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LEANDRO DOS SANTOS

**EFEITOS DE DIFERENTES ZONAS DE REPETIÇÕES DO
SISTEMA PIRAMIDAL CRESCENTE SOBRE A FORÇA
MUSCULAR, COMPOSIÇÃO CORPORAL E
BIOMARCADORES SANGUÍNEOS EM MULHERES IDOSAS
NÃO-TREINADAS**

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Tese de Doutorado apresentada ao Programa de Pós-Graduação Associado em Educação Física UEM/UEL, como requisito parcial para obtenção do título de Doutor em Educação Física.

Orientador: Prof. Dr. Edilson Serpeloni Cyrino
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Londrina, 29 de maio de 2017.

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“Não é sobre chegar no topo do mundo e saber que venceu. É sobre escalar e sentir que o caminho te fortaleceu.”

Ana Vilela (Trem Bala)

SANTOS, Leandro dos. **Efeitos de diferentes zonas de repetições do sistema piramidal crescente sobre a força muscular, composição corporal e biomarcadores sanguíneos em mulheres idosas não-treinadas.** 2017. 133f. Tese (Doutorado em Educação Física) – Centro de Educação Física e Esporte. Universidade Estadual de Londrina, Londrina, 2017.

RESUMO

Introdução: O treinamento com pesos (TP) é uma das principais estratégias de intervenção não-farmacológicas para prevenção e tratamento dos efeitos deletérios do envelhecimento sobre a saúde da mulher. Apesar dos inúmeros benefícios proporcionados pela prática do TP, com destaque para o aumento de força muscular, melhoria da composição corporal e do comportamento de biomarcadores sanguíneos, a magnitude das respostas induzidas por este tipo de exercício físico está associada à estrutura do programa de treinamento. Portanto, a determinação da dose-resposta adequada para maximizar os benefícios promovidos pelo TP em idosos tem sido um grande desafio para a comunidade científica. **Objetivo:** Analisar os efeitos de duas zonas de repetições do sistema de TP piramidal crescente (PR) sobre a força muscular, composição corporal e biomarcadores sanguíneos em mulheres idosas não-treinadas. **Métodos:** Sessenta mulheres idosas, fisicamente independentes e não-treinadas, foram alocadas em três grupos, a saber: grupo controle (CON, n = 20), instruído a manter o padrão de atividade física cotidiano e sem envolvimento em programas de treinamento físico sistematizados ao longo do período de intervenção; grupo pirâmide com zona de repetições restrita (NPR, n = 20, 12/10/8 repetições); grupo pirâmide com zona de repetições ampla (WPR, n = 20, 15/10/5 repetições). Ambos os grupos (NPR e WPR) foram submetidos a um período de oito semanas de treinamento com pesos no sistema PR, com zonas de repetições diferentes e volume equivalente. A massa muscular foi estimada a partir de exames de absorptometria radiológica de dupla energia (DEXA), ao passo que o estado de hidratação corporal e saúde celular foram determinados por bioimpedância espectral (BIS). Testes de uma repetição máxima (1RM) foram empregados para análise da força muscular. Bioquímica sanguínea foi utilizada para análise do perfil metabólico e inflamatório. **Resultados:** Interação significativa grupo x tempo ($P < 0,05$) foi identificada para força muscular (NPR = +11,3%, WPR = +13,8% e CON = -7,3%), massa muscular (NPR = +4,7%, WPR = +8,4% e CON = -4,5%), água corporal total (NPR = +1,1%, WPR = +1,9% e CON = -2,6%), ângulo de fase (NPR = +6,0%, WPR = +11,2% e CON = -5,9%), glicose em jejum (NPR = -7,8% e WPR = -9,5% e CON = +8,9%), HDL-C (NPR = +10,3%, WPR = +9,4% e CON = -6,1%), LDL-C (NPR = -21,4%, WPR = -15,9% e CON = +13,0%) e proteína C-reativa (NPR = -19,9%, WPR = -14,6% e CON = +23,1%). Na comparação entre os grupos submetidos ao TP, diferenças estatisticamente significantes ($P < 0,05$) foram encontradas somente para o ângulo de fase (WPR > NPR). **Conclusão:** Os resultados sugerem que o sistema piramidal crescente é efetivo para a melhoria da força muscular, composição corporal e biomarcadores sanguíneos em mulheres idosas. Além disso, a utilização de uma zona de repetições com maior amplitude parece ser mais eficiente para a melhoria da saúde celular.

