs* 8.32 (7.88-8.76), flexibility (cm) -0.60 (-2.44-1.24) *vs* 1.71 (-0.51-3.92), and level of physical activity (walking time in min.week) 85 (39-131) *vs* 233 (154-313). No differences were found for glycaemic profile, triglycerides, total cholesterol, quadriceps thickness and muscular strength. **Acute responses study:** (n=10 participants from the dancing group, results in mean ± standard deviation): Maximum effort test: VO_2 ($mL.kg^{-1}.min^{-1}$): VO_2peak (23.3 ± 4.3). first ventilatory threshold (VT1) (17.2 ± 3.5) and second ventilatory threshold (20.9 ± 3.4). Dance class: VO_2 ($mL.kg^{-1}.min^{-1}$. %VO_2peak): warm-up (12.8 ± 2.4, 55%), across-the-floor (14.2 ± 2.4, 62%), choreography (14.6 ± 3.2, 63%) and show (16.1 ± 3.3, 69%). The show part (choreography learned) was equal to participants' VT1.

CONCLUSIONS: Results from the RCT showed that dancing induced similar increases in VO_2peak, lower body muscle power and static balance as walking, while the stretching group remained unchanged. Additional gains for gait ability and dynamic balance were observed for the walking group. The engagement in any of the interventions (stretching, dancing or walking) attenuated inflammatory markers and lipid profile, as well as induced positive changes in body composition. Results from the acute cardiorespiratory responses study showed that the dance class designed for older women was at low aerobic intensity (VT1).

KEYWORDS: aging, aerobic exercise, dancing, walking, cardiovascular risk, functional capacity, cardiorespiratory fitness.

LISTA DE ABREVIATURAS

CMJ – *Counter movement jump*

PCR – Proteína C-reativa

DMT2 - Diabetes mellitus tipo 2

ECR - Ensaio clínico randomizado

ECRc - Ensaio clínico randomizado controlado

ECnR - Ensaio clínico não-randomizado

FC – Frequência cardíaca

FCmax - Frequência cardíaca máxima

HDL-C – Lipoproteína-colesterol de alta densidade

HOMA-IR - Modelo Homeostático de Avaliação da Resistência à Insulina

IMC - Índice de massa corporal

LDL-C - Lipoproteína-colesterol de baixa densidade

LV1 e LV2 – Primeiro e segundo limiar ventilatório

PAS e PAD - pressão arterial sistólica e pressão arterial diastólica

RCV - Risco cardiovascular

RER – *Respiratory exchange ratio*

RPE – *Rate of perceived exertion*

TNFα – Fator de necrose tumoral alfa

TUG – *Time to up and go*

VCO_2 – Produção de dióxido de carbono

VE – Ventilação

VO_2 – Consumo de oxigênio

VO_{2max} – Consumo máximo de oxigênio

VO_{2pico} - Consumo de oxigênio de pico

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SUMÁRIO

1. APRESENTAÇÃO DA TESE

Essa tese é composta por uma introdução, quatro artigos completos já publicados em periódicos internacionais indexados, conclusões gerais acerca dos quatro estudos realizados, suas limitações e perspectivas futuras. Os dois primeiros artigos são de revisão, sendo uma revisão de literatura sistemática e uma revisão sistemática com metanálise. Ambos os estudos de revisão englobam o referencial teórico da tese. Após, são apresentados dois artigos experimentais, um estudo sobre as repostas cardiorrespiratórias agudas a uma aula de dança (estudo de respostas agudas), e um ensaio clínico randomizado controlado (ECRc), correspondentes aos objetivos do projeto de pesquisa. Os quatro manuscritos seguem incorporados ao documento em seu formato original, com introdução, objetivos, metodologia utilizada, discussão dos resultados, conclusões e referências bibliográficas correspondentes a cada estudo.

Os artigos são apresentados na seguinte ordem:

Artigo 1: *Dancing for Healthy Aging: Functional and Metabolic Perspectives (Altern Ther Health Med. 2018 Feb 10 Epud ahead of print) [1]*

Artigo 2: *Effects of Dance Interventions on Cardiovascular Risk with Ageing: Systematic Review and Meta-Analysis Effects of Dance Interventions on Cardiovascular Risk with Ageing: Systematic Review and Meta-Analysis (Complement Ther Med. 2016 Dec; 29:16-28) [2]*

Artigo 3: *Cardiorespiratory Responses of a Dance Session Designed for Older Women: A Cross Sectional Study (Exp Gerontol. 2018 Sep; 110:139-145) [3]*

Artigo 4: *Effects of a Dance Intervention Compared to Walking on Cardiovascular Risk Factors and Functional Capacity of Older Women: a Randomized Controlled Trial (Exp Gerontol. 2018 Oct 31;114:67-77) [4]*

O documento está em consonância com o novo regimento interno do Programa de Pós-Graduação em Ciências do Movimento Humano, a partir da resolução 10/2014 do Comitê de Ética em Pesquisa (CEPE)/UFRGS. O projeto foi aprovado pelo CEPE/UFRGS (CAAE 53438516.0.0000.5347), com o título "Efeitos de uma intervenção de dança comparada à caminhada em marcadores de risco cardiovascular e capacidade funcional em mulheres idosas: um ensaio clínico randomizado". Todas as participantes assinaram o termo de consentimento livre e esclarecido para engajamento no estudo.

2. INTRODUÇÃO

Diante das mudanças demográficas que vêm ocorrendo nos países em desenvolvimento, caracterizadas por avanços na longevidade, mais atenção tem sido dada ao conceito de envelhecimento saudável [5]. Isso implica na prevenção de doenças e na manutenção das funções físicas e cognitivas, o que pode ser atingido através do engajamento em atividades sociais, físicas e produtivas [6]. Assim, a preocupação com os custos econômicos e humanitários associados com uma futura perda de independência física relacionada ao envelhecimento e/ou a um estilo de vida sedentário, vem crescendo.

De fato, o processo de envelhecimento da população mundial vem aumentando, principalmente nos países em desenvolvimento, como o Brasil [7]. Declínios nas taxas de mortalidade e reduções de fecundidade, indicam que a população acima de 60 anos passará de 18 milhões (2010) para 65 milhões (2050) [7]. Isso gera uma grande demanda aos serviços de saúde, culminando em grande aumento de gastos com cuidados médicos e internações hospitalares [8]. As complicações de saúde associadas ao envelhecimento, como doenças crônicas, limitações funcionais e cognitivas, consistem na principal fonte de gastos dos sistemas de saúde com essa população [9].

O processo de envelhecimento fisiológico é caracterizado por uma diminuição de massa muscular concomitante a um aumento de tecido adiposo visceral [10]. Metabolicamente, isso se traduz em diminuição da captação de glicose e aumento da liberação de citocinas pró-inflamatórias, o que de um lado, podem levar ao desenvolvimento de um processo inflamatório crônico de baixo grau, ligado a desequilíbrios do perfil lipídico, aumentos de citocinas pró-infalmatórias, resistência à insulina e doenças associadas a risco cardiovascular (RCV) mais elevado, como diabetes mellitus tipo 2 (DMT2). De outro lado, a diminuição de massa muscular, principalmente atribuída à atrofia das fibras musculares de contração rápida [11], está associada a reduções de força e potência muscular, induzindo a declínios funcionais que culminam em reduções nos níveis de atividade física, dificuldade para realização de atividades de vida diária, aumento do risco de quedas e possível perda de independência física [5, 12].

Além disso, ambos os fatores, funcionais e metabólicos, estão associados a diminuições significativas na capacidade aeróbia com o processo de envelhecimento [13, 14]. Há uma redução em torno de 5 $mL.kg^{-1}.min^{-1}$ por década de vida no consumo de oxigênio de pico (VO_2pico) a partir dos 35 anos de idade, mediante inatividade física [14]. Mais do que isso, a cada 1 $mL.kg^{-1}.min^{-1}$ abaixo do limiar de independência física

(18 mL.kg^{-1}.min^{-1}), perde-se 8 vezes em capacidade funcional [15]. Dessa forma, a manutenção e/ou ganhos de uma reserva aeróbia parece ser um elemento fundamental, pois está ligada a ambos, capacidade funcional e RCV [13, 15]. A primeira, especialmente ligada ao retardo da fadiga muscular induzida por esforço físico, principalmente em intensidades submáximas de trabalho, como as atividades de vida diária [14, 15]. A segunda, pela ativação de enzimas importantes do metabolismo oxidativo, como a enzima lipase lipoproteica no músculo esquelético, que aumenta o transporte de lipídeos e lipoproteínas da circulação periférica e dos tecidos para o fígado [16].

De fato, nível de atividade física e condicionamento cardiorrespiratório têm sido considerados como fatores de risco cardiovascular importantes no processo de envelhecimento [13]. Por exemplo, condicionamento cardiorrespiratório mais elevado parece atenuar a elevação de lipídeos séricos e lipoproteínas ao longo da vida [16]. Ademais, condicionamento cardiorrespiratório pode ser considerado um preditor quantitativo de todas as causas de mortalidade e eventos cardiovasculares em homens e mulheres saudáveis [17].

Assim, a busca por estratégias de prevenção dessas doenças parece essencial, principalmente aquelas que propiciam ganhos globais ao idoso (físicos, mentais e sociais) [18]. O elevado custo social, pessoal e para os sistemas de saúde do tratamento destas comorbidades metabólicas no envelhecimento, associados à perda de independência física, tem gerado atenção para o exercício como forma de retardar os efeitos negativos da idade. Por exemplo, a prática regular de exercícios atenua aumentos de gordura visceral, perda de massa magra e inflamação, ligados à obesidade, DMT2 e doenças cardiovasculares [10]. Em 2004, os custos com doenças cardiovasculares representaram 30,8 bilhões de reais em alguns estados brasileiros [19]. Por outro lado, investimentos em projetos que estimulem a adesão à prática de exercícios podem representar uma economia anual de aproximadamente um bilhão de reais no setor de saúde pública no Brasil e outros países em desenvolvimento [19].

Os efeitos do exercício físico, em especial do treinamento aeróbio e de força mais tradicionais, são bem conhecidos, tais como melhoras na composição corporal, capacidade cardiorrespiratória, sensibilidade à insulina, melhoras no sistema antioxidante, aumentos de força e potência muscular, capacidade funcional, além da redução de diversos marcadores de RCV em idosos [5, 10, 20]. Além disso, o número de estudos usando terapias alternativas de exercício vem crescendo, como Tai-chi [21], Yoga

[22] e dança [1], principalmente devido a altas taxas de aderência, ligadas a sociabilidade dos trabalhos em grupo, e ao baixo custo das intervenções [23].

Particularmente em relação à dança, ela contempla características neuromotoras e é uma forma de promover a atividade física, aumentar a interação social durante os programas de treinamento, bem como manter elevados índices de continuidade mesmo após os períodos de intervenção [24]. Sabe-se que as intervenções de dança têm sido eficazes em induzir melhorias em elementos funcionais como equilíbrio, marcha e capacidade aeróbia de idosos, fatores relacionados à manutenção e/ou ganhos de independência física no processo de envelhecimento [25]. No entanto, as respostas metabólicas têm sido menos estudadas [1].

Do ponto de vista funcional, as mudanças de direção, ritmo e velocidade dos movimentos de dança favorecem o controle postural, o equilíbrio, a orientação espaço-temporal, o desenvolvimento da potência muscular e aspectos relacionados à mobilidade, todos esses fatores associados à diminuição do risco de queda em idosos [26]. Por exemplo, oito semanas de treinamento de salsa melhoraram velocidade de marcha e comprimento da passada, assim como equilíbrio dinâmico e estático de idosos [26]. Dança-terapia, baseada em movimentos modificados da aeróbica de baixo impacto, *ballet* e *jazz*, foi também efetiva em melhorar equilíbrio estático e velocidade de marcha nessa população [24].

Em relação aos aspectos metabólicos, efeitos positivos de intervenções de dança têm sido demonstrados em alguns estudos *quasi*-experimentais e ensaios clínicos não-randomizados (ECnR) [27-30], apesar de em menor extensão em ECRc [31-33]. Por exemplo, melhoras nas concentrações sanguíneas de triglicerídeos, colesterol total, HDL-C, vasodilatação endotélio-dependente e velocidade de enchimento do ventrículo esquerdo foram detectadas após oito semanas de treinamento de valsa em pacientes com insuficiência cardíaca crônica (ICC) [31]. Além disso, a dança foi tão efetiva quanto exercícios convencionais (cicloergômetro) em melhorar VO_2pico e qualidade de vida nesses pacientes [31]. Adicionalmente, uma relação dose-resposta de incrementos de 1h de prática de dança por semana foi associada com reduções em triglicerídeos, glicose sanguínea, pressão arterial sistólica e diastólica (PAS e PAD), e circunferência da cintura; bem como aumentos no HDL de idosos chineses, analisados em um amplo estudo transversal [34].

De fato, adaptações cardiovasculares específicas podem ser induzidas pelas características intermitentes da dança, as quais incluem baterias de exercício de curta duração e intensidade ligeiramente elevada (como a execução veloz do trabalho de pés com sucessivos saltos de baixo impacto), alternadas com movimentos contínuos de mais baixa intensidade (como movimentos suaves, em grande amplitude, dos membros inferiores e superiores) [35]. Além disso, idosos parecem ter maior tolerância a baterias de exercício de duração mais curta, devido à menor sobrecarga ortopédica [1]. A percepção de sucesso após o cumprimento dos objetivos propostos em sequências de dança de menor duração também aumenta a motivação e contribui para maior engajamento nas rotinas de exercício [1].

Nosso grupo de pesquisa, há mais de 10 anos, vem estudando as respostas fisiológicas da dança em ambos os níveis profissional e recreativo [35-37]. Consistentemente, tem se observado que as demandas cardiorrespiratórias das aulas de dança são aeróbias de baixa intensidade, próximas ao primeiro limiar ventilatório (LV1) das bailarinas. Por outro lado, as demandas de palco podem atingir ou superar o segundo limiar ventilatório (LV2), devido à maior intensidade das diversas coreografias, executadas com menor intervalo de recuperação entre elas, em um espetáculo. Dessa forma, as demandas cardiorrespiratórias das coreografias finais de um espetáculo são usualmente mais elevadas do que as demandas de uma aula de dança, que têm um tempo efetivo de exercício comumente interrompido pelo processo cognitivo de aprendizado das rotinas, correções técnicas em aula, e/ou aprimoramento artístico [37].

Nesse contexto, surgiram as questões de pesquisa que nortearam a presente tese de doutorado: Será que a intensidade das aulas de dança para não-bailarinos também é baixa? Será que a dança pode servir como forma de exercício para a saúde em populações especiais, em especial idosos, que usualmente praticam dança como uma atividade de lazer? "Quais seriam as demandas, e as consequentes adaptações fisiológicas das aulas de dança para essa população?

Especificamente, objetivou-se investigar se a dança poderia servir como alternativa de exercício para promover adaptações cardiorrespiratórias, funcionais e metabólicas em diferentes aspectos que entram em declínio com o processo de envelhecimento (composição corporal, perfil lipídico, capacidade cardiorrespiratória, equilíbrio, força, potência muscular, etc). Em especial, considera-se que o processo cognitivo envolvido no aprendizado das rotinas coreográficas pode influenciar na implementação, manutenção e controle da intensidade das aulas de dança [37]. De fato, o controle de fatores como intensidade, volume e frequência de treinamento são essenciais para desencadear adaptações cardiorrespiratórias e neuromusculares na periodização de treinamento aeróbio e/ou de força para essa população [20].

Em uma primeira ampla revisão de literatura, *Dancing for Healthy Aging: Functional and Metabolic Perspectives* [1], de caráter prioritariamente narrativo, teve-se por objetivo identificar e descrever uma ampla faixa de estudos usando a dança como forma de intervenção para promover a saúde funcional e metabólica de indivíduos mais velhos, sumarizando-os e colocando-os em perspectiva para análises futuras. A fim de identificar o maior numero de referências possíveis, estudos com diferentes desenhos experimentais foram incluídos, assim como idosos saudáveis ou com diferentes condições clínicas. A revisão incluiu uma busca sistemática, seguida por uma discussão qualitativa sobre uma gama de desfechos funcionais e metabólicos afetados pelo processo de envelhecimento, como equilíbrio, força e potência muscular, capacidade cardiorrespiratória, composição corporal, pressão arterial, perfil lipídico, glicêmico, inflamatório, etc. Numerosos estudos foram identificados, reportando a dança como intervenção efetiva para a melhoria de aspectos funcionais (equilíbrio, marcha, flexibilidade) de indivíduos acima de 60 anos, com ou sem condições clínicas associadas [1]. Por outro lado, evidências sobre os benefícios à saúde metabólica provenientes da prática de dança para essa população são limitadas, principalmente pelos desenhos experimentais e ausência de comparação com outros modelos de exercício [1].

Dessa forma, aprofundamos a busca sobre os efeitos das intervenções de dança em desfechos relacionados a RCV, em uma segunda revisão de literatura intitulada *Effects of Dance Interventions on Cardiovascular Risk with Ageing: Systematic Review and Meta-Analysis* [2]**.** O objetivo desta revisão foi verificar os efeitos de intervenções de dança especificamente sobre marcadores de RCV em idosos, comparando praticantes de dança com grupos controle não praticantes de exercício, ou com outros tipos de exercício, em ECR e ECnR. O desfecho primário dessa revisão foi o VO_2pico, e os desfechos secundários foram peso corporal, índice de massa corporal (IMC), percentual de gordura e perfil lipídico. Os resultados desse estudo indicaram que a dança pode ser considerada uma intervenção potencial para melhoria da capacidade cardiorrespiratória e RCV associado ao envelhecimento. Entretanto, conclusões acerca de desfechos metabólicos associados a RCV são limitadas pela escassez de estudos.

As lacunas encontradas a partir dessas duas revisões de literatura, as quais limitam as conclusões sobre os efeitos da dança em desfechos associados a RCV no envelhecimento, baseiam-se em dois pontos principais: (1) ausência de ECRc de boa qualidade metodológica, principalmente comparando a magnitude dos efeito das intervenções de dança com outros tipos de exercício; (2) descrição limitada da intensidade das aulas de dança para essa população, com ausência de descrição não só de medidas diretas como VO_2 e FC, mas também de parâmetros simples e de aplicabilidade prática para possível prescrição de treinamento em dança, como as batidas por minuto (bpm) das músicas utilizadas.

Desse modo, o objetivo geral do projeto de pesquisa dessa tese foi verificar e comparar os efeitos de uma intervenção de dança a uma intervenção de caminhada, e a um grupo controle (ativo, alongamento), sobre marcadores de RCV e capacidade funcional de mulheres idosas. Adicionalmente, verificar as respostas cardiorrespiratórias agudas de uma aula de dança para idosas.

Assim, o terceiro estudo que compõe este documento, *Cardiorespiratory Responses of a Dance Session Designed for Older Women: A Cross Sectional Study*, teve por objetivo descrever as respostas cardiorrespiratórias agudas de uma sessão de dança para mulheres idosas, e identificar zonas de intensidade da aula de dança em relação ao VO_2pico, LV1 e LV2 das participantes. O estudo também relacionou aspectos metodológicos da sessão de dança, como os bpm das músicas utilizadas em diferentes partes da aula, às respectivas respostas cardiorrespiratórias de cada parte. Essa avaliação aguda da aula de dança serviu como base para construção da intervenção de dança de oito semanas, descrita no quarto estudo, o ECRc.

Por fim, o quarto estudo, *Effects of a Dance Intervention Compared to Walking on Cardiovascular Risk Factors and Functional Capacity of Older Women: a Randomized Controlled Trial*, visou verificar os efeitos de uma intervenção de dança comparada a um exercício aeróbio tradicional, a caminhada, sobre marcadores de RCV e capacidade funcional de idosas, em um ECRc. O desfecho principal foi o VO_2pico, relacionado a ambos, RCV [13] e funcionalidade [14]. Os desfechos secundários foram medidas de composição corporal (tecido adiposo visceral, espessura muscular do quadríceps, circunferências da cintura e quadril); respostas metabólicas (perfil lipídico, glicêmico e inflamatório) associadas a RCV; e desempenho em testes funcionais (equilíbrio estático e dinâmico, habilidade de marcha, sentar e levantar, flexibilidade, força e potência muscular). Mudanças nos níveis de atividade física diária e hábitos alimentares também foram registradas.

As hipóteses iniciais referentes ao objetivo geral da tese eram as seguintes:

H1: A intervenção de dança é tão eficiente quanto à intervenção de caminhada em melhorar parâmetros de RCV e capacidade cardiorrespiratória em idosas; sendo ambas as intervenções melhores do que a situação controle.

H2: A intervenção de dança é mais eficiente do que a intervenção de caminhada em melhorar potência muscular, equilíbrio estático e dinâmico e flexibilidade; sendo ambas as intervenções melhores do que a situação controle.

H3: As repostas cardiorrespiratórias agudas de uma sessão de dança para idosos são correspondentes à zona aeróbia de moderada intensidade, entre o LV1 e o LV2 das participantes.

A seguir, encontram-se os quatro artigos que compõe essa tese na íntegra, com introdução, objetivos, metodologia utilizada, discussão dos resultados, conclusões e referências bibliográficas correspondentes a cada estudo.

3. APRESENTAÇÃO DOS ARTIGOS

3.1 ARTIGO 1: REVISÃO SISTEMÁTICA

DANCING FOR HEALTHY AGING:

FUNCTIONAL AND METABOLIC PERSPECTIVES

REVIEW ARTICLE

Dancing for Healthy Aging: Functional and Metabolic Perspectives

Josianne Rodrigues-Krause, MS, PhD(c); Mauricio Krause, PhD; Alvaro Reischak-Oliveira, PhD

ABSTRACT

Context • Dancing has been used as a form of exercise to improve functional and metabolic outcomes during aging. The field lacks randomized, clinical trials (RCTs) evaluating metabolic outcomes related to dance interventions, but dancing may be a form of exercise that could induce positive effects on the metabolic health of older adults. However, primary studies seem very heterogonous regarding the trial designs, characteristics of the interventions, the methods for outcomes assessments, statistical powers, and methodological quality.

Objective • The current research team intended to review the literature on the use of dance as a form of intervention to promote functional and metabolic health in older adults. Specifically, the research team aimed to identify and describe the characteristics of a large range of studies using dance as an intervention, summarizing them and putting them into perspective for further analysis.

Design • The research team searched the following data sources—MEDLINE, Cochrane Wiley, Clinical Trials.gov, the Physiotherapy Evidence Database (PEDRO), and the Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS)—for RCTs, quasi-experimental studies, and observational trials that compared the benefits of any style of dancing, combined with other exercises or alone, to nonexercising controls and/or controls practicing other types of exercise.

Setting • The study took place at the Federal University of Rio Grande do Sul (Porto Alegre, Brazil).

Participants: Participants were aging individuals, >55 y, both with or without health conditions.

Interventions • Interventions should be supervised, taking form as group classes, in a dance setting environment. Dance styles were divided into 5 categories for the review: (1) cultural dances developed by groups of people to reflect the roots of a certain region, such as Greek dance; (2) ballroom dance (ie, dances with partners performed socially or competitively in a ballroom, such as foxtrot); (3) aerobic dance with no partner required, which mixes aerobic moves with dance moves; (4) dance therapies, which are special dance programs including emotional and physical aspects; and (5) classical dances, which are dances with a unique tradition and technique, such as ballet or jazz dance.

Outcome Measures • Studies needed to have evaluated functional and/or metabolic outcomes. Functional outcomes included (1) static and/or dynamic balance, (2) gait ability, (3) upper and/or lower muscle strength or power, (4) cardiorespiratory fitness, (5) flexibility, (6) risk of falls, and (7) quality of life. Metabolic outcomes included (1) lipid and glycemic profile; (2) systolic and diastolic blood pressure; (3) body composition; and (4) other specific cardiovascular risk factors or inflammatory or oxidative stress markers.

Results • The research team retrieved 1042 articles, with 88 full texts assessed for eligibility, and 50 articles included in the analysis. Of the analyzed studies, 22 were RCTs evaluating dancing vs controls, and 3 were RCTs evaluating dancing vs other exercise. Regarding the participants of the reviewed studies: (1) 31 evaluated healthy individuals, (2) 7 evaluated patients suffering from Parkinson's disease, (3) 4 evaluated postmenopausal women, (4) 2 evaluated obese women, (5) 2 evaluated patients with chronic heart failure, (6) 1 evaluated frail older adults, (7) 1 evaluated individuals with visual impairments, (8) 1 evaluated persons with metabolic syndrome, and (9) 1 evaluated individuals with severe pain in the lower extremities. Regarding the interventions, most interventions were 12 wk long, 3 ×/wk, for 60 min each session. The dance styles most used were ballroom and cultural dances. Regarding the outcomes, functional and metabolic benefits were described in most of the included studies. Balance was the functional outcome most often assessed.

Conclusions • Any dance style can induce positive functional adaptations in older adults, especially related to balance. Metabolic improvements may also be a result of dancing; however, more RCTs are needed. Dancing may be a potential exercise intervention to promote health-related benefits for aging individuals. (*Altern Ther Health Med.* [E-pub ahead of print.])

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The concept of healthy aging has been expanding with the rapid growth of the older population in developing countries.[1] Concerns about the economic costs associated with the possible loss of independence due to aging[2,3] have brought attention to exercise interventions as an effective way of delaying the negative effects of aging on functional and metabolic parameters.[1,4]

An increasing number of studies have used dance as an exercise intervention to promote physical activity and health-related benefits for older adults.[5] Dancing has been recommended as a form of exercise for the older individual because it includes a variety of stimuli for different physiological elements that are progressively impaired with aging.[6] For example, studies on interventions with waltz and Greek dance have been shown to increase aerobic capacity and quality of life for older men with chronic heart failure.[7,8] Furthermore, salsa dance has been shown to improve components of mobility, such as the balance and stride time and length of healthy older adults.[9] In fact, dancing may be adjusted to a population's age and physical limitations[5]; it is likely an attractive way of promoting exercise adherence and further functional and metabolic benefits.

Dance has already been shown to be an efficient strategy for reducing factors related to risk of falling in healthy older adults, providing functional benefits, such as improvements in static and dynamic balance, flexibility, and gate ability.[10] For instance, 8 weeks of Turkish dance improved elements of physical independence, such as the ability to sit down and rise again and to move up stairs.[11] Hwang and Braun's[5] study evaluated the benefits of dancing on other health-related outcomes, such as cognition, strength, and endurance; however, metabolic outcomes were not included in the study.[5]

The field lacks randomized, controlled trials (RCTs) evaluating metabolic outcomes related to dance interventions,[12] but dancing may be a form of exercise that could induce positive effects on the metabolic health of older adults. For example, improvements in triglycerides and total cholesterol levels were detected after 1 year of ballroom dancing once per week.[13] In addition, a recent meta-analysis demonstrated that dancing might be a potential exercise intervention for improving cardiorespiratory fitness, and consequently, reducing the cardiovascular risk associated with aging.[12]

Thus, evidence on the potential of dancing as an exercise intervention to improve functional and metabolic outcomes with aging has been increasing.[5,10,12] However, primary studies seem very heterogonous regarding the trial designs, characteristics of the interventions, the methods for outcomes assessments, statistical powers, and methodological quality.

Therefore, the current research team intended to review the literature on the use of dance as a form of intervention to promote functional and metabolic health in older adults. Specifically, the research team aimed to identify and describe the characteristics of a large range of studies using dance as an intervention, summarizing them and putting them in perspective for further analysis.

METHODS

Participants

The study took place at the Federal University of Rio Grande do Sul (Porto Alegre, Brazil). Participants in the reviewed studies were aging individuals, older than 55 years, both with or without health conditions. Of the reviewed studies, (1) 31 evaluated healthy individuals, (2) 7 evaluated patients suffering from Parkinson's disease, (3) 4 evaluated postmenopausal women, (4) 2 evaluated obese women, (5) 2 evaluated patients with chronic heart failure, (6) 1 evaluated frail older adults, (7) 1 evaluated individuals with visual impairments, (8) 1 evaluated persons with metabolic syndrome, and (9) 1 evaluated individuals with severe pain in the lower extremities.

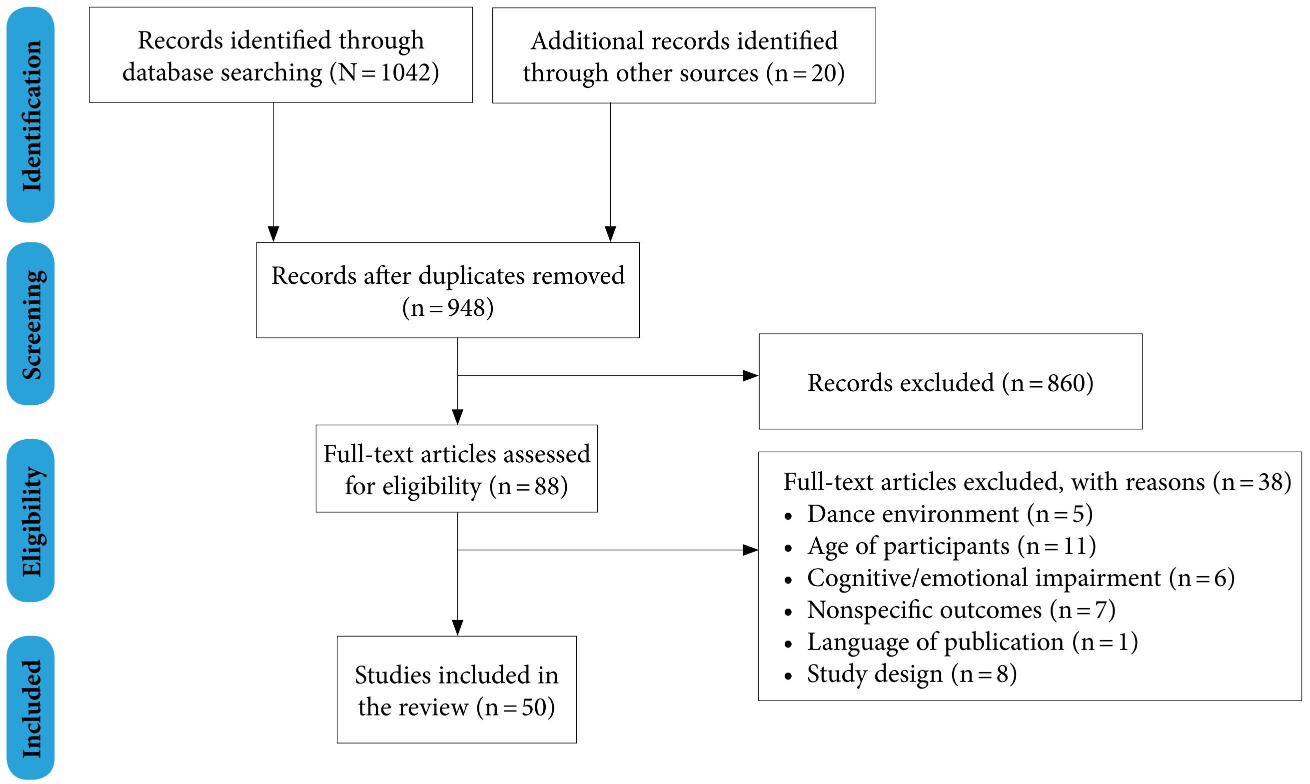
Procedures

Search Strategy. The following electronic databases were searched covering a publication period from November 1980 to March 2016: Medical Literature Analysis and Retrieval System Online (MEDLINE), accessed through PubMed; the Cochrane Wiley database, a central register of controlled trials; Clinical Trials.gov; the Physiotherapy Evidence Database (PEDRO); and the Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS). In addition, the reference lists of published studies were searched manually. Two search themes were combined using a Boolean operator, with no language restriction. The first key words were related to the population (exploded versions of the Medical Subject Headings [MeSH]) as follows: *elderly* OR *aging* OR *ageing* OR *aged* OR *senescence* OR *biological aging* OR *older* OR *older adults*). The second keywords were related to the intervention (combined exploded versions of MeSH) using the following words: *dance* OR *dancing* OR *dance* therapy. Articles in English, Spanish, or Portuguese were included.

Eligibility Criteria. The review included the following types of study designs: (1) RCTs; (2) quasi-experimental trials, including pre- and postintervention studies with 1 group (1-group), nonrandomized controlled trials (nRCTs), and studies with other nonrandom distributions; and (3) observational designs—cross-sectional or cohorts. Comparison groups included nonexercising control groups and/or groups performing other types of exercise.

The research team excluded studies if they (1) evaluated older patients with cognitive and/or emotional impairment,

Figure 1. Flow Diagram of Search and Selection of Studies



such as Alzheimer's disease, depression, and dementia; (2) the dance environment was categorized as a dance videogame or a dance on the water; or (3) had study designs that did not fit the current study's protocols or were case-studies .

Risk of Bias Assessment. Risk of bias was evaluated according to the PRISMA recommendations.[14] The research team assessed the quality of the reviewed RCTs based on a 6-item instrument, as follows: (1) adequate sequence generation, allocation concealment, blinding of patients and investigators, blinding of outcomes assessors; (2) use of intention-to-treat analysis; and (3) description of losses and exclusions. Studies without clear descriptions of an adequate sequence generation or of the way in which the allocation list was concealed were considered not to have fulfilled those criteria. The standards of assessment for risk of bias, by consensus of the authors, were as follows: low, 4 or more items; moderate, 3 items; and high, 2 or fewer items.

Interventions

Dance interventions were considered to be the attendance of regular dance classes for at least 2 weeks. Studies of any style of dance were included, either combined with other types of exercise or performed alone. Dance environments included dance studios and stage and/or dance ballrooms.

Categories of Dance Styles

Dance styles were divided into 5 categories for the review: (1) cultural dances developed by groups of people to reflect the roots of a certain region, such as Greek, Turkish, Caribbean, Thai, and Bhangra dance; (2) ballroom dance (ie, dances with partners performed socially or competitively in a ballroom, such as waltz, tango, salsa, and foxtrot); (3) aerobic dance with no partner required, which mixes aerobic moves—knees up, marches, mambos, and cha-chas—with dance moves—isolations of hips, shoulders, and chest, including line dances; (4) dance therapies, which are special dance programs including emotional and physical aspects—the Labed method, Health-Steps, creative dance, and exercise dance for seniors (EXDASE); and (5) classical dances, which are dances with a unique tradition and technique, such as ballet or jazz dance.

OUTCOME MEASURES

Studies needed to have evaluated functional and/or metabolic outcomes. Functional outcomes included (1) static and/or dynamic balance, (2) gait ability, (3) upper and/or lower muscle strength or power, (4) cardiorespiratory fitness, (5) flexibility, (6) risk of falls, and (7) quality of life. Metabolic outcomes included (1) lipid and glycemic profile—total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), triglycerides, fasting insulin, and glucose; (2) systolic blood pressure (SBP) and diastolic blood pressure (DBP); (3) body composition—body weight, body mass index (BMI), skinfolds, body fat, and lean mass; and (4) other specific cardiovascular risk factors or inflammatory or oxidative stress markers. Outcomes such as cognitive performance, depression, sensory/fine motor performance, and bone mineral density were not taken in consideration in the review.

RESULTS

Description of Studies

From 1042 potentially relevant citations identified through searches of the electronic database plus a search of reference lists (20 citations), 948 records were screened. After removing duplicates, 88 full-text articles were assessed for eligibility. Of those articles, 38 were excluded for the following reasons: (1) dance environment: 5 studies—1 dance in the water, 3 dance video games, 1 online dance therapy; (2) age of participants: 11 studies—mean age younger than 55 years or lower range younger than the 50s; (3) cognitive and/or emotional impairment of participants studied: 6 studies; (4) no outcomes of interest to the current study: 7 studies—1 study of proprioception, 2 of cognition, 1 of bone density, 1 of self-perception, 1 of level of physical activity, and 1 of sleeping problems; (5) language of publication: 1 study—article in Korean; and (6) study design: 8 studies—1 describing only the protocol of intervention to be performed in the future, with no results so far, 2 case studies, and 5 reviews. Finally, 50 studies were included in the descriptive synthesis. Figure 1 shows a flow diagram of the search for and selection of studies.

Study Designs

From the 50 studies included in this descriptive synthesis, the following study designs were identified: (1) 31 RCTs[7-9,11,13,15-39,44]; (2) 8 pre- and postintervention studies with 1 group only[40-43,45-48]; (3) 8 observational studies—all cross-sectional trials[49-56]; and (4) 3 quasi-experimental studies—2 nRCTs and 1 trial comparing participants who completed the dance intervention with the ones who did not finish the study.[57-59] See Table 1 for the details on the RCTs and Table 2 for details on the other types of studies .