Palavras-chave: Treinamento de força. Envelhecimento. Saúde. Idoso.

SANTOS, Leandro dos. **Effects of pyramid systems performed with wide or narrow repetition zone on muscle strength, body composition, and blood biomarkers in older women.** 2017. 128 pp. Thesis Project (Doctoral of Physical Education) – Physical Education and Sports Center. Londrina State University, Londrina, 2017.

ABSTRACT

Introduction: Resistance training (RT) is recognized as one of the main non-pharmacological intervention strategies for prevention and treatment of deleterious effects of aging in women's health. Despite the numerous benefits associated with the practice of RT, particularly on increased muscular strength, improves in body composition and blood biomarkers, the magnitude of responses induced by this physical exercise type is associated to training program structure. Therefore, adequate dose-response determination to maximize the benefits promoted by RT in old people has been a major challenge for the scientific community. **Objective:** The main objective was to analyze the effects of two different forms of manipulation of the crescent pyramidal RT system on muscle strength, body composition and blood biomarkers in old women. **Methods:** Sixty untrained older women were allocated in three groups, a control group (CON, n = 20), who were instructed to maintain their normal physical activity pattern and not to engage in systematic training programs over the period of intervention and two groups of RT, which were submitted to 8 weeks of training in the PR system, with different repetition zones and equivalent volume, namely: pyramidal group with narrow repetition zone (NPR, n = 20, 12/10 / 8 petitions) and pyramid group with wide repetition zone (WPR, n = 20, 15/10/5 replications). Body composition was determined by dual-energy X-ray absorptiometry (DXA), body hydration status and cellular health were determined by spectral bioimpedance (BIS). Tests of a maximal repetition (1RM) were used to analyze muscle strength. Blood biochemistry was used to analyze the metabolic and inflammatory profile. All measurements were taken at the baseline and the end of the intervention period. **Results:** Significant interaction group x time (P <0.05) was identified for muscle strength (NPR = + 11.3%, WPR = + 13.8% and CON = -7.3%), muscle mass (NPR = + 1.1%, WPR = + 1.9% and CON = -2.6%), phase angle (NPR = +6.0%, WPR = + 11.2% and CON = -5.9%), (NPR = -7.8%, WPR = -9.5% and CON = + 8.9%), HDL-C (NPR = + 10.3%, WPR = + 9.4% CON = -6.1%), LDL-C (NPR = -21.4%, WPR = -15.9% and CON = + 13.0%) and C-reactive protein (NPR = -19.9% WPR = -14.6% and CON = + 23.1%). In the comparison between the groups submitted to PT, statistically significant differences (P <0.05) were found only for the phase angle (WPR>NPR). **Conclusion:** The results suggest that the increasing pyramidal system is effective for the improvement of muscle strength, body composition and blood biomarkers in elderly women. In addition, the use of a wider repetitions zone seems to be more efficient for improving cellular health.

Keywords: Strength training. Aging. Health. Older.

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1RM	Uma repetição máxima
ABF	Gordura corporal andróide
ASMM	Massa muscular apendicular
BIA	Impedância bioelétrica
BIS	Bioimpedância espectral
BIVA	Análise dos vetores da impedância bioelétrica
BMI	Índice de massa corporal
CON	Grupo controle
CP	Supino vertical
CRP	Proteína C-reativa
DXA	Absortometria radiológica de dupla energia
ECF	Fluídos extracelulares
ES	Tamanho do efeito
FFM	Massa isenta de gordura
FM	Massa gorda
GBF	Gordura corporal ginóide
GEPEMENE	Grupo de estudos e pesquisa em metabolismo, nutrição e exercício
GLU	Glicose
HDL-C	Lipoproteína de alta densidade
ICC	Coeficiente de correlação intraclasse
ICF	Fluídos intracelulares
KE	Extensão de joelhos
LDL-C	Lipoproteína de baixa densidade
LLMM	Massa muscular dos membros inferiores
LST	Tecido mole magro
NPR	Grupo piramidal com zona de repetições restrita
PC	Rosca scott
PhA	Ângulo de fase
PR	Sistema piramidal
R	Resistencia
RT	Treinamento com pesos
SEM	Erro padrão de medição

SMM	Massa muscular esquelética
TBF	Gordura corporal total
TBW	Água corporal total
TC	Colesterol total
TG	Triglicérides
TP	Treinamento com pesos
ULMM	Massa muscular de membros superiores
WPR	Grupo sistema piramidal com zona de repetições ampla
Xc	Reactância

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CAPITULO 1

Projeto de pesquisa

1.1 INTRODUÇÃO

Diversos sistemas de treinamento com pesos (TP) têm sido utilizados por atletas e não-atletas na tentativa de melhorar o desempenho físico ou, ainda, induzir adaptações crônicas de maior magnitude (AHTIAINEN et al., 2003; 2004; CHARRO et al., 2010; 2012; FISHER et al., 2014; HEAVENS et al., 2014; AGUIAR et al., 2015; ANGLERI; UGRINOWITSCH; LIBARDI, 2017; FINK et al., 2017). Entretanto, muitos desses sistemas, apesar de serem frequentemente utilizados, carecem ainda de um maior número de investigações científicas que comprovem ou não a efetividade da aplicação de cada um deles para se atingir diferentes objetivos (hipertrofia muscular, emagrecimento, definição muscular, etc.) em diversas populações (atletas, não atletas, jovens, adultos, idosos, entre outras).

Entre os sistemas de TP mais frequentemente utilizados, o sistema piramidal se destaca por possibilitar uma importante variação de estímulos, em virtude da manipulação simultânea do volume e da intensidade do treinamento, caracterizada pelo aumento das cargas (intensidade) com redução do número de repetições (volume) a cada série ou vice-versa. Nesse sentido, considerando a interdependência entre volume e intensidade, a utilização de cargas elevadas tende a gerar um número de repetições reduzido favorecendo um maior estímulo mecânico, ao passo que um alto número de repetições é suportado por cargas relativamente mais leves o que favorece um maior estímulo metabólico. Portanto, é plausível acreditar que o sistema piramidal permite uma boa combinação entre estímulos mecânicos e metabólicos, possibilitando uma maior gama de respostas adaptativas do que outros sistemas que adotam cargas e/ou número de repetições fixas, tais como o sistema tradicional, pré-exaustão, super-set, série composta, tri-set, entre outros.

Três são as formas mais comuns de estruturação do sistema de treinamento piramidal, a saber: (1) pirâmide crescente ou ascendente, cujas cargas aumentam a cada série, enquanto o número de repetições diminui; (2) pirâmide decrescente ou descendente, cujas cargas diminuem a cada série, enquanto o número de repetições aumenta; (3) sistema triangular que adota a combinação entre as duas estratégias anteriores, com as cargas aumentando até uma determinada série e passando a serem reduzidas nas séries subsequentes, comportamento inverso do número de repetições a ser executado em cada série. Acredita-se que o sistema piramidal seja uma adaptação dos métodos DeLorme (DELORME; WEST; SHRIBER, 1950; DE LORME; FERRIS; GALLAGHER, 1952; TODD; SHURLEY; TODD, 2012) e Oxford (ZINOVIEFF, 1951).

No método DeLorme a carga de treinamento era fixada em 50%, 75% e 100% de 10RM e os indivíduos deveriam realizar uma série em cada intensidade (DELORME; WEST; SHRIBER, 1950; DE LORME; FERRIS; GALLAGHER, 1952; TODD; SHURLEY; TODD, 2012), ao passo que no método Oxford a primeira série iniciava-se com 100% de 10RM e, nas séries subsequentes, a carga era reduzida para 75% e 50% para a realização do mesmo número de repetições (ZINOVIEFF, 1951).