Table 1. Characteristics of Randomized Control Trials Using Dance as a Form of Exercise Intervention on Functional and/or Metabolic Outcomes in the Older Adults

Reference, Study Design, General Features	Dancers Group Characteristics of Dance Sessions/Intervention	Comparison Group Characteristics of Controls and/or Exercise Sessions/Interventions	Outcomes Measured Method of Analysis	Conclusions
Belardinelli et al[7] (2008) • RCT • N = 130 • 107 men, 23 women with chronic heart failure • Mean age: 59 ± 11 y	Waltz dance • n = 44 • 36 men and 8 women • 60 ± 11 y • 8 wk; 3 ×/wk; 40 min • 10-min warm-up; 21-min main part; cooldown • 21-min waltz; 5-min slow waltz vs 3-min fast waltz • 70% VO_2peak • Experienced partner required	Controls • n = 42 • 35 men and 7 women • 58 ± 10 y • Required to keep current daily habits Exercisers: • n = 44 • 38 men and 6 women • 59 ± 10 y • Aerobic exercise on cycle ergometer, or treadmill, or both • 8 wks; 3 ×/wk, 30 min • 70% VO_2peak	• VO_2peak and VO_2AT: indirect calorimetry; incremental exercise test; V-slope method for AT analysis • Quality of life: MHFLQ questionnaire • Wave peak velocity: ultrasound cardiac imaging • Endothelial function: brachial artery flow-mediated dilation • Oxidative stress: liquid chromatography fluorescence; xylenol orange assay • Triglycerides, LDL, HDL, fasting blood glucose: enzymatic methods • SBP	• Waltz dancing improved VO_2peak, VO_2AT, quality of life; endothelial-dependent vasodilation, early filling wave/peak velocity of left ventricle; triglycerides, and HDL. • Dancing was as effective as traditional aerobic exercise for most parameters, both being better than controls. Dancers had higher scores for emotion domains in questions about quality of life. • Energy expenditure of 4.1 MetS[a] was measured in 15 patients during 21-min waltz.
Borges et al[15] (2009) • RCT • N = 75 • Healthy isolated older adults in long-term care institutions	Ballroom dance (foxtrot, waltz, rumba, swing, samba, and bolero) • n = 39 • 77.68 ± 11.23 y • 8 mo; 3 ×/wk; 50 min • Warm-up; main part; cooldown • Technical progressions were developed individually • Borg scale	Controls • n = 36 • 67.22 ± 1.28 y • Required to keep current daily habits	• Functional autonomy: walking 10 m, standing up from a seated and prone position, standing up from a chair and moving about the room, putting on and taking off a shirt. GDLAM index (GI) was calculated. • Balance: stabilometer and posture meter platform	• Ballroom dance program increased functional autonomy and balance. Within- and between-group differences were detected in favor of dancers, whereas the control group remained the same.
Cruz-Ferreira et al[30] (2015) • RCT • N = 57 • Healthy women • Range of ages: 65 to 80 y	Creative dance • n = 32 ± 3.9 y • 24 wk; 3 ×/wk; 50 min • 15-min warm-up; 25-min main part; 10-min cooldown • Specific images and themes were given: walking on a floor with ice, glue, or rain • Different styles of music were used (classic, jazz, pop, ethnic, traditional music, etc)	Controls • n = 25 • 72.8 ± 4.5 y • Required to keep current daily habits	• Strength: 30-s chair stand • Aerobic endurance: 6MWT • Flexibility: chair sit-and-reach • Motor ability/dynamic balance: 8-ft-up-and-go test • Body composition: body weight (kg); waist circumference (cm); BMI (kg/m^2) • Life satisfaction: Life Scale questionnaire	• Within- and between-group improvements occurred in all outcomes of physical fitness, anthropometric measurements and life satisfaction in favor of the dancers. No significant improvements occurred for controls. • Creative dance may play a role in the prevention of falls.
Duncan et al[16] (2014) • RCT • N = 10 • Men with Parkinson's disease	Argentine tango • n = 5 • 69.6 ± 6.6 y • 2 y; 2 ×/wk; 60 min	Controls • n = 5 • 66 ± 11 y • No prescribed exercise	• Balance and gait ability: Mini-BESTest; gait velocity (forward and backward); TUG; dual-task TUG; 6MWT	• MiniBESTest scores improved within dance group from baseline to 12 mo. Dancers were better than controls at all time points. • Dual task TUG improved overtime for dancers, but no differences occurred comparing dancers to controls. • Distance in 6MWT was longer for dancers than controls at 24 mo. Dancers maintained walking distances with time, whereas controls decreased them. • Participation in community-based classes in the course of 2 y led to improvements in motor ability and balance in people with Parkinson's disease. All gains were achieved by 12 mo and maintained up to 24 mo, noteworthy given the progressive nature of the disease.

Table 1. (continued)

Reference, Study Design, General Features	Dancers Group Characteristics of Dance Sessions/Intervention	Comparison Group Characteristics of Controls and/or Exercise Sessions/Interventions	Outcomes Measured Method of Analysis	Conclusions
Engels et al[17] (1998) • RCT • N = 34 • 28 women, 8 men • Healthy • Mean age: 68.6 ± 5.6 y	Aerobic dance • n = 11 • 10 wk; 3 ×/wk, 60 min • 10-min warm-up; 30-min aerobic dance; 10 to 15 min toning, flexibility, and balance; 10-min cooldown • Low impact; continuous and controlled moves of arms and legs • 50% to 70% HR_{max}	Controls • n = 11 • Required to keep current daily habits; aerobic dance with wrist weights • n = 12 • Same aerobic dance program with 0.68-kg wrist attached	• VO_2peak: indirect calorimetry; treadmill incremental test (Balke protocol) • Antropometry: 7 skinfolds: triceps, suprailium, subscapular, axilla, calf, thigh, abdomen; body weight (kg) and height (cm) • Strength: isokinetic dynamometry (peak torque)—right shoulder and elbow • Flexibility: goniometry for elbow, hip, knee flexion/extension and shoulder abduction; sit-and-reach test for trunk forward flexion • Static and dynamic balance: 1-legged stance and functional reach test • SBP and DBP: auscultation	• 10 wk of low-impact aerobic dance improved aerobic fitness and lower extremity muscular strength in older people. • No difference observed between dancing with and without wrist weights. • Improvements were detected over time and in comparison with the control group. • No significant changes occurred for anthropometric variables, upper body peak torque, blood pressure, balance, and flexibility within or between groups.
Eyigor et al[11] (2009) • RCT • N = 40 • Healthy women	Turkish dance • n = 19 • 73.5 ± 7.6 y • 8 wk, 3 ×/wk, 60 min • 10-min warm-up; 40 min specific steps; 10 min stretching and cooldown • Folk dance routines included sequences of moves performed in a circle, holding hands; semiflexion and bouncing of both knees; walking forward and backward; standing in one foot while the other is in the air; opening and closing the circle	Controls • n = 18 • 71.2 ± 5.5 y • Required to keep current daily habits	Functional performance: • 20-m walking, 6MWT, chair raise and stair climbing • Balance: Berg balance scale • Quality of life: SF-36	• Turkish dance improved physical functioning within the dance group, especially 6MWT, chair raise, and stair climbing. • Balance and quality of life improved within the dance group and between dancers and controls. • Adaptation of folk-specific folk dances into exercise programs for older adults may be helpful to maintain an active and independent life through these gains.
Federici et al[18] (2005) • RCT • N = 40 • Healthy women and men • Mean age: 62.7 ± 4.1 y	Caribbean dance • n = 20 • 63.5 ± 3.7 y • 12 wk, 2 ×/wk, 30 to 60 min (first 2 wk, 30 min, increasing time until 60 min) • Basic steps fo salsa, merengue and bachata. Exercise to improve mobility, coordination, strength and balance. Weeks 1 and 2: general physical conditioning, stretching, and breathing. Weeks 3 and 4: exercises for static and dynamic balance, coordination and specific elements of dancing. Following week: progression of dance technique. • 60% and 70% HRmax; or 50% and 75% VO_2max • Borg scale 11 to 13 (light-somewhat hard)	Controls • n = 20 • 62.7 ± 4.1 y • Required to keep current daily habits	• Balance: Tinetti, Romberg, improved Romberg, and TUG tests	• Caribbean dance improved balance of the intervention group after 3 mo of training; with dancers having better balance than controls for all tests. • Dancing may be used as an alternative form of exercise for improving balance and reducing risk of falls in older adults.
Granacher et al[9] (2012) • RCT • N = 28 • Healthy women and men • Range of ages: 63 to 82 y	Salsa dance • n = 14 • 9 women, 5 men • 71.6 ± 5.3 y • 8 wk; 2 ×/wk; 60 min • 10-min warm-up (salsa exercises for developing balance); 45-min salsa dance; 5-min cooldown • Basic steps transferring the body weight; moving forward, backward, lateral, transversal, and rotational directions. Taps, kicks, stomps, knee swings, hip rotations, and toe dancing walks were progressively incorporated. • Tempo of the music progressed from 50 to 70 BPM (salsa goes up to 180 BPM) • After learning basic steps, partner work introduced with both genders practicing leading	Controls • n = 14 • 8 women, 6 men • 68.9 ± 4.7 y • Required to keep current daily habits	• Balance: balance platform • Gait ability: pressure-sensitivity walking way • Strength/power: CMJ test (ground reaction on a force platform)	• Salsa group improved walking performance (stride velocity, time and length) after the intervention, whereas the control group's performance did not improve. • Stand performance was improved only regarding mediolateral CoP displacement for the salsa group over time, as well as CMJ power. • Salsa dance is a safe, feasible, and enjoyable exercise for older adults. It seems especially to promote dynamic postural control, which makes it a useful intervention for preventing falls. • However, if the goal is to induce a change in spatiotemporal gait variability and muscle power, more specific training stimuli appears to be necessary.
Hackney et al[20] (2009) • RCT • N = 58 • Women and men with Parkinson's disease	Tango • n = 14 • 11 men, 3 women • 68.2 ± 1.4 y Waltz/foxtrot • n = 17 • 11 men, 6 women • 66.8 ± 2.4 y • 13 wk; 2 ×/wk; 60 min • Steps performed in adapted ballroom frame, holding hands with bent elbows, keeping the forearms parallel to the floor, with both genders practicing leading • Healthy, young volunteers serving as dance partners for those with Parkinson's disease and trained for monitoring, anticipating, and spotting loss of balance and/or falls	Controls • n = 17 • 12 men, 5 women • 66.5 ± 2.8 y • Required to keep current daily habits	• Balance: Berg balance scale, TUG • Functional mobility: 6MWT • Forward and backward walking: 5 m instrumented, computerized GAITRite walkway (gait velocity, stride length, and single support time). Results from 3 trials in each direction were averaged.	• Both dance groups improved balance and gait more than the controls, who did not improve. • The tango and waltz/foxtrot groups improved significantly on the Berg Balance Scale, 6MWT, and backward stride length. • The tango group improved as much or more than those in the waltz/foxtrot group on several measures. • Tango may target deficits associated with Parkinson's disease more than waltz/foxtrot, but both dances may benefit balance and locomotion.

Table 1. (continued)

Reference, Study Design, General Features	**Dancers Group Characteristics of Dance Sessions/Intervention**	**Comparison Group Characteristics of Controls and/or Exercise Sessions/Interventions**	**Outcomes Measured Method of Analysis**	**Conclusions**
Hackney et al[19] (2007) • RCT • N = 38 • Men and women; healthy or with Parkinson's disease • >55 y old	Argentine tango • n = 18 • 9 with Parkinson's; 9 healthy • 13 wk; 2 ×/wk, 60 min • Warm-up (circle, imagery for weight awareness, and posture control); main part with basic timing, footwork, and movement quality • Including postural stretches, balance exercises, tango-style walking, footwork games, and rhythmical experimentation, both with and without a partner • Footwork learned first and separately, then partnership introduced with both genders practicing leading; focus more on shape of movement, transition, and partnership skills and less on dancing to a prescribed beat • Partners rotating approximately every 10 to 15 min, encouraging faster learning	Traditional exercise • n = 20 • 10 with Parkinson's disease; 10 healthy • 13 wk; 2 ×/wk, 60 min • Chair exercise class—strength/flexibility • 40 min chair exercises: breathing; resistance, and dexterity exercises (bottles or yard sticks for resistance) • Use of imagination such as rowing down the river • After, participants stand and use the chair support as a barre; exercises including hula, heel-toe jig, flamingo balance, and apple picking; last 10 min for core strengthening and stretching	• Balance: functional reach; 1 leg stance test and activities-specific balance confidence scale • Walking velocity: motion captures system • Falls: falls efficacy scale	• The Parkinson's tango group improved on 1-leg stance, functional reach test, falls efficacy scale, and activities-specific balance confidence scale. • The exercise Parkinson's group improved only functional reach and 1-leg stance, whereas scores declined on the falls efficacy scale and activities balance confidence scale. • Improvements in all measures of falls, gait, and balance comparing tango and control groups suggest that therapeutic movement approaches should incorporate tango dance.
Holmerová et al[21] (2010) • RCT • N = 52 • 46 women and 6 men; healthy (residential care facilities) • Mean age: 81.9 ± 8.6 y	Exercise Dance for Seniors (EXDASE) program • n = 27 • 25 women, 2 men • 81.0 ± 9.6 y • 12 wk; 1 ×/wk; 75 min • 10 min warm-up (leg movements, seated, slow music); main part (strong music); and cooldown (stretching major muscle groups, deep breathing, slow music) • Main dance-based exercise involving basic figures and combinations of ballroom dance such as polka, waltz, foxtrot, cha-cha-cha, or cancan • Different arrangements, from line dancing through creations in small groups to dancing with the instructor incorporated, all aiming to improve mobility • Intensity varied depending on fitness status; participants encouraged to reach further, bend deeper, move faster, or perform more demanding figures	Controls • n = 25 • 21 women, 4 men • 82.8 ± 7.5 y • Required to keep current daily habits	Lower-body functioning • Balance: TUG • Flexibility: chair sit-and-reach test • Strength/power: chair stand test • Aerobic fitness: 2-min step test	• Dance group was superior to control group and from pre- to postintervention for the chair stand test, the 2-minute step test, and the TUG test. • Findings indicate that previously sedentary, low-functioning adults in advanced old age can improve lower-body functioning with simple dance-based exercise. • EXDASE program is easily modifiable for different physical levels, being suitable for people at risk of dependency.
Hopkins et al[31] (1990) • RCT • N = 65 • Healthy women • Range of ages: 57 to 67 y	Aerobic dance • n = 35 • 65 ± 3.7 y • 12 wk; 1 ×/wk; 50 min • Low-impact aerobic dance • 20-min warm-up; 20-min aerobic workout; 15-min cooldown • Walking, stretching, dance moves to music, continuous moves of arms and legs 100 to 120 BPM	Controls • n = 30 • 66 ± 3.8 y • Required to keep current daily habits	• Sum of skinfolds: triceps, suprailium, and thigh • Cardiorespiratory endurance: half-mile walk test • Strength/endurance: 30-s sit-and-stand test • Body agility: chair agility test • Motor control/coordination: soda pop test • Flexibility: modified sit and-reach test • Balance: 1-foot stand test	• Dancers were better than controls in cardiorespiratory endurance, balance, strength/endurance, flexibility, agility, and body fat. • Motor control/coordination was not different. • In the control group, all functional fitness measures either remained the same or declined. • Within dance group, improvements occurred on all functional fitness measures except for motor control/coordination. • Low-impact aerobic dance can be an effective mode for improving functional fitness in older women.
Hui et al[32] (2009) • RCT • N = 111 randomized, 97 completed the trial • 94 women, 3 men • Healthy individuals • Range of ages: 60 to 75 y	Aerobic dance • n = 52: 50 women, 2 men • 68.0 ± 4.5 y • 12 wk; 2 ×/wk; 50 to 60 min, 10-min warm-up; 30 to 40 min dancing (brief rests); 10-min cooldown • Choreographed dance consisted of stretching, walking, and progressive dance movements, such as cross steps and cha-cha, completed within 4 cycles of 8 beats at a moderate pace. Routines easy to learn, requiring use of back and upper and lower limbs,	Controls • n = 45 • 44 women, 1 men • 69.1 ± 4.2 y • Required to keep current daily habits	• Cardiopulmonary performance: 6MWT • Trunk flexibility: sit-and reach test • Anthropometry: BMI and waist-hip ratio • Lower limb endurance/strength: sit-and-stand-test (10 s) and knee extension strength, with hand-held dynamometer • Balance: static balance: 4-test balance scale • Dynamic balance: TUG • Quality of life: SF-36 questionnaire • Resting HR and blood pressure	• Significant differences within and between groups were observed in favor of dancers for 6 of the outcome measures: resting HR, 6MWT, TUG, lower limb endurance, and general health and bodily pain domains of SF-36. • The majority of the dance group felt the intervention improved their health status. • Dancing has physical and psychological benefits and should be promoted as a form of leisure activity for seniors.

Table 1. (continued)

Reference, Study Design, General Features	Dancers Group Characteristics of Dance Sessions/Intervention	Comparison Group Characteristics of Controls and/or Exercise Sessions/Interventions	Outcomes Measured Method of Analysis	Conclusions
Janyacharoen et al[33] (2013) • RCT • N = 38 • Healthy women • Mean age: 65.8 ± 5.1 y	Thai dance • n = 20 • 64.9 ± 4.0 y • 6 wk; 3 ×/wk; 40 min • 5-min warm-up (stretching); 30 min dancing; 5-min cooldown (relaxation) • The postures of Thai dance were performed in a slow but continuous rhythm. They included raising/lowering/bending/stretching, raising right and left arms alternately, raising and lowering legs, stretching knees, standing on toes and flat feet, and turning around.	Controls • n = 18 • 66.8 ± 6.0 y • Required to keep current daily habits	• Gait ability: 6MWT • Strength/power: 5×-sit-to-stand-test • Flexibility: sit-and-reach test	• There were within- and in-between group improvements in favor of the Thai dance group for all measurements (6MWT, 5×-sit-to-sand, and flexibility).
Kaltsatou et al[8] (2014) • RCT • N = 51 • Men with chronic heart failure	Greek dance • n = 18 • 67.2 ± 4.2 y • 10 mo; 3 ×/wk; 50 min • 10-min warm-up; 40-min Greek dance routines, for 3 to 4 min each choreography vs 15-s rest • Low-impact steps, performed in a single group while holding hands in a semicycle—stepping to the side, closing feet together or passing the foot in front or behind the other, single limb standing, hopping, jumping, and trunk extension • Moderate intensity: 13 to 14 Borg scale; somewhat hard	Controls • n = 17 • 67.2 ± 5 y • Keeping daily habits exercises • n = 16, • 67.1 ± 7.2 y, aerobic and resistance exercises 10 mo, 3 ×/wk, 50 min; • 20 min aerobic exercise on cycle ergometer or treadmill, plus 20 min resistance exercises for upper and lower extremities (1 to 2 sets; 10 to 15 reps; 60% to 85% 1RM)	• VO_2peak: indirect calorimetry • Incremental cardiopulmonary treadmill test (Bruce protocol) • ECG and blood pressure continuously monitored • Ventilator anaerobic threshold: intercept of the 2 slopes on a CO_2 vs VO_2 in the incremental test • Body composition: body weight and BMI • Quality of life: Greek version of SF-36 • Functional capacity: 10×-sit-to-stand-test; balance with Berg balance scale; strength with baseline leg dynamometer	• Greek dance improved measures: cardiorespiratory—VO_2peak and VO_2AT—and functional—sit-to-stand; Berg balance scale; isokinetic strength—from pre- to postintervention. • Increases were similar for the traditional exercise group, and both dancers and exercisers were superior to control group. • Exercise training in patients with chronic heart failure with Greek traditional dances led to functional and cardiovascular benefits similar to formal exercise training and to a higher level of motivation.
Kattenstroth et al[22] (2013) • RCT • N = 35 • 24 women, 11 men; healthy • Range of ages: 60 to 94 y	Agilando dance program • n = 25 • 17 women, 8 men • 68.8 ± 1.45 y • 24 wk; 1 ×/wk; 40 min • Special dance program developed for elderly; participants learning step sequences of increasing complexity, performed alone, without a partner	Controls • n = 10 • 7 women, 3 men • 72.3 ± 1.84 y	• VO_2peak: indirect calorimetry • Balance: static stance and controlled displacement of the subject's CoP on a force platform. • 7 subtests of 30 s each	• After 6 mo, the dance group improved balance and postural control, with no changes in cardiorespiratory fitness. • Other outcomes such as reaction times; cognitive, tactile, and motor performance; and general well-being also improved. • Control group did not change, or even had degraded performance.
Krampe et al[24] (2014) • RCT • N = 34 • 31 women, 3 men; lower extremity pain/stiffness • Mean age: 80.6 ± 8.9 y	Dance therapy (Healthy-Steps) • n = 19 • 17 women, 2 men • 79.4 ± 8.75 y • 12 wk; 2 ×/wk; 45 min • Warm-up (sitting or standing) • Low-impact aerobic protocol, designed to improve gait ability, increase respiration and reduce lower extremity pain; dance-based movements for stretching lower extremities—shift weight from side to side; strengthen feet, thighs, and hips; and develop flexibility of hips, knees and thighs • Steps to be safely performed; could sit anytime, helping to decrease fear of falling	Controls • n = 15 • 14 women, 1 man • 81.7 ± 9.1 y • Required to keep current daily habits • Wait-list for dance therapy	• Gait speed: 10-m walk test; 8-foot walk; TUG • 16-foot GAITRite electronic walkway	• Dance therapy group showed improvements for the 8-foot walk and 10-m walk test. • GAITRite velocity and TUG did not change. • Dance based-therapy is feasible for older adults with lower-extremity pain.
Krampe et al[23] (2013) • RCT • N = 27 • 17 women, 10 men; • Healthy • Mean age: 85 ± 7.5 y	Dance therapy (Lebed method) • n = 15 • 73% women • 85 ± 8.49 y • 6 wk; 3 ×/wk; 45 min • 10-min lymphatic warm-up; 30 min active dance-based therapy; 5-min cooldown • Low-impact aerobics and stretching mixed with dance movements; based on simple jazz and ballets steps adapted for older adults; dance steps designed to improve balance by shifting body and relocating center of gravity; reaching arms in every direction, lifting legs, and flexing feet; same dance sequences used during the entire intervention to develop confidence and experience a cumulative effect	Controls • n = 12 • 50% women • 85 ± 8.86 y • Required to keep current daily habits	• Balance: multidirectional reach test • Mobility: GAITRite System electronic walkway 20-m (step length, walking velocity, and functional ambulation profile)	• Although no statistical significance existed between groups, effect size analyses suggest that dance-based therapy was mildly or moderately effective in several components of balance (forward, backward, right and left reach) and mobility (walking velocity, step length, and functional ambulation profile), especially considering participants with high attendance.

Table 1. (continued)

Reference, Study Design, General Features	Dancers Group Characteristics of Dance Sessions/Intervention	Comparison Group Characteristics of Controls and/or Exercise Sessions/Interventions	Outcomes Measured Method of Analysis	Conclusions
Lesser et al[34] (2016) • RCT • N = 75 • Postmenopausal women	Bhangra dance • n = 26 • 57.7 ± 6.2 y • 12 wk; 3 ×/wk; 60 min • 10-min group warm-up; 40 min Bhangra dance; 10-min cooldown • Bhangra dance consists of high intensity jumps, kicks and upper body movement to Bhangra music. Intensity progressed as technical skills and fitness improved. Participants were encouraged to keep their HR up and to modify too challenging exercises.	Controls • n = 26 • 57.7 ± 6.1 y • Keeping daily habits Gym-based exercise • n = 23 • 56.4 ± 6.9 y, • 12 wk, 3 ×/wk, • 60 min. 10 min group warm-up, 40 min aerobic conditioning (treadmills and stationary bicycles), 10 min cooldown • initial intensity at 55% HRmax; increasing 10% every 3 wk; last 3 wk at 85% HRmax	• Visceral adipose tissue • Total and subcutaneous abdominal adipose tissue: multidetector computed tomography scanning • Body composition: BMI, waist circumference; body fat (DXA) • Glucose, insulin and HOMA-IR: fasting blood laboratory measurements • VO_2peak: indirect calorimetry; incremental treadmill test (Bruce protocol)	• Following an intention-to-treat analysis, visceral adipose tissue was not significantly reduced in Bhangra or gym-based exercise compared with controls. However, visceral adipose tissue was reduced among women who adhered to the programs. • Subcutaneous and total abdominal adipose tissue were reduced after Bhangra compared to controls, but not gym-based exercise. • Relative VO_2peak and time to exhaustion improved in the Bhangra group compared with controls. • No differences occurred for adiposity measures or insulin/glucose compared with controls.
Lim et al[35] (2015) • RCT • N = 20 • Obese women	Korean dance + aerobic and resistance exercises • n = 10 • 70.7 ± 2.2 y • 12 wk; 3 ×/wk; 45 min • 10-min warm-up; 25 min exercise; 10-min cooldown • Aerobic exercise—walking and arm raises, jumping and swinging arms, side walking, front, back, and side leg raises, jumping and knees up, walking and leg raise; walking and jumping • Resistance exercise—arms folded and spread, arms raises to front and side, turn shoulder, waist bending, waist bending to side, twist trunk, knee up, stretch legs and raise to back and side. • Korean dance—movements of arms, legs, trunk, and whole body, including jumping upward and to the side and balance, with 1 leg standing and 1-leg jumping • 50% to 70% HRmax for 15 min	Controls • n = 10 • 71.1 ± 1.7 y • Keeping daily habits	• CRP, MCP-1, sE-selectina, sVCAM: ELISA kits • Glucose, insulin, HOMA-IR: fasting blood laboratory measurements; body composition: BMI, weight, % body fat; blood pressure	• MCP-1 and the arteriosclerosis adhesion molecules sE-selectin and sVCAM-1 were decreased after 12-wk intervention. • Within-group analyses showed that body mass, BMI, and body fat were decreased in the exercise group, with changes for controls. • Also, glucose, insulin, and HOMA-IR were reduced in the exercise group. • A healthy life exercise program including Korean dance may be useful in preventing arteriosclerosis and improving quality of life in older obese women.
Marín et al[13] (2009) • RCT • N = 700 • Women (mostly) and men • Healthy • >60 y old	Ballroom dance meetings + toning exercise • n = 350 • 70.1 y • 67.1 % women • 12 mo, 3 ×/wk, 45 min • Dance meetings, several styles, 1 ×/wk • Toning sessions (quadriceps, psoas, spinals, biceps, and triceps), 2 ×/wk	Controls • n = 350 • 69.8 y • 65.8% women • Required to keep current daily habits	• Fasting glucose; total cholesterol and triglycerides: laboratory methods • Oxidase glucose • BMI (percentage of participants (>25 kg/m²) • Blood pressure: sphygmomanometer • Quality of life: SF-12 v1 survey.	• The intervention group showed significant within-group reduction in blood pressure, lipids, and cholesterol values; also improved compared with control group. • Reduction on cardiovascular events were also obtained. • Quality of life also improved in comparison to control group. • The health program with exhaustive follow-up administration, significantly reduced complications associated with aging.
McKinley et al[58] (2008) • RCT • N = 25 • 19 women, 6 men; fallers • Range of ages: 62 to 91 y	Argentine tango • n = 14 • 11 women, 3 men • 10 wk, 2 ×/wk, 90 min • 20-min warm-up (basic components of tango); 20 min couple practice (specific patterns of tango); 30-min break; 20 min couple practice; 30 min free practice • Basic tango: walk forward and backward, the pivot, postural alignment and weight shift (mirror). Partners changed regularly during the class, both genders practiced leading. Expert guidance at least 4 times for each participant.	Walking • n = 11 • 8 women, 3 men • 10 wk; 2 ×/wk; 40 min • 5-min warm-up; 30 min walking; 5-min cooldown • Walking at comfortable, but slight difficult pace. Resting was allowed at any time. • Borg scale: 12 to 13	• Strength: sit-to-stand test (EPESE) • Gait ability: normal and fast walk (EPESE) • Balance: activities-specific balance confidence scale	• Although both interventions were effective activities for increasing strength and walk speed, tango might result in greater improvements in balance skills and in walking speed in the 10-wk intervention. • Improvements in balance confidence could not be determined in the walking group, because they scored above cutoff for improvement at baseline. • Clinical improvements measured using EPESE scoring were greater for the tango group. • These results were sustainable for 1 mo postintervention. • Argentine tango dancing as a physical activity is feasible in a population of older individuals and serves to improve both physical fitness and balance for individuals at risk for falls.
Mavrovouniotis et al[25] (2008) • RCT • N = 111 • 75 women and 36 men • Healthy • Range of ages: 60 to 91 y	Greek dance • n = 76 • 67.62 ± 6.29 y • Mostly women • 10 wk; 1 ×/wk; 60 min • Holding hands in semicircles • 2.5- to 3-min choreographies; 10 s rest; frequency of rhythms alternated to dance continuously the whole session • Intensity low-moderate	Controls • n = 35 • 74.51 ± 6.78 y • Discussing and watching television	• Quality of life: The Subjective Exercise Experiences Scale • HR: HR response to dancing was monitored for assessing workout intensity (baseline, 30 min, immediately after session)	• After dancing, dancing group reached approximately 63% of maximum heart rate, whereas decreases in state anxiety and psychological distress were observed as well as significant increases in positive well-being. • A nonsignificant difference in control group was observed. • Traditional dances may be used as a functional psychophysical activity to produce both physical and mental benefits for older individuals.

Table 1. (continued)

Reference, Study Design, General Features	**Dancers Group Characteristics of Dance Sessions/Intervention**	**Comparison Group Characteristics of Controls and/or Exercise Sessions/Interventions**	**Outcomes Measured Method of Analysis**	**Conclusions**
Park et al[37] (2015) • RCT • N = 20 • Obese women	Korean dance + aerobic and resistance exercises • n = 10 • 70.7 ± 0.7 y • 12 wk; 3 ×/wk; 45 min • Same protocol as Lim et al[35] (2015) • Initial intensity: 50% to 60% HR reserve Final intensity: 60% to 70% HR reserve	Controls • n = 10 • 71.3 ± 0.6 y • Required to keep current daily habits	• Oxidized LDL: enzyme-linked immunosorbent assay kits • Tryglicerides, total cholesterol; HDL and LDL: laboratory methods • CIMT: ultrasound • Blood pressure: Mercury sphygmomanometer • Body composition: BMI, % body fat; upper and lower body muscle mass; appendicular skeletal muscle mass (DXA scan)	• For dance group, within-group analysis showed that body mass and DBP was reduced after 12 wk. • Upper-and lower-limb and appendicular muscle mass, and HDL increased in dancers. • No significant differences in BMI, % body fat, or SBP occurred. • Furthermore, oxidized LDL and the ratio of oxidized LDL to HDL cholesterol and CMIT were reduced significantly in dancers. • A 12-week low- to moderate-intensity exercise program appears to be beneficial for obese older women by improving risk factors for cardiovascular disease.
Rios Romenets et al[38] (2015) • RCT • N = 33 • 14 women, 19 men with Parkinson's disease	Argentine Tango • n = 18 • 6 women, 12 men	Controls • n = 15 • 8 women, 7 men	• Balance and gait: Mini-BESTest; Single and dual task TUG; falls questionnaire (Canadian Community Health Survey, Healthy Aging May, 2010); Freezing of Gait Questionnaire; Purdue Pegboard for assessment of upper extremity function	• Dynamic balance (Mini-BESTest) significantly improved in the tango group compared to controls and difference remained significant even after multivariate adjustment for the baseline average time on exercise/dance. • Analyzing individual items of Mini-BESTest showed significant improvements in balance during gait in favor of tango in TUG and dual-task TUG, with a borderline significant improvement in walking with pivot turns. • Argentine tango can improve balance and functional mobility in patients with Parkinson's disease.
Shigematsu et al[26] (2002) • RCT • N = 38 • Healthy women • Range of ages: 72 to 87 y	Aerobic dance • n = 20 • 78.6 ± 4 y • 12 wk; 3 ×/wk; 60 min • Routines targeting balance, strength, locomotion/agility, and motor processing; steps including single leg standing, squatting, marching, heel touching	Controls • n = 18 • 79.8 ± 5 y • Instructed not to attend exercise classes	• Cardiorespiratory fitness: VO_2, HR and lactate—incremental treadmill test • Balance: single leg stand eyes open and closed; functional reach • Strength: hand grip; keeping half-squat position • Locomotion/agility: walking around 2 cone; 3 min walking	• Aerobic dance group was superior in single-leg balance with eyes closed, functional reach, and walking time around 2 cones. • No improvements occurred for the control group. • Improvements may attenuate risk of falling in older women.
Sofianidis et al[27] (2009) • RCT • N = 26 • 20 women, 6 men • Healthy • Mean age: 70.89 ± 5.67 y	Greek dance • n = 14 • 13 women, 1 man • 69.23 ± 4.35 y • 10 wk; 2 ×/wk; 40 to 60 min 5-min warm-up (stretching); 50 min dancing (weeks 1 to 2: 30 to 35 min); • 5-min cooldown (stretching) • Basic, low-impact steps, performed in group with participants holding hands; Greek music and dances following a progressive order from simplest and least physically demanding, to most complex and dynamic movement elements; at least 1 d rest in between dance sessions • Low to moderate intensity; 50% to 60% HRmax	Controls • n = 12 • 7 women, 5 men • 72.57 ± 5.25 y • Required to keep current daily habits	• Balance: Sharpened-Romberg test (CoP variations and trunk kinematics); 1-leg stance, and dynamic weight shifting (force platform)	• Dance group significantly decreased CoP displacement and trunk sway in 1-leg stance. • A significant increase in the range of trunk rotation was noted during performance of dynamic weight shift in the sagittal and frontal planes. • Findings support use of traditional dance as effective means of physical activity for improving static and dynamic balance control in older adults.
White et al[39] (1984) • RCT • N = 51 • Postmenopausal women • Range of ages: 50 to 63 y	Aerobic dance • n = 24 • 6 mo; 4 ×/wk (1 ×/wk supervised) • Performing 5 aerobic dances	Exercisers • n = 27 • 6 mo; 4/wk (1 ×/wk supervised) • Walking 2 miles/d	• Arm strength: cable tensiometer	• Arm strength increased in both groups but in greater magnitude in the dance group. • Bone-mineral content increased in dance and exercise groups, whereas in the control group, it did not change. • The results support hypothesis that mechanical loading due to exercise may be effective in preventing postmenopausal osteoporosis.
Wu et al[44] (2016) • RCT • N = 32 • Sedentary women • Mean age: 59 ± 4 y	Low-impact aerobic dance • n = 32 • 60 ± 4 y • 16 wk; 3 ×/wk; 60 min • 5- to 8-min warm-up, 45 min main part, 5- to 10-min cooldown • Main part: reviewing routines learned a few days earlier or the previous week, repracticing whole routines, and teaching new routines • Moves for upper limbs—stretch, circle, shrug, abduction, adduction, NA circumduction; moves for lower limbs—side-stepping, forward and backward walking, circling, lifting the legs, tiptoeing with the foot to the front, side, and rear, and heel raises	Controls • n = 32 • 58 ± 5 y • Required to keep current daily habits	• Knee extension torque: torque sensor • Lower extremity ROM: goniometer (knee flexion and extension, ankle inversion and eversion, plantar flexion and dorsi-flexion) • Falls: Modified Falls Efficacy Scale • Blood lipids: triglycerides, total cholesterol, HDL and LDL (Friedewald equation). Commercial kits, enzymatic methods (laboratory standard). • BMI and body fat (%): InBody 720	• Results showed that average score for modified falls efficacy scale, some parameters of blood chemistry, and joint ROM were significantly improved after low-impact intervention. • In addition to improvements in blood lipids and body fat percentages, the increases shown in the parameters for lower extremities may have contributed to confidence in performing common daily activities in older women, although the number of falls did not significantly differ between the 2 groups during the 16-wk period.

Table 1. (continued)

Reference, Study Design, General Features	Dancers Group Characteristics of Dance Sessions/Intervention	Comparison Group Characteristics of Controls and/or Exercise Sessions/Interventions	Outcomes Measured Method of Analysis	Conclusions
Wu et al[28] (2011) • RCT • N = 38	Low-impact dance • n = 26 • 16 wk	Controls • n = 12	• Knee torque • Lower extremity ROM	• Several ROMs of the lower extremity joints in the dominant leg, ankle inversion, plantarflexion, and dorsiflexion were higher in the dance group than in the control group. • Knee extension torque of the nondominant leg in the dancers was higher than in the controls. • Low-impact dance can help achieve higher lower-extremity ROM and knee-torque values than attained by inactive individuals.
Young et al[29] (2007) • RCT • N = 45 • Postmenopausal women	Line dance only • n = 15 • 61.9 ± 7.0 y • 1 year; 1 ×/wk; 45 min • Increasing tempo and complexity of choreography as participants move from beginner to intermediate level • Dancing involving stepping and/or balance forward, backward, or to either side, with turns of either 90 or 180 degrees	Line dance (1 ×/wk) + squats (5 ×/wk) • n = 15 • 61.5 ± 5.2 y • Same line dance previously described • Month 1: 2 sets × 8 reps squats (unloaded) • Loading added (2-kg bottle of water) when participants demonstrated musculoskeletal control during 16 squats (3 ×/wk). • Load increased when 16 reps were comfortably performed with the previous load (5 ×/wk) • Technique of squats: trunk and limb alignment; position of centre of mass to the base of support Line dance (1 ×/wk) + squats + 4 foot stamps (2 ×/d; 5 ×/wk) • n = 15 • 64.4 ± 8.0 y • Same routine of line dance and squats previously described • Practicing stamping 4 times with each bare foot on a sheet of bubble wrap placed on a timber floor (force platform, 1 Hz). • Technique of stomp acquired when a participant could burst the air pockets under foot with clear popping sounds	• Balance: static and dynamic balance: single leg stance and TUG • Falls: step reaction time device. Step distance, velocity, and length were recorded. • Muscle strength: squat number	• Line dancing, particularly in concert with regular squats and foot stamping, is a simple and appealing strategy that may be employed to improve lower limb muscle strength and balance as well as prevent bone loss in independently living postmenopausal Caucasian women.

[a]MetS: the separate metabolic equivalent (MET) in hours per week were calculated for each activity subtype according to the following formulas: MET coefficient of activity × duration (hours per time) × frequency (times per week).

Abbreviations: 6MWT, 6-minute walking test; BMI, body mass index; BMP, beats per minute; CIMT, carotid intima-media thickness; CMJ, counter movement jump; CoP, center of pressure; DBP, diastolic blood pressure; DXA, dual-energy X-ray absorptiometry; EXDASE, Exercise Dance for Seniors; GAITRite, computerized system to assess walking hability, such as walking time, distance, and step length; HDL, high-density lipoproteins; HR, heart rate; HRmax, maximum heart rate; LDL, low-density lipoproteins; MHFLQ, Minnesota Living With Heart Failure Questionnaire, for evaluating quality of life; Mini-BESTest, Mini-Balance Evaluation Systems Test, which includes 14 balance tasks that score a total of 32 points for no balance impairments; EPESE, Established Populations for the Epidemiological Study of the Elderly; RCT, randomized control trial; ROM, range of motion, systolic blood pressure; SF-12v1, a 12-item short form health survey for evaluating quality of life; SF-36, short-form healthy survey—a 36-item questionnaire of quality of life; TUG, time to up and go; VO_2AT, oxygen consumption at the anaerobic threshold; VO_2peak, peak oxygen consumption.

Table 2. Characteristics of Other Study Designs Using Dance as a Form of Exercise Intervention on Functional and/or Metabolic Outcomes in Older Adults

Reference Study Design General Features	Dancers Group Characteristics of Dance Sessions/Intervention	Comparison Group Characteristics of Controls and/or Exercise Sessions/Interventions	Outcomes Measured Method of Analysis	Conclusions
Alpert et al[40] (2009) • One-group pre-post • N=13 • Healthy women • Range of ages: 52 to 88 y	Jazz dance • n=13 • 68±8.4 y		• Balance: sensory organization test	• Jazz dance was effective in improving balance in older women. • Significant improvements were detected at 8 to 9 wk of intervention and from weeks 1 to 15. • Improvements were greater in the younger participants.
Chen et al[49] (2013) • Cross-sectional • N=15.514: 6952 men, 8562 women • Chinese retirees • Prevalence of MetS: • 33.2% total; 27.4% men; 37.8% women • Range of ages: 50 to 70 y	Dancing as leisure activity • n=1236 • 4.5±3.4 h/wk • 5.0 METs/h[a]	Other exercise types: • Walking: n=12437; 6.0±4.9 h/wk; 3 METs/h • Biking: n=1160; 3.9±3.3 h/wk; 4.0 METs/h • Tai chi: n=962; 4.0±3.0 h/wk; 4.5 METs/h • Gym: n=492; 3.3±2.4 h/wk; 6 METs/h • Ball games: n=959; 4.2±3.3 h/wk; 6 METs/h • Jogging: n=948; 3.9±3.0 h/wk; 7.7 METs/h • Swimming: n=145; 3.1±2.4; 7.5 METs/wk • Climbing: n=2923; 4.3±3.4 h/wk; 4.5 METs/h	• Risk of MetS[a] • Definition of metabolic syndrome by waist circumference ≥90 and 80 cm, men and women, respectively • Triglycerides ≥1.7 mmol/L; HDL <1.03 and 1.30 mmol/L, men and women, respectively • Blood pressure ≥130/85 mm Hg; fasting glucose ≥5.6 mmol/L	• Dancing, jogging, and tai chi were associated with a significantly lower odds ratio for MetS.[a] • Each 1-h/wk increment in dancing and tai chi were associated with a 9% and 5% lower risk of MetS,[a] respectively—reductions in triglycerides, blood glucose, blood pressure, and waist circumference—as well as increases in HDL.
Grant et al[50] (2002) • Cross-sectional • N=12 • 6 women, 6 men • Healthy • Mean age: 68±7.1 y	Aerobic dance • n=12 • Continuous moves to the music, 1 foot always on the floor. Gas collection for 18 min, corresponding to the aerobic component of the session. • Intensity following a comfortable range of motion	Walking • n=12 (same ones)	• VO_2peak: incremental treadmill test; Douglas Bag; VO_2 also measured continuously during exercise sessions, and recorded every 3 min. • HR: electrocardiograph during the incremental test, and PE3000 sports tester during the exercise sessions, with continuous monitoring • RPE: rate of perceived exertion test	• The intensity of the dance was higher than the walking session for %VO_2peak (67 vs 52); %HRmax (74 vs 60); and RPE (11 vs 10), respectively. • Both sessions were of enough intensity to induce improvements in aerobic fitness in most participants.
Goertzen et al[55] (1984) • Cross-sectional • N=24 • Healthy men and women	Dancing as leisure activity for the 11 y prior to the study • n=12 • 70±6.5 y • Waltz and foxtrot (4,5 kcal/min^{-1}); square dance (5.5 kcal/min^{-1}); polka and Latin dances (6.0 kcal/min^{-1})	Card players as leisure activity • n=12 • 72.4±7.3 y	• Functional capacity (MetS)[a]: treadmill incremental test (modified Balke protocol) • Time of the treadmill test • Resting and peak HR: ECG • Resting and peak blood pressure • Level of physical activity: modified Minnesota questionnaire	• Dancers had lower resting HR and higher levels of physical activity than card-game practitioners. • Both leisure activities were associated with improved functional capacity of the older adults.
Hackney et al[48] (2013) • One-group pre-post • N=12 • 7 women and 5 men with visual impairments • Mean age: 86.9±5.9 y	Tango dance • n=12 • 12 wk; 4 ×/wk offered (until completing 20 sessions); 60 to 90 min • 15-min warm-up—standing dance-based, increasing body segment awareness and confidence; tango dance • Participants dancing holding elbows facing one another; both genders practicing leading, paired with partners without vision loss • Progressive lessons, with modifications incorporated when needed; new steps introduced each class. Participants encouraged to move continuously but allowed to sit.		• Balance: postural control during gait (dynamic gait index), including walking while changing speed and stair climbing; total score 20/24 indicates risk for falling • Lower body strength: 30 s of chair stand test, without using hands • Quality of life: VFQ-25 measured vision-related quality of life questionnaire	• Older individuals with visual impairments benefited from 30 h of adapted tango. • Dynamic postural control, lower body strength, and general vision-related quality of life were improved.
Hackney et al[41] (2009) • One-group pre-post • N=14 • Men and women with Parkinson's disease	Argentine tango • n=14 • 2 wk; 5 ×/wk; 90 min • Warm up—breathing, limbering and postural alignment; tango dance • Working in new steps with partner; walking in various rhythms; step of the day tagged onto steps previously learned in other sessions, with both genders practicing leading • Participants with Parkinson's dancinga partner without the disease		• Balance: Berg balance scale, TUG • Gait and mobility: gait velocity, functional ambulation profile, step length, stance, and single support percent of gait, 6MWT	• Participants significantly improved on the Berg balance scale and percentage of time spent in stance during forward walking. • No significant improvements occurred on TUG and 6MWT. • Tango dance lessons completed within a short period appeared to be effective in improving balance and mobility of individuals with mild-moderately severe Parkinson's disease.

Table 2. (continued)

Reference Study Design General Features	Dancers Group Characteristics of Dance Sessions/Intervention	Comparison Group Characteristics of Controls and/or Exercise Sessions/Interventions	Outcomes Measured Method of Analysis	Conclusions
Kattenstroth et al[51] (2011) • Cross-sectional • N=49 • 35 women, 14 men • Healthy • Range of ages: 60 to 94 y	Ballroom dance • n=11 • 5 women, 4 men • 71.18±1.13 y • Expert/competitive senior dancers (22±3.39 y dancing) • 4.55±0.15 h/wk of performing workload for competitions, 10 different dances to be performed in mandatory order: slow waltz, tango, Viennese waltz, slow fox, quickstep, samba, cha-cha-cha, rumba, paso doble, and jive • Routines 1.5 to 2 min long	Controls • n=38 • 30 women, 8 men • 71.66±1.11 y • Sedentary individuals	• Balance and gait ability: Romberg test, TUG, and standing-turn test	• Dancers were superior to controls for the Romberg test with eyes open and needed less time for the completion of the standing-turn and TUG tests. • Substantially better performance was found in the expert dance group than in the controls in terms of expertise-related domains like posture, balance, and reaction times.
Kattenstroth et al[52] (2010) • Cross-sectional • N=62 • Women and men; healthy • Range of agea: 61 to 94 y	Multiyear ballroom dancing activities • n=24 • 19 women, 5 men • 71.69±1.15 y • Amateur dancers (16.5±12.7 y dancing) • 1.33±0.24 h/wk of performing workload	Controls • n=38 • 71.66±1.13 y	• Balance and gait ability: Romberg test, TUG, and standing-turn test	• Amateur dancers were superior to controls for the stand-turn and TUG tests, which may preserve everyday competence in older individuals. • Better performance of dancers for cognitive and sensory outcomes indicates that a regular schedule of dancing into old age can prevent several systems degradation.
Kim et al[57] (2011) • Quasi-experimental (nRCT) • N=38 • 29 women, 9 men with metabolic syndrome	Latin dance (cha-cha) • n=26 • 19 women, 7 men • 68.19±3.66 y • 6 mo; 2 ×/wk; 60 min • 5-min warm-up, 45 min of dance; 10-min cooldown • Main structure of cha-cha: 3 fast steps and 2 slow steps with forward-backward and backward-forward weight transfer; first 3 steps require coordinated movement of one-leg take-off, 2-leg knee-bends and light 1-leg push, free hand motion • 50% to 80% HR reserve	Controls • n=12 • 10 women; 2 men • 68.16±5.14 y • Required to keep current daily habits	• Glucose, total cholesterol, triglycerides, HDL: laboratory methods • Body composition: BMI and waist circumference • Blood pressure	• No significance difference was found in BMI, blood pressure, waist circumference, fasting plasma glucose, triglycerides, and HDL between groups during the 6-mo period. • Other outcomes such as cognitive function were improved, suggesting that dancing may reduce the risk for cognitive disorders in older people with metabolic syndrome.
Kim et al[43] (2007) • One-group pre-post • N=64 • Institutionalized women • Mean age: 76.4±6.2 y	Korean dance+nutritional classes • n=64 • 10 wk; 4 ×/wk; 45 min • Same protocol as Kim et al[42] (2003) • 1500 to 2000 steps • 80 to 100 kcal (individual 50 kg) • 50% HRmax		• Total cholesterol, triglycerides and HDL: fasting laboratory measurements • LDL Friedewald's equation • Atherogenic index: total cholesterol/HDL	• The Korean dance program associated with educational nutritional classes was successful in improving LDL, HDL, LDL/HDL and atherogenic index of older women. • However, these positive effects on serum-lipid profile as well as dietary behaviors could not be maintained when the formal program was discontinued.
Kim et al[42] (2003) • One-group pre-post • N=21 • Institutionalized women • Mean age: 77.1±5.6 y	Korean dance+health education • n=21 • 12 wk; 4 ×/wk; 45 min • 5-min warm-up; 30 min main part; 10-min cooldown • Korean traditional dance moves include individual, pairs, and group movements to maximize use of arm and leg muscles and joints • Low intensity		• Cardiovascular risk factor profile: sum of weighted scores of age, family history, cholesterol and triglycerides, systolic blood pressure, obesity (BMI), stress, smoking, and exercise habits • Laboratory measures for biochemical analyses; and interview data for the others	• Total cardiovascular risk score, total cholesterol, triglycerides, and BMI were reduced after 3 mo of Korean dance intervention. • Although total-risk score and BMI decreased significantly by the end of the program, they increased again in 3-mo follow-up.
Krampe et al[45] (2010) • One-group pre-post • N=11 • 7 women, 4 men, all frail seniors	Dance therapy (Lebed method) • n=11 • 6 wk; 3 ×/wk; 45 min • Same protocol as Krampe et al[23] (2013)		• Balance and gait ability: functional reach test and TUG	• Most participants showed about a 50% improvement in TUG and functional-reach-test performance. • Positive trends were shown for incorporating dance-based therapy in a program of all-inclusive care for older adults.
Mckee et al[58] (2013) • Quasi-experimental (nRCT) • N=33 • 13 women, 20 men with Parkinson's disease	Tango dance • n=24 • 12 women, 12 men • 68.4±7.5 y • 10-12 wk; 90 min • 20-min warm-up (previously learned steps); followed by partnering and rhythmic enhancement exercises • Novel steps introduced progressively; partners changed regularly during the class; both genders practicing leading • Participants with Parkinson's disease always danced with individuals without the disease	Education lessons • n=9 • One woman, 8 men • 74.4±6.5 y	• Balance and falls: Fullerton advanced balance scale; 4-square step test; single/dual task TUG test	• The number of individuals falling versus not falling was not significantly different between groups. • Tango was 1.42 times more likely than education to provide decreased or no change in fall incidence during the follow-up period compared to the year prior to the program. • Among participants who improved balance, 66% of tango group and 50% of education group, experienced decreased or no change in fall incidence. • Tango participants also improved on disease severity and spatial cognition compared to education participants. • Tango participants also improved in balance and executive function. • Gains were maintained at 10 to 12 wk postintervention.

Table 2. (continued)

Reference Study Design General Features	Dancers Group Characteristics of Dance Sessions/Intervention	Comparison Group Characteristics of Controls and/or Exercise Sessions/Interventions	Outcomes Measured Method of Analysis	Conclusions
Murrock et al[46] (2014) • One-group, pre-post • N=40 • 92% women; underserved elderly in federally subsidized complex • Mean age: 63±7.9 y	Dance style not specified • n=40 • 12 wk; 2x/wk; 45 min • 5-min warm-up; 30 min dance; 10-min cooldown • Simple steps; same music and dance routines throughout the time of the intervention • Steps could be modified to lower intensity to accommodate physical limitations; participants could sit if needed • Moderate intensity		• Physical functioning and disability: late life function and disability—32 physical tasks for upper, lower, and advanced lower extremity, scale ranging from 1 (cannot do) to 5 (none) for each item • Ability to perform activities for living independently, such as walking, climbing stairs, and handling objects • Disability: limitations in performing 16 major life tasks on a scale ranging from 1 (completely limited) to 5 (not at all) • Higher scores indicated higher physical function and fewer disability limitations	• The 12-wk dance intervention significantly reduced disability and increased physical function as well as reduced depression in underserved older adults.
Song et al[59] (2004) • Quasi-experimental • N=73 • Women and men; healthy	Korean dance • n=46 • 43 women; 3 men • 76.4±8.3 y • 6 mo; 4 ×/wk; 50 min • (10 wk supervised; 14 wk unsupervised sessions—videotape) • 5-min warm-up, increasing range of motion of arms and legs; 30 min dancing; 10-min cooldown, stretching, and relaxation • Individual, paired, and group movements, with and without contact; to maximize use of arm and leg muscles and joints • Standing exercises, moving forward and backward, to improve muscle strength and balance • Low intensity; 50% HRmax	Dropouts, the participants who started the study but not finished the intervention protocol (cutoff attendance rate of 80%) • n=27 • 74.2±8.3 y	• Mobility: Korean version of the sickness impact profile: physical dimensions—mobility, body care, movement, and ambulation; higher scores represents greater limitations	• Significant group differences through time were found in overall physical dimensions, specifically in the dimensions of body care and ambulation, representing a more improved physical function for the program participants.
Uusi-Rasi et al[53] (1999) • Cross-sectional • N=233 • Postmenopausal women	Folk dancers and recreational gymnasts • n=117 • 19 folk dancers; 98 recreational gymnasts • 62.1±4.7 y • Estrogen nonusers: n=54 • Estrogen users: n=63 • Minimum 20 y in recreational gymnastics or folk dance clubs • Recreational gymnastics: rhythmic, aesthetic, and pliant body movements; for physical—balance, flexibility, endurance, strength; mental; and social well-being • Folk dance: aerobic dancing in group; with brisk turns and light jumps—low to moderate impact	Controls • n=116; sedentary • 61.5±4.6 y • Estrogen nonusers: n=54 Estrogen users: n=62	• Muscle strength: maximal isometric strength—strain gauge dynamometer; grip strength—grip strength meter • Muscle Power: vertical CMJ test-force platform • Cardiorespiratory fitness: estimated • VO_2max was from 2-km walking test • Balance: dynamic balance tested by a figure-8 running test, static balance by one leg standing with the eyes open	• Cardiorespiratory fitness, muscular strength, and dynamic balance of the recreational gymnasts and folk dancers combined were significantly better than those of the controls. • Estrogen replacement therapy was not associated with the fitness indicators, muscular power, or balance but was significantly associated with the bone-mass content. • Estrogen replacement therapy seems effective in preventing postmenopausal bone loss, whereas recreational gymnastics and folk dancing improve muscular performance and body balance in addition to increased bone mass. • All these factors are essential in prevention of fall-related fractures of older adults.
Verghese et al[54] (2006) • Cross-sectional • N=108 • Women (mostly) and men; healthy	Social dancers • n=24 • 16 women; 8 men • 80.0±6.5 y • 4.3±3.0 d/mo frequence (range, 1 to 12); 36.5±26.5 y of practicing (range, 3 to 75). • Types of dancing: ballroom dancing (n = 10), line dancing (3), swing dancing (3), square dancing (1), unspecified (7) • Three dancers (12.5%) rating their dancing skills as expert; 10 (41.7%) as intermediate; and 3 (12.5%) as beginners; 8 (30.3%) did not rate themselves; no professionals or competitive dancers	Controls • n=84; nondancers • 69.7% women • 80.8±4.9 y	• Gait ability: normal walking speed (computerized gait mat) • Balance: hold a side-by side stand, semitandem, tandem and unipedal stance (sec) • Strength: 5× chair rise test; grip strength—dynamometer • Falls	• Older social dancers had better balance but not strength than nondancers, had a longer stride compared to nondancers, with a more stable pattern during walking—reduced stance time, increased swing time, and decreased double support time. • No differences in falls were found. • Long-term social dancing may be associated with better balance and gait in older adults.
Wallmann et al[47] (2009) • One-group pre-post • N=12 • Healthy women • Mean age: 68±8.6 y	Jazz dance • n=12 • 15 wk; 1 ×/wk; 90 min • 30- to 45-min warm-up (balance and flexibility); 30 to 40 min dancing • Balance exercises standing on 1 foot for 30 s, extending the nonweight-bearing leg forward, to the side, and backward • Learning 3 dances involving different combinations of dance steps (no sliding on the floor, leaping or 1-leg turns) • Moderate intensity		• Static balance: Sensory organization test—NeuroCom smart balance master system	• A 15-wk jazz dance class 1 ×/wk was beneficial in improving static balance, exposing the visual, vestibular, and somatosensory systems to new challenges in older women.

Table 2. (continued)

Reference Study Design General Features	Dancers Group Characteristics of Dance Sessions/Intervention	Comparison Group Characteristics of Controls and/or Exercise Sessions/Interventions	Outcomes Measured Method of Analysis	Conclusions
Zhang et al[56] (2008) • Cross-sectional • N=404 • Women and men; healthy • Range of ages: 50 to 87 y	Social dancers • n = 202 • 61.5±7.5 y	Social dancers • n=202 • 61.5±7.5 y	• Balance: force platform • Walking speed: a 10-m walkway • Lower limb reaction time: motor choice reaction test • Lower back flexibility: sit-and-reach test	• Dancers older than 60 y had better postural stability and faster leg reaction times, while dancers aged 50 to 59 y showed only better flexibility, when compared with controls. • Male dancers had greater low back flexibility and leg reaction time compared with controls. • In contrast, female dancers had superior performance only for leg reaction time when compared with controls. • Social dancing may be associated with enhanced postural stability and physical performance in older adults.

[a]MetS: the separate metabolic equivalent (MET) in hours per week were calculated for each activity subtype according to the following formulas: MET coefficient of activity × duration (hours per time) × frequency (times per week).

Abbreviations: 6MWT, 6-minute walking test; BMI, body mass index; CMJ, counter movement jump; HR, heart rate; HRmax, maximum heart rate; ECG, electrocardiogram; HDL, high-density lipoproteins; LDL, low-density lipoproteins; nRCT: nonrandomized control trial; TUG, time to up and go; VFQ-25, The National Eye Institute Visual Function Questionnaire-25; VO_2peak, peak oxygen consumption; VO2max, maximum oxygen consumption.

Participants

The range of ages of the participants among all studies was between 50 and 94 years. The majority of the participants were characterized as healthy, in 31 studies: (1) 18 RCTs[9,11,13,15,17,18,21-23,25-28,30-33,44]; (2) 7 cross-sectional studies[49-52,54-56]; (3) 5 one-group studies[40,42,43,46,47]; and (4) 1 quasi-experimental study.[59]

In addition, 7 studies included participants with Parkinson's disease: (1) 5 RCTs[16,19,20,36,38]; (2) 1 one-group study[41]; and (3) 1 quasi-experimental study.[58] Four studies evaluated postmenopausal women: (1) 3 RCTs[29,34,39] and (2) 1 cross-sectional study,[53] and 2 RCTs included patients with chronic heart failure.[7,8] Obese women were evaluated in 2 RCTs.[35,37] Frail older adults were assessed in 1 study with a 1-group design,[45] and individuals with visual impairment took part in 1 one-group study.[48] Metabolic syndrome patients were participants in 1 quasi-experimental study,[57] and older adults with severe pain of a lower extremity took part in 1 RCT.[24]

Sample sizes for the RCTs ranged from 10 participants[16] to 700 participants.[13] In total, 1087 participants were involved as dancers in the RCTs, whereas 858 were controls and 188 performed other exercises. One-group designs included from 12 participants[48] to 64 participants,[43] with 187 dancers in total. Quasi-experimental studies had a minimum of 33 participants[58] and a maximum of 73 participants,[59] with 96 dancers and 48 controls.

For the cross-sectional trials, the number varied from 12 participants[50] to 15 514 participants.[49] This last trial evaluated the prevalence of metabolic syndrome in Chinese older adults who practiced different subtypes of physical activity, with 1236 people practicing dance. The cross-sectional studies involved 1662 participants as dancers, and 490 controls did not engage in any type of regular physical training.

Dance Styles

Ballroom dance was the most frequent style, with 18 studies.[7,9,13,15,16,18-20,36,38,41,48,51,52,54,56,57,58]

Seven of those studies examined tango specifically: (1) 4 RCTs including patients with Parkinson's disease[16,19,20,38]; (2) 1 quasi-experimental study of patients with Parkinson's disease[58]; (3) 1 RCT with individuals prone to falling[36]; and (4) 1 one-group study with persons with visual impairment.[48] Cultural dances were used by 12 studies,[8,11,25,27,33,34,35,37,42,43,53,59] with 5 studies specifically examining Korean-style dance.[35,37,42,43,59] Aerobic dance appeared in 9 studies[17,26,28,29,31,32,39,44,50]; dance therapies in 6 studies[21-24,30,45]; and jazz in 2 studies.[40,47] Three studies did not report dance styles.[46,49,52]

Considering only the RCTs, cultural and ballroom dances were the most used interventions. Nine RCTs used cultural dances: 3 Greek,[8,25,27] 2 Korean,[35,37] 1 Turkish,[11] 1 Caribbean,[18] 1 Thai,[33] and 1 Bhangra.[34] Nine RCTs used ballroom dance: 5 tango[16,19,20,36,38]; 1 waltz[7]; 1 ballroom mix—foxtrot, waltz, rumba, swing, samba, and bolero[15]; 1 salsa[9]; and 1 ballroom dance meetings (weekly organized social meetings for dancing different Latin rhythms with different partners).[13] Aerobic dance was used by 8 RCTs.[17,26,28,29,31,32,39,44] Dance therapies appeared in 5 RCTs: (1) 1 with creative dance[30]; (2) 3 with dance programs developed for the older adults—Agilando,[22] EXDASE,[21] and Health Steps[24]; and (3) 1 with the Labed method.[23]

The 3 quasi-experimental trials used the Latin dance cha-cha,[57] tango,[58] and Korean dance.[59] One-group studies had 2 interventions using Korean dance,[42,43] and 1 used dance therapy.[45] Two 1-group studies used jazz.[40,47] Only 1 one-group trial did not specify the dance style.[46]

Regarding the observational studies, 1 cross-sectional trial evaluated acute cardiorespiratory responses during an aerobic dance and a walking session.[50] Seven cross-sectional studies evaluated the effects of regular practicing of dancing on metabolic and/or functional parameters, using the following types of dance: (1) recreational ballroom dance,[55] (2) competitive ballroom dance,[51] (3) amateur multiyear dancing,[52] (4) social dancing,[54] and (5) gymnastics and/or folk dancing.[53] Chen et al[49] evaluated dance as a subtype of physical activity practiced during the life span, but did not specify any particular style of dance.

Characteristics of Interventions

The interventions lasted from 2 weeks[41] to 2 years.[16] Interventions of 12 weeks—RCTs, quasi-experimental, and 1-group—were the most used, with 13 studies using that period.[18,21,24,26,31,32,34,35,37,41,44,45,58] The weekly frequency most used was 3 times per week, with 15 studies included using that frequency.[7,8,9,12,13,15,17,23,26,30,33-35,37,47] The duration of the dance sessions varied from 40 minutes[7] to 90 minutes,[36] with 60-minute sessions being the most reported in 14 studies.[9,11,16-20,25-27,32,34,44,57]

In general, dance sessions were described in 3 parts: (1) warmup—from 5 to 20 minutes, including stretching major muscle groups and basic steps of each specific dance style; (2) main part—from 20 to 50 minutes, practicing specific dance moves of each style (2 studies combined dancing with aerobic and resistance exercise in the same session,[35,37]); and (3) cool-down—varying from 5 to 15 minutes, usually stretching major muscle groups.

The main part of a session was usually described in detail in terms of pedagogic processes and technical progressions. On the other hand, intensity was not described in most of the studies (ie, not described in 30 trials). Eight RCTs did use quantitative parameters for description of exercise intensity, such as: $\%VO_{2peak}$,[7,18] $\%HR_{max}$,[17,18,27,35] average HR,[31] $\%HR_{reserve}$,[37] and the Borg scale.[8]

The range of intensity varied from 50% to 75% VO_{2peak} and from 50% to 70% HR_{max}. Two quasi-experimental studies reported an intensity of 50% HR_{max}[59] and from 50% to 80% HRreserve,[57] whereas 1 one-group study reported the physiological intensity of the dance session, 50% HR_{max}.[43] Of the 11 studies that properly described intensity, 8 included metabolic outcomes.

Comparison Groups

Twenty-two RCTs compared dance interventions with control groups,[9,11,13,15,18,21-28,30-32,35,37,38,44,57,58] whereas 3 compared dance with controls and groups performing other types of exercises.[7,8,34] The control groups generally included people who maintained their daily habits and did not undergo any type of prescribed physical activity.

One study included people on the waiting list for dance therapies as controls.[24] Other control groups included people practicing other types of exercise, such as aerobic exercise using a cycloergometer or treadmill[7,34] and aerobic exercise plus resistance training.[8] Engels et al[17] compared dancing alone with dancing with wrist weights attached, and also to a control group. Young et al[29] compared a group who performed line dance only with another group who performed line dance plus squats.

Three RCTs compared dance only with other exercises: (1) dancing versus walking[36,39] and dancing versus chair exercise classes.[19] The duration of the other exercise interventions was the same as for the dancing, except for Young et al.[29] The intensity of the other exercises was described in 5 studies[7,8,17,34,36] and identical to the dance intensity in 3 studies.[7,8,17]

Three cross-sectional trials compared expert[52] and recreational[51,55] ballroom dancers with controls: (1) 2 compared social dancers with controls[54,56] and (2) 1 compared folk dancers plus gymnastics with controls.[53] Grant et al[50] compared the same participant's cardiorespiratory responses during dancing and walking sessions. Chen et al[49] verified the prevalence of metabolic syndrome in older individuals engaged in different subtypes of physical activity (dancing, jogging, and swimming).

Functional and Metabolic Outcomes

Thirty-four studies evaluated exclusively functional outcomes such as balance, gait ability, muscle strength/power, cardiorespiratory fitness, and flexibility: (1) 20 RCTs [9,11,15,16,18-29,33,36,38,39]; (2) 6 1-group studies[40,41,45-48]; (3) 6 cross-sectional studies[50-54,56]; and (4) 2 quasi-experimental designs.[58,59]

Seven studies evaluated exclusively metabolic outcomes, such as blood lipids, glucose levels, blood pressure, and body composition: (1) 3 RCTs,[13,35,37] (2) 2 one-group studies,[42,43] (3) 1 quasi-experimental study,[57] and (4) 1 cross-sectional study.[49] Nine studies evaluated both functional and metabolic outcomes: (1) 8 RCTs[7,8,17,30-32,34,44] and (2) 1 cross-sectional study.[55] Functional outcomes appeared in 41 studies, whereas metabolic outcomes were evaluated in 16 studies.

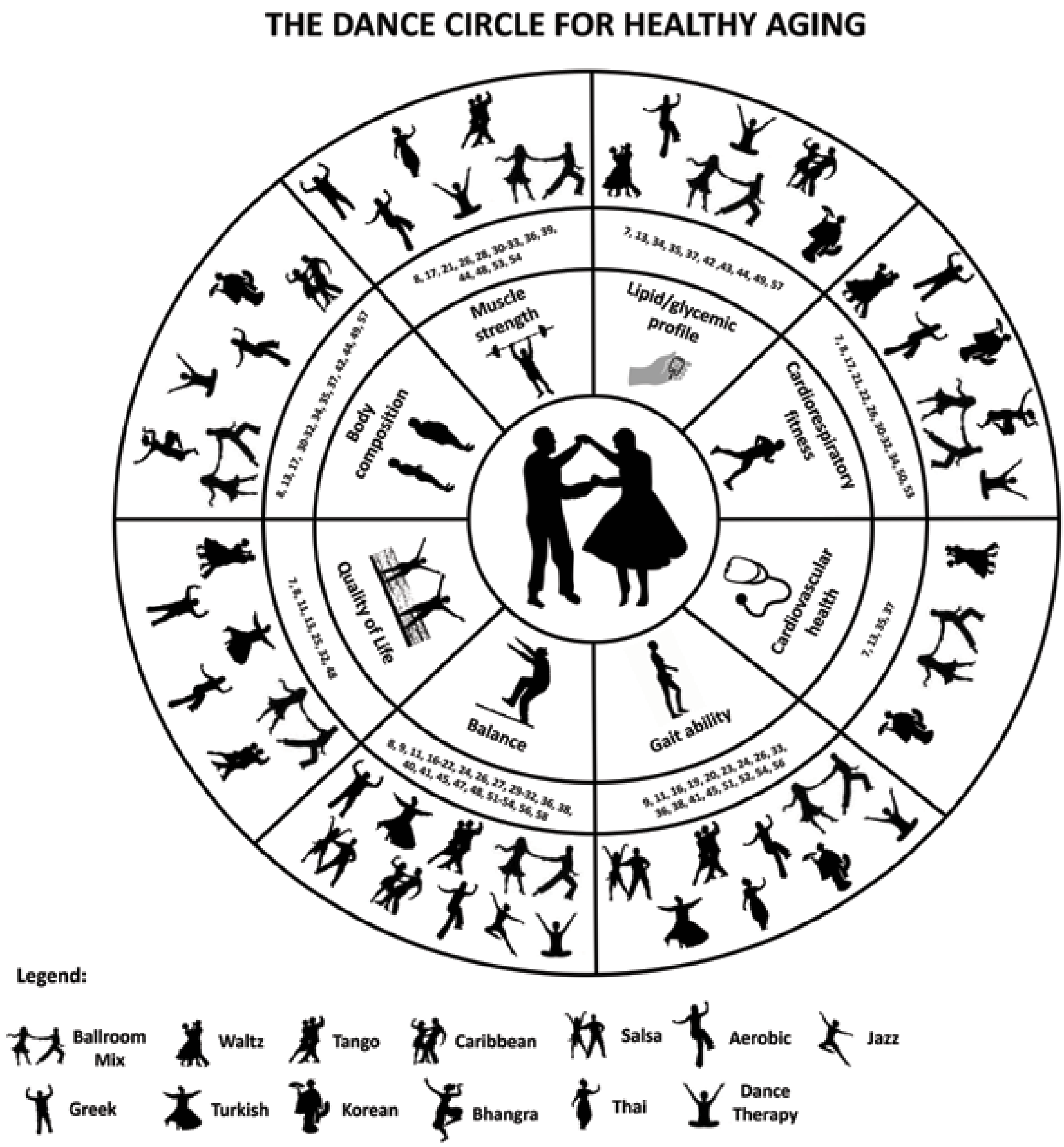
The dance styles most used for evaluating functional outcomes only were (1) ballroom dances, with 10 studies[9,15,16,19,20,36,38,41,48,58]; (2) cultural dances, with 6 studies[11,18,25,27,33,59]; (3) dance therapies, with 5 studies[21-24,45]; (4) aerobics, with 4 studies[26,28,29,39]; and (5) jazz, with 2 studies.[40,47]

When metabolic outcomes were also analyzed, aerobics, with 4 studies[17,31,32,44] and cultural dances, with 4 studies,[8,34,42,43] were the most usual interventions. Three combined interventions were found: 2 studies using Korean dance plus aerobic/resistance exercise in the same session[35,37] and 1 study using ballroom dance meetings plus toning sessions on separate days.[13] Waltz[7] and cha-cha[57] were used in 1 RCT and 1 quasi-experimental study, respectively. Figure 2 displays functional and metabolic outcomes generally improved by different dance styles for aging individuals.

Balance

The outcome most assessed among all studies was balance, with 30 studies measuring it: (1) 19 RCTs[8,9,11,16-22,24,26,27,29-32,36,38;] (2) 1 quasi-experimental study[58]; (3) 5 one-group studies[40,41,45,47,48]; and (4) 5 cross-sectional studies.[51-54,56] All interventions showed within- and between-group improvements in favor of dancing, except for Engels et al,[17] who did not detect changes after aerobic dance.

Figure 2. Dance Circle For Healthy Aging



Krampe et al[23] reported a significant effect size, suggesting that dance-based therapy was moderately effective in improving balance. Granacher et al[9] reported improvements for standing performance regarding mediolateral, center-of-pressure displacement for salsa practitioners. All cross-sectional studies showed dancers with better balance than controls.

Only 3 studies compared balance between dancing and other exercise[8,19,36] and showed similar improvements (eg, Greek dance vs aerobic/resistance training).[8] More accentuated improvements in balance were seen in patients with Parkinson's disease who performed the tango intervention versus traditional chair-exercise classes,[19] as did individuals prone to falling in a comparison of participants who practiced tango versus participants who practiced walking.[36] Postmenopausal women who performed line dancing plus squats/stomps increased balance more than the ones who practiced line dance alone.[29]

The studies evaluating balance included a variety of participants: (1) healthy participants in 20 studies[9,11,15,17,18,21-23,26,27,30-32,40,47,51-54,56]; (2) Parkinson's patients in 6 studies[16,19,20,36,41,58]; (3) postmenopausal women in 2 studies[29,53]; (4) patients with chronic heart failure in 1 study[8]; (4) frail older adults in 1 study[45]; and (5) visually impaired participants in 1 study.[48]

Regarding the types of dance, ballroom dancing was the most-used intervention for evaluating balance, with 10 studies using that dance type,[9,15,16,19,20,36,38,41,48,58] of which 8 used tango.[16,19,20,36,38,41,48,58] After ballroom dance, the other dance types used for evaluating balance were (1) cultural dances in 5 studies[8,11,18,27,59]; (2) aerobic dance in

5 studies[17,26,29,31,32]; (3) dance therapies in 5 studies[21-23,30,45]; and (4) jazz in 2 studies.[40,47]

The TUG test was the most used method of assessment of dynamic balance, with 14 studies using it: (1) 9 RCTs,[16,18,20,21,24,29,30,32,38]; (2) 2 one-group studies[41,45]; (3) 2 cross-sectional studies[51,52]; and (4) 1quasi-experimental study.[58] Four studies used the functional reach test: (1) 3 RCTs[17,19,26] and (2) 1 one-group study.[45] Four studies also used the Berg balance scale: (1) 3 RCTs[8,11,20] and (2) 1 one-group study.[41] Four RCTs[9,22,27,29] used force platforms to check the center of pressure and trunk displacements.