Das três possíveis formas de estruturação do sistema piramidal, o modelo denominado de crescente ou ascendente parece ser o mais atraente, uma vez que os aumentos progressivos das cargas a cada série podem favorecer à estimulação de unidades motoras com diferentes potenciais de excitação, proporcionando uma preparação gradativa do sistema neuromuscular para esforços mais intensos, bem como preparação psicológica para estímulos cada vez maiores, o que em tese pode induzir importantes aumentos de força e massa muscular.

Em mulheres idosas não-treinadas, estudos recentes do Grupo de Estudo e Pesquisa em Metabolismo Nutrição e Exercício (GEPEMENE) demonstraram a eficácia do sistema piramidal crescente para a melhoria da força e hipertrofia (RIBEIRO et al., 2016a); redução da glicose em jejum, triglicérides, LDL-C e proteína C-reativa; aumento de HDL-C e melhoria da qualidade muscular (RIBEIRO et al., 2016a). Tais modificações ocorreram de forma similar a um outro grupo submetido ao sistema de treinamento tradicional. Provavelmente, os resultados encontrados nesses dois estudos, em particular, tenham sido influenciados, pelo menos em parte, pelo número de repetições relativamente semelhante, estabelecido para ambos os grupos (três séries de 8 a 12 repetições no grupo tradicional e três séries de 12/10/8 repetições no grupo pirâmide crescente). Adicionalmente, com a redução nos níveis de força muscular com o avançar da idade, a pequena variação no número de repetições entre as séries, no grupo submetido ao sistema piramidal, parece não ter sido suficiente para a diferenciação dos estímulos realizados pelo grupo submetido ao sistema de treinamento tradicional, o que teria resultado em volume e intensidade de treinamento muito próximos em ambos os grupos. Portanto, não se pode desprezar a necessidade de se adotar uma variação maior no número de repetições entre cada série ao utilizar o sistema de treinamento piramidal para promover um TP com intensidade progressiva em idosos.

O TP tem sido reconhecido historicamente e indicado para o desenvolvimento e manutenção da força muscular e do tecido muscular esquelético (GARBER et al., 2011), bem como, na prevenção e tratamento de diferentes patologias (WESTCOTT, 2012). Além desses benefícios, o TP pode auxiliar na redução do tecido adiposo (CAMPBELL et al., 1994), manutenção ou melhora do equilíbrio estático e dinâmico (ORR; RAYMOND; FIATARONE SINGH, 2008) e da

flexibilidade (CARNEIRO et al., 2015), aumento da velocidade da marcha (SANTOS et al., 2017), melhora da função cognitiva (WESTCOTT, 2012) e do perfil inflamatório (CALLE; FERNANDEZ, 2010; TOMELERI et al., 2016), redução do estresse oxidativo (PADILHA et al., 2015), melhora da autonomia funcional (LIU, LATHAM, 2009; DIAS et al., 2015). Logo, esse tipo de treinamento pode trazer inúmeros benefícios, particularmente, para a população idosa.

É importante ressaltar que o envelhecimento é um processo gradual e contínuo, responsável por alterações importantes na composição corporal, sobretudo em mulheres, promovendo em média incrementos superiores aos dos homens na massa corporal (0,55 kg/ano vs. 0,3 kg/ano) e no índice de massa corporal (IMC = 0,22 kg/m²/ano vs. 0,11 kg/m²/ano) (BUFFA et al., 2011). Esse aumento é relativamente constante até aproximadamente a sétima década de vida, quando uma redução gradativa, tanto nos valores de massa corporal, quanto do IMC, passa a ocorrer em ambos os sexos (PERISSINOTTO et al., 2002). Às alterações na massa corporal e no IMC guardam estreita relação com alterações teciduais, como o aumento da adiposidade corporal (subcutânea, visceral e ectópica), redução da massa corporal magra, em especial do tecido muscular esquelético, e diminuição da densidade e do conteúdo mineral ósseo (BUFFA et al., 2011). Tais alterações ocorrem ao longo da vida, com importantes consequências funcionais e metabólicas para a longevidade (FIELDING et al., 2011).