Gait Ability

Gait ability was assessed by 17 studies: (1) 11 RCTs,[9,11,16,19,20,23,24,26,33,36,38]; (2) 2 one-group studies[41,45]; and (3) 4 cross-sectional studies.[51,52,54,56] Normal and/or fast walking speeds were assessed by gait computer systems,[9] the 6MWT,[33] and the TUG test.[24] Three studies evaluated walking ability as part of a battery of functional tests, generating a final score.[15,46,48]

Nearly all interventions induced improvements within and between groups when comparing dancers with controls. One RCT showed no within- or between-group changes in walking performance.[19] One 1-group study did not show changes in the 6MWT or TUG performance, but improved the percentage of time that dancers spent in stance during forward walking.[41] The same studies evaluating balance in patients with Parkinson's disease also evaluated gait ability.

Falls and Quality of Life

Dancing was suggested as a useful intervention for fall prevention in 13 studies: (1) 9 RCTs[9,18,19,26,29,30,36,38,44]; (2) 1 quasi-experimental study[58]; (3) 1 one-group study[48]; and (4) 2 cross-sectional studies.[53,54]

Quality of life was assessed in 7 studies: (1) 6 RCTs,[7,8,11,13,25,32] and (2) 1 one-group study,[48] with all the studies showing dancing-related improvements. Visually impaired patients improved quality of life related to general vision.[48] Three of those studies used cultural dances,[8,11,25] 3 studies used ballroom dance,[7,13,48] and 1 used aerobic dance.[32]

Muscle Strength/Power and Flexibility

Muscular strength was analyzed in 15 studies: (1) 12 RCTs[8,17,21,26,28,30-33,36,39,44]; (2) 1 one-group study[48]; and (3) 2 cross-sectional studies.[53,54] The most used method of assessment was the seat-and-stand test, performed either 5 or 10 times or during 30 seconds, with 7 studies using it.[17,21,30,31,36,48,54]

Muscle power was assessed by the counter-movement jump in 2 studies: (1) 1 RCT[9] and (2) 1 cross-sectional study.[53] Another 2 studies reported the 5× sit-to-stand test for assessing strength/power.[21,33] Only 2 studies did not find positive results for muscle strength: (1) 1 RTC[26] and 1 cross-sectional study.[54] All interventions resulted in within- and in-between group improvements (ie, dancers vs controls), which were similar to other exercises: (1) aerobic/resistance[8] and (2) walking.[36]

Eight studies evaluated flexibility: (1) 7 RCTs,[17,21,30-33,44] and (2) 1 cross-sectional study.[56] All used the sit-and-reach test, except Engels et al[17] and Wu et al,[44] who measured the range of motion of different joins with a goniometer. The adapted, chair sit-and-reach test was reported in 3 studies.[21,30,31] Only 2 interventions did not detect differences within and between groups.[17,32]

Cardiorespiratory Fitness

Cardiorespiratory fitness was assessed by 12 studies, with 8 evaluating maximum cardiorespiratory capacity: (1) 6 RCTs[7,8,17,22,26,34] and (2) 2 cross-sectional studies.[50,53] Seven studies used indirect calorimetry during an incremental treadmill protocol.[7,8,17,22,26,34,50] One study estimated VO_{2max} from the 2-km walking test.[53] Four studies evaluated cardiovascular endurance: (1) 2 by 6MWT,[30,32] (2) 1 by a half-mile walking test,[31] and (3) 1 by a 2-minute step test.[21]

All dance interventions increased aerobic fitness within and between groups, except Kattenstroth et al.[22] Belardinelli et al,[7] Lesser et al,[34] and Kaltsatou et al[8] showed dance improvements similar to other exercises, such as aerobics or aerobic/resistance training. Grant et al[50] showed acute exercise intensity for dance at 67% VO_{2max}, higher than walking at 52% VO_{2max}. Two studies involved patients with chronic heart failure.[7,8] Five studies used aerobic dance[17,26,31,32,50]; 3 used cultural dances[8,34,53]; 3 used dance therapies[21,22,30]; and 1 used ballroom dance.[7]

Metabolic Outcomes and Cardiovascular Risk

Regarding the metabolic outcomes, which 16 studies used, (1) healthy older adults were the participants in 10 studies[13,17,30-32,42-44,49,55]; (2) another 2 assessed patients with chronic heart failure[7,8]; (3) 2 involved obese women[35,37]; (4) 1 included patients with metabolic syndrome[57]; and (5) 1 included postmenopausal woman.[34]

Lipid and/or glycemic profile—such as total cholesterol, LDL, HDL, triglycerides, fasting glucose—were analyzed by 10 studies: (1) 6 RCTs[7,13,34,35,37,44]; (2) 2 one-group studies[42,43]; (3) 1 cross-sectional study[49]; and (4) 1 quasi-experimental study.[57]

Seven studies showed within- and/or between-group improvements for dance in at least 1 of the parameters studied: (1) 6 RCTs[7,13,34,35,37,44] and (2) 2 one-group studies.[42,43] One quasi-experimental study[57] and 1 RCT[34] did not detect any changes.

Two combined interventions were successful in promoting positive changes within the dance group.[35,37] Another combined intervention[13] promoted within and between group improvements for dancers in these parameters.

Blood pressure was measured in 11 studies: (1) 7 RCTs[7,8,13,17,32,35,37]; (2) 2 cross-sectional studies[49,55]; (3) 1 one-group study[42]; and (4) 1 quasi-experimental study.[57] Within- and between-group improvements for dancers were seen in 2 RCTs, 1 with 700 participants evaluating SBP and DBP,[13] and the other one considering evaluating only DBP.[37] The cross-sectional trial of Goertzen et al[55] did not find differences between dancers and controls in evaluating SBP and DBP.

Other specific metabolic outcomes were analysed analyzed in 3 RCTs. Belardinelli et al[7] analyzed endothelial function, wave peak velocity, and oxidative stress, verifying improvements for the dancers. Moreover, dancing was as efficient as traditional aerobic exercise, and superior to the control. Lim et al[35] verified that arthrosclerosis adhesion molecules and C-reactive protein improved after 12 weeks of a Korean-dance intervention, whereas the control group remained the same. Park et al[37] verified that oxidized LDL and the thickness of the carotid media intimae also was reduced after Korean dance combined with aerobic/resistance exercise.

Body Composition

Body composition—such as body weight, BMI, waist circumference, skinfolds, body fat—was assessed in 13 studies: (1) 10 RCTs[8,13,17,30-32,34,35,37,44]; (2) 1 one-group study[42]; (3) 1 cross-sectional study[49]; and (4) 1 quasi-experimental study.[57] Positive results were found in 9 trials: (1) 7 RCTs[13,30,31,34,35,37,44]; (2) 1 one-group study[42]; and (3) 1 cross-sectional study.[49] It remained the same in 4 studies: (1) 3 RCTs[8,17,32] and (2) 1 quasi-experimental study.[57] Gold-standard methods for assessment of body composition, such as a DEXA scan, were used in 3 studies,[34,35,37] and computer tomography was used in 1 study.[34]

The cross-sectional trial of Chen et al[49] showed a dose-response relationship related to each 1-hour increment of dance practice per week, which was associated with reductions in triglycerides, blood glucose, blood pressure, and waist circumference, as well as increases in the HDL of Chinese older participants.

Risk-of-Bias Assessment

Of the 30 RCTs analyzed, 9 were deemed to low risk of bias[7,9,13,18,24,29,30,34,38]; 4 a moderate risk[16,23,28,44]; and 17 a high risk.[8,11,15-17,19-22,25-28,31,32,35-37,39,44] Overall, the major weaknesses among the studies were a lack of appropriate description of the generation of randomized sequences and of the methods of allocation concealment, with 20 studies lacking the information.[8,11,15-17,19-22,25-28,31,32,35-37,39,44] Blinding of patients and investigators was not indicated in any studies, which the research team expected in studies with exercise interventions involving individual or group classes. Intention-to-treat analysis was performed by 14 studies.[7,9,13,16,18,24,26,28,29,34,35,37,38,44] Studies were more successful in meeting quality criteria for the description of losses and exclusions, except for Kattenstroth,[22] and of the blinding of outcome assessors, with 15 studies meeting the criteria.[7,8,11,16,18,19,20,21,24,28,30,32,34,36,44]

DISCUSSION

The main findings of this review underline 3 major points: (1) all dance styles seemed to be successful in inducing positive effects in functional outcomes in older adults; (2) balance was the outcome most assessed in the studies using dance as an intervention or exposition factor; and (3) although metabolic outcomes were assessed to a lesser extent, they may also improve in response to dancing.

Dancing stimuli for balance improvement involved moving constantly in an upright posture in a unilateral stance as well as transferring the line of gravity to alternate the base of support of the body during the choreographies.[6] For example, Sofionidis et al[27] showed that dancers decreased their center of pressure displacement and trunk sway in 1-leg stances as well as increased the range of trunk rotation during the performance of dynamic weight shifts in the sagittal and frontal planes.

Gains in gait ability were often associated with balance improvements, resulting in reduced fall-related risks with practice of dance.[6,10] This finding is relevant considering that most falls occur during dynamic activities, such as walking, turning, and reaching.[10] Moreover, patient with Parkinson's disease maintained their gains in balance for 10 weeks after the tango intervention,[58] whereas healthy older adults from control groups did not change balance or even showed degraded performance after 6 months, likely as an effect of the aging process.[22] The cross-sectional trials showed that older individuals who have practiced dancing lifelong, whether they were amateurs[52] or experts[51] or only dancing socially,[54] presented better balance than their paired controls.

Even though a number of RCTs have evaluated static and/or dynamic balance, no quantitative evidence exists regarding a pooled effect size related to improvements for this outcome as a result of dance interventions for older adults. The TUG test, the most used method of dynamic-balance assessment found in the current review, might be selected as a tool for a future meta-analysis regarding the effects of dance interventions on dynamic balance in healthy older adults, comparing dancers with controls and other exercise groups. When considering individuals with specific medical conditions, the meta-analyses of Lotze et al[65] have already shown consistent evidence that tango dance is effective in improving balance and gait ability and decreasing disease severity in patients with Parkinson's disease.

A variety of dance styles have consistently shown improved aerobic fitness in older adults. For instance, Bhangra dance[34] and aerobic dance[17] were able to increase VO_{2peak} after 10 and 12 weeks of the intervention, respectively. Both were performed 3 times per week for 60 minutes. Aerobic endurance measured by the 6MWT also increased after Turkish dance for 8 weeks at 3 times per week for 60 minutes[11] and creative dance interventions for 24 weeks at 3 times per week for 50 minutes.[30]

In fact, Grant et al[50] suggested that the exercise intensity that can be reached during a dance session (67% VO_{2peak}) is enough to induce improvements in the aerobic capacity of an older adult, which might be linked to mechanisms by which dancing can improve cardiovascular health. The only study that did not find changes in aerobic fitness had its dance therapy performed only once per week for 24 weeks,[22] indicating that weekly frequency, rather than length of the intervention may influence cardiorespiratory gains in older adults. In addition, dance was as effective as other types of exercise in improving the VO_{2peak} of patients with chronic heart failure, as was shown with the waltz[7] and Greek dance[8] interventions, both performed 3 times per week.

Positive results were also found for muscle strength; however, the common use of the seat-and-stand test may limit proper conclusions about this outcome. Few of the trials used gold-standard methods, such as the study of Engels et al,[17] which evaluated peak torque by isokynetic dynamometry. Despite that lack, the characteristics of dance moves, such as landing from a low-impact jump or maintaining a pose, may favor the development of eccentric and isometric strength.[66,67] For instance, Shigematsu et al[26] pointed out that the plyometric component of the lunges in aerobic dance may increase the eccentric preload to the leg muscles, which induces the myotatic stretch reflex, and eventually, results in a more forceful concentric contraction. Because eccentric contractions can increase the force output at by around 30% to 40% more than concentric ones,[67] it may be that practicing dance moves regularly is useful for aging individuals at risk of losing muscle mass, strength, and power.

Although the muscle power of folk dancers was better than sedentary controls,[53] the training stimulus during salsa dancing was not enough to induce significant improvements in the outcome.[9] In fact, specific, high-velocity strength training was needed to induce increases in muscle power.[68]

Considering that fact, dance interventions may have the potential of increasing muscle power if the speed of the specific dance moves is properly manipulated. The advantages of using dance moves for developing muscle power include the use of body weight as an initial workload and the presence of the stretching-shortening cycle in most dance moves.[66] Accordingly, strength training at higher speeds and with lighter loads as well as a stair climbing exercise program were more efficient than traditional strength training using heavy, slow contraction in improving muscle power and functional capacity in older adults.[68] Because muscle power decreases occur even before muscle strength[68] and is associated with functionality and independence during aging—such as balance, gait ability, ability to sit and stand, and incidence of falls,[69] it is an element of relevance to be developed in exercise training programs, including dance.

Flexibility was also improved as result of dance interventions in most of the reviewed trials, with the chair sit-and-reach test a commonly used method of assessment. Keogh et al[6] reported a moderate-to-high level of evidence indicating that older adults can significantly improve their flexibility with dance training, because flexibility is a natural element of various dance styles.

To the best of the current research team's knowledge, this review is the first studying the effects of dance interventions or dance on metabolic outcomes. Even though metabolic outcomes have been assessed less extensively than functional measures—20 RCTs in the current review for exclusively functional and 3 RCTs for metabolic outcomes, metabolic measures positively responded to dance interventions. For instance, 2 one-group studies verified that the total cardiovascular risk score, total cholesterol, triglycerides, and BMI were reduced after 3 months of a Korean-dance intervention,[42] as well as improvements in LDL, HDL, LDL/HDL, and the atherogenic index for older women.[43]

Also, the RCT of Belardinelli et al[7] verified similar improvements in HDL and triglycerides after a waltz dance intervention and traditional aerobic exercise. Blood pressure was the metabolic outcome that responded least to dance interventions, which corroborates with the long-term (1-year) nature of adaptation to different types of exercise interventions for blood pressure, such as tai chi[70] and endurance and/or resistance exercises.[71] Indeed, the only dance intervention included in the current review that detected improvements in SBP and DBP was performed for 12 months.[13]

Changes in body composition were not always the result of pure dance interventions.[8,17,32] Three combined interventions were successful in improving BMI, body weight, and body-fat percentage[13,35] as well as upper-and-lower limb and appendicular lean mass.[37] However, 2 of them evaluated obese women[35,37] and, therefore, might have had larger scopes for body composition improvements. The other combined intervention did not report exercise intensity, but it had a large sample size, 700 participants, and likely had a higher statistical power for detecting significant changes.[13]

It may also be that the energy expenditure for the combined interventions was higher than the pure dance ones, because the few reported exercise intensities were similar—50% to 70% HR_{max}. In fact, total energy expenditure was positively correlated with metabolic responses to exercise for people in a lower range of physical activity, whereas for participants in an upper range, the total energy expenditure plateaued, with activity intensity appearing to be the main modulator of metabolic responses.[72]

In particular, Bhangra dance alone could reduce visceral adipose tissue in older women who attended classes; however, it was not able to induce metabolic adaptations in other outcomes, such as insulin resistance.[34] On the other hand, the combined intervention of Korean dance plus aerobic and resistance exercise was able to promote improvements in insulin resistance with time, together with improvements in body composition.[35] Again, it is possible that a higher energy expenditure provided by the combination of exercises may have attained certain dose-response thresholds for favorable metabolic changes.[73]

The current research also found few studies properly describing the physiological intensity of the dance sessions, sometimes mistaking exercise intensity with increases in technical difficulty and/or individual fitness status.[21,34] This confusion might be connected to a lack of cross-sectional studies evaluating acute responses of dance sessions in older adults, with only 1 study examining the measure.[50]

Considering the fact that the goals of the interventions designed for older adults should go beyond technical development, characterizing dance exercise intensities may be as important as detailing the pedagogic process of specific dance steps. Describing the acute cardiorespiratory and/or neuromuscular responses of different dance styles and further relating them to individual metabolic breakpoints, such as ventilatory thresholds, would clarify in which zones of intensity older adults exercise while dancing—low-, moderate-, or high-aerobic intensity or anaerobic. This information would also allow for insights regarding periodization of dance programs using different styles, targeting volume, intensities, and energy expenditure sufficient to attain favorable metabolic responses.[72,73]

It seems that the 8 reviewed studies evaluating metabolic outcomes considered the description of physiological intensities more than the 3 studies evaluating functional outcomes. Although exercise intensity may not influence gains in some functional outcomes, such as balance, they are associated with improvements in other measures, aerobic capacity, for example.[74] It is of importance to maintain and/or acquire an aerobic reserve because it can delay muscle fatigue onset, improve performance in daily activities, and reduce risk of falls, all fundamental elements for independence with aging.[75] Increases of 5 to 10 mL/kg^{-1}/min^{-1} in maximum aerobic capacity, following appropriate progressive aerobic training, may counteract the anticipated age-related loss of 5 mL/kg^{-1}/min^{-1} per decade, which reduces a person's biological age by more than 10 years.[76]

The fact that dancing may be a potential intervention for improving metabolic and cardiovascular risk markers is highlighted in the cross-sectional trial of Chen et al,[49] which demonstrated that each 1-hour increment of dance practice per week was associated with significant improvements in triglycerides, blood glucose, blood pressure, and waist circumference, which eventually translated into a lower risk for the development of metabolic syndrome in Chinese older adults. Supporting those findings, the cohort study of Meron et al[77] has recently shown that moderate-intensity dancing is associated with a reduced risk for cardiovascular-disease mortality to a greater extent than walking, which may be explained by the higher-intensity, intermittent exercise during dancing, lifelong adherence, or psychosocial benefits.

Indeed, specific cardiovascular adaptations may be induced by the intermittent characteristics of the dance.[78] They may include bouts of exercise of shorter duration and slightly higher intensity, such as quick foot work or small jumps of low impact, alternated with continuous moves of lower intensity, such as smooth arm moves combined with slow and wide range-of-motion leg movements.[78] Furthermore, older practitioners seem to have greater tolerance for short bouts of exercise, due to its lower orthopaedic overload and greater perception of success in being able to complete the tasks.[6]

Possible mechanisms by which dance has such diverse metabolic and functional benefits may be linked to cardiorespiratory adaptations that regular dance practice can induce.[12] Metabolically, increasing the aerobic reserve may increase the lipoprotein lipase activity in skeletal muscle, enhancing the transport of lipids and lipoproteins from the peripheral circulation and tissues to the liver.[60] Functionally, it can delay onset of muscle fatigue and improve performance in daily activities, which is fundamental to independence with aging.[75]

Indeed, dancing has been suggested as a form of exercise that induces favorable effects similar to aerobic exercise training, such as improved myocardial perfusion and function, increased size and volume density of the mitochondria and oxidative enzymes of skeletal muscle, reduced endothelial dysfunction, and improved autonomic balance.[7] In addition, the variety of skeletal muscle contractions during the performance of dance exercises, in association with the intermittent characteristic of dancing, can lead to increases in venous return, cardiac output, and stroke volume that may be generated at maximum and submaximum workloads,[79] with the last benefits being of more importance for optimized performance in daily activities.

Regarding quality assessment, the general quality of the studies was low, reflecting a high risk of bias in some studies. Inappropriate description of randomization-sequence generation and allocation concealment—20 of 30 RCTs—may result in increased selection bias, influencing the baseline characteristics of the groups that were compared. This fact, together with small sample sizes, should be taken in account for future studies, to minimize possible threats to the external validity of primary data.

Another limitation was the absence of proper control groups in a number of studies involving dance interventions—9 one-group studies and 3 quasi-experimental studies, which may have reduced the strength of the evidence. Particularly regarding dance interventions, other potential sources of bias might be the benefits simply of learning new things and of being in a social environment, or even being in a wait-list control group, which might secondarily improve certain outcomes just as a result of improved mood. In fact, quality of life has been consistently improved after dance interventions,[7,8,11,13,25,32,48] especially regarding emotional domains.[7]

Finally, based on the fact that functional and metabolic gains can be induced by different dance styles, the current research team suggests building mixed-dance sessions in a dance program for older adults. In other words, a dance session in which fitness elements—aerobic endurance, muscle strength, and power—are manipulated to induce sufficient increases in exercise intensity and, therefore, optimize metabolic improvements, together with functional gains, without the need of combining dance with other exercises.

CONCLUSIONS

The current review showed that all dance styles can induce positive effects over functional outcomes in older adults. Balance is the most often evaluated outcome in the studies using dance as an intervention, showing between- and within-group improvements in nearly all trials. Positive metabolic modifications can also be a result of dance practice; however, more RCTs need to be performed to improve the level of evidence. Because dancing incorporates elements—such as changes in direction, musicality/speed, and weight shifts—that can be manipulated to develop functional, fitness and produce metabolic outcomes, it may be a potential exercise intervention to promote a healthy aging process.

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AUTHOR DISCLOSURE STATEMENT

The research team has no conflicts of interest related to the study.

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3.2 ARTIGO 2: REVISÃO SISTEMÁTICA COM METANÁLISE

EFFECTS OF DANCE INTERVENTIONS ON CARDIOVASCULAR RISK WITH AGEING: SYSTEMATIC REVIEW AND META-ANALYSIS

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Effects of dance interventions on cardiovascular risk with ageing: Systematic review and meta-analysis

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ABSTRACT

Background: Exercising, including dancing, has been recommended to improve cardiovascular health of older people. Herein, we conducted a systematic review and meta-analysis verifying the effects of dance interventions on cardiovascular risk (CVR) in the elderly, comparing dancers to non-exercise controls and other types of exercise, in randomised (RCTs) and non-randomised control trials (nRCTs). Primary/Secondary outcomes: peak oxygen consumption (VO_2peak)/anthropometric measurements (body weight, BMI), and lipid profile.

Methods: Data Sources: MEDLINE, Cochrane Wiley, Clinical Trials.gov, PEDRO and LILACS databases. Study Selection: RCTs and nRCTs comparing elderly before and after dance interventions with non-exercising controls and/or practitioners of other types of exercise. Two independent reviewers extracted data and assessed the quality of included studies.

Results: A total of 937 articles were retrieved, 64 full texts were assessed for eligibility, and 7 articles met the inclusion criteria. Pooled mean differences between intervention and control were calculated by random-effects model. VO_2peak improved in favour of dancers (3.4 mL kg^{-1} min^{-1}, 95%CI: 1.08, 5.78, I2 = 71%), compared to non-exercise controls. No differences were found between dance and other exercises. Body weight and BMI were not altered by dance interventions.

Conclusions: Dance interventions may increase VO_2peak compared to non-exercising controls. Results also indicate it is as effective as other types of exercise in improving aerobic capacity of the elderly. Dancing might be a potential exercise intervention for improving cardiorespiratory fitness and consequent CVR associated with ageing. Proper reporting on adverse events is needed to base the benefits of dancing for the older on both efficacy and safety of the interventions.

Contents

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1. Introduction

Biological ageing is associated with declines in different physiological aspects, including structural and functional deteriorations to the cardiovascular system and unfavourable changes in body composition.[1,2] For example, the progressive decrease of lean body mass and consequent decay of resting metabolic rate implies a decrease of daily physical activity and in total energy expenditure.[3] Eventually, it may predispose the elderly to accumulate visceral and total body fat.[3] There are a number of metabolic consequences of these changes in body composition, such as an altered lipid profile, poor insulin sensibility, and post-prandial hyperglycaemia.[3] Accompanied by reduced levels of physical activity, it has been extensively associated to the development of cardiovascular disorders, such as myocardial infarction, stroke, and peripheral vascular disease.[4–6]

In particular, the level of physical activity has been suggested as a potential risk marker for cardiovascular disease.[7] For instance, cardiorespiratory fitness was a predictor of cardiovascular risk (CVR) in healthy individuals.[8] Accordingly, higher cardiorespiratory fitness seems to avoid the elevation of serum lipids and lipoproteins during the entire life span.[9] Maintaining and/or acquiring an aerobic reserve implies positive metabolic and functional adaptations with ageing. Metabolically, it increases the lipoprotein lipase activity in skeletal muscle, enhancing the transport of lipids and lipoproteins from the peripheral circulation and tissues to the liver.[9] Functionally, it can delay muscle fatigue onset and improve performance in daily activities, which is fundamental for independence with ageing.[10] In fact, increases of 5–10 $mL\,kg^{-1}\,min^{-1}$ in peak oxygen consumption (VO_2peak) may counteract the anticipated age-related loss of 5 $mL\,kg^{-1}\,min^{-1}$ per decade, reducing a person's biological age by more than 10 years.[11]

Following that, exercise training, in addition to slowing the decline in maximal aerobic power and exercise capacity,[12] has further positive effects against other ominous correlates of ageing, such as the progressive loss of lean body mass and gains in visceral fat.[3] Thus, aerobic and resistance exercise have been widely recommended for older people, in order to improve functional capacity and metabolic and cardiovascular health.[13–15]

In particular, dancing has been increasingly used as an attractive form of exercise for the elderly, because it can be adjusted to fit a target population's age and physical limitations.[16] This may reduce the safety concerns of the sedentary older adults in starting a physical activity program, which is shown by great adherence rates to dance interventions.[17,18] Higher levels of tolerance to intermittent exercise bouts,[19] consequent greater perception of success, and higher levels of motivation[18] also favour dance practising at old ages.

Indeed, dance therapies have been demonstrated as effective as conventional exercise in improving VO_2peak and quality of life in older patients with chronic heart failure.[20] Additionally, previous studies demonstrated positive effects of dance interventions on metabolic parameters.[21–24] In Fact, a dose-response relationship was found for hours of dance practice per week and improvements in triglycerides and high-density lipoprotein cholesterol (HDL) levels in Chinese elderly.[6] However, most of the studies are presented as one-group pre-post test designs,[22–24] while randomised control trials (RCTs) are found in less extension.[21]

Although functional benefits of dancing for reducing risk of falling related factors (i.e., balance, gate, flexibility)[17] and for other health-related outcomes such as cognition and strength/endurance in healthy older adults have been recently reviewed,[25] the impact of dance interventions on metabolic, anthropometric, and fitness parameters associated with increased CVR has not been reviewed yet.

Therefore, we aimed to conduct a systematic review and meta-analysis to verify the level of evidence regarding the adaptations of dance interventions on CVR factors in the elderly. The primary outcome was cardiorespiratory fitness, measured by VO_2peak. The secondary outcomes were the anthropometric measurements of body weight, body mass index (BMI), waist circumference, and sum of skinfolds, as well as the measurements of lipid profile by the levels of triglycerides, total cholesterol, low-density lipoprotein cholesterol (LDL) and HDL. Comparisons of dance practitioners with non-exercise controls and/or practitioners of other types of exercise were performed. Randomised (RCTs) and non-randomised control trials (nRCTs) were included.

2. Methods

2.1. Search strategy and study selection

The following electronic databases were searched for articles published between November 1980 and December 2015: Medical Literature Analysis and Retrieval System Online MEDLINE (accessed by Pubmed), Cochrane Wiley (Central Register of Controlled Trials), Clinical Trials.gov, Physiotherapy Evidence Database (PEDRO), and "Literatura Latino-Americana e do Caribe em Ciências da Saúde" (LILACS). In addition, the reference lists of relevant published studies were searched manually. To identify relevant publications, the combined search term (exploded versions of the Medical Subject Headings [MeSH]) were used: (Elderly OR Aging OR Ageing OR Aged OR Senescence OR Biological Aging OR Older OR Older Adults) AND (Dance OR Dancing OR Dance Therapy). Studies were reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement.[26] Meta-analysis was performed for outcomes sufficiently reported in at least two studies.[27]

2.2. Eligibility criteria

We included RCTs and nRCTs that compared dance interventions with a non-exercising control group and/or other exercising groups receiving another type of intervention (i.e., aerobic or resistance exercise) in elderly subjects (mean age over 60 years). Elderly participants with or without health conditions were eligible. In addition, the intervention should have been designed to improve any of the outcomes of interest. For instance, our primary (VO_2peak) and/or secondary outcomes (body weight, BMI, waist circumference, sum of skin folds, triglycerides, total cholesterol, LDL, HDL). Data should be reported as means or difference in between means and respective dispersion values at baseline and after the intervention period. Eligible full texts in English, Portuguese, or Spanish were considered for review.

We considered dance interventions those with a structured dance programme design, weekly frequency, and information on duration and/or intensity of sessions reported. Studies assessed for eligibility could include dance interventions of any style (i.e., traditional folk, ballroom, aerobic dancing, etc.), based on the fact that they require similar physiological and kinesiological patterns.[18]

Exclusion criteria were as follows: (1) less than 4 weeks of intervention; (2) elderly patients with neurodegenerative diseases; (3) combined interventions (exercise programmes combining dance with other exercises); (4) duplicate publications/sub-studies; and (5) studies including outcomes of no interest (i.e., aerobic fitness estimated by the 6 min walking test).

2.3. Data extraction

Titles and abstracts of retrieved articles were independently evaluated by two investigators. Abstracts that did not provide enough information about the inclusion and exclusion criteria were submitted to full evaluation. Two reviewers independently evaluated full text articles, determined study eligibility, and conducted data extraction. Disagreements were solved by consensus or by a third reviewer. Specific characteristics of the intervention (dance style, duration of follow-up, intensity of the sessions, etc.); age and gender of participants; specific outcomes and methods of assessments; and adherence and/or dropout rates were also extracted.

2.4. Study quality assessment

Study quality was assessed using the Downs and Black criteria, a 27-item instrument designed for use in both randomised and non-randomised study designs.[28] A maximum score of 32 points is obtained from four quality domains: (1) reporting (10 items, 11 points); (2) external validity (3 items, 3 points); (3) internal validity (bias assessment, 7 items, 7 points; confounding assessment, 6 items, 6 points); and (4) power (1 item, 5 points). Responses were scored and summed to produce subscales and a total score, with higher scores indicating higher quality. The instrument has a high internal consistency (Kuder-Richardson Formula 20:0.89), acceptable interrater reliability ($r = 0.75$), and good test-retest reliability ($r = 0.88$).[28] Moreover, Downs and Black scale is based on epidemiological principles, reviews of study designs, and an existing checklist for assessment of RCTs.[29] It considers relevant topics for RCTs' quality assessment, such as appropriate statistical analysis, description of withdrawals and dropouts, baseline comparability, definition of inclusion and exclusion criteria, use of intention-to-treat analysis, and outcomes objectivity.[29] Therefore, face, content, and criterion validity have been conferred for this instrument.[29]

2.5. Data analysis

Pooled-effects estimates were obtained by comparing absolute post intervention means for each group, and were expressed as the weighted mean difference between the groups. Calculations were performed using a random-effect model. Comparisons were made among dance, control and another type of exercise groups. An α value = 0.05 was considered statistically significant.

Statistical heterogeneity of the treatment effect among studies was assessed using the inconsistency I^2 test, in which values greater than 50% were considered indicative of high heterogeneity.[30] We explored heterogeneity first by rerunning the meta-analysis removing each study at the time to check if a particular study was explaining heterogeneity; and second by performing sensitivity analysis to evaluate subgroups of studies most likely to yield valid estimates of the intervention based on previous relevant clinical information. All analysis was conducted using Reviewer Manager Software 5.3 version.

Unweighted analysis (i.e., descriptive analysis without an effect measure) was performed for outcomes of interest that appeared isolated in only one study, and therefore could not be included in the meta-analyses. Changes within and in between-groups (dance vs. controls) before and after the intervention period were then explored.

Finally, the GRADE approach[31] was applied for rating the quality of the evidence and the strength of future recommendations generated by this study, through the analysis of each outcome under five quality domains: (1) risk of bias (absence of concealing allocation and blinding); (2) imprecision (low sample size and large confidence intervals); (3) inconsistence (heterogeneity not explored); (4) indirectness (generalised conclusion, research question not answered); and (5) publication bias (failure in the inclusion of studies). Each item assessment was made subjectively as "serious," "very serious" or "not serious." Seriousness was increased as larger confidence intervals and higher heterogeneity was found for the same outcome among studies. In addition, a lack of blinded assessment of outcomes and intention-to-treat principle for analysis were identified.

3. Results

3.1. Study selection process

From 965 potentially relevant citations identified through electronic database searching, plus searches of reference lists (20 citations), 937 records were screened (after removing duplicates) and 64 full text articles were assessed for eligibility. After that, 57 articles were excluded due to the following reasons: (1) type of intervention (5 studies: 3 studies with combined intervention; 1 study investigating dance performed on the water; 1 study using a dance video-game protocol); (2) age of participants (9 studies; mean age under 60 years); (3) neurodegenerative diseases (2 studies intervention and control groups with Parkinson disease); (4) outcomes of no interest (27 studies; general functional capacity: seat-and-stand, gate, balance); and (5) study design (14 studies: quasi-experimental and one-group pre-post test).

Finally, seven studies were included in the systematic review (six RCTs and one nRCT), and five studies underwent the meta-analysis. Specifically, four studies were included in the VO_2peak outcome meta-analysis[21,32–34] while three studies for the body weight[32,33,35] and two studies for the BMI[33,35] meta-analysis, respectively. Outcomes that underwent unweighted analysis were: waist circumference (1 RCT[35] and 1 nRCT[36]); sum of skinfolds (2 RCT)[32,37]; HDL and triglycerides (1 RCT[21] and 1 nRCT[36]). Total

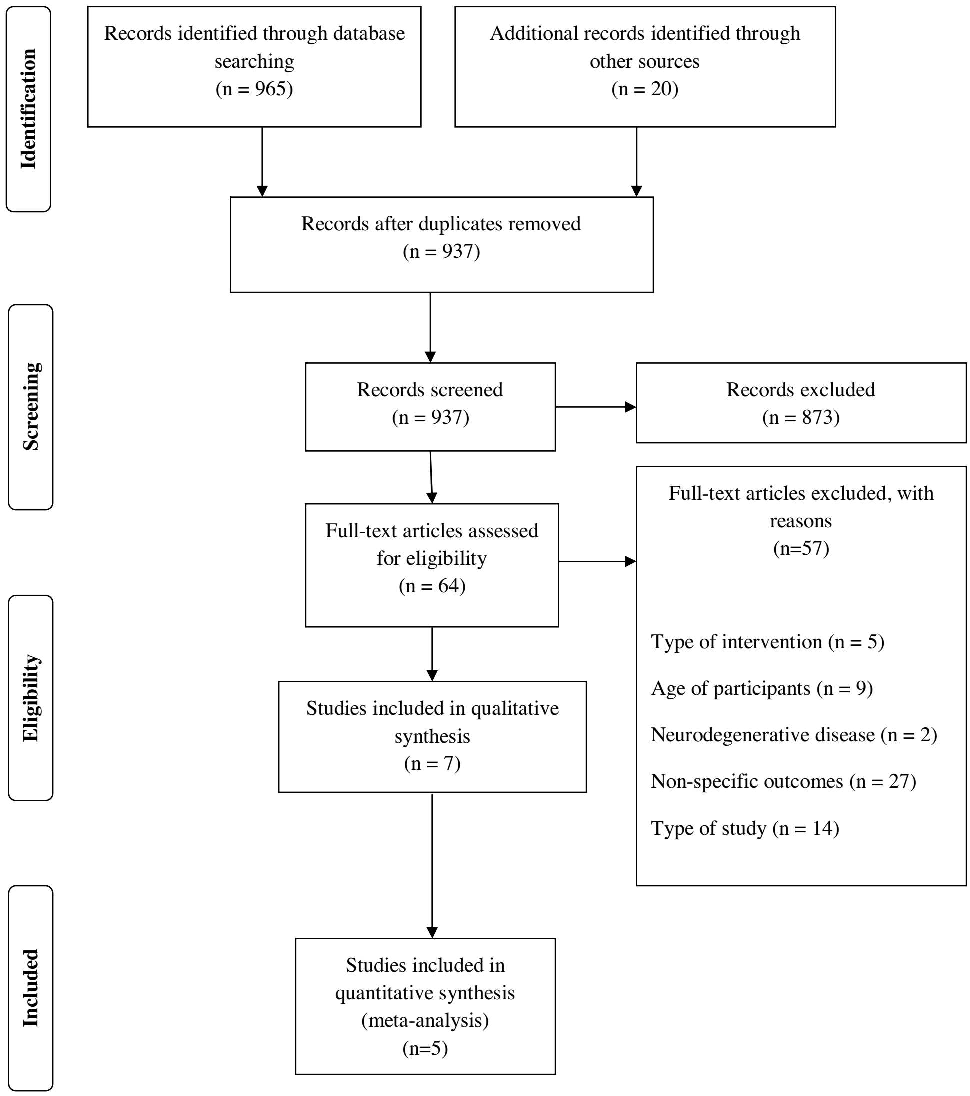


Fig. 1. Flow diagram of search and selection of studies.

cholesterol and LDL were presented in one RCT.[21] Fig. 1 shows a flow diagram of the study selection process.

3.2. Characteristic of participants

Included studies had a total of 377 participants involved with dance interventions, control groups, or another type of exercise other than dancing. Of these, 190 participants were included in some type of dance intervention[21,32–37]; 127 in control groups (not undertaking any type of physical exercise)[21,32–37]; and 60 were engaged in other exercise modes (aerobic and/or resistance).[21,33]

Range of age of participants was in between 58 and 72 years old. Female gender was predominant in five studies,[32,34–37] while males in other two.[21,33] Four studies evaluated the elderly without any associated health condition.[32,34,35,37] Two studies included patients with chronic heart failure[21,33] and one study assessed participants with metabolic syndrome.[36] See Table 1.

3.3. Characteristics of interventions

Despite participants' particularities, the characteristics of intensity of the dance interventions was always classified as moderate: 70% VO_2peak[21]; Borg scale 13–14[33]; 50–70% of maximum heart rate[32]; 50–80% of reserve heart rate[36]; and heart rate average in between 100 and 120 bpm.[37] Two studies did not report the intensity of the dance sessions.[34,35] The frequency of sessions was mostly 3 times/week.[21,32,33,35] Duration of the intervention period varied in between 8 weeks[21] and 8 months.[33] Duration of the sessions varied in between 40 and 60 min, with the main dancing phase between 20 and 40 min. Dance styles varied across studies. Aerobic dance style was used in two studies.[32,37] The other trials used waltz,[21] Greek dance,[33] Latin dance (Cha-Cha),[36] and creative dance.[35] Creative dance is a class based on improvisation, where different themes are given to develop body awareness through the movement.[35] Another study used a special dance programme developed for elderly subjects, without specific definition of style.[34]

From the seven studies included in the systematic review, only one study did not report data on adherence[34] while the other six studies[21,32,33,35–37] indicated adherence rates over 80%. Dropout rates were less than 20% for all studies, mainly connected to personal reasons.

Regarding safety, only three studies[21,32,33] reported some information on the adverse events that could be a consequence of the intervention; for instance, dizziness and hypotension during recovery[21] and injury risk.[32] One trial stated there were no complications caused by the exercise interventions during the study period.[33] Minor untoward events were detailed described in only one study.[21] See Table 1.

Only two studies compared dance with another types of exercise: aerobic exercise on cycle ergometer, or treadmill or both

Table 1
Characteristics of studies included in the systematic review and meta-analysis.

Source (Study design)	Control Group • Number of participants (n) • Age (yrs) (mean ± SD) • Gender • Specific features	Exercise Group • Number of participants (n) • Age (yrs) (mean ± SD) • Gender • Specific features	Dance Group • Number of participants (n) • Age (yrs) (mean ± SD) • Gender • Specific features	Dance Style • Duration of intervention • Specific features	Structure of sessions • Frequency • Duration • Intensity	Drop- outs and Safety • Reasons of drop-outs • Comment on safety	Specific Outcomes • Methods of measurement • Meta-analysis/ Unweighted analyses
Belardinelli et al.[21] (RCT)	• n = 42 • 58 ± 10 • Mixed (35 male; 7 female) • CHF; keeping daily habits	• n = 44 • 59 ± 10 • Mixed (38 male; 6 female) • CHF; aerobic exercise on cycle ergometer, or treadmill or both. 30 min at 70% VO_2peak, 3x/week, for 8 weeks.	• n = 44 • 60 ± 11 • Mixed (36 male; 8 female) • CHF	Waltz • 8 weeks • Experienced partner required	• 3x/week • ≈ 40 min (10 min warm up; 21 min waltz – 5 min slow waltz vs 3 min fast waltz; cool down) • 70% VO_2peak	1 drop-out dance group • Personal reasons • Waltz dance was safe for CHF patients. Minor untoward events were dizziness and hypotension during recovery. Sporadic ventricular premature contractions were observed in 6 and 8 patients from the exercise and dance groups, respectively.	VO_2peak (mL.Kg^{-1}.min^{-1}) • Indirect calorimetry; cycle-ergometer; ramp-pattern protocol • Meta-analysis
Cruz-Ferrreira et al.[35] (RCT)	• n = 25 • 72.8 ± 4.5 • Female	–	• n = 32 • 71.1 ± 3.9 • Female	Creative dance • 24 weeks • Improvisation classes with different themes to develop body awareness through the movement. Variety of music styles.	• 3x/week • 50 min (15 min warm up; 25 min main phase; 10 min cool down) • Main phase: specific images and themes were given: walking on a floor with ice, glue or rain. Different styles of music were used (classic, jazz, pop, ethnics, traditional music, etc).	21 drop outs (out of 112 participants recruited) before baseline assessment. • Personal issues, sudden illness, lack of interest • Classes designed to develop a safe and progressive training	Body weight (kg) • Meta-analysis BMI (kg/m^2) • Meta-analysis Waist (cm) • Unweighted analysis

Engels et al.[32] (RCT)	• n = 11 • 68.6 ± 5.6 (in between groups); range 59–81yrs • Mixed (most female) • keeping daily habits	–	• n = 10 • 68.6 ± 5.6 (in between groups); range 59–81yrs • Mixed (most female)	Aerobic dance • 10 weeks • Low impact (continuous and controlled moves of legs and arms)	• 3x/week • 60 min (10 min warm up; 30 min aerobic workout; 10–15 min toning, flexibility and balance; 10 min cool down) • 50–70% HRmax	1 drop-out dance group • Illness unrelated to the participation • Dancing protocol was safe and well tolerated by the participants. Adverse events would include muscle soreness and injury risk.	VO_2peak ($mL.Kg^{-1}.min^{-1}$) • Indirect calorimetry; treadmill; Balke protocol • Meta-analysis Sum of skinfolds (mm) • 7 skinfolds: triceps, suprailium, subscapular, axilla, calf, thigh, abdomen • Unweighted analysis Body weight (kg) • Meta-analysis
Hopkins et al.[37] (RCT)	• n = 30 • 66±3.8 • Female • keeping daily habits; engaged intervention after 12 weeks control	–	• n = 35 • 65±3.7 • Female	Aerobic Dance • 12 weeks • Low impact (walking, stretching, dance moves to music, continuous moves of arms and legs)	• 1x/week • 50 min (20 min warm up; 20 min aerobic workout; 15 min cool down) • 100–120 bpm	12 drop-outs total: 5 dance; 7 control group • Personal reasons • Low beginning levels of functional fitness could affect safety. Participants were aware of potential risks.	Sum of skinfolds (mm) • 3 skinfolds: triceps, suprailium and thigh • Unweighted analysis
Kaltsatou et al.[33] (RCT)	• n = 17 • 67.2±5 • Male • CHF; keeping daily habits	• n = 16 • 67.1±7.2 • Male • CHF; aerobic and resistance exercise. 20 min aerobic exercise on cycle ergometer or treadmill; plus 20 min resistance exercises for upper and lower extremities (1-2 sets; 10-15 reps; 60-85% 1RM)	• n = 18 • 67.2±4.2 • Male • CHF	Greek dance • 8 months • Low impact steps, performed in a single group while holding hands in a semi-circle (stepping to the side, closing feet together or passing the foot in front or behind the other, single limb standing, hopping, jumping and trunk extension).	• 3x/ week • 50 min (10 min warm up; 40 min Greek dance routines – 3 to 4 min each choreography vs 15 sec rest) • Moderate intensity: 13-14 Borg scale (somewhat hard)	3 drop-outs: 1 dance; 2 control group • Refused to be retested • The dancing program was specifically designed to meet the abilities of CHF patients. There were no complications caused by the exercise interventions during the study period.	VO_2peak ($mL.Kg^{-1}.min^{-1}$) • Indirect calorimetry; treadmill; Bruce protocol • Meta-analysis BMI (kg/m^2) • Meta-analysis Body weight (kg) • Meta-analysis

Table 1 (*Continued*)

Kattenstroth et al.[34] (RCT)	• n = 10 • 72.3 ± 1.84 • Mixed (7 female; 3 male)	–	• n = 25 • 68.6 ± 1.45 • Mixed (17 female, 8 male)	Special dance programme developed for the elderly, called Agilando. • 24 weeks • Participants learned step sequences of increasing complexity, performed alone, without a partner	• 1x/week • 60 min (20 min warm up; 40 min dancing)	• NR • NR	VO_2peak ($mL.Kg^{-1}.min^{-1}$) • Indirect calorimetry • Meta-analysis
Kim et al.[36] (nRCT)	• n = 12 • 68.16 ± 5.14 • Mixed (10 female; 2 male) • Keeping daily habits	–	• n = 26 • 68.19 ± 3.66 • Mixed (19 female; 7 male)	Latin dance – Cha-Cha • 6 months • Basic structure of Cha-Cha: 3 fast and 2 slow steps with forward-backward (and reverse) weight transfer.	• 2x/week • 60 min (5 min warm up; 45 min dancing; 10 min cool down) • 50–80% of HR reserve	6 drop-outs (after 4 weeks intervention) • Personal reasons: fall in the house, family problems, moving to another area, pre-existing osteoarthritis. • NR	HDL (mg.dL) • Unweighted analysis TG (mg.dL) • Unweighted analysis BMI ($Kg.m^2$) • Meta-analysis Waist (cm) • Unweighted analysis

Note: Markers: Please read the table following the marker of each column in the vertical way. Each marker within each study corresponds to the ones on the headings. For example: Belardinelli et al.[21] N = 42 (it corresponds to the number of participants of the control group). RCT: Randomised control trial. nRCT: non-randomised control trial. CHF: Chronic heart failure Specific features: it refers to specific characteristics of each group (dance, control or exercise); and dance style. Specific outcomes: it refers to each outcome of interest of this systematic review found on included studies. The following markers describe methods of measurements of these outcomes in the individual studies; and the way they were assessed in this systematic review (meta-analysis or un-weighted analysis). VO_2peak: Peak oxygen consumption ($mL\,kg^{-1}\,min^{-1}$) BMI: Body mass index (kg/m^2). Triglycerides (mg.dL) HDL: high-density lipoprotein cholesterol (mg.dL).

(30 min at 70% VO_2peak, 3×/week, for 8 weeks)[21]; or aerobic combined with resistance exercise (20 min aerobic exercise on cycle ergometer or treadmill; plus 20 min resistance exercises for upper and lower extremities: 1–2 sets; 10–15 reps; 60–85% of 1 repetition maximum).[33] The other studies compared dance intervention to non-exercise control groups.[32,34–37] See Table 1.

3.4. Study quality assessment

From the seven studies assessed, the poorest scores were 17 points,[32,34,37] while the best ones were 24,[21,35] out of 32 total points. Greater scores mean higher methodological quality.[28] A study that achieved a score of 24 (75% of the total) was deemed to be of reasonable quality by consensus of the authors.

Overall, the major weaknesses among studies were the lack of power analysis (mean 1.4 out of 5 points) and external validity (0.6/3). For example, only two studies reported that an a priori power analysis was conducted and statistical power was achieved.[21,35]

Studies were more successful in meeting quality criteria for the categories of reporting (8.7/11) and internal validity (5.4/7.0 for bias; 3.6/6 for confounding) (Fig. 2). Only three studies described the distribution of principal confounders in each group of subjects.[34,36,37] Actual probability values for the main outcome were also reported by only three studies.[34–36] For internal validity (bias assessment), only two studies[33,36] attempted to blind those measuring the main outcomes of the intervention. Confounding analysis of internal validity showed only two studies[21,33] reporting that the randomised intervention assignment was concealed from both patients and health care staff until recruitment was complete; and only one study[36] reporting adequate adjustment for confounding in the analysis of the main findings.

3.5. Effect measures

3.5.1. Peak oxygen consumption (VO_2peak)

Significant improvements in VO_2peak were found among three individual trials of dance interventions when compared with non-exercising controls.[21,32,33] Only one study did not find any difference in between dance and control groups.[34] The meta-analysis showed a significant improvement in VO_2peak of 3.43 mL kg^{-1} min^{-1} (95%CI: 1.08, 5.78, N = 177, P for heterogeneity = 0.02, I^2 = 71%) for participants in the dance group compared with non-exercising control group (Fig. 3A). Rather than that, meta-analysis of two studies[21,33] revealed that VO_2 increases after dance interventions were not different from other types of exercise: 0.15 mL kg^{-1} min^{-1} (95%CI: −1.07, 1.37, N = 122, P for heterogeneity = 0.81, I^2 = 0%) (Fig. 3B).

Sensitivity analysis of VO_2peak (dance vs. control) showed no heterogeneity when the study with the highest increase in VO_2peak[33]; and the study with no increase in VO_2peak[34] were removed (3.45 mL kg^{-1} min^{-1} improvement; 95%CI: 1.51, 5.30; N = 107, P for heterogeneity = 0.54, I^2 = 0%). Additionally, reduced heterogeneity was observed when only interventions performed three times a week were considered[21,32,33] (4.48 mL kg^{-1} min^{-1} improvement; 95%CI: 2.56, 6.40; N = 142, P for heterogeneity < 0.0001, I^2 = 51%) (Table 2).

GRADE approach revealed moderate level of evidence for VO_2peak outcome (Fig. 5).

3.5.2. Body weight and body mass index (BMI)

No within or in between-group differences were found for body weight and BMI, comparing dancers with non-exercising controls. For the outcome body weight, three studies were included in the meta-analysis[32,33,35] while two studies were included in the meta-analysis of the outcome BMI.[33,35] Results are presented as follows: Body weight: −0.76 kg (95%CI: −4.50, 2.98, N = 113, P for heterogeneity = 0.69, I^2 = 0%). BMI: 0.01 (95%CI: −1.40, 1.41, N = 92, P for heterogeneity = 0.99, I^2 = 0%) (Fig. 4A and B). GRADE approach revealed moderate level of evidence for body weight and BMI outcomes (Fig. 5).

3.6. Unweighted analysis

3.6.1. Lipid profile

One RCT evaluated triglycerides, total cholesterol, LDL, and HDL levels, comparing dancers to non-exercise controls and to a group who performed aerobic exercise.[21] While total cholesterol and LDL remained the same within and in between all groups, HDL and triglycerides presented similar improvements comparing dancing to aerobic exercise, being both interventions superior to the control group. Another nRCT[36] evaluated triglycerides and HDL levels comparing dancers to non-exercising controls, showing neither within nor in between-group differences over time.

3.6.2. Sum of skinfold and waist circumference

Sum of skinfolds was an outcome of two studies,[32,37] with no within-group changes in both of them but dancers were better than controls in one study.[37] Waist circumference was assessed by two studies[35,36]; with no differences within or in between-groups (dancers vs. controls) for Kim et al.[36], and within group reductions for Cruz-Ferreira et al.[35] (Table 2).

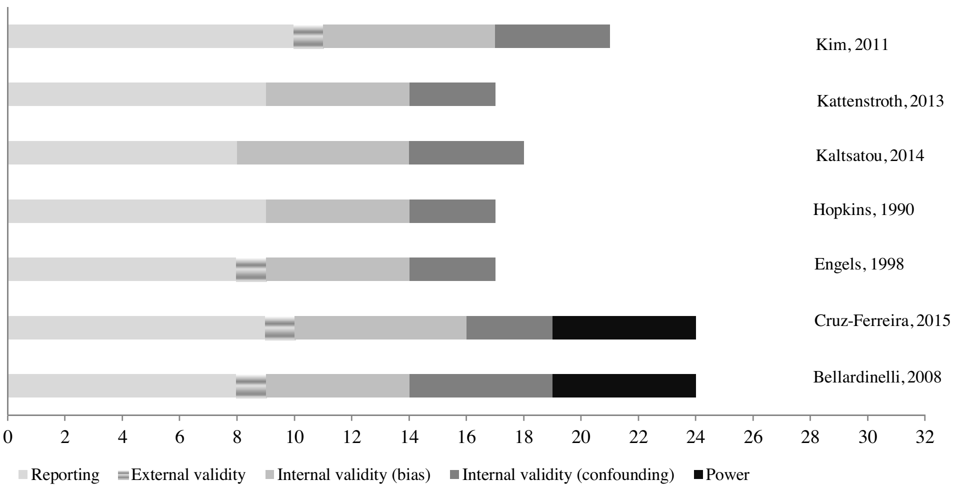
4. Discussion

This systematic review with meta-analysis aimed to verify the effects of dance interventions on CVR in the elderly, comparing dancers to non-exercise controls and/or practitioners of other types of exercise. We primarily demonstrate that dance interventions can elicit improvements in VO_2peak of elderly subjects when compared to non-exercising controls.[21,32–34] Furthermore, dancing may be as effective as other types of exercise in promoting VO_2 increases in the elderly.[21,33]

In fact, enhanced cardiorespiratory fitness has been associated with reductions of cardiovascular risk factors and the prediction of coronary heart disease.[8] For instance, an increase of 1-MET in maximum aerobic capacity was associated with a reduction of 7 cm in waist circumference and 1 mmol/L in triglycerides levels, as well as 0,2 mmol/L increment in HDL.[8] Nevertheless, this review detected a lack of RCTs evaluating the responses of CVR outcomes to dance interventions as a form of exercise for the elderly.

In order to explore heterogeneity among studies evaluating VO_2peak,[21,32–34] we analysed specific characteristics of the dance interventions. Kaltsatou et al. demonstrated the highest improvement in VO_2peak, which increased approximately 25% after Greek dance intervention in men with chronic heart failure[33] (Table 2). It is true that these patients may have a larger scope for improvements, because they come from a low baseline level of maximum cardiorespiratory capacity. However, subjects from Belardinelli et al.,[21] also chronic heart failure patients, presented lower improvements in VO_2peak (19%), although both exercises intensities were reported as moderate. It might be that a better structure of the dance intervention purposed by Kaltsatou et al.[33] induced the greater improvements in cardiorespiratory fitness, considering duration of the intervention, exercise frequency, and intensity.

Indeed, the Greek dance intervention lasted for 8 months[33] while the other dance interventions that induced VO_2 improvements lasted 8 and 10 weeks, respectively.[21,32] Also, the study of Kaltsatou et al.[33] was the only one to report the duration of the dance routines (3–4 min) together with the rest time in between them (15 s), besides the frequency of 3×/week. In fact,



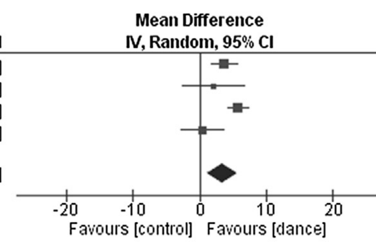
Each colour refers to a different domain of Downs and Black scale: reporting; external validity; internal validity - bias assessment; internal validity - confounding assessment; and power. Higher scores indicate higher quality.

Fig. 2. Study quality assessment.
Each colour refers to a different domain of Downs and Black scale: reporting; external validity; internal validity – bias assessment; internal validity – confounding assessment; and power. Higher scores indicate higher quality.

(A)

	Dance			Control				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Belardinelli et al. 2013	19.5	5	44	15.8	4.5	42	29.9%	3.70 [1.69, 5.71]
Engels et al. 1998	22.4	5.9	10	20.3	5	11	15.1%	2.10 [-2.60, 6.80]
Kaltsatou et al. 2014	26.1	2.6	18	20.3	2	17	32.9%	5.80 [4.27, 7.33]
Kattenstroth et al. 2013	12.71	4.1	25	12.27	4.58	10	22.0%	0.44 [-2.82, 3.70]
Total (95% CI)			**97**			**80**	**100.0%**	**3.43 [1.08, 5.78]**

Heterogeneity: Tau² = 3.76; Chi² = 10.24, df = 3 (P = 0.02); I² = 71%
Test for overall effect: Z = 2.86 (P = 0.004)



(B)

	Dance			Exercise				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Belardinelli et al. 2013	19.5	5	44	19.6	4.5	44	37.8%	-0.10 [-2.09, 1.89]
Kaltsatou et al. 2014	26.1	2.6	18	25.8	2	16	62.2%	0.30 [-1.25, 1.85]
Total (95% CI)			**62**			**60**	**100.0%**	**0.15 [-1.07, 1.37]**

Heterogeneity: Tau² = 0.00; Chi² = 0.10, df = 1 (P = 0.76); I² = 0%
Test for overall effect: Z = 0.24 (P = 0.81)

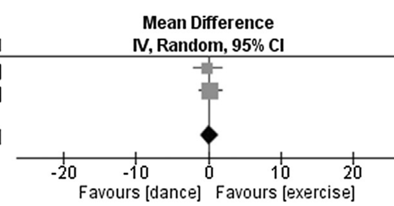


Fig. 3. (A) Peak oxygen consumption (VO_2peak) responses of individual studies: dance interventions vs. non-exercising controls. (B) Peak oxygen consumption (VO_2peak) responses of individual studies: dance interventions vs. other types of exercise.

higher volumes of exercise and consequent total energy expenditure increased significantly the responsiveness of postmenopausal women in improving cardiorespiratory fitness at a fixed intensity.[38] In addition, work-to-rest ratios that favour intermittent bouts of higher intensity and shorter recovery have been recommended for improving dancers' cardiorespiratory performance.[19]

Apart from that, the difference of only 0.8 mL kg^{1} min^{1} on VO_2peak gains of the healthy elderly studied by Engels et al.[32] and the chronic heart failure patients from Belardinelli et al.[21] suggest that dance interventions may induce aerobic power increases in similar magnitudes to different ageing groups, with or without health conditions (Table 2).

The lack of changes in anthropometric variables as a result of dance interventions may be attributed to the moderate intensity of their performance. As a matter of the fact, high-intensity aerobic dance intervention was successful in reducing BMI, body fat, waist circumference, and body weight in middle-aged women with intra-abdominal obesity[39] while low-intensity *biodanza* was not enough to reduce BMI and body fat in women with fibromyalgia.[40]

Indeed, changes in body composition have been associated to higher exercise intensities, rather than exercise volume and/or length of interventions.[41]

On the other hand, particular improvements in lipid profile may be related to a higher energy expenditure provided by the combination of exercise volume and intensity found on the RCT of Belardinelli et al.[21] It may have been enough to attain certain dose-response thresholds for favourable lipid changes[42] in contrast with no changes in triglycerides and HDL levels verified in the nRCT of Kim et al.[36] Wide dispersion measurements commonly found on the analysis of blood parameters[43] as well as to the methodological quality of different study designs may also be related to these divergent findings.

Regarding quality assessment, presence of bias emerges in the individual trials assessed, as a result of lack of blinding, confounding analysis and its further adjustments. This, together with small sample sizes, should be taken in account for future studies, in order to minimise threats to external validity. Larger RCTs properly exploring potential confounders, such as characteristics of exercise

Table 2
Pre and post absolute changes of primary and secondary outcomes following dance interventions.

Source	Dance Group				
	Outcome	Pre Mean ± SD	Post Mean ± SD	P value (within-group)	P value (in between-groups)
Belardinelli et al.[21]	VO_2peak (mL.Kg^{-1}.min^{-1})	16.8 ± 5.0	19.5 ± 5.0	<0.05	<0.05
	Triglycerides (mg/dL)	175 ± 23	144 ± 22	<0.05	<0.02
	Total cholesterol (mg/dL)	191 ± 24	186 ± 24	= 0.43	NS
	HDL (mg/dL)	35 ± 9	39.5± 8	<0.05	<0.02
Cruz-Ferreira et al.[35]	BMI (kg/m^2)	32.43 ± 5.54	30.64 ± 4.7	<0.001	= 0.691
	Body weight (kg)	75.39 ± 12.5	72.61 ± 11.5	<0.001	= 0.667
	Waist circumference (cm)	105.51 ± 11.4	96.87 ± 9.4	<0.001	= 0.974
Engels et al.[32]	VO_2peak (mL.Kg^{-1}.min^{-1})	20.5 ± 5.2	22.4 ± 5.9	<0.05	NS
	Sum of skinfolds (mm)	163 ± 48	163.7 ± 62.1	NS	NS
	Body weight (kg)	69.4 ± 10.7	70 ± 11.9	NS	NS
Hopkins et al.[37]	Sum of skinfolds (mm)	73 ± 22	69 ± 22	NS	<0.01
Kaltsatou et al.[33]	VO_2peak (mL.kg^{-1}.min^{-1})	19.5 ± 1.7	26.1 ± 2.6	<0.05	<0.5
	BMI (Kg/m^2)	28.8 ± 2.7	28.7 ± 2.6	NS	NS
	Body weight (kg)	83.5 ± 8.8	83.2 ± 8.4	NS	NS
Kattenstroth et al.[34]	VO_2peak (mL.kg^{-1}.min^{-1})	14.8 ± 4.1	12.71 ± 4.1	NS	= 0.110
Kim et al.[36]	Triglycerides (mg/dL)	126.76 ± 54.41	120.21 ± 45.68	NS	= 0.564
	HDL (mg/dL)	53.38 ± 14.2	53.29 ± 14.19	NS	= 0.458
	BMI (kg/m^2)	25.71 ± 2.87	25.55 ± 2.95	NS	= 0.156
	Waist circumference (cm)	94.43 ± 6.22	90.27 ± 6.13	NS	= 0.703

Note: Pre: before the intervention period. Post: after the intervention period. *P* value (within-group): dance group compared do itself before and after the intervention period. *P* value (in between-group): dance *vs* control group comparison of absolute post intervention values of primary and secondary outcomes. NS = non significant *p* values. VO_2peak: Peak oxygen consumption BMI: Body mass index HDL: high-density lipoprotein cholesterol.

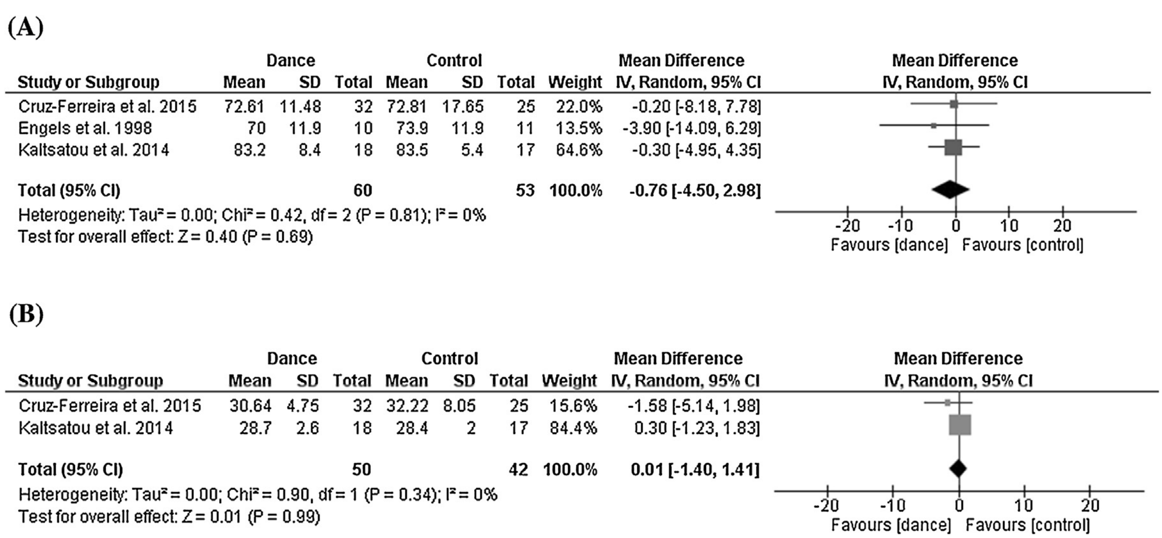


Fig. 4. (A) Body weight responses of individual studies: dance interventions vs. non-exercising controls. (B) Body mass index (BMI) responses of individual studies: dance interventions vs. non-exercising controls.

interventions, populations, diseases, methodological diversity, etc., would support that.

In addition, there is a lack of information on the description of adverse events and other safety-related data of the dance interventions. Accordingly, insufficient reporting on safety data has been also noted for other types of alternative exercise interventions, such as yoga.[44] Nevertheless, dance has been already described as a safe and feasible exercise intervention for older adults.[17,45] Supporting that, dancing has been suggested as a useful intervention for fall prevention in the elderly without[17] or with health-associated conditions, such as Parkinson disease.[46] Indeed, drop-out rates in the studies included in this review were low and not related to the interventions.

For quality of the evidence assessment using GRADE approach, a common weakness of the outcomes analysed (VO_2peak, body weight, and BMI) comparing dance with control groups, was the suspected publication bias. It means few studies evaluated the outcome, not allowing proper publication bias assessment through a funnel plot analysis. Risk of bias in individual studies was detected only for VO_2peak, comparing dancers with controls. Lack of blinding assessment of the outcome, absence of intention to treat principle for data analysis, and high heterogeneity among studies may explain that. Indirectness was not seriously detected in any of

Dance vs Control

Quality assessment							№ of patients		Effect		Quality	Importance
№ of studies	**Study design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**	**Dance**	**Control**	**Relative (95% CI)**	**Absolute (95% CI)**		
VO2peak												
4	randomised trials	serious [1]	not serious	not serious	not serious	publication bias strongly suspected all plausible residual confounding would reduce the demonstrated effect [2]	97	80	-	MD **3.43 more** (1.08 more to 5.78 more)	⊕⊕⊕◯ MODERATE	CRITICAL
Body Weight												
3	randomised trials	not serious	not serious	not serious	not serious	publication bias strongly suspected [2]	60	53	-	MD **0.76 fewer** (4.5 fewer to 2.98 more)	⊕⊕⊕◯ MODERATE	CRITICAL
BMI												
2	randomised trials	not serious	not serious	not serious	not serious	publication bias strongly suspected [2]	50	42	-	MD **0.01 more** (1.4 fewer to 1.41 more)	⊕⊕⊕◯ MODERATE	CRITICAL

1. Lack of blinded assessment of the outcome; lack of intention to treat principle for data analysis; considerable heterogeneity among studies.
2. Few studies evaluating the outcome pre and post intervention

Dance vs Exercises

Quality assessment							№ of patients		Effect		Quality	Importance
№ of studies	**Study design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**	**Dance**	**Exercise**	**Relative (95% CI)**	**Absolute (95% CI)**		
VO2peak												
2	randomised trials	not serious	not serious	not serious	not serious	publication bias strongly suspected [1]	62	60	-	MD **0.15 more** (1.07 fewer to 1.37 more)	⊕⊕⊕◯ MODERATE	

1. Few studies comparing dance interventions with other types of exercise

CI: Confidence interval; **MD:** Mean difference

Fig. 5. Quality of evidence by GRADE approach.

the outcomes assessed. Therefore, in relation to VO_2peak, the benefits of the intervention outweigh the risks, but it is recognised that the interventions have limitations. Future research should focus on the development of higher quality RCTs using dance interventions to modify metabolic, anthropometric, and fitness CVR factors associated with ageing.

Finally, the limitations of this systematic review underlie two main points: high heterogeneity and small number of studies included. In order to address the first one, sensitivity analyses were performed to explain the outcome (VO_2peak) that induced a positive effect in favour of the dance interventions. Second, the small number of studies indicates a need for more RCTs evaluating the effects of dance interventions on cardiovascular risk with ageing.

5. Conclusions

Dance interventions may induce increases in VO_2peak of elderly subjects when compared to non-exercising controls. Results also indicate it is as efficient as other types of exercise. This suggests that dancing might be a potential exercise intervention for improving cardiorespiratory fitness and consequent CVR with ageing. Reporting on adverse events should be also properly provided by the trials, in order to base the benefits of dancing for the older on both efficacy and safety of the interventions. Body weight and BMI were not affected by dance interventions. Unweighted analyses indicate that larger studies are required to detect positive effects of dancing on lipid profile. Hence, the insufficient number of RCTs identified, with general low statistical power, indicate that further research with higher methodological quality is need to clarify how dance interventions may lead to improvements on other CVR factors with ageing.

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3.3 ARTIGO 3: ESTUDO DE RESPOSTAS AGUDAS

CARDIORESPIRATORY RESPONSES OF A DANCE SESSION DESIGNED FOR OLDER WOMEN: A CROSS SECTIONAL STUDY

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Cardiorespiratory responses of a dance session designed for older women: A cross sectional study

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ABSTRACT

Background: Dancing has been increasingly used as a type of exercise intervention to improve cardiovascular fitness of older people. However, it is unclear which may be the exercise intensity of the dance sessions.
Objective: To describe cardiorespiratory responses of a dance session for older women, and to identify intensity zones in relation to peak oxygen consumption (VO_2peak), first and second ventilatory thresholds (VT1 and VT2).
Methods: Ten women (66 ± 5 yrs., BMI 27 ± 4) were examined on three occasions: Familiarization, maximum effort and dance sessions. Incremental treadmill test: 5 km/h, 2% slope each min, until maximum effort. Dance class (60 min): warm-up (20 min), across-the-floor (10 min), choreography (15 min), show (10 min) and cool-down (5 min). Ventilatory parameters were measured continuously (breath-by-breath).
Results: VO_2 ($mL{\cdot}kg^{-1}{\cdot}min^{-1}$): Maximum effort: VO_2peak (23.3 ± 4.3), VT1 (17.2 ± 3.5) and VT2 (20.9 ± 3.4). Dancing: warm-up (12.8 ± 2.4, ~55%VO_2peak), across-the-floor (14.2 ± 2.4 ~62%VO_2peak), choreography (14.6 ± 3.2 ~63%VO_2peak) and show (16.1 ± 3.3, ~69% VO_2peak). Show was similar to VT1.
Conclusions: Cardiorespiratory demands of a dance class for older women are at low aerobic intensity. Show was similar to VT1, indicating that a dance class may be modulated to improve aerobic fitness, at least at initial stages of training.

1. Introduction

Longevity rates have been progressively increasing worldwide, with significant reductions in rates of mortality and fecundity indicating that the population over 60 years old will jump from 18 million (2010) to 65 million (2050) (WHO, 2001). However, health complications associated with the aging process, such as the development of chronic diseases (obesity and type 2 diabetes mellitus), functional and cognitive limitations, have been reported as the major source of health costs with this population (WHO, 2001). In fact, deteriorations on the neuromuscular system, such as loss atrophy of type II muscle fibers, together with deteriorations in the cardiovascular system (reduced maximal cardiac output, systolic volume, arteriovenous oxygen difference) have been connected to early fatigue onset, reduced levels of physical activity, difficulty in performing daily activities and eventually loss of physical independence (Cadore & Izquierdo, 2013).

Particularly, reduced levels of physical activity have been related to a reduction in peak oxygen consumption (VO_2peak) (Myers et al., 2015), which can dramatically decrease 5 $mL{\cdot}kg^{-1}{\cdot}min^{-1}$ per decade of life from the 30's, reaching critical thresholds for physical independence (VO_2 peak lower than 18 $mL{\cdot}kg^{-1}{\cdot}min^{-1}$) (Shephard, 2009). On the other hand, increases in the level of physical activity suggest an attenuation of age-associated declines in VO_2peak with habitual endurance training (Kohrt et al., 1991). Indeed, the elderly undergo cardiovascular adaptations to exercise, although in lower magnitude than middle-age individuals (Evans et al., 2005). The capacity of older individuals to adapt to endurance exercise training may be limited by biological aging effects on oxidative capacity, such as reduced capillary bed, mitochondrial density and slower VO_2 kinetics (Babcock et al., 1994; Safdar et al., 2010). Regarding the last one, it is true that older individuals present increased O_2 deficit and debit compared to the youngest (Babcock et al., 1994), as well as the impaired older compared

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to the healthy ones (Alexander et al., 2003). It means that the older take longer to adjust to a new workload in sub maximum efforts, which impacts the performance in daily activities (Alexander et al., 2003). Along with that, the ability to withstand physiological overload due to orthopedic and morbidity-related limitations may refrain the elderly to engage in structured exercise training programs (Evans et al., 2005).

Thus, alternative forms of exercise have been suggested in order to optimize cardiorespiratory, metabolic and functional adaptations, while reducing early fatigue onset and orthopedic overload. For example, circuit training (Romero-Arenas et al., 2013), multicomponent training (Forte et al., 2013a), tai chi (Wolf et al., 1996) and yoga (Chu et al., 2016) have been studied. Particularly, dancing has been increasingly suggested because it can be widely adjusted to a population's age and physical limitations (Hwang & Braun, 2015). Higher levels of tolerance to intermittent exercise bouts, consequent greater perception of success, and higher levels of motivation also favor dance practicing at old ages (Rodrigues-Krause et al., 2016). There is evidence that dancing improves functionality and reduces fall-risk related factors by improvements in balance and gate ability (Fernandez-Arguelles et al., 2015). Dancing has been also suggested as potential intervention for improving the elderly maximum aerobic capacity and reduce cardiovascular risk (CVR) associated factors, when compared to the sedentary older (Rodrigues-Krause et al., 2016).