Outro aspecto importante é que a senescência influencia no balanço hídrico dos tecidos, especialmente pela redução dos fluídos intracelulares em paralelo a redução da massa isenta de gordura (BUFFA et al., 2011). Em mulheres, a água corporal total se mantém constante até a meia-idade e diminui acentuadamente após os 60 anos de idade (SCHOELLER, 1989). Estas alterações têm sido acompanhadas

por meio da análise dos vetores da impedância bioelétrica (BIVA) e do ângulo de fase (PHA) e associadas com desnutrição (CAMINA MARTIN et al., 2014; SLEE; BIRC; STOKOE, 2015), sarcopenia (MARINI et al., 2012) e saúde celular (GUNN et al., 2008; DITTMAR; REBER; KAHALY, 2015).

O tecido muscular esquelético compreende em média 30% a 40% da massa corporal total de um adulto jovem, dividido em aproximadamente 600 músculos, que além de responsáveis pela manutenção da postura, locomoção e controle da temperatura corporal, são grandes armazenadores e consumidores de energia, com quantidades substanciais de triglicérides e glicogênio (SCHNYDER; HANDSCHIN, 2015). A capacidade dos músculos em produzir e secretar citocinas e outras proteínas capazes de exercer efeitos sob diferentes tecidos e órgãos do corpo humano, permite classificar o tecido muscular esquelético como um órgão endócrino (SCHNYDER; HANDSCHIN, 2015). Entre os 20 e os 80 anos de idade, ocorre uma redução na ordem de aproximadamente 30% no tecido muscular esquelético, com a taxa de declínio sendo próxima de 4% por década de vida após os 60 anos de idade (MITCHELL et al., 2012). Tal degradação ocorre em virtude da redução, tanto do tamanho, quanto do número de fibras musculares (LEXELL et al., 1983).

Na tentativa de identificar os efeitos da perda do tecido muscular esquelético durante o envelhecimento e a longevidade, estudos tem relacionado este declínio ao risco para o desenvolvimento de doenças cardiometabólicas (MICHAUD et al., 2013; ALEMAN-MATEO et al., 2014; COSTANTINO; PANENI; COSENTINO, 2015; LIU, LI, 2015), sarcopenia (FIELDING et al., 2011; MONTERO-FERNANDEZ, SERRA-REXACH, 2013), caquexia (EVANS, 2010; MORLEY, ANKER, VON HAEHLING, 2014) e perda da independência funcional (CLARK, MANINI, 2010; SANTOS et al., 2016). Além disso, a redução do tecido muscular esquelético revelou-

se um fator de risco independente para mortalidade (KIM et al., 2014; FILIPPIN et al., 2015).

Entretanto, tanto a redução, quanto o aumento da massa corporal, são fenômenos que podem ocorrer de forma independente de alterações no tecido muscular esquelético ou no tecido adiposo (GALLAGHER et al., 2000; NEWMAN et al., 2005). Aproximadamente 9% do corpo das mulheres é composto por gordura essencial, localizada na medula óssea, coração, pulmões, fígado, rins, intestinos, músculos e sistema nervoso central. Adicionalmente, as mulheres armazenam aproximadamente 15% de gordura subcutânea e visceral, o que assegura um bom funcionamento dos sistemas orgânicos (NORGAN, 1997).