Actually, no matter the dance style, recently reviewed metabolic and functional adaptations of dance practice have been generally linked to exercise program adherence, rather than to objective results of cardiorespiratory and neuromuscular adaptations from the exercise training itself (Rodrigues-Krause et al., 2018). Primary studies evaluating functional or metabolic outcomes usually focus on the description of the pedagogic process of the dance lessons, poorly describing intensity of work, which limits its reproducibility in terms of exercise prescription. This regards to direct measures of exercise intensity, such as oxygen consumption (VO_2) and heart rate (HR), as well as simple and practically useful indicators of intensity, such as the beats per minute (bpm) of the songs used during the dance classes (Rodrigues-Krause et al., 2018).

Therefore, the main goal of this study was to evaluate the cardiorespiratory responses of a dance class, especially designed to develop aspects that deteriorate with the aging processes, such as functionality and aerobic conditioning. Specifically, VO_2 and HR were measured during a whole dance session and analyzed separately in different parts of the class: warm up, across-the-floor, choreography and show (each of them performed in different music *tempos*, it means, the songs' bpm). We also aimed to verify the zones of intensities of the whole class and its different parts in relation to the participants' first and second ventilatory thresholds (VT1 and VT2) and VO_2peak, determined during a maximum effort test. Energy expenditure and lactate responses were also measured after the whole dance session.

2. Materials and methods

2.1. Participants

Ten women from 60 to 75 years old, body mass index (BMI) lower than 35 kg/m^2, and independent for performing daily activities volunteered for this study. They provided informed consent after being informed about the study protocol, approved by the local Research Ethical Committee. Participants were previously familiarized with the class structure and choreography routines. They did not engage in any other type of regular exercise practice for at least 6 months. All participants underwent a medical evaluation during a maximum effort test, simultaneously to an electrocardiogram (ECG) assessment. Exclusion criteria were: not controlled-hypertension, type 2 diabetes mellitus (T2DM), mobility limitations, not being able to perform the maximum effort test, alteration in the ECG or any other condition that could limit the exercise practice.

2.2. Study design

Participants were examined on three occasions: Familiarization session, maximum effort test session and dance session. At the familiarization session, participants were familiarized with the maximum effort test protocol, including the use of the facial mask and the treadmill. They were also introduced to the dance class structure, basic dance steps and choreography routines. At the maximum effort test session, body composition and a maximum effort test on treadmill, simultaneously to an ECG and medical evaluation were performed. At the dance session, the dance class was performed. Two weeks separated sessions 1 and 2, during which participants learned and practiced the dance routines in group, 3 × /wk for 60 min, with a specialized dance instructor. Participants were instructed to refrain from any unusual physical activity 48 h before the exercise sessions, in order to avoid effects of fatigue and muscle soreness on the selected performance. They were also instructed to maintain their usual food intake.

Ventilatory parameters, such as VO_2 and carbonic dioxide production (VCO_2) were measured continuously during the dance and the maximum effort sessions, by the breath-by-breath method, using an open-circuit spirometry system (Quark CPET, Cosmed, Italy). HR was also measured continuously using a chest belt telemetry (Polar Electro Oy, Kempele, Finland). Fingertip blood samples for lactate analyses (Accusport-portable-analyser, Roche-Diagnostics-GmbH, D-68298, Mannheim/Germany) were collected before and after both exercise sessions.

2.3. Protocols of assessment

2.3.1. Body composition

Height and weight (Urano, Canoas, Brazil) were measured with the participants wearing light clothing. Waist and hip circumferences and skin folds were also measured, and body composition was calculated using a 5-component method, following the standards of the International Society for the Advancement of Kinanthropometry (ISAK) (Marfell-Jones et al., 2006).

2.3.2. Maximum effort test

Participants' VO_2peak and maximum heart rate (HRmax) were determined through an incremental exercise test on a treadmill (Inbramed, Porto Alegre/Brazil). The test started with a 5-min warm-up (from 3 to 5 km/h, increasing 0.5 km/h each min, until 5 min), followed by 2% increases in slope every 1 min, while maintaining a constant speed of 5 km/h throughout the entire test (Flo et al., 2012). In order to be considered a maximum effort test, participants must have attained at least two of the following criteria: (1) age-predicted HRmax, (2) respiratory exchange ratio (RER) ≥ 1.1, (3) subjective perception of effort ≥ 17 (Borg scale 6–20), (4) signals of muscle fatigue, such as loss of motor coordination (Cadore et al., 2012).

VO_2peak was identified as the highest VO_2 value in a line of tendency plotted against the time. Criteria to determine the ventilatory thresholds were: VT1: lowest workload at which the ventilatory equivalent of O_2 (VE/VO_2) increased without concomitant raises in the ventilatory equivalent of CO_2 (VE/VCO_2). VT2: lowest workload at which VE/VO_2 increased concomitantly, but disproportionally to VE/VCO_2. VT1 and VT2 were also associated with the first and second nonlinear increases in the ventilation's curve plotted against VO_2 (Cunha et al., 2011; Dekerle et al., 2003).

2.3.3. Dance class

The dance session duration was 60 min and included five parts: (1) Warm up (20 min), (2) Across-the-floor (10 min), (3) Choreography (15 min), (4) Show (10 min), and (5) Cool-down (5 min). Elements from different dance styles were used in selected parts of the class, specially designed to develop functional and fitness elements that tend to naturally deteriorate with the aging process, such as balance, flexibility, muscle power, aerobic conditioning, etc. Integrating elements from different dance styles may be more attractive for the elderly than technical specialization, working functionality and conditioning with fun. Participants were previously familiarized with the class structure and routines. A specialized dance instructor conducted the same dance session individually with each participant at the time. Firstly, the instructor reminded the dance sets of steps with the participant, marking (i.e. remembering the steps without too much physical effort) the full exercise routine without music. Secondly, the instructor performed the routine with the participant, with the respective song. VO_2, VCO_2 and HR were measured continuously during the entire session, considering the cognitive process of learning and/or remembering steps on the cardiorespiratory evaluation.

Total energy expenditure of the whole dance class (all parts taken together) was calculated according to Weir's equation (Weir, 1949). Fingertip blood samples for lactate analyses were taken before and after the dance session. Subjective perception of effort (Borg scale 6–20) was also registered immediately after the dance class. Each part of the dance class was performed as follows:

(1) Warm-up (20 min): Focus on functionality, it means, in developing functional aspects such as balance, flexibility, muscle power, etc. It was composed of three songs, with *tempo* from 95 to 115 bpm, using technical basic elements from ballet and jazz dance.
Song 1: focusing in posture, join mobilization, isolation of shoulder and pelvic girdle, and improving range of motion (ROM) of large muscle groups.
Song 2: focusing in developing static and dynamic balance, performing passes, *tendus*, *jetés* and *grand battements*.
Song 3: focusing in developing muscle resistance and power, performing *pliés*, *relevés* and *sautés* in first and second feet positions. See Table 1 for the description of the dance exercises.
(2) Across-the-floor (10 min): Focus on learning and conditioning. In this part of the class, the set of moves were short, easy to learn and memorize, resulting in short recovery time in between them. The duration of the sets was from 10 to 20 s. Sets were performed by two participants at the time. Songs were from 115 to 125 bpm. Dance elements from Latin dances and aerobic dance were used. For example, isolated sets of *chassés*, kicks, kick ball change, tap to the side and *glissades* were performed (Table 1). All moves were performed in a comfortable ROM, to both right and left sides, and arms moving naturally with the pattern of the movement.
(3) Choreography (15 min): Focus on learning and conditioning. Here the sets of moves put together were longer, in order to develop a full choreography. Thus, the longer learning time resulted in longer breaks in between the effective time of exercise properly dancing the choreographic routine. Combination of legs with arms, turning (always both feet on the floor), posing, falling, attitude (high and medium level, no floor work), duos work, etc., were used to compose a Latin dance choreography. The duration of the full choreography was 4 min, at 128 bpm.
(4) Show (10 min): Focus on conditioning. With the learning set, choreography could be repeated without breaks. The Latin song used was at 128 bpm, for 4 min. Choreography was performed twice, with 2 min break in between the repetitions.
(5) Cool-down (5 min): exercises for stretching and relaxation of the major muscle groups, using a song at 90 bpm.

2.4. Statistical analyses

One-way analysis of variance (ANOVA) for repeated measures, followed by *Bonferroni* post-hoc test, was used to identify differences in VO_2 and HR (absolute and percentage values) among the different parts of the class (warm-up, across-the-floor, choreography and show) and participants' VT1, VT2 and VO_2peak (SPSS 22.0). Differences were considered significant for $p < 0.05$. Results are described as mean ± standard deviation (SD).

3. Results

3.1. Participants

Participants' age was 66 ± 5 years old, BMI 27 ± 4 km/m^2 and body fat (%) 37 ± 4. Five of the participants took anti-hypertensive medication (3 beta-blockers), 3 of them used cholesterol regulators, and 2 used thyroid regulators. Participants' characteristics are detailed in Table 2.

3.2. Maximum effort test

Participants' VO_2peak, VT1 and VT2 (mL·kg^{-1}·min^{-1}) values were, respectively: 23.3 ± 4.3, 17.2 ± 3.5 and 20.9 ± 3.4. Other responses at maximum effort were: HRmax (bpm) = 143 ± 26, RER (a.u.) = 1.10 ± 0.05, maximum workload (% slope) = 10 ± 5, and maximum test duration (min) = 10 ± 3. Lactate values (mmol·L^{-1}) before and after the maximum effort test were 2.0 ± 0.5 and 5.4 ± 1.5, respectively. Subjective perception of effort (Borg scale) varied from 17 to 20 (very hard to maximal exertion). Please see Table 3 for details on VO_2 and HR responses (absolute and percentage values) at VT1, VT2 and maximum effort.

Table 1
Description of the dance steps.

Dance step	Definition of the movement
Chassé	A gliding step in which one foot is kept in advance of the other. One foot is extended forward, while the back foot meets up with the front for a quick moment before the front foot shoots forward again, all while traveling forward. The back foot literally looks like it is chasing after the front.
First position	One of the five ballet positions. Heels touch and toes pointed outward, forming a line with the feet.
Glissade	A small leap to the side, almost a gliding motion across the floor.
Grand Battement	A powerful beating action where the dancer `brushes` the floor with the working foot and `throws` the leg as high as possible, keeping it straight, while the supporting leg also remains straight.
Jeté	A beating sharp movement of the working leg taken to the front or to the side, up to 45^0 off the floor (*battement jeté*). It can be a leap from one foot to the other.
Kick	One foot kicks forward, stretching the knee and the point of the foot, alternating right and left leg.
Kick ball change	One foot kicks either forward and then is brought behind for a ball change step, shifting weight from one foot to the other, and back again.
Passé	The toes of one foot are brought up to the knee of the opposing leg.
Plié	A smooth and continuous bending of the knees. It was performed in first and second position.
Relevé	To balance on your toes, either stationary or in movement.
Second position	One of five ballet positions. Feet are separated about shoulders' width, with toes turned outward.
Tap to the side	Tap with the toes to the right side, with the working leg stretched and the supporting leg on a *plié*. Then the working leg cross in front of the supporting leg, alternating right and left sides while moving forward across-the-floor.
Tendu	French word for "to stretch", in which a foot reaches out from the body and extends outward, with toes remaining on the floor.
Sauté	A sudden spring or jump from both feet and returning to the starting position. It was performed in first and second feet positions.

Table 2
General characteristics and body composition of the participants (n = 10). Values in mean ± SD.

Age (yrs)	66 ± 5
Independence for daily activities (OARS)	27.9 ± 0.3
BMI (kg/m^2)	27 ± 4
Body weight (kg)	66.4 ± 10.4
Waist (cm)	84.4 ± 9.9
Hip (cm)	102.4 ± 8.9
Body fat (%)	37.0 ± 3.7
Lean mass (%)	36.0 ± 2.2
SBP (mm Hg)	140 ± 8.1
DBP (mm Hg)	87 ± 6.5
Medication	
Anti-hypertensive (n)	5
Cholesterol regulator (n)	3
Antidepressant (n)	1
Thyroid regulator (n)	2
Osteoporosis (n)	1

BMI: Body Mass Index. Older American Resources and Services questionnaire of daily living activities. Total score = 28 points (14 points for instrumental and 14 for physical activities of daily life). Total scores lower than 20 points (or lower than 10 points for each instrumental or physical activities) indicate physical dependence. SBP and DBP: systolic and diastolic blood pressure (measured by auscultatory method).

Table 3
Cardiorespiratory responses to the whole dance class, to the different parts of the dance class, and to the maximum effort test (n = 10).

	VO_2 (mL·kg^{-1}·min^{-1})	% VO_2peak	HR (bpm)	% HRmax
Warm-up	12.8 ± 2.4^{a}	55	101 ± 15^{a}	70
Whole class	13.7 ± 2.4^{ab}	59	104 ± 17^{a}	73
Across-the-floor	14.2 ± 2.4^{abc}	62	105 ± 17^{a}	74
Choreography	14.6 ± 3.2^{bc}	63	107 ± 20^{ab}	76
Show	16.1 ± 3.3^{c}	69	110 ± 20^{b}	78
VT1	17.2 ± 3.5^{c}	74	116 ± 21^{ab}	82
VT2	20.9 ± 3.4^{d}	90	137 ± 23^{c}	96
Max	23.3 ± 4.3^{e}	100	143 ± 55^{c}	100

Oxygen consumption (VO_2) and heart rate (HR) responses to different parts of a dance class designed for older women (n = 10). Comparisons were performed among the different parts of the dance class (warm-up, across-the-floor, choreography and show) with the whole class (all parts taken together) and the participants' first and second ventilatory thresholds (VT1 and VT2) and maximum effort (Max). Those that do not share a letter are significant different from one another. Common letters mean no statistical difference. Results are expressed in absolute (mL·kg^{-1}·min^{-1} or bpm) and % values.

3.3. Dance class

VO_2 values (mL·kg^{-1}·min^{-1}) varied from 12.8 ± 2.4 (55% VO_2peak) during the warm-up to 16.1 ± 3.3 (69% VO_2peak) during the show part of the dance class. The latest was not different from VT1 values, across-the-floor (14.2 ± 2.4) and choreography (14.6 ± 3.2) parts of the class. VO_2 responses of the warm-up and the whole class (13.7 ± 2.4) were significantly lower than the show and participant's VT1. All parts of the dance class were different from participants' VT2 and VO_2peak. Fig. 1 displays the VO_2 responses for each part of the dance class in relation to the participant's VT1, VT2 and VO_2peak.

Regarding HR responses (bpm), there was no difference among the different parts of the dance class (e.g., warm up = 101 ± 15) and the participant's VT1 (116 ± 21). Table 3 shows HR and VO_2 (absolute and % values) for the different parts of the class, in relation to participants' VT1, VT2 and VO_2peak.

Lactate values (mmol·L^{-1}) before and after the whole dance class were 2.0 ± 0.5 and 4.7 ± 2.0, respectively (not different from the maximum effort test). The energy expenditure (kcal) of the whole dance class (60 min) was 276 ± 49. Subjective perception of effort varied from 11 to 13 (fairly light to somewhat hard).

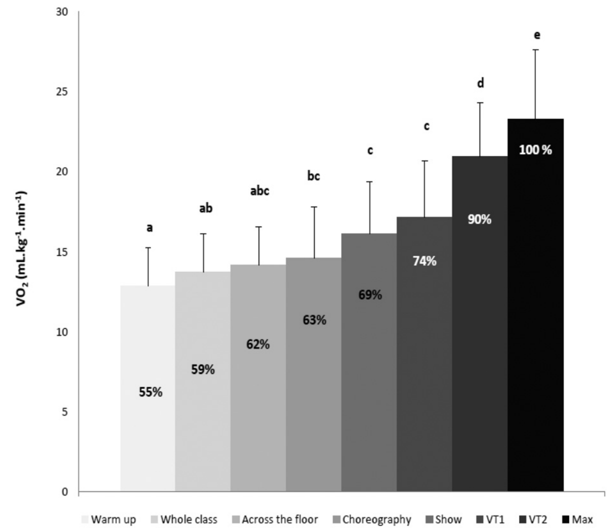

Fig. 1. VO_2 responses to different parts of a dance class designed for older women (n = 10). Comparisons were performed among the different parts of the dance class (warm-up, across-the-floor, choreography and show) with the whole class (all parts taken together) and the participants' first and second ventilatory thresholds (VT1 and VT2) and VO_2peak (Max). The percent values depicted are in relation to the participants' VO_2peak. Those that do not share a letter are significant different from one another. Common letters mean no statistical difference.

Fig. 2 integrates the cardiorespiratory responses of each part of the dance class with its methodological characteristics (songs' bpm, functionality, learning, conditioning) and the participant's maximum cardiorespiratory responses.

4. Discussion

The main goal of this study was to evaluate the cardiorespiratory response of a dance session designed for older women, in order to identify zones of exercise intensities of the whole class and its different parts (warm up, across-the-floor, choreography and show) in relation to the participants' VT1, VT2 and VO_2peak.

The main finding of this study is that some parts of a dance class designed for older women can induce VO_2 increases that reach a minimum metabolic breakpoint (VT1), which may trigger initial aerobic adaptations. Specially, the show part of the dance class was similar to the participants' VT1, and performed at higher demands than the warm-up. Across-the-floor and choreography parts also elevated the aerobic demand to participants' VT1, but they were not different from the warm-up and the whole class. Moreover, this is the first study, at our knowledge, that describes the cardiorespiratory responses of a dance class designed for elderly women, further relating them to the methodological characteristics of a dance session.

It is true that low aerobic intensities (60%VO_2peak) are enough to induce initial cardiorespiratory adaptations, such as increased mitochondrial biogenesis, capillary density and oxidative enzymes activity, to previously sedentary elderly performing traditional aerobic exercises (Cadore & Izquierdo, 2013). The fact that parts of a dance session (across-the-floor, choreography and show) may reach that point, even considering the pauses for the cognitive process, supports dancing as a type of exercise for developing the aerobic conditioning of the older. This is even more relevant considering the better orthopedic tolerance to short bouts of intermittent dance exercises, followed by high levels of motivation and exercise adherence (Rodrigues-Krause et al., 2018). Moreover, optimized performance at workloads corresponding to VT1 have been associated to greater aerobic reserve and neuromuscular economy, leading to delayed muscle fatigue onset and

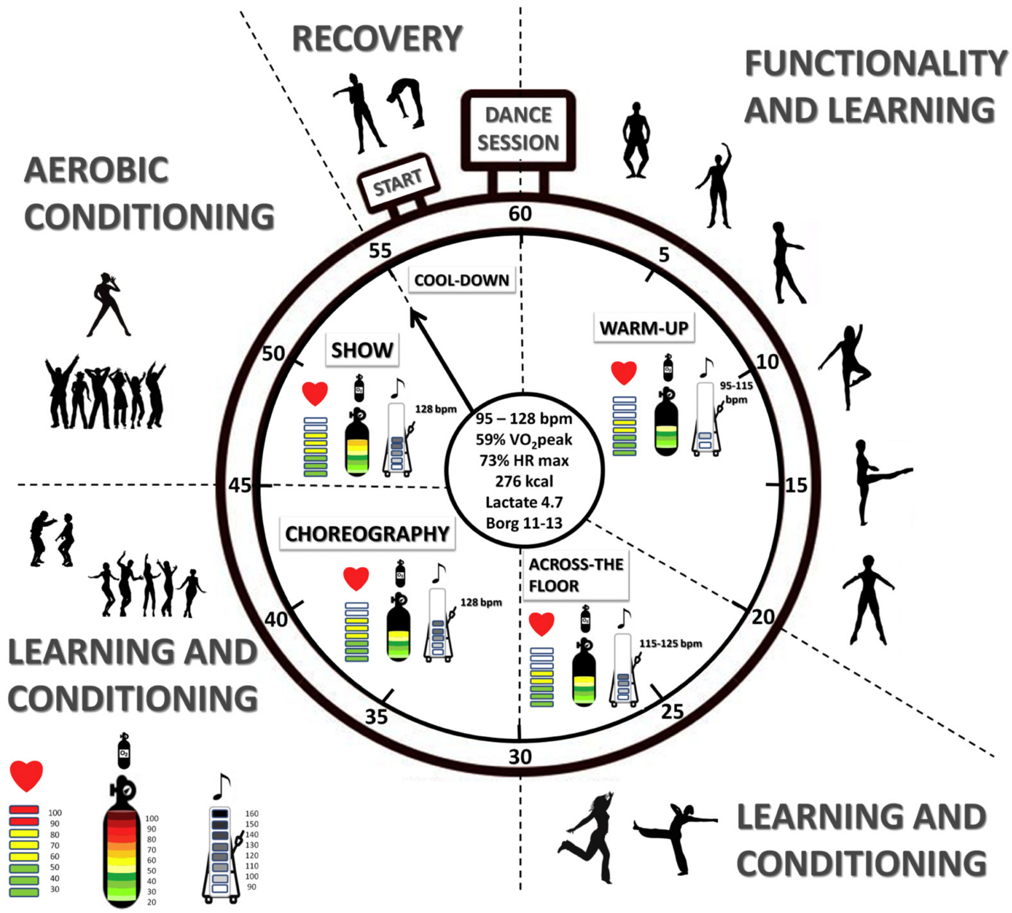

Fig. 2. Structure of the a dance class designed for older women, integrating the cardiorespiratory responses of each part of the dance class with its methodological characteristics (songs' bpm, functionality, learning, conditioning) and the participant's maximum cardiorespiratory responses (% values of VO_2peak and HRmax). The diagram represents a timer, starting a 60 min dance session, as follows: *Warm-up* (20 min): Focus on functionality and learning proper dance technique. It was composed of three songs, with tempo from 95 to 115 bpm. Technical basic elements from ballet and jazz dance were used to develop functional aspects, such as posture, range of motion, isolation of shoulder and pelvic girdle, static and dynamic balance, muscle resistance and power. Average VO_2 response was 55% VO_2peak. Average HR response was 70% HRmax. *Across-the-floor* (10 min): Focus on learning and conditioning. In this part of the class, the set of moves were short, easy to learn and memorize, resulting in short recovery time in between them. The duration of the sets was from 10 to 20s. Songs were from 115 to 125 bpm. Dance elements from Latin dances and aerobic dance were used. For example, isolated sets of *chassés*, kicks, kick ball change, tap to the side and *glissades*. Average VO_2 response was 62% VO_2peak. Average HR response was 74% HRmax. *Choreography* (15 min): Focus on learning and conditioning. Here the sets of moves put together were longer, in order to develop a full choreography. Thus, the longer learning time resulted in longer breaks in between the effective time of dancing. Combination of legs with arms, turning, posing, falling, attitude, duos work, etc., were used to compose a Latin dance choreography. The duration of the full choreography was 4 min, at 128 bpm. Average VO_2 response was 63% VO_2peak. Average HR response was 76% HRmax. Show (10 min): Focus on conditioning. With the learning set, choreography could be repeated without breaks. The Latin song used was at 128 bpm, for 4 min. Choreography was performed twice, with 2 min break in between the repetitions. Average VO_2 response was 69% VO_2peak. Average HR response was 78% HRmax. *Cool-down* (5 min): exercises for stretching and relaxation of the major muscle groups, using a song at 90 bpm. *Whole class*: the small circle in the centre of the timer diagram displays the results of the whole class, it means, all parts of the class taken together (warm-up, across-the-floor, choreography and show). Songs varied from 95 to 128 bpm. Average VO_2 response was 59% VO_2peak. Average HR response was 73% HRmax. Average energy expenditure of the whole class was 276 kcal. Average lactate response after the whole class was 4.7 mmol·L. Subjective perception of effort (Borg scale) varied from 11 to 13 (fairly light to somewhat hard). VO_2: oxygen consumption. VO_2peak: peak oxygen consumption. HR: heart rate. HRmax: maximum heart rate. BPM: beats per minute of the songs used during the dance session.

enhanced performance of daily activities, mostly performed at sub maximal intensities (Cadore & Izquierdo, 2013).

Regarding the warm-up, the very low aerobic demands may be explained by the focus on developing technical aspects that do not require from fitness performance, which are fundamental for properly learning and performing different dance styles. In fact, in the vocational dancers' curriculum, aerobic fitness is only developed after setting neuromuscular coordination (Wyon, 2010; Wyon, 2015). It is also applied for recreational dancers, especially the older ones, that may potentially develop functional abilities in this part of the class, such as balance, flexibility, muscle resistance and power (Rodrigues-Krause et al., 2018). For instance, weight bearing activities, including dancing, have been related to a reduction in fall risk-associated factors (Fernandez-Arguelles et al., 2015).

The aerobic requirements of the whole class, it means, all parts taken together, also do not attain participants' VT1, which may be due two main reasons: (1) the warm-up takes quite a long part of the class (20 min), which is common for different dance disciplines, due to specific technique, neuromuscular and/or functional development, and (2) the cognitive process of learning and/or remembering the dance routines performed in the other parts of the class, such as across-the-floor and choreography. It should be considered that the process of learning or remembering dance routines may interfere on setting proper exercise intensity to increase the aerobic demand of a dance class. In fact, even at professional level, ballet classes do not offer enough stimuli for developing aerobic conditioning, due to the focus on refining technique or learning different choreographic pieces (Rodrigues-Krause et al., 2014). On the other hand, ballet stage performances often demand high aerobic intensities, after the learning, creation and artistic process of the rehearsals are completed (Rodrigues-Krause et al., 2015).

Specially regarding the learning process, when first attempting a new skill, substantial attention is required to consciously select and guide each aspect of the movement, with the information coming mainly from sensing, and resulting in a less efficient performance (VanSwearingen & Studenski, 2014). As skill develops, less attention is required and the movements become more automatic, with minimal neural, muscle and joint requirements. Movement efficiency is enhanced by optimized energy expenditure, with strength, acceleration and deceleration appropriately dosed and planned (VanSwearingen & Studenski, 2014).

The main difference in between across-the-floor and choreography parts was the duration of the exercise routines and consequent break time in between them. Across-the-floor sets are shorter and quicker to learn, requiring shorter breaks in between memorizing and performing the dance routines. Choreographic sets, in turn, are more complex, due to more aesthetic elements involving arms, turns and changes in direction that build up the artistic part of the dance. This involves longer periods of learning and refining moves, increasing the time without properly physically performing them. However, after all that is set, the effective exercise time of the choreography is longer, and the extended duration of the dance routine may be the reason why both parts of the class were very similar in terms of aerobic demands. Once the cognitive and aesthetic elements are established and incorporated by the participants, the choreography can be repeated as many times it is considered appropriated, without any pauses. This may explain why only the show part was more intense than the warm-up and whole class, reaching the ladies' VT1.

Nevertheless, the total energy expenditure of the whole dance session (276 kcal) may be significant for modulating other responses to exercise for people in a lower range of physical activity, rather than intensity of the activity itself (Pontzer et al., 2016). For example, changes in body composition and lipid profile, as a result of increased energy expenditure by increasing the level of physical activity, have been associated to reductions of CVR factors in postmenopausal women (Polotsky & Polotsky, 2010). In addition, lactate concentrations after the entire dance session were similar to those found after the maximum effort test, indicating that a cumulative effect of the whole dance exercise session might also depend upon anaerobic contribution (Rodrigues-Krause et al., 2013).

Particularly, the eccentric muscle actions of the dance moves may be involved in the physiological mechanisms by which dancing can induce cardiovascular adaptations. Indeed, only 30 min of eccentric exercise per week for 8 weeks was sufficient to improve resting energy expenditure, fat oxidation, insulin resistance and blood lipid profile in adult women (Paschalis et al., 2011). Enhanced resting energy expenditure and fat oxidation induced by eccentric exercise (at non-damaging workloads) may be related to improved mitochondria function, oxidative metabolism (Silva et al., 2013; Schnyder & Handschin, 2015) and increased lipid/lipoprotein delivery and utilization (Park et al., 2015). As a matter of fact, depressed total cholesterol and LDL-cholesterol values were found after repeated sessions of eccentric exercises, because cholesterol molecules would be needed for muscle cell repair processes, which may lead to prolonged positive effects on lipid profile (Nikolaidis et al., 2008). This may partly explain how the regular practicing of dancing, rich in sub maximal eccentric actions (weight-bear), may lead to improvements in cardiovascular risk-associated factors, such as lipid profile and insulin sensitivity (Paschalis et al., 2012), and aerobic capacity (Rodrigues-Krause et al., 2016). Supporting that, physiological increases in oxidative stress and muscle damage markers, indicated that the eccentric load of a ballet class was optimal for protecting advanced ballet dancers from exercise-induced muscle damage (Rodrigues-Krause et al., 2013).

Regarding HR responses, it has already been described as a poor parameter to monitor exercise intensity in dance (Rodrigues-Krause et al., 2014; Redding et al., 2004). Indeed, all parts of the dance class were similar to the participants' HR at VT1. Also, the use of medication by the elderly may influence HR responses to exercise. Our results indicate that VO_2 responses raise with the increase in the songs' bpm of different parts of the class (Fig. 2), suggesting that this could be practically used for monitoring dance-based exercise intensities, rather than relying on HR. Subjective measures of effort (e.g. Borg scale) need specific familiarization in dance, because high levels of motivation or cognitive difficulties may be confounded with physical effort (Eston, 2012).

In addition, because dancing requires constant cognitive and motor learning, by combining dance moves with externally paced *tempo*, it stimulates coordination, attention and memory (Niemann et al., 2014). Recent research has identified the potential of dancing in inducing neuroplasticity in the brain of seniors, being superior to engaging in repetitive physical exercise, and potentially contra-interacting the gray matter age-related declines (Muller et al., 2017). Also, task complexity has been related to increases in hippocampal volume region (Niemann et al., 2014), executive function and therefore cognitive function in the older (Forte et al., 2013b).

Another promising dance feature is the potential to enhance muscle resistance and power. Indeed, dance moves such as the *pliés* (bending and flexing the legs in external rotated position) elicited greater muscle activation of gluteus maximum and medium, long abductor, gastrocnemius and rectus femoris than the natural position in health adults, being recommend as clinical therapeutic exercises for lower limb muscle enhancement (Kim & Kim, 2016). Muscle power may be also elicited by the stretching-shortening cycle present in many dance moves, such as the low impact jumps (*chassés*, *hops*, *glissades*) (Koutedakis & Metsios, 2005).

Thus, it is of relevance the potential of dancing as a form of exercise to meet the *American College for Sports Medicine* recommendations to maintain cardiorespiratory, musculoskeletal, and neuromotor fitness in adults (Garber et al., 2011). If properly structured and planned in terms of manipulating the exercise-to-rest ratios of the choreographies, dance classes may attain the cardiorespiratory moderate intensity recommended. Alternatively, dancing may be used to complement the traditional forms of aerobic training in different days through the week, in order to attain the 150 min·wk of aerobic exercise guidelines. Muscle power and resistance may be also elicited by specific features of dance moves, at least in early stages of training, as a bear-weight activity. Neuromotor skills (balance, agility, coordination), plus flexibility, which are intrinsic to dance training (Wyon et al., 2011), also meet the recommendations.

Overall, the findings of this study indicate that dancing may be an alternative exercise strategy for inducing cardiorespiratory adaptations in the older, at least for initial stages of aerobic training. The limitation of a laboratory setting analysis should be mentioned here. It is possible that dancing in a real, larger dance studio, might have induced different cardiorespiratory demands to the participants. Another limitation is the small sample size and the lack of power analysis for this cross sectional design. Finally, these findings support dancing as an exercise strategy for improving health with aging, at least regarding initial stimuli for building up aerobic conditioning. It also strengths the dance interventions as an attractive way of increase the levels of physical activity with aging.

5. Conclusions

Cardiorespiratory demands of a dance class designed for older women are mostly at low aerobic intensity. The most demanding part of the dance class was the show, with VO_2 responses similar to participants' VT1. This indicates that some parts of a dance class can be modulated to induce improvements in the cardiorespiratory fitness of the elderly, at least at initial stages of aerobic training. Additionally, our results showed that raises in VO_2 demands followed the increases in the songs' bpm used in different parts of the class.

Conflict of interest

The authors have no conflicts of interest to declare.

Acknowledgments

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3.4 ARTIGO 4: ENSAIO CLÍNICO RANDOMIZADO CONTROLADO

EFFECTS OF A DANCE INTERVENTION COMPARED TO WALKING ON CARDIOVASCULAR RISK FACTORS AND FUNCTIONAL CAPACITY OF OLDER WOMEN: A RANDOMIZED CONTROLLED TRIAL

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Effects of dancing compared to walking on cardiovascular risk and functional capacity of older women: A randomized controlled trial

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ABSTRACT

Introduction: Aging is characterized by reductions in lean mass simultaneously to increases in visceral adipose tissue, elevating cardiovascular risk (CVR) and physical dependence. Dancing has been recommended for improving fall-risk and CVR, however, comparisons with traditional exercises are limited. This study aimed to compare the effects of dancing with walking on CVR and functionality of older women.

Methods: Thirty sedentary women (65 ± 5 years, BMI 27 ± 4 kg/m^2) were randomized into three groups (n = 10/group): dancing, walking or stretching (active control). All interventions lasted 8 weeks (60 min sessions): dancing/walking 3 × /week, stretching 1 × /week. Dancing: several styles, no partner. Walking: treadmill, 60% peak oxygen consumption (VO_2peak). Stretching: large muscle groups, no discomfort. Before and after interventions assessments: VO_2peak (primary outcome), total cholesterol, HDL-C, LDL-C, glucose, insulin, CRP, TNF-α, waist and hip circumferences, visceral adipose tissue (VAT), muscle thickness, maximal muscle strength/power, static and dynamic balance, gait ability, flexibility, chair-raise and level of physical activity (PA). Statistics: generalized estimating equations, post-hoc LSD ($p < 0.05$), SPSS 22.0.

Results: (Mean-CI): (before *vs* after): group *vs* time interaction showed increases in VO_2peak (mL·kg^{-1}·min^{-1}) for dancing 23.3 (20.8–25.8) *vs* 25.6 (23.4–27.8), and walking 23.4 (21.3–25.5) *vs* 27.0 (25.4–28.6), with no differences for stretching 23.5 (21.3–25.7) *vs* 23.0 (21.0–24.9). Lower body muscle power and static balance also improved for dancing and walking, but not for stretching. Main time effect showed improvements in CRP, TNF-α, LDL-C, HDL-C, VAT, waist, hip, chair raise, flexibility and level of daily PA for all groups.

Conclusion: Dancing induced similar increases in VO_2peak, lower body muscle power and static balance as walking, while the stretching group remained unchanged. Pooled effects showed improvements in body composition, lipid and inflammatory profile, which are supported by increased PA levels.

Trial registration: NCT03262714.

1. Introduction

Aging is a multifactor process that involves natural declines in physical, cognitive and sociability levels, which may be accentuated by a sedentary lifestyle (DeCarlo et al., 2014). Indeed, reduced levels of physical activity (PA) have been linked to increases in metabolic comorbidities and physical dependence during aging (Myers et al., 2015). It is particularly true for developing countries, where longevity is simultaneously increasing with the health costs associated with the treatment of cardiovascular disorders resulting from chronic diseases, such as obesity and type 2 diabetes mellitus (T2DM) (Bielemann et al., 2010). On the other hand, investing in PA programmes has represented

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a substantial economy for the health systems, and has an important role in dictating lifespan (Bielemann et al., 2010).

In fact, exercise programmes are low cost, non-pharmacological neither invasive interventions, which have been widely recommended for attenuating deteriorations on several biological aspects with aging (Cadore and Izquierdo, 2013). For example, aerobic and/or strength exercise can attenuate the expansion of visceral adipose tissue (VAT), which occurs concomitantly to a loss of skeletal muscle mass and cardiorespiratory fitness (Dalle et al., 2017). In another words, exercising regularly may attenuate the development of a chronic low-grade inflammatory state associated to adiposity levels, which is a known effect of aging connected to insulin resistance, obesity, and elevated cardiovascular risk (CVR) (Krause et al., 2013). In addition, the loss of muscle mass followed by reductions in muscle strength, power and cardiorespiratory fitness may induce to early fatigue onset and consequent functional declines that culminate in difficulties to perform daily activities (Tomas et al., 2018). This may lead to progressive reductions in PA levels, in a vicious cycle that may culminate in loss of physical independence.

Analysing CVR markers together with functional and fitness responses may provide a deeper understanding of the benefits from particular types of PA widely practiced by the older, such as dancing and walking. Indeed, cardiovascular health has been closely associated with metabolic and functional responses with aging (Rodrigues-Krause et al., 2018a). For example, the progressive decrease of lean body mass and consequent decay of resting metabolic rate implies in a decrease of daily physical activity and in total expenditure; predisposing the elderly to accumulate visceral and total body fat (Bruseghini et al., 2015). The metabolic consequences of these changes in body composition (*e.g.* poor insulin sensibility, altered lipid profile, post-prandial hyperglycaemia) (Bruseghini et al., 2015); together with reduced levels of physical activity; have been extensively associated to the development of cardiovascular disorders (*e.g.* myocardial infarction, stroke and peripheral vascular disease) (Krause et al., 2013; Pattyn et al., 2013; Chen et al., 2013). In particular, level of physical activity has been suggested as a potential risk marker for cardiovascular disease (Myers et al., 2015), specially cardiorespiratory fitness as predictor of CVR in healthy individuals (Kodama et al., 2009).

Thus, strategies for increasing the level of PA of the elderly have been studied, mainly those offering global gains to the older, it means, at the physical, mental and social domains (Chase, 2013). Indeed, dancing has been recommended because it includes a variety of stimuli for different physiological elements that are progressively impaired with aging, including improvements in body composition, strength, and endurance (Rodrigues-Krause et al., 2018a). In addition, dance interventions are developed by integrating social, cognitive and physical domains associated to improvements in quality of life and long term intervention adherence, which may be a trigger for changes in life style, at least, regarding the level of PA (Mangeri et al., 2014).

This may be of relevance considering that moderate-intensity dancing was associated with a reduced risk for cardiovascular disease mortality to a greater extent than walking (Merom et al., 2016). Merom et al. (2016) reported that the association between dance and cardiovascular disease mortality may be explained by (1) high-intensity bouts during dancing, (2) psychosocial benefits, and (3) lifelong adherence. Firstly, some types of dance (*e.g.* folk and ballroom dance) are classified at high-moderate intensity range, usually intercepted with light-intensity dancing, possibly mimicking high-intensity interval training (Ainsworth et al., 2000). Indeed, there is evidence that cardiopulmonary function is improved to a greater extension by low volume high intensity interval-training than continuous moderate training in post-menopausal women (Klonizakis et al., 2014). Secondly, dancing is inherently a social, enjoyable and entertaining activity, which may buffer the effect of psychosocial stress on CVR, likely leading to longer chronic adaptation to daily mental stressors than other types of PA (Hamer, 2012). It may be that physiological and psychosocial benefits of performing short duration and moderate-high intensity intermittent bouts of exercise are related to higher levels of orthopedic tolerance, greater perception of success, increased motivation and exercise adherence (Rodrigues-Krause et al., 2018a). Therefore, dance may confer greater benefits due to life-long participation compared with dropout rates reported for other exercise classes (Merom et al., 2016).

Moreover, increasing evidence has been supporting dancing for preventing losses on functional aspects related to falls, such as balance, gait ability and flexibility (Fernandez-Arguelles et al., 2015). Indeed, it is known that exercise programmes could reduce risk of falls and improve quality of life of the older, however, not all types of exercises prevent dependency in a spectrum that includes neural and cognitive declines with aging (Bianco et al., 2014). Rather than promoting physical benefits, the regular practice of dance throughout old age leads to improvements in elements which contribute to neuro-plasticity, such as reaction times, motor behavior, cognitive performance, sensory stimulation and social interaction (Karpati et al., 2015). Thus, there is an importance in investigating types of interventions that may promote global gains to the older, at the physical, social and mental levels, such as group fitness activities, including dancing (Bianco et al., 2014).

Lastly, dancing has been associated to improvements in aerobic capacity and reduction in biochemical CVR factors in the elderly (*e.g.* tryglicerides, total cholesterol, *etc.*), although in much less extent than functional outcomes (Rodrigues-Krause et al., 2016). However, the magnitude of these gains compared to other type of traditional exercise programmes is still limited. Although undertaking structured dance of any genre was recently reviewed as equally or more effective than other types of structured exercise on a range of physical outcomes (*e.g.*, cardiovascular function and biomarkers), the analysis of different populations taken together (*e.g.*, children, adolescents, elderly, cognitive impaired, heart failure patients, among others) substantially weakens the level of the evidence (Fong Yan et al., 2018). Moreover, poor study designs and methodological quality, lack of description of intensity of the dance sessions, and the use of mixed interventions (dance plus another type of exercise) limit the findings on metabolic responses as a result of dance practicing (Rodrigues-Krause et al., 2018a).

Therefore, the aim of this study was to verify the effects of a structured dance intervention compared to a traditional aerobic exercise, walking, on CVR factors and functional capacity of older women, in a randomized controlled trial. The main outcome of this study was the peak oxygen consumption (VO_2peak), because it is connected to both, CVR (Myers et al., 2015) and functional capacity (Shephard, 2009). The secondary outcomes were body composition, functional and biochemical parameters.

2. Methods

2.1. Settings and participants

After advertising in social networks, word-to-mouth and posters at the university and neighborhood, an initial phone screening was performed in order to check on eligibility of the participants. Women from 60 to 75 years old, body mass index (BMI) < 35 kg/m^2, independent for performing daily activities, and not engaged in any type of regular exercise training during the last 6 months were recruited for this study. Exclusion criteria were: not controlled-hypertension, T2DM, mobility limitations, not being able to perform the maximum effort test, alteration in the electrocardiogram (ECG) or any other condition that could limit the exercise practice. They provided informed consent after being informed about the study protocol, which was approved by the local Research Ethical Committee (53834516.0.0000.5347) and registered in Clinical Trials.gov: NCT03262714.

2.2. Study design and procedures

This study was designed as a three-arm randomized controlled clinical, parallel design, open-label trial, with an allocation ratio of 1:1:1. No changes in the methods were made after trial commencement.

After being fully informed about the study protocol and signed the informed consent, participants visited the laboratory on three occasions for the before interventions assessments. Visit 1: medical evaluation, anthropometric measurements, familiarization with testing protocols and diet record explanation. Visit 2: fasting blood sample for lipid, glycemic and inflammatory profile analysis, ultrasound for VAT and quadriceps thickness, *ad libitum* breakfast, PA questionnaire, and maximum effort test (with ECG), for cardiorespiratory fitness assessment. Visit 3: functional tests, for assessing static and dynamic balance, gait, flexibility and seat-to-stand ability, plus jump power and knee extensors strength tests.

Following that, thirty participants who fulfilled the inclusion criteria were randomly allocated (*randomizer.org*) in blocks of three, according to their VO_2peak, into three groups: 1. Stretching (n = 10): active control group, performing stretching classes once/week (with adherence purposes), 2. Dancing (n = 10): dance classes 3 × /week, 3. Walking (n = 10): walking training 3 × /week. The processes of randomization and allocation were performed after completion of initial assessments by an impartial researcher. The duration of the interventions was eight weeks, followed by the after intervention assessments (same as before). All assessments were blinded to the allocation of the participants. The period from recruitment to initial assessments was of two moths, and the delay between randomization and initiation of the interventions was two weeks. Final assessments were performed from 48 h to maximum one week after the last exercise session.

2.3. Interventions

Dancing and walking interventions were performed 3 × /week, in non-consecutive days, with 60 min classes. The stretching intervention was used as an active control, once a week, also with 60 min classes. Dancing and stretching were group classes, setting in a dance studio, while the walking intervention was gym-based, in small groups (2–3 people). Participants frequency was registered every class, being mandatory to complete 24 (dancing and walking) or 8 (stretching) sessions during intervention period of 8-weeks. The same specialized instructors conducted all the interventions.

2.3.1. Dancing

Elements from different dance styles were used in selected parts of the class, specially designed to develop functional and fitness elements that tend to naturally deteriorate with the aging process (balance, flexibility, muscle power, aerobic conditioning, *etc.*). It included five parts: warm-up, across-the-floor, choreography, show and cool-down. The intensity of the class followed the beats per minute (bpm) of the songs used. The dance session was previously tested (Rodrigues-Krause et al., 2018b), showing that increases in VO_2 followed increases in the songs' bpm. The intensity of the whole class was approximately 60% VO_2peak, being the warm up ~55% VO_2peak (95–115 bpm), the across-the-floor ~62% VO_2peak (115–125 bpm), choreography ~63% VO_2peak (128 bpm), and the show ~69% VO_2peak (128 bpm). Detailed description of the dance class structure, including dance moves, songs' bpm, intensity and duration of each part of the class can be also found in Rodrigues-Krause et al. (2018b). The 8-week dance-based intervention prescription is described in Table 1.

2.3.2. Walking

Walking sessions started with a 10 min warm-up, using dynamic moves for join mobilization and static stretching for major muscle groups, all in comfortable range of motion. After that, participants performed 40 min walking on a treadmill, starting with a heart rate (HR) corresponding to 50% VO_2peak for 5 min. Following that, participants walked for 30 min at a HR corresponding to 60%VO_2peak, and another 5 min at 50% VO_2peak. The final 10 min were for a cool-down with stretching and relaxation of major muscle groups. At the week 5, the 30 min walking intensity was adjusted for 65% VO_2peak (Cadore and Izquierdo, 2013). There was no music set for the walking sessions.

2.3.3. Stretching

Stretching sessions included exercises for large muscle groups, performed standing or on the floor, with the participant supporting the positions by themselves. Exercises were performed at low intensity, gently moving the body segments, without discomfort. There was no external load offered by the instructor, who interfered only for correcting the exercise technique. No songs were played during the stretching sessions.

The session started standing by the *barre* (a handle rail support used for ballet classes), bringing awareness for posture and axial elongation. With hands resting on the *barre*, and standing with legs slightly apart, the following stretching exercises were performed for both right and left sides: lateral flexion of the cervical spine, horizontal adduction of the shoulder (holding the own arm with the opposite one), knee flexion (holding the foot with the hand at the same side, while the opposite hand rested on the *barre*), and calf stretch. Then, with legs and hands (on the *barre*) wider apart, a spine flexion was performed to the point of gently feeling the hamstrings stretching. After that, exercises for stretching lower back, hamstrings, hip adductors and abductors, hip internal and external rotators, were performed sitting on a matt or in the supine position. This circuit was repeated twice, with positions maintained for 10 s. At the end of the session, breathing exercises were performed in a circle for relaxation.

2.4. Before and after interventions assessments

2.4.1. Body composition

Standing height, body mass, waist and hip circumferences were measured with standard anthropometric procedures. VAT and muscle thickness were obtained by ultrasound images using real-time Bmode ultrasonography (Nemio XG ultrasound, Toshiba, Japan). VAT thickness was considered as the distance between the posterior part of the abdominal muscle and the posterior wall of aorta at the level of umbilicus (Schlecht et al., 2014). For muscle thickness, transversal images of the right *vastus lateralis*, *rectus femoris*, *vastus intermedius*, and *vastus medialis* muscles were obtained using a 38-mm, 9.0 MHZ linear-array transducer (image depth 70 mm; 90 dB general gain, time gain compensation at the neutral position) with a Nemio XG ultrasound (Toshiba, Japan). Participants rested in supine position with the lower limbs extended and relaxed for 15 min before measurements in order to allow fluid shifts to stabilize. Transverse images of the right vas*tus lateralis*, *rectus femoris*, *vastus intermedius*, and *vastus medialis* muscles were acquired with the probe perpendicular to the surface of the thigh. Measurement of the VL was taken at the midpoint between the greater trochanter and the lateral epicondyle of the femur, whereas the measurement for the VM was taken at 30% of the distance from the lateral epicondyle of the femur to the greater trochanter; RF-VI measurements were made at two thirds the distance from the greater trochanter of the femur to the lateral epicondyle and 3-cm lateral to the midline of the limb. The ultrasound muscular images were analysed *via* ImageJ software (National Institute of Health, USA, version 1.37). The subcutaneous adipose tissue and bone tissue were identified, and the distance between them was defined as muscle thickness. All measurements were performed by the same experienced evaluator. Quadriceps femoris muscle thickness was considered as the sum of the four lower-body muscles MT (VL + VM + VI + RF) (Pinto et al., 2014). ICC = 0.97 for VL, VM, VI and RF. The probe was coated with water-soluble transmission gel to provide acoustic contact, and care was taken to avoid compression of the dermal surface. Three images were acquired and then exported to a personal computer for analysis by the same investigator using ImageJ 1.42 software (National Institute of Health, USA).

Table 1
Eight week dance-based training prescription.

	Weeks 1–3	Weeks 4–6	Weeks 7–8
Warm-up[a]	Learning posture, technique and neuromuscular coordination	Performing exercises as continuously as possible, preserving learning.	Performing exercises with no pauses
Across-the-floor[a]	Learning isolated steps: 10–20 s sets (1 × 8 or 1 × 16 music *tempos*)	Performing sets already learned, 1:1. Incorporating new elements (*e.g.* arm work), preserving learning.	Performing sets already learned, 1:1
Choreography[a]	Learning steps put together for a choreography, using legs, arms, turns, directions, *etc.*	Adding on new steps to the choreography, preserving learning.	Completing the full chorography, marking as many times it is needed.
Show[a]	Performing the choreography learned so far, 2×, 1:2	Repeating the choreography learned so far 3×, 1:1	Repeating the full choreography (4 min), 3×, 1:1/5

Weeks 1–3: focusing on the learning aspects of the warm-up, across-the-floor and choreography parts of the class, to proper develop neuromuscular coordination, technique and confidence. Using sets of 10–20s for the across-the-floor (1 × 8 or 1 × 16 music *tempos*), in order to learn fast and optimize the recovery time. Performing the show part with the amount of choreography learned to the moment, repeating that at least twice at an exercise-to-rest ratio of 1:2. Weeks 4–6: performing the warm-up exercises as continuously as possible, without pauses for learning, but always preserving the technical corrections or refining of the moves. Repeating the across-the-floor sets already learned at an exercise-to-rest rate of 1:1. Incorporating new elements to the sets already learned (such as arm work) and/or introducing new ones, preserving the learning process. Adding on new steps to the choreography, respecting the learning process of the group, and repeating that at least 3 times at an exercise-to-rest ratio of 1:1 during the show part. Weeks 7–8: performing the warm-up and across-the-floor (1:1) parts of the class, already learned, with no pauses. Repeating the choreography learned at least twice at an exercise-to-rest ratio of 1:1. Completing the artistic and pedagogic process of the choreography, preserving the learning aspects. Marking the full choreography put together as many times it is necessary. During the show part, repeating the full choreographic piece (4 min) 3 times, at an exercise-to-rest ratio of 1:1/5.

[a] Please, see Rodrigues-Krause et al. (2018b) for detailed description of the dance session.

2.4.2. Lipid, glycemic and inflammatory profile

After 8 h fasting, venous blood samples were drawn into 4-mL EDTA anticoagulant tubes using standard aseptic techniques. Samples were immediately centrifuged (at 4 °C and 1000 g for 15 min), after which plasma was removed and stored at −80 °C for further analysis. Glucose, total cholesterol, high density lipoprotein cholesterol (HDL-C), and triacylglycerol were measured using an automated analyzer (Cobas C111, Roche Diagnostics, Basel, Switzerland). Low density lipoprotein cholesterol (LDL-C) levels were estimated by Friedewald equation (Friedewald et al., 1972). Plasma levels of insulin (DRG International, Springfield, IL, USA), tumor necrosis factor alpha (TNF-α) and C-reactive protein (CRP) (BosterBio, Pleasanton, USA) were determined by enzyme-linked immunosorbent assay (ELISA), according to manufacturer's instructions. Insulin resistance was calculated by the insulin resistance homeostatic model (HOMA-IR) (Krause et al., 2014).

2.4.3. Maximum effort test

Participants' VO_2peak and maximum heart rate (HRmax) were determined through an incremental exercise test on a treadmill (Inbramed, Porto Alegre/Brazil). The test started with a 5 min warm-up (from 3 to 5 km/h, increasing 0.5 km/h each min, until 5 min), followed by 2% increases in slope every min, while maintaining a constant speed of 5 km/h throughout the entire test (Flo et al., 2012). In order to be considered a maximum effort test, participants must have attained at least two of the following criteria: (1) age-predicted HRmax, (2) respiratory exchange ratio (RER) ≥1.1, (3) subjective perception of effort ≥17 (Borg scale 6–20), (4) signals of muscle fatigue, such as loss of motor coordination (Howley et al., 1995).

Ventilatory parameters were measured continuously, breath-by-breath, using an open-circuit spirometry system (Quark CPET, Cosmed Italy) calibrated according to manufacture instructions prior to each day of testing. HR was also measured continuously using a chest belt telemetry (Polar Electro Oy, Kempele, Finland).

VO_2peak was identified as the highest VO_2 value in a line of tendency plotted against the time. Participants were verbally encouraged to perform at maximum effort during the test. Two independent and blinded reviewers analysed the data.

2.4.4. Isometric and isokinetic knee extension peak torques and jump performance

The maximal isometric and isokinetic knee extension capacity was measured using an Isokinetic Dynamometer (Cybex Norm, Ronkonkoma, NY, USA), calibrated according to manufacture instructions. Participants were seated with their hips and thighs firmly strapped to the seat of the dynamometer, with the hip angle at 85°. After the dominant limb adjustment (*i.e.*, lateral epicondyle centered to the dynamometer rotation axis and force application point 2 cm above medial malleolus), the warm up consisted of 10 submaximal isokinetic knee extension and flexion repetitions at an angular velocity of $120^{o}.s^{-1}$. Thereafter, the participants performed 3 sets of 5 s and were instructed to isometrically produce the maximal knee extension force as fast as possible at 60° of knee flexion (0° represents full extension). After a pre-test of 3 submaximal repetitions for angular velocity familiarization, maximal isokinetic knee extension peak torque was measured during one set of 4 repetitions at the angular velocity of $60°\cdot s^{-1}$. The test was performed in a 90° range of motion (*i.e.*, 0° - full extension). Both maximal isometric and isokinetic sets were performed with 3 min of rest between them (da Silva et al., 2018).

Participants performed a jump test using an electronic contact mat system (Cefise, Jump System Pro, São Paulo, Brazil). Jump height was determined using an acknowledged flight-time calculation (Bosco and Rusko, 1983) and the software Jump System Pro 1.0. Each participant was instructed to use maximum effort to perform the double-leg countermovement jump (CMJ) tests. They were given 3 attempts to obtain their maximum jump height in each test, with 10 s of rest between attempts, with the highest value utilized for subsequent analysis. Moreover, variation of 3% was established as minimum between valid attempts. During the CMJ test, participants started in the orthostatic position. They were instructed to jump for maximal height. Participants were again instructed to leave the electronic contact mat system with their knees and ankles fully extended and to land in a similarly extended position to ensure the validity of the test. Four techniques were stressed: (a) correct posture (*i.e.*, spine erect, shoulders back) and body alignment (*e.g.*, chest over knees) throughout the jump; (b) jumping straight up with no excessive side-to-side or forward-backward movement; (c) soft landing, including toe-to-toe heel rocking and bent knees; and (d) instant recoil preparation for the next jump. When performing the jumps, all the participants held their hands on their hips.

2.4.5. Functional tests

Static balance was evaluated with the participant in unipedal stance of the dominant leg, with eyes closed. The opposite leg remained in the air, with hip and knee flexed at a 90° angle. The longest duration keeping the position (30s maximum) in three attempts was recorded (stopwatch), with 2 min break. Volunteers were allowed to move upper body or knees to keep the balance, but not the foot, nor holding the rail security support.

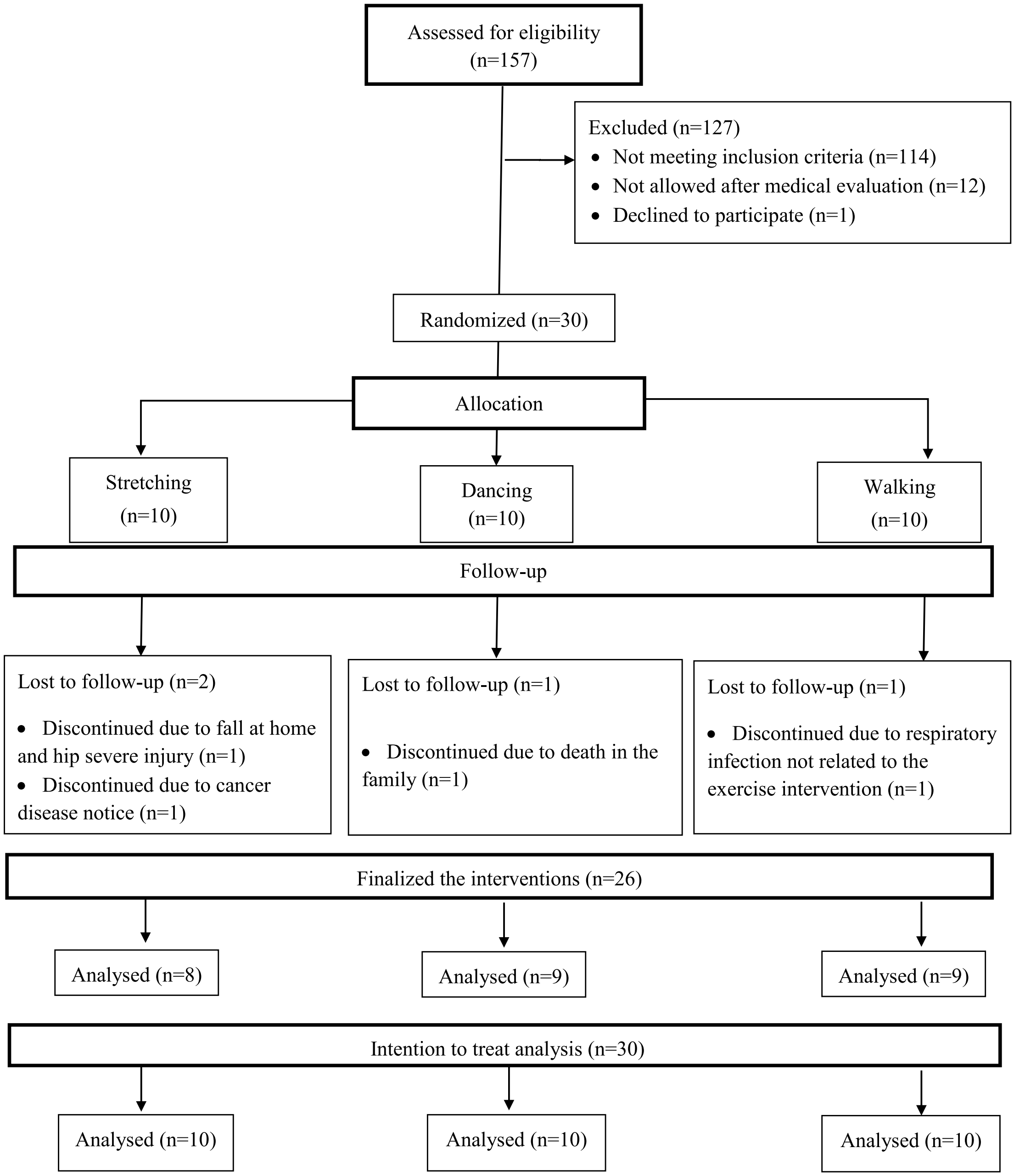

Fig. 1. Flow diagram of eligibility, allocation and analysis of participants.

Dynamic balance and gate ability were measured by the Time to Up and Go Test (TUG). The test consist in measuring the time (s) that the participant need to get up from a standard arm chair (43 cm), walk for 3 m at usual walking speed, turn, and walk back to sit down. The fastest time in three attempts was recorded, with 2 min break in between them. Times were recorded to the nearest millisecond and transformed in m/s.

Lower body flexibility was assessed using the chair version of the sit and reach test (dominant leg). The subject sit on the edge a chair (placed against a wall for safety). One foot remained flat on the floor. The other leg was extended forward with the knee straight, heel on the floor, and ankle bent at 90°. One hand was placed on top of the other with tips of the middle fingers even. The subject was instructed to inhale, and then as they exhale, reach forward toward the toes by bending at the hip. They were also instructed to keep the back as straight as possible, the head up, avoiding bouncing or quick movements, keep the knee straight, and hold the reach for 2 s. The distance between the tip of the fingertips and the toes was measured. If the fingertips touched the toes, the score was zero. If they did not touch, the distance between the fingers and the toes was measured (a negative score, *e.g.* −2 cm). If they overlap, it was measured by how much (a positive score, *e.g.* +2 cm). Two trials were performed and the best score was registered.

The ability to seat and stand (chair raise test) was assessed by the time required to rise from sitting five times as fast as possible from a standard chair with the participants folding arms across their chest. Recordings were made using a stopwatch starting at the initiation of the movement and stopping when subjects stood upright for the 5th time. All functional tests based on Rikli et al. 2013 (Rikli and Jones, 2013).

2.4.6. *Level of physical activity and diet record*

The short form of the International Physical Activity Questionnaire (IPAQ) was used to assess the PA level of the participants, which includes four domains: walking (at least for 10 min continuously), moderate (daily activities, except walking) and vigorous physical activities, and sitting time (week and weekends). The questionnaire provides a full evaluation of the number of week days in which PA is carried out and its average daily duration (min/week). Nutritional habits (total calorie intake) were assessed by a 3-day diet record (Dietwin, São Paulo, Brazil).

2.5. Statistical analyses and sample size calculation

To achieve 80% power at an α level of 0.05 (two-tailed), 24 participants would be required to detect an effect size of 0.344 on VO_2peak at the end of the 8-week intervention (Hollekim-Strand et al., 2014). Based on our previous experience with exercise trials, we anticipated an attrition rate of up to 20%. As a result, to adequately ensure that we had sufficient participant numbers at the end of the intervention, 30 participants were recruited and randomly assigned to dancing (n = 10), walking (n = 10), and stretching (n = 10).

Results were reported as mean and 95% confidence intervals (CI 95%). Baseline measurements of the three groups were compared by One way Analysis of Variance (for scalar variables) and chi-square test (for categorical variables). Generalized estimating equations (GEE) followed by the least significant difference post-hoc test was used to compare the means of all dependent variables (primary and secondary outcomes in intention-to-treat analysis), testing the main effects of group and time (pooled effects, it means, all interventions taken together, n = 30), as well as the interaction effects (group *vs* time).

Additionally, the Cohen's *d* effect size (ES) was calculated from the difference of values at the moment after intervention, comparing dancing *vs* stretching (DxS) and walking *vs* stretching (W × S) groups. The ES was classified as small (0.2–0.5), moderate (0.5–0.8), or large (0.8 or greater) (Sullivan and Feinn, 2012). Significance level was set at α = 0.05 for all tests (SPSS 22.0).

3. Results

Participants' compliance with the interventions was higher than 95% for the three groups. From the thirty participants randomized, four did not finish the interventions (two from the stretching group, one from dancing, and one from walking, representing 13% of loss). Reasons for discontinuing the interventions included personal reasons not related to the intervention (Fig. 1). Interventions were safe, with no severe adverse events, except light muscle soreness. General characteristics of the participants, such as age, BMI and medication used are shown in Table 2. No significant differences at baseline in any measurements were observed.

Group *vs* time interaction was found for VO_2peak, static balance, CMJ and TUG test. VO_2peak ($mL\cdot kg^{-1}\cdot min^{-1}$) increased as a result of dancing ((23.3 (20.8–25.8) *vs* 25.6 (23.4–27.8), p = 0.002)) and walking ((23.4 (21.3–25.5) *vs* 27.0 (25.4–28.6), $p < 0.001$)) from before to after interventions, with no differences for the stretching group ((23.5 (21.3–25.7) *vs* 23.0 (21.0–24.9), p = 0.269)). Also, VO_2peak of the walking group was superior to the stretching group after interventions (p = 0.002). A large and moderate ES were observed for walking (d = 1.28 (0.32–2.24)) and dancing (d = 0.71 (−0.19–1.62)) (Fig. 2A). VO_2peak responses in $L\cdot min^{-1}$ followed the same pattern of increases for dancing ((1.53 (1.39–1.67) *vs* 1.67 (1.45–1.88), p = 0.012)) and walking ((1.63 (1.52–1.74) *vs* 1.85 (1.70–2.00), $p < 0.001$)) from before to after interventions. Stretching group did not change ((1.64 (1.50–1.77) *vs* 1.59 (1.4ç–1.71), p = 0.104)). Also, the walking group was superior to the stretching group after interventions (p = 0.008).

The CMJ (cm) was also improved as a result of dancing ((11.2 (9.3–13.1) *vs* 12.2 (10.3 to 14.0), p = 0.042)) and walking ((10.3 (9.0 to 11.6) *vs* 11.3 (9.7 to 13.0), $p < 0.003$)) from before to after interventions, with no differences for the stretching group ((9.8 (8.6 to 11.3) *vs* 9.3 (7.8 to 10.7), p = 0.234)). CMJ of the dancing group was superior to the stretching after the interventions (p = 0.016), with a large and moderate ES for dancing (d = 1.00 (0.07 to 1.33)) and walking (d = 0.74 (−0.17 to 1.64)) (Fig. 2B).

Static balance (s) also improved from before to after dancing ((5.44 (2.34 to 8.55) *vs* 11.07 (6.53 to 15.62), p = 0.002)) and walking ((5.67 (2.91 to 8.42) *vs* 14.46 (9.09 to 19.84), p = 0.001)), being both superior to stretching ((4.05 (2.28 to 5.82) *vs* 4.04 (3.12 to 4.97), p = 0.962)) after the interventions. ES was large for both dancing (d = 1.22 (0.27 to 2.18)) and walking (d = 1.55 (0.55 to 2.55)) (Fig. 2C). Dynamic balance and gait ability, assessed by the TUG test, improved for the walking group ($p < 0.001$), which was superior to the stretching group at the moment after the intervention (Table 3). However, a large ES was observed for both, dancing and walking (Table 3).

A main time effect (pooled data) was found for the following outcomes: body composition (VAT, waist and hip circumference) (Table 4), inflammatory (TNF-α and CRP) and lipid profile (HDL-C, LDL-C) (Table 5), functional capacity (chair raise and flexibility) (Table 3), and PA levels (time spent per week in walking at least 10 min continuously) (Table 3).

Table 2
Baseline characteristics of the participants. Analysed by groups of exercise interventions: stretching (n = 10), dance (n = 10), and walking (n = 10). Analysed all together (total, n = 30).

	Stretching (n = 10)	Dancing (n = 10)	Walking (n = 10)	Total (n = 30)	p value
	Mean (CI 95%)	Mean (CI 95%)	Mean (CI 95%)	Mean (CI 95%)	
Age (years)	66 (61–70)	66 (63–70)	64 (62–65)	65 (63–67)	0.386
BMI (kg/m^2)	27.7 (25.2–30.3)	27.1 (24.2–29.9)	28.2 (25.6–30.9)	27.7 (26.3–29.0)	0.780
Independence for daily activities (OARS)	27.8 (27.5–28.1)	27.9 (27.7–28.1)	27.8 (27.9–28.1)	27.9 (27.7–28.0)	0.804
SBP (mm Hg)	135 (126–143)	140 (135–145)	140 (135–144)	138 (134–142)	0.525
DBP (mm Hg)	86 (81–90)	87 (83–91)	86 (83–90)	86 (84–89)	0.907
RHR (bpm)	69 (60–78)	68 (64–71)	65 (60–70)	67 (64–71)	0.606
Medication					
Anti-hypertensive (n)	4	5	3	12	0.659
Cholesterol regulator (n)	2	3	1	6	0.596
Antidepressant (n)	2	1	2	5	0.787
Thyroid regulator (n)	1	2	2	5	0.787
Osteoporosis (n)	1	1	0	2	0.585
Others (n)	3	2	2	7	0.830

p values: Anova One-Way for comparisons among the stretching, dancing and walking groups. BMI: Body Mass Index. OARS: Older American Resources and Services questionnaire of daily living activities. Total score = 28 points (14 points for instrumental and 14 for physical activities of daily life). Total scores lower than 20 points (or lower than 10 points for each instrumental or physical activities) indicate physical dependence. SBP and DBP: systolic and diastolic blood pressure (measured after 30 min resting in the supine position). RHR: resting heart rate (measured continuously during 30 min resting in the supine position). Medication: p values after chi-squared test. Others: gastritis, asthma, acetylsalicylic acid, glaucoma, arthritis.

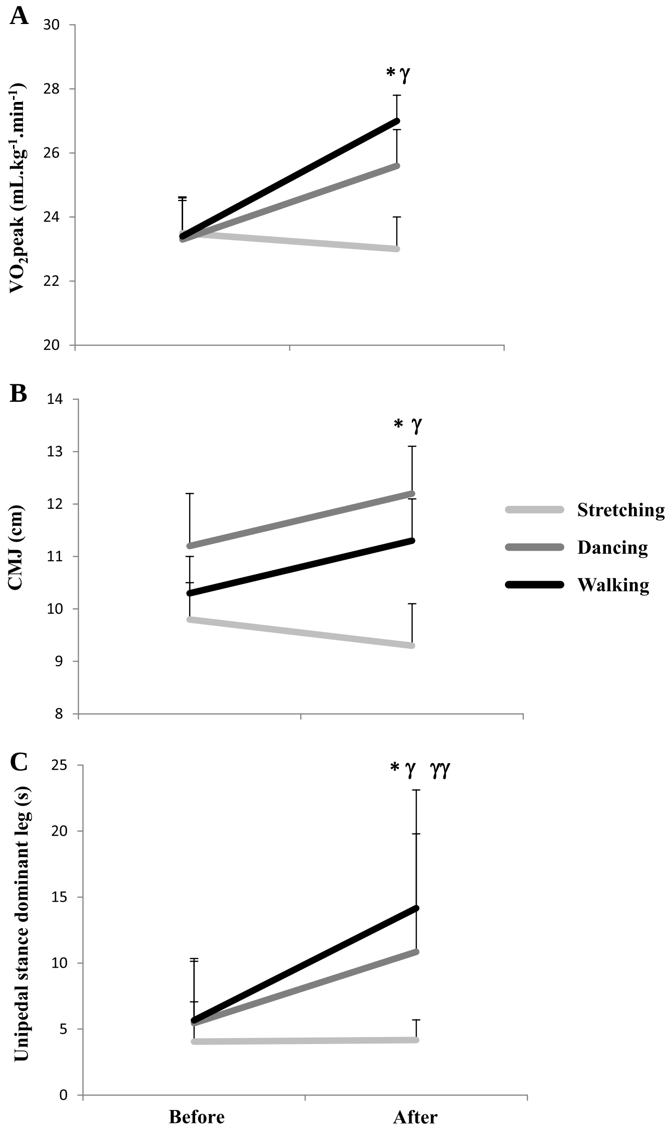

Fig. 2. Cardiorespiratory and functional responses of older women before and after 8 weeks intervention of stretching (n = 10), dancing (n = 10) or walking (n = 10). 2A: Maximum cardiorespiratory capacity evaluated by the peak oxygen consumption (VO_2peak). 2B: Lower body muscle power, evaluated by the counter movement jump (CMJ). 2C: Static balance evaluated by the unipedal stance on the dominant leg with eyes closed. * Difference from before to after the intervention for dancing and walking groups. γ Difference at the moment after the intervention comparing dancing with stretching group. γγ: Difference at the moment after the intervention comparing walking with stretching group.

4. Discussion

Increasing evidence has been supporting dancing for improvements in functionality, metabolic health, cardiorespiratory fitness and reduction in CVR factors in the older (Rodrigues-Krause et al., 2018a; Fernandez-Arguelles et al., 2015; Rodrigues-Krause et al., 2016). Our trial firstly covers, at our knowledge, the lack of evidence on comparing these gains with a traditional exercise programme for the elderly without any aging-associated comorbidities. The main finding of this study was that dancing induced similar VO_2peak increases as walking, while the stretching active control group remained the same. Similarly, dancing and walking improved CMJ and static balance performance. In addition, pooled effects showed improvements in body composition, lipid and inflammatory profile, and PA levels of older women after eight week interventions.

We did show that dancing induces similar improvements as walking to the cardiorespiratory capacity of older women, however, in a lower proportion (moderate and large ES for dancing and walking, or 10% and 15% increases, respectively). This is particularly important, considering the characteristics of both types of training, mainly regarding exercise intensity prescription and monitoring. While the walking training sessions can be entirely controlled, the dance sessions rely upon several unpredictable aspects, such as the speed of learning new dance routines, the homogeneity of the group, previous motor experience, *etc.*

Having said that, the gains in aerobic performance for a structured dance-based exercise intervention had as much potential as a traditional aerobic exercise in attenuating the age-associated declines in VO_2peak (Myers et al., 2015). Maximal aerobic power can decrease 5 mL·kg^{-1}·min^{-1} per decade of life from the 30's (Shephard, 2009), being each 1 mL lower than the independence threshold (18 mL·kg^{-1}·min^{-1}) related to eight times reduction in functional capacity (Arnett et al., 2008). Thus, the gains of 2,3 and 3,6 mL·kg^{-1}·min^{-1} for dancing and for walking group, respectively, may counter-interact the losses in cardiorespiratory capacity inherent to the aging process in only eight weeks of training.

Nevertheless, it should be also considered that gains in VO_2 peak might be partially related to body weight loss and/or lean mass improvements (Boo et al., 2018; Lee et al., 2012). In fact, pooled effects showed that all participants lost approximately 1 kg after the intervention period. However, only the intervention groups which trained 3 times/week (dancing and walking) increased VO_2peak, while the active control group did not (once/week stretching sessions). This suggests that the gains in cardiorespiratory fitness may be associated with the exercise training frequency, as the stretching group had similar changes in body weight, but not in aerobic fitness. As our participants did not change muscle thickness, their VO_2peak increases may be attributed to improvements in oxidative capacity as a result of regular exercise training. According to that, Lee et al. (2012) showed that although high-intensity exercise training was beneficial in whole body and abdominal fat loss; cardiorespiratory enhancement was linked to a dose-response relationship with weekly exercise volume in middle-aged women. From another point of view, it may also be suggested that the engagement in an exercise intervention only once a week (stretching) was enough to maintain cardiorespiratory capacity and avoid age-related losses, at least during eight week period.