Ao longo da vida as mulheres passam por um processo de redistribuição da gordura corporal, com aumento da adiposidade do tipo ginóide (WELLS, 2007) na idade adulta e transição para a adiposidade andróide no período pré-menopausa, especialmente a adiposidade abdominal, visceral e ectópica, perdurando durante a senescência (TOTH et al., 2000; WELLS, 2007; PARK et al., 2013). O tecido adiposo, além de armazenar energia, é um órgão endócrino, responsável pela secreção de diversas substâncias bioativas, como a leptina e a adiponectina, que podem provocar importantes alterações no metabolismo da glicose (GLI), na sensação de saciedade, no comportamento da pressão arterial, entre outras (FORTUNO et al., 2003). Tanto a menopausa, quanto o processo de envelhecimento, promovem alterações na adiposidade ectópica e visceral, fatores de risco preponderantes para o desenvolvimento de doenças cardiometabólicas (NICKLAS et al., 2004; LIM; MEIGS, 2013; PARK et al., 2013; SMITH, 2015). Assim, o aumento do perímetro abdominal e a obesidade têm sido associados ao maior risco para a redução da autonomia

funcional e qualidade de vida (BATSIS et al., 2014; RILLAMAS-SUN et al., 2014; BATSIS et al., 2015).

Além das alterações na composição corporal, o envelhecimento promove alterações metabólicas, predispondo os idosos a um quadro pró-inflamatório, o qual *per si*, aumenta o risco para o desenvolvimento de doenças cardiometabólicas e a morte (SOWERS et al., 2007; COSTANTINO; PANENI; COSENTINO, 2015; LIU, LI, 2015). A idade e o sexo são dois fatores fisiológicos que exercem influência nas concentrações de lipídeos e de lipoproteínas, de modo que o envelhecimento promove elevações substanciais nas concentrações plasmáticas de lipoproteínas de baixa densidade (LDL-C) (ABBOTT et al., 1983). Nas mulheres, o período pós-menopausa pode causar aumento nos níveis plasmáticos do LDL-C, bem como dos níveis de colesterol total (CT), que a partir da quinta década de vida podem ser superiores em relação aos homens de mesma idade (KREISBERG; KASIM, 1987).

De forma associada, o acúmulo de adiposidade visceral e as desordens no metabolismo dos lipídeos apresentam relação com o aumento dos ácidos graxos livres e glicerol circulante (BJÖRNTORP, 1992), acarretando aumento da resistência à insulina e ineficiência dos adipócitos em reciclar eficazmente os ácidos graxos livres (RYAN, 2000). Essas alterações provocam o aumento nas concentrações de glicose e insulina no sangue, podendo resultar em risco elevado para o desenvolvimento de diabetes do tipo 2, hipertensão, síndrome metabólica e doenças cardiovasculares (RYAN, 2000; LIU; LI, 2015).

Por outro lado, os resultados de algumas pesquisas indicam que a perda da força muscular pode ser considerada a alteração de maior impacto para a saúde e qualidade de vida do idoso (CLARK, MANINI, 2008; 2010; 2012). Apesar da conhecida relação entre o declínio da força muscular e a redução do tecido muscular esquelético,

nem o volume tecidual, nem o desuso são determinantes nesta relação, visto que, possivelmente, o maior contributo esteja nas alterações celulares, neurais e/ou metabólicas no tecido muscular esquelético, influenciando na qualidade muscular (GOODPASTER et al., 2006; NEWMAN et al., 2006; DELMONICO et al., 2009). Prova disso é que após os 70 anos de idade, as mulheres tendem a perder aproximadamente 3% da força muscular a cada ano (GOODPASTER et al., 2006) e essa perda é de duas a cinco vezes maiores que a perda de tecido muscular esquelético (MITCHELL et al., 2012). Esse declínio pode estar associado a alterações na composição e na arquitetura muscular (FRAGALA; KENNY; KUCHEL, 2015).

A redução no tamanho das fibras musculares, o ângulo de penação alterado, declínio na síntese de proteínas, devido ao ambiente pró-inflamatório, aliado ao aumento no número de lisossomos, resultam em prejuízos a função contrátil e aumento da degradação proteica, processos que parecem estar diretamente relacionados a redução da força muscular (FRAGALA; KENNY; KUCHEL, 2015). Além disso, a infiltração adiposa no músculo (DELMONICO et al., 2009) e a neurodegeneração, ou seja, declínio funcional e estrutural neuromuscular, com perda do axônio motor, ou até mesmo de todo o motoneurônio, bem como alterações nas junções neuromusculares, ou junções mioneurais, também contribuem para esse declínio (DELBONO, 2003; CLARK, FIELDING, 2012).