Another point for consideration is the possible influence of the music on the psychophysical effects of the exercise. Karageorghis and Terry (1997) reviewed that synchronization of submaximal exercise with musical accompaniment results in increased work output. Also, music apparently reduces the rate of perceived exertion during submaximal exercise, and tends to enhance affective states at both medium and high levels of work intensity. The fact that the dance intervention was tailored based on specific songs set for the different parts of the class, may have positively influenced enhancements in cardiorespiratory responses of the dancers. On the other hand, cardiorespiratory responses from the walking and stretching groups were certainly not influenced by that.

The mechanisms by which dancing may improve aerobic fitness have been previously described (Rodrigues-Krause et al., 2018a). Briefly, dancing has been suggested as a form of exercise that induces favorable effects similar to aerobic-exercise training, such as improved myocardial perfusion and function, increased size and volume density of the mitochondria and oxidative enzymes of skeletal muscle, reduced endothelial dysfunction, and improved autonomic balance (Belardinelli et al., 2008). In addition, the variety of skeletal muscle contractions during the performance of dance exercises, in association with the intermittent characteristic of dancing, can lead to increases in venous return, cardiac output, and stroke volume that may be generated at maximum and sub-maximum workloads (Rodrigues-Krause et al.,

Table 3
Functional responses of older women before and after 8 weeks exercise interventions. Analysed by groups: stretching (n = 10), dance (n = 10), and walking (n = 10). Pooled effects: total (n = 30).

	Group	Before	After	Group	Time	Group *vs* time	Effect size
		Mean (CI 95%)	Mean (CI 95%)	P	p	P	d Cohen
Gait ability TUG (m·s)	Stretching	0.32 (0.29–0.35)	0.33 (0.30–0.35)	0.022	< 0.001	0.026	D × S = 0.92
	Dancing	0.33 (0.30–0.37)	0.36 (0.33–0.39)				W × S = 2.17
	Walking	0.34 (0.32–0.36)	0.39 (0.37–0.40)* γγ				
	Total	0.33 (0.31–0.35)	0.36 (0.35–0.37)				
Chair raise (s)	Stretching	11.04 (9.79 a 12.3)	8.90 (7.98–9.83)	0.073	< 0.001	0.376	D × S = 0.48
	Dancing	10.35 (9.58–11.12)	8.27 (7.73–8.81)				W × S = 0.75
	Walking	9.31 (8.79–9.82)	7.79 (7.04–8.54)				
	Total	10.23 (9.71–10.75)	8.32 (7.88–8.76)#				
Hamstrings flexibility (cm)	Stretching	−2.60 (−6.53–1.33)	0.56 (−2.93–4.05)	0.527	< 0.001	0.598	D × S = 0.28
	Dancing	0.75 (−1.83–3.33)	2.24 (−1.23–5.72)				W × S = 0.25
	Walking	0.50 (−2.82–2.92)	2.32 (−2.14–6.77)				
	Total	−0.60 (−2.44–1.24)	1.71 (−0.51–3.92)#				
Knee extensors isometric peak torque (N·m)	Stretching	114.0 (96.4–131.6)	113.0 (88.7–137.3)	0.690	0.106	0.487	D × S = 0.42
	Dancing	120.6 (104.2–137.1)	128.3 (112.2–144.5)				W × S = 0.23
	Walking	114.5 (99.8–137.3)	121.5 (105.0–138.0)				
	Total	116.4 (107.0–125.8)	120.9 (109.8–132.1)				
Knee extensors concentric peak torque 60°s (N·m)	Stretching	91.2 (78.6–103.8)	88.2 (75.6–100.82)	0.391	0.197	0.836	D × S = 0.62
	Dancing	101.8 (89.1–114.5)	101.1 (89.9–112.3)				W × S = 0.18
	Walking	96.2 (79.4–113.0)	92.7 (77.5–107.9)				
	Total	96.4 (88.2–104.6)	94.0 (86.4–101.6)				
Walking time (min·week)	Stretching	63 (7–120)	220 (30–409)	0.342	< 0.001	0.200	D × S = 0.23
	Dancing	92 (22–163)	164 (100–229)				W × S = 0.34
	Walking	99 (−6–203)	316 (188–445)				
	Total	85 (39–131)	233 (154–313)#				

D × S: effect size (d Cohen) of the dancing intervention in relation to the stretching intervention. W × S: effect size (d Cohen) of the walking intervention in relation to the stretching intervention. #: Significant time effect (pooled effects, from before to after the intervention, n = 30). TUG: Time to up and Go test. Walking time: at least for 10 min continuously during the week (not including the walking training).

2014), with the last benefits being of more importance for optimized performance in daily activities.

Particularly exploring the characteristics of our dance-based aerobic training prescription, the manipulation of exercise-to-rest ratios during the show part of the class (similar to the dancers' VT1), was successful in promoting initial stimuli for improving aerobic fitness. Along with that, gains in functional capacity showed mainly by the CMJ and static balance for both, walking and dancing interventions, enhance the potential of dancing as an alternative exercise strategy for improving several aspects that are naturally deteriorated by the aging process.

Indeed, the warm-up part of the dance sessions focused in developing functional aspects such as balance, muscle resistance and power through specific dance technique, taking up 30% of the total time of the class (Rodrigues-Krause et al., 2018b). This may explain why the gains in CMJ performance from dancing were in slightly higher clinical relevance than walking (large and moderate ES, respectively). It may be

Table 4
Body composition responses of older women before and after 8 weeks exercise interventions. Analysed by groups: stretching (n = 10), dance (n = 10), and walking (n = 10). Pooled effects: total (n = 30).

	Group	Before	After	Group	Time	Group *vs* time	Effect size
		Mean (CI 95%)	Mean (CI 95%)	P	p	P	d Cohen
Body weight (kg)	Stretching	70.3 (63.5–77.1)	69.5 (63.7–75.3)	0.584	0.003	0.758	D × S = 0.45
	Dancing	66.4 (60.3–72.5)	65.6 (59.8–71.3)				W × S = 0.00
	Walking	70.8 (63.2–78.5)	69.5 (62.1–77.8)				
	Total	69.2 (65.2–73.2)	68.2 (64.5–71.8)#				
Waist (cm)	Stretching	85.4 (79.3–91.4)	84.5 (78.7–90.3)	0.915	< 0.001	0.369	D × S = 0.19
	Dancing	84.4 (78.5–90.2)	82.7 (77.5–88)				W × S = −0.07
	Walking	86.4 (80.6–92.2)	83.8 (78.8–88.9)				
	Total	85.4 (82–88.8)	83.7 (80.6–86.8)#				
Hip (cm)	Stretching	104.3 (100.4 a 108.3)	103.9 (100.2 a 107.5)	0.797	< 0.001	0.219	D × S = 0.32
	Dancing	102.4 (97.2 a 107.6)	101.5 (96.7 a 106.4)				W × S = 0.19
	Walking	103.7 (98.7 a 108.8)	102.5 (97.8 a 107.2)				
	Total	103.5 (100.7 a 106.2)	102.6 (100.1 a 105.2)#				
VAT (mm)	Stretching	50.4 (33.1–67.7)	48.2 (34.5–61.8)	0.562	0.045	0.557	D × S = 0.61
	Dancing	45.3 (32.8–57.3)	35.9 (26.8–41.5)				W × S = 0.15
	Walking	48.5 (38.0–59.0)	44.7 (31.3–58.2)				
	Total	48.1 (40.1–56.0)	42.9 (35.9–50.0)#				
Quadriceps thickness (mm)	Stretching	65.8 (59.8–71.9)	66.2 (60.3–72.2)	0.815	0.456	0.946	D × S = 0.04
	Dancing	64.4 (59.4–69.4)	65.8 (59.0–72.6)				W × S = 0.16
	Walking	66.8 (62.8–70.8)	67.6 (63.7 a 71.5)				
	Total	65.7 (62.8–68.6)	66.5 (63.3–69.8)				

D × S: effect size (d Cohen) of the dancing intervention in relation to the stretching intervention. W × S: effect size (d Cohen) of the walking intervention in relation to the stretching intervention. #: Significant time effect (pooled effects, from before to after the intervention, n = 30). VAT: Visceral adipose tissue.

Table 5
Metabolic responses of older women before and after 8 weeks exercise interventions. Analysed by groups: stretching (n = 10), dance (n = 10), and walking (n = 10). Pooled effects: total (n = 30).

	Group	Before	After	Group	Time	Group *vs* time	Effect size
		Mean (CI 95%)	Mean (CI 95%)	P	p	P	d Cohen
Glycaemia (mg/dL)	Stretching	103.4 (97.1–109.7)	105.9 (100.0–111.7)	0.535	0.310	0.298	D × S = 0.01
	Dancing	107.1 (100.6–113.6)	106.0 (99.1–112.9)				W × S = 0.43
	Walking	106.2 (101.8–110.6)	110.5 (104.1–116.9)				
	Total	105.6 (102.2–108.9)	107.4 (103–111.1)				
Insulin (Um·mL)	Stretching	11.2 (9.1–13.2)	12.3 (10.4–14.1)	0.395	0.541	0.217	D × S = 0.10
	Dancing	12.0 (9.3–14.8)	12.0 (10.5–13.6)				W × S = 0.00
	Walking	15.0 (11.3–18.7)	12.3 (9.7–14.8)				
	Total	12.7 (11.1–14.4)	12.2 (11.0–13.4)				
HOMA-IR (u·a)	Stretching	1.50 (1.20–1.80)	1.67 (1.41–1.93)	0.372	0.608	0.200	D × S = 0.16
	Dancing	1.62 (1.28–1.96)	1.60 (1.39–1.81)				W × S = 0.02
	Walking	2.00 (1.53–2.47)	1.68 (1.35–2.02)				
	Total	1.70 (1.49–1.93)	1.65 (1.49–1.81)				
Triglycerides (mg/dL)	Stretching	144.8 (102.4–187.2)	140.2 (109.0–171.4)	0.552	0.887	0.623	D × S = 0.33
	Dancing	151.4 (113.3–189.5)	166.2 (110.3–222.1)				W × S = 0.28
	Walking	132.5 (94.7–170.4)	126.3 (100.5–152.1)				
	Total	142.9 (120.1–165.7)	144.2 (121.2–167.2)				
Total cholesterol (mg/dL)	Stretching	225.8 (195.0–256.5)	217.1 (190.5–243.7)	0.389	0.590	0.519	D × S = 0.26
	Dancing	202.7 (184.5–220.9)	203.5 (171.1–235.9)				W × S = 0.47
	Walking	195.5 (170.2–220.8)	195.7 (170.4–221.0)				
	Total	208.0 (193.4–222.6)	205.4 (189.1–221.6)				
LDL-C (mg/dL)	Stretching	150.6 (121.8–179.4)	137.5 (114.0–161.1)	0.589	0.035	0.560	D × S = 0.32
	Dancing	130.7 (115.2–146.1)	123.2 (95.7–150.6)				W × S = 0.16
	Walking	136.1 (117.4–154.7)	131.5 (112.1–151.0)				
	Total	139.1 (126.6–151.7)	130.7 (117.1–144.4)#				
HDL-C (mg/dL)	Stretching	46.2 (40.7–51.6)	50.8 (44.0–57.7)	0.466	< 0.001	0.782	D × S = 0.36
	Dancing	41.8 (30.9–52.6)	46.2 (35.4–51.0)				W × S = 0.47
	Walking	42.0 (36.5–47.4)	45.2 (38.3–52.1)				
	Total	43.3 (38.9–47.7)	47.4 (42.6–52.3)#				
CRP (mg/L)	Stretching	1.68 (1.55–1.81)	1.61 (1.48–1.74)	0.596	< 0.001	0.604	D × S = 0.23
	Dancing	1.70 (1.59–1.82)	1.56 (1.44–1.69)				W × S = 0.39
	Walking	1.56 (1.37–1.75)	1.47 (1.21–1.73)				
	Total	1.65 (1.56–1.73)	1.55 (1.44–1.65)#				
TNF-α (pg/mL)	Stretching	6.24 (5.64 to 6.85)	5.85 (5.44 to 6.26)	0.068	< 0.001	0.335	D × S = 0.51
	Dancing	7.27 (6.59 to 7.96)β	6.21 (5.81 to 6.61)				W × S = 0.31
	Walking	6.53 (6.06 to 6.99)	6.04 (5.74 to 6.35)				
	Total	6.69 (6.36 to 7.02)	6.04 (5.82 to 6.25)#				

D × S: effect size (d Cohen) of the dancing intervention in relation to the stretching intervention. W × S: effect size (d Cohen) of the walking intervention in relation to the stretching intervention. #: Significant time effect (pooled effects, from before to after the intervention, n = 30). β: Significant difference before the intervention for the dancing group compared to walking and stretching. TNF-α: tumor necrosis factor alpha. CRP: C-reactive protein. HOMA-IR: Insulin resistance homeostatic model. LDL-C and HDL-C: low and high density lipoprotein cholesterol.

also that the across-the-floor part of the dance session had the potential of enhancing muscle power. For instance, the characteristics of particular dance moves (*chasses*, *hops*, *glissades*) (Rodrigues-Krause et al., 2018b), which include successive landings from low impact jumps while moving across-the-floor, may favour the developing of lower body muscle power, just by being a weight bear activity and by recruiting the stretching-shortening cycle under a variety of stimulus (Koutedakis et al., 2005). This may be related to the greater ES for dancing than walking for lower body muscle power, as the stretching-shortening cycle is also present in walking. Also, the manipulation of the songs' bpm and exercise-to-rest ratio in this part of the class seemed enough to trigger initial adaptations in muscle power as a result of regular dance practicing. As a matter of the fact, it was demonstrated that both, either power training specific to functional tasks, or progressive resistance training, were able to induce significant changes on the performance of daily activities and self-reports of functionality in old individuals (Bean et al., 2009).

Additionally, muscle power improvements are associated with many functional aspects related to reduced risk of falls, (balance, flexibility, gait, *etc.*) (Wilhelm et al., 2014). Indeed, we also found positive pooled effects for flexibility and chair raise tests. Supporting that, recent evidence showed increased range of motion benefits in the elderly performing supported and gentle stretching exercises, which may be relevant to counter interact age-related musculoskeletal and physiological changes, such as muscle atrophy, loss of strength and elasticity (Apostolopoulos et al., 2015). Regarding muscle strength and quadriceps thickness, the fact that the interventions prevented from natural losses from the aging process, outweigh the lack of improvements, which was quite expected due to the aerobic nature of the training programmes purposed.

In relation to balance, both dancing and walking improved static balance with large clinical relevance. Technical elements from ballet (*tendus*, *jetes*, *passes* (Rodrigues-Krause et al., 2018b)), which require standing and balance on a supporting leg while moving or holding the opposite one in the air, may have induced neuromuscular adaptations for improving static balance. Also, walking on the treadmill without holding the support was quite challenge for many participants, which also may be related to not only static, but also dynamic balance and gate improvements for the walking group (TUG test). Although no statistical significance for dancing, a large ES of the dance intervention on TUG test indicates the potential of dancing in improving dynamic balance. Dancing involves even greater challenges than walking, which include moving constantly transferring the line of gravity to alternate the base of support of the body during the choreographies (Keogh et al., 2009), while performing dynamic weight shifts in the sagittal and frontal planes (Sofianidis et al., 2009). Furthermore, all of the participants were in a zone of risk of falls before the interventions for the static balance test (5 s in unipedal stance), substantially moving away from this zone at the moment after the interventions of dancing and walking.

With respect to metabolic responses, pooled effects on body composition (VAT, waist and hip circumferences) and biomarkers of CVR (LDL, HDL, TNF-α, CRP) may be explained by the relationship of VAT with lipid and inflammatory responses and PA levels. It is true that a sedentary life style leads to an accumulation of adipose tissue, just based on the fact that the energy expenditure is lower than the energy intake (Nimmo et al., 2013). In this context, free-living activity energy expenditure was strongly associated with lower risk of mortality in healthy older adults (Manini et al., 2006). Our participants did increase the level of PA by increasing the time spent in walking activities during the week (Table 3). We suggest that this could be associated to the reductions in VAT, and that it may prevent from an insulin resistance state generated by the low-grade inflammation due to increased VAT as a natural effect of aging (Krause, 2014). This is also supported by the maintenance of muscle mass (quadriceps thickness) and glycemic profile along the 8 weeks of interventions. Here, the moderate ES of dancing for VAT decreases should be mentioned. It might be that the intermittent characteristics of dance moves promoted higher energy expenditure that trigger for increased lipolysis of adipose tissue and further greater clinical relevance of the decreases in VAT.

In addition, it may be that the gentle and self-supported positions for the stretching exercises included in our three interventions may be related to inflammatory and VAT improvements in the three groups. Indeed, a single bout of low intensity passive stretching stimulated metabolism, carbohydrate oxidation, and reduced blood glucose (Russell et al., 2013). On the other hand, chronic expose to high force developments may activate local inflammatory pathways in damaged muscle fibers, resulting in pain, inflammation and tissue damage (Apostolopoulos et al., 2015). In another words, stretching intensity and joint position play a whole in inducing pro or anti-inflammatory responses in different populations, including the elderly (Apostolopoulos et al., 2015).

It seems that the simple engagement in any type of exercise intervention, even once a week (stretching) can trigger initial metabolic adaptations, which seem to be firstly connected to changes in PA levels, and secondly to exercise programme structure. The down-regulation of inflammatory molecules we found across the three groups may be related to increases in PA levels, which may have led to decreases in VAT and consequent reductions in inflammation (TNF-α and CRP). In addition, the anti-inflammatory effects of PA may improve mitochondrial function (*e.g.* oxidative metabolism), further enhancing insulin sensitivity (Ertek and Cicero, 2012). Although we did not find any difference in HOMA-IR, the greater reduction of 16% for the walking group indicates that improvements in insulin sensitivity may be dependent on structured training and longer interventions, rather than only increases in PA levels, especially regarding non-insulin resistant individuals. The importance of regular training is reinforced by the elevated levels of TNF-α and CRP negatively associated to muscle mass and insulin sensitivity (Aleman et al., 2011), muscle strength and functional capacity (Bautmans et al., 2011), aerobic fitness (Levinger et al., 2010), and fragility syndrome (Leng et al., 2011), eliciting a chronic low-grade inflammation state related to the development of sarcopenia in old individuals followed during five years (Aleman et al., 2011).

Furthermore, other specific conditioning and functional adaptations (VO_2peak, muscle power and balance) seem to be dependent on regular training. At this point, improvements in VO_2peak seem to be as a central element, because it has been associated to both, metabolic (Park et al., 2015) and functional changes (Arnett et al., 2008). Our results indicate that increases in PA levels, either as a cause or consequence of cardiorespiratory fitness gains, may be associated to (1) improvements in body composition, lipid and inflammatory profile, (2) improvements in functionality, mainly muscle power and balance. Herein, increases in aerobic capacity may be the connection in between metabolic and functional adaptations, which eventually will culminate in reduced CVR and preservation of physical independence with aging.

Overall, our results showed that a low intensity dance-based intervention can be used as a strategy of exercise to improve fitness, metabolic and functional health of healthy older women, being as much effective as walking, at least at initial stages of training. However, how to manipulate exercise-to-rest ratios to progress the dance training prescription for longer, still has to be tested. The challenge in building up a regular training prescription in dance rely on two main points: 1) the process of learning new dance routines (which reduces the effective exercise time and therefore the intensity of the class), and 2) usual difficulties of the older to withstand physiological overload due to orthopedic limitations. Finally, the limitations of this study are the small sample size to detect specific differences on the variety of outcomes assessed, and the lack of follow up after the interventions period.

5. Conclusions

Dancing induced similar VO_2peak, CMJ and static balance increases as walking in older women after eight week intervention, while the stretching group remained unchanged. Walking induced gains in cardiorespiratory fitness in a larger clinical relevance, while did dancing for lower body muscle power. Pooled effects showed improvements in body composition, lipid and inflammatory profile, which is supported by increased PA levels of the participants overall. Thus, dancing may be considered as effective as walking in improving CVR associated factors, such as VO_2peak, as well as fall-risk factors (static balance and lower body muscle power) in older women with no aging-associated comorbidities. Eventually, these metabolic and functional gains will contribute for preserving physical independence with aging.

Conflict of interest

The authors have no conflicts of interest to declare.

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Authors' contributions

J.R.-K. conceived of the original idea, developed the theory, performed the interventions, carried out cardiorespiratory and biochemical analysis, and wrote the manuscript. J.B.F. carried out cardiorespiratory and biochemical analysis. T.R.R. performed body composition and cardiorespiratory tests. R.C.O.M. performed the nutritional analysis and blood samples collection. F.P.B. carried out cardiorespiratory tests and blood samples collection. G.C.S. and J.V.J. assisted the training sessions. P.L. and R.G. carried out ultrasound, muscle strength and power tests and analysis. R.R.C. provided statistical support. R.S.P., M.K. and A.R.O. supervised the project and contributed to the final version of the manuscript.

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4. CONCLUSÕES GERAIS

De um modo geral, os resultados dos quatro estudos realizados para o desenvolvimento desta tese de doutorado indicam que a dança pode ser considerada uma alternativa de exercício para promover a saúde cardiometabólica e independência física no envelhecimento, especialmente no que concerne às mulheres entre 60 e 75 anos, sem comorbidades metabólicas, neurodegenerativas ou limitações de mobilidade associadas.

Primeiramente, o estudo inicial de revisão [1] mostrou que uma variedade de estilos de dança podem ser utilizados para induzir adaptações positivas em aspectos funcionais de idosos com ou sem condições clinicas associadas. Equilíbrio foi o desfecho mais frequentemente avaliado nos estudos usando dança como forma de intervenção, mostrando mudanças positivas tanto intra quanto entre grupos na maioria dos estudos. Modificações metabólicas positivas, relacionadas a RCV também podem ser um resultado de intervenções de dança. No entanto, a ausência de descrição da intensidade das aulas de dança, bem como progressões nas intervenções propostas em termos de volume e intensidade de treinamento, limita a interpretação desses parâmetros. Um número maior de ECRc analisando desfechos metabólicos também é necessário para fortalecer as recomendações da dança como intervenção de exercício, até então ainda muito empírica.

A partir disso, aprofundando a busca e a análise sobre os efeitos da dança em marcadores de RCV com o envelhecimento em uma revisão sistemática com metanálise [2], verificou-se de maneira mais acurada, que a dança pode ser uma intervenção de exercício potencial para aumentar o VO_2pico de idosos, e consequente RCV associado ao envelhecimento, quando comparada a grupos controle não praticantes de exercício. Os resultados também indicaram que a dança pode ser tão eficiente quanto outros tipos de exercício, apesar de apenas dois estudos terem realizado essa comparação até o momento dessa revisão. Outros marcadores de RCV, como peso corporal e IMC, não foram afetados pelas intervenções de dança incluídas nessa metanálise, mas conclusões sobre esses desfechos são limitadas pelo reduzido número de estudos. Análises não ponderadas indicaram que estudos com maior tamanho amostral, bem como maior numero de estudos, são necessários para detectar os efeitos da dança sobre o perfil lipídico de idosos e RCV associado.

Ambos os estudos de revisão identificaram número insuficiente de ECRc verificando os efeitos de intervenções de dança sobre marcadores de RCV em indivíduos idosos, assim como a baixa qualidade metodológica dos estudos. Esta última, baseada principalmente em inapropriada geração da sequência de randomização e alocação dos participantes, o que pode resultar em elevado viés de seleção. Além disso, para fortalecer o nível de evidência acerca dos benefícios da dança para saúde cardiometabólica e funcional do idoso, estudos devem também reportar os eventos adversos, a fim de basear os benefícios da dança em ambos, eficácia e segurança das intervenções. Especificamente em relação ao VO_2pico, os benefícios das intervenções de dança parecem superar os riscos, entretanto, esses fatores metodológicos devem ser considerados em estudos futuros, para aumentar a validade externa dos dados provenientes dos estudos primários. Dessa forma, haverá mais suporte metodológico para entender como as intervenções de danças podem modificar aspectos metabólicos e funcionais que naturalmente declinam com a idade.

Assim, a partir dessas duas revisões de literatura sobre efeitos de intervenções de dança em parâmetros metabólicos e funcionais associados a RCV no envelhecimento, identificaram-se duas lacunas principais, como previamente descrito: (1) a ausência de descrição de parâmetros fisiológicos de intensidade das sessões de dança, (2) número reduzido de ECRc com qualidade metodológica apropriada. A partir disso, como já mencionado na introdução, originaram-se os dois estudos experimentais dessa tese: um estudo de respostas agudas intitulado *Cardiorespiratory Responses of a Dance Session Designed for Older Women: A Cross Sectional Study*, e um ECRc intitulado *Effects of a Dance Intervention Compared to Walking on Cardiovascular Risk Factors and Functional Capacity of Older Women: a Randomized Controlled Trial*.

Especificamente em relação ao estudo de respostas agudas, as demandas cardiorrespiratórias de uma aula de dança elaborada para mulheres idosas encontraram-se majoritariamente em zona aeróbia de baixa intensidade. A parte de maior demanda cardiorrespiratória da aula foi o *show*, com respostas de VO_2 similares ao LV1 das participantes. A parte do *show* também mostrou intensidade mais elevada do que o aquecimento da aula e do que a aula inteira (todas as partes analisadas juntas). De fato, o aquecimento focou no aprendizado de elementos básicos da dança, relacionados ao desenvolvimento de aspectos funcionais, como equilíbrio, flexibilidade, resistência e potência muscular. Isso pode explicar, pelo menos em parte, o porquê das demandas cardiorrespiratórias mais baixas nessa parte da aula. Os deslocamentos e a coreografia, por sua vez, embora tenham atingido intensidades relativas ao LV1, não foram diferentes do aquecimento e da aula inteira. Deve-se considerar aqui o processo de aprendizado inerente a essas partes da aula. Assim, a parte do *show*, na qual o aprendizado das sequências coreográficas já está estabelecido, pode ser usada para desenvolver o condicionamento aeróbio, principalmente por meio da manipulação das taxas entre exercício e recuperação das coreografias. Adicionalmente, os resultados mostraram que os aumentos no VO_2 seguiram os aumentos dos bpm da música usados em diferentes partes da aula. Em outras palavras, os bpm da música têm aplicação prática para controle de intensidade nas aulas de dança. Isso é particularmente importante considerando que as respostas da FC, parâmetro comumente utilizado na prática, podem ser influenciadas pelo uso permanente de medicamentos, principalmente para controle da pressão arterial, por grande parte dos idosos.

O ECRc, por sua vez, mostrou que a dança induziu melhorias similares à caminhada para os desfechos VO_2pico, potência de salto vertical e equilíbrio estático de mulheres idosas saudáveis, após oito semanas de intervenção, com frequência de 3x/sem. Entretanto, o grupo controle ativo, que realizou sessões de alongamento 1x/sem, não apresentou nenhuma mudança nesses desfechos. A caminhada induziu ganhos cardiorrespiratórios com maior tamanho de efeito do que a dança, possivelmente devido ao controle e monitoramento de intensidade durante as sessões de treinamento. Já a magnitude das melhorias no VO_2pico do grupo dança podem ter sido influenciadas pelo processo de aprendizado inerente às atividades de dança. O quão rápido será o processo de aprendizado é fator difícil de prever e controlar em um trabalho em grupo, o que influencia o tempo efetivo exercício (taxa exercício/recuperação) nas aulas e, consequentemente, as adaptações cardiorrespiratórias subsequentes. Por outro lado, a dança induziu ganhos de potência de membros inferiores com maior tamanho de efeito do que a caminhada (verificados por uma maior altura do salto vertical). Isso pode estar relacionado aos aspectos técnicos da dança, às características intermitentes dos exercícios, e à presença ciclo alongamento-encurtamento em uma variedade de estímulos. Por exemplo, a aterrissagem de saltos de baixo impacto, os deslocamentos, poses e transferências de peso específicas dos movimentos de dança.

Em relação aos biomarcadores, o engajamento em quaisquer das intervenções propostas (dança, caminhada ou alongamento) foi capaz de induzir melhorias metabólicas, bem como melhorias na composição corporal. Possivelmente, isso está relacionado a um aumento no nível atividade física diário, representado por um aumento no tempo de caminhada (min/sem) no dia-a-dia de todas as participantes analisadas juntas. Entretanto, progressos em parâmetros funcionais e de condicionamento específicos, como capacidade cardiorrespiratória, potência de membros inferiores e equilíbrio estático, parecem ser dependentes de treinamento estruturado em termos de volume, intensidade e frequência semanal, pelo menos para idosas sem limitações funcionais. Vale ressaltar que esses fatores são extensamente relacionados à redução do risco de quedas em idosos [25], repercutindo na manutenção de sua independência física. Em especial, o VO_2pico, está relacionado a ambos, RCV [13] e capacidade funcional [14].

Dessa forma, a hipótese 1 dessa tese foi parcialmente confirmada, uma vez que a intervenção de dança foi tão eficiente quanto a intervenção de caminhada em melhorar marcadores de RCV e capacidade cardiorrespiratória em idosas. Entretanto, o grupo controle (ativo, alongamento), embora não tenha induzido ganhos cardiorrespiratórios, apresentou melhoras similares aos grupos dança e caminhada nos parâmetros metabólicos associados a RCV (tecido adiposo visceral, LDL-C, CRP, TNF-α, etc). Isso provavelmente está ligado a aumentos nos níveis de atividade física diário das participantes em geral.

A hipótese 2, de que intervenção de dança seria mais eficiente do que a intervenção de caminhada em melhorar potência muscular, equilíbrio estático e dinâmico e flexibilidade; sendo ambas as intervenções melhores do que a situação controle, também foi parcialmente confirmada. Dançar induziu ganhos em maior magnitude do que caminhar apenas sobre a potência muscular de membros inferiores, mas todas essas variáveis funcionais foram melhoradas com ambos os tipos de intervenção. Além disso, o grupo alongamento melhorou flexibilidade (esperado, pela natureza do treinamento em mulheres previamente sedentárias), embora nenhuma mudança tenha sido apresentada para os demais desfechos. Isso indica que as adaptações funcionais estão ligadas a treinamento estruturado, em termos de volume, intensidade e frequência semanal.

A hipótese 3, referente às respostas cardiorrespiratórias agudas da aula de dança, foi também parcialmente confirmada. A aula foi, de fato, realizada em intensidade predominantemente aeróbia, mas de baixa intensidade, e não moderada, como previamente sugerido. Isso demonstra a influência do processo de aprendizagem das sequências coreográficas nas demandas cardiorrespiratórias das aulas de dança.

Assim, especificamente respondendo ao objetivo geral da tese, conclui-se que a dança induziu aumentos similares à caminhada nas variáveis VO_2pico, potência de membros inferiores e equilíbrio estático em mulheres idosas após oito semanas de intervenção. Entretanto, a intervenção de alongamento (controle ativo) não foi capaz de afetar essas variáveis, que permaneceram iguais antes e depois de oito semanas. Efeitos agrupados mostraram melhorias na composição corporal, perfil lipídico e inflamatório para os três grupos de intervenção, o que pode estar relacionado a aumentos nos níveis de atividade física das participantes no geral. Adicionalmente, a análise das respostas cardiorrespiratórias agudas mostrou que a parte do *show* da aula de dança, similar ao LV1 das participantes, isto é, em zona aeróbia de baixa intensidade, pode ser usada para desenvolver o condicionamento aeróbio das idosas, pelo menos em estágios inicias de treinamento.

De forma geral, os achados dessa tese indicam que a dança pode ser considerada uma intervenção de exercício potencial para promover um envelhecimento saudável, pelo menos no que concerne a adaptações cardiorrespiratórias, funcionais e metabólicas em mulheres sem limitações físicas ou comorbidades associadas. Em geral, tais adaptações são similares a um exercício aeróbio tradicional, como a caminhada, pelo menos no que concerne aos estágios iniciais de treinamento. Equilíbrio, potência muscular e resistência aeróbia são variáveis que podem ser manipuladas em uma proposta de intervenção de dança, através de mudanças de direção, música, velocidade, transferências de peso, repetições da coreografia, etc.

Em última análise, a dança pode ser considerada tão efetiva quanto a caminhada em melhorar fatores associados a RCV, como VO_2pico, bem como fatores associados a quedas, como equilíbrio estático e potência muscular de membros inferiores. Ganhos metabólicos (relacionados a um aumento no nível de atividade física diária) e funcionais (ligados a treinamento estruturado em termos de volume, intensidade e frequência semanal) das intervenções de dança e caminhada, podem contribuir para redução de RCV e manutenção da independência física com o envelhecimento. De outro ponto de vista, o simples fato de se engajar em uma intervenção de exercício, mesmo que apenas 1x/sem (grupo alongamento), evita perdas em parâmetros que naturalmente entram em declínio com o processo de envelhecimento, como condicionamento aeróbio, força e potência muscular.

5. LIMITAÇÕES E PERSPECTIVAS FUTURAS

Como limitação comum dos estudos dessa tese está o pequeno tamanho amostral, tanto em relação ao número de estudos que atenderam aos critérios de elegibilidade da metanálise, quanto ao número de participantes necessários para detectar diferenças mais específicas nos biomarcadores avaliados no ECRc. Além disso, a ausência de seguimento dos participantes após o período de intervenção limita a extensão dos achados com relação a mudanças no estilo de vida, bem como a manutenção, ganho ou perda dos benefícios funcionais e metabólicos provenientes das intervenções. Dito isso, os tamanhos de efeito moderado e grande encontrado para o desfecho primário (VO_2pico) para dança e caminhada, respectivamente, indicam que pelo menos aproximadamente 70% dos indivíduos que experimentarem essas intervenções, no futuro, irão apresentar valores médios de VO_2pico superiores aos de um grupo controle [38]. Isso confere validade externa aos achados principais do ECRc. Em adição, há a limitação de uma avaliação de laboratório para as respostas agudas da aula de dança. É possível que dançar em um estúdio de dança com mais espaço induza demandas cardiorrespiratórias mais intensas às participantes.

Entretanto, os dados obtidos e perspectivas geradas pelos quatro estudos dessa tese podem representar uma contribuição positiva na área do envelhecimento populacional, pois tanto a dança quanto a caminhada tratam-se de intervenções não farmacológicas ou cirúrgicas, de baixo custo para a sociedade, que são adaptáveis a condições físicas diversas, contemplando idosos com diferentes características. Os materiais básicos para realização das sessões de exercício incluem uma sala com espaço para dançar e caixa de som, esteiras e/ou espaço ao ar livre para caminhada. Além disso, uma intervenção realizada em grupo pode promover sociabilidade e motivação, altas taxas de adesão e possíveis mudanças no estilo de vida que podem levar à manutenção dos ganhos metabólicos e funcionais em longo prazo [39]. Tais efeitos podem ter impacto na manutenção da independência física do idoso, principalmente considerando a redução de fatores de risco associados a quedas (força, equilíbrio, marcha) e doenças cardiovasculares (perfil lipídico, glicêmico, inflamatório) [1]. Em particular, destacam-se os aumentos no VO_2pico, relacionados a melhorias em ambos, RCV [13] e capacidade funcional [14]. Em longo prazo, isso pode resultar na redução de gastos com internações hospitalares e taxas de mortalidade associadas a reduções no nível de atividade física provocadas pelo envelhecimento [40].

Como perspectivas futuras para a linha de pesquisa em fisiologia do exercício aplicada à dança, provenientes dos resultados dos quatro estudos dessa tese, estão:

1. Desenvolver ECRc de maior porte, maior tamanho amostral, e mais longo prazo, usando a intervenção de dança descrita e testada no estudo de respostas agudas, com base na prescrição proposta no ECRc. Isso permitirá examinar o potencial de uma intervenção de dança em avançar em termos de periodização de treinamento aeróbio para os idosos.

2. Correlacionar as respostas do VO_2 a diferentes bpm de músicas de diferentes estilos de dança, testando essas respostas em diferentes populações (idosos, crianças, obesos, pacientes com ICC, Parkinson, etc).

3. Verificar os efeitos da dança para idosos com doenças crônicas, como DMT2 e obesidade, considerando os achados positivos em relação a composição corporal e marcadores inflamatórios, ligados a resistência à insulina e consequente RCV.

4. Conduzir uma revisão sistemática com metanálise sobre os efeitos de intervenções de dança no equilíbrio dinâmico de idosos saudáveis, pois já há evidências em relação a idosos com condições clínicas específicas, como a doença de Parkinson [41]. O teste TUG, mais usado para avaliação do equilíbrio dinâmico como resultado de intervenções de dança, de acordo com a nossa primeira revisão, pode ser utilizado como ferramenta metodológica na comparação de idosos praticantes de dança com grupos controle e/ou outros tipos de exercício.

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