Clark e Manini (CLARK; MANINI, 2008) denominaram dinapenia a perda de força muscular advinda do processo de envelhecimento e a sua ocorrência tem sido associada a queda da função cognitiva (HUANG et al., 2015), redução da autonomia funcional (CLARK, MANINI, 2010; YANG et al., 2014; SANTOS et al., 2016) e mortalidade (NEWMAN et al., 2006; MITCHELL et al., 2012). Apesar do processo de envelhecimento afetar a força muscular, o exercício físico tem sido uma das

contramedidas mais eficazes para sua manutenção e/ou aumento, em especial o TP (PETERSON; RHEA; ALVAR, 2005; PETERSON et al., 2010; HURLEY; HANSON; SHEAFF, 2011; PETERSON; GORDON, 2011; SILVA et al., 2014).

Entretanto, informações sobre a forma de progressão no TP e condutas efetivas para induzirem uma relação dose-resposta, evitar lesões e minimizar os riscos da prática em idosos, ainda, são escassas e necessárias (PETERSON; GORDON, 2011; BORDE; HORTOBAGYI; GRANACHER, 2015).

1.2 OBJETIVOS

1.2.1 Objetivo geral

- Comparar os efeitos de diferentes zonas de repetições do sistema piramidal crescente sobre a força muscular, composição corporal e biomarcadores sanguíneos em mulheres idosas não-treinadas.

1.2.2 Objetivos específicos

- Analisar os efeitos de diferentes zonas de repetições do sistema piramidal crescente sobre a força muscular e hipertrofia muscular em mulheres idosas (Artigo 1);
- Comparar os efeitos de diferentes zonas de repetições do sistema piramidal crescente sobre a adiposidade corporal e biomarcadores sanguíneos em mulheres idosas (Artigo 2);
- Investigar os efeitos de diferentes zonas de repetições do sistema piramidal crescente sobre os vetores da bioimpedância e o ângulo de fase em mulheres idosas (Artigo 3).

1.3 MÉTODOS

1.3.1 Participantes

A amostra de mulheres idosas foi selecionada voluntariamente a partir da divulgação por meio da distribuição de panfletos em residências, feiras e regiões comerciais próximas ao local de treinamento, além de informativos em jornais, rádio e televisão. As interessadas foram convidadas a participar de uma reunião preliminar, na qual foi apresentada a proposta do estudo. Na sequência, as candidatas foram submetidas a uma entrevista estruturada, incluindo uma anamnese clínica. Os critérios iniciais de inclusão foram: (1) possuir idade igual ou superior a 60 anos; (2) ser aparentemente saudável e fisicamente independente; (3) não ser portadora de doenças cardíacas; (4) não estar envolvida com a prática de treinamento com pesos nos seis meses precedentes ao início do estudo. Além disso, as participantes somente foram incluídas no estudo após serem liberadas sem restrição para a participação em programas de exercícios físicos, mediante avaliação médica atestada por médico cardiologista.

O cálculo para o tamanho da amostra foi estabelecido adotando-se a massa muscular esquelética como variável critério, utilizando o tamanho do efeito igual a 0,24, observado em um estudo recente conduzido pelo nosso laboratório, no qual o treinamento de meia-pirâmide crescente, com séries de 12, 10 e 8 repetições foi realizado durante oito semanas (RIBEIRO et al., 2016a). O cálculo indicou a necessidade de 15 sujeitos por grupo para se atingir a significância de 5% e o poder estatístico de 80%. Foram acrescentados 20% para possíveis perdas amostrais, totalizando 18 idosas em cada grupo. Para o cálculo foi adotado um delineamento

com análise de variância para medidas repetidas com interação entre fatores. A análise foi realizada no G*Power, versão 3.1.9.2 e o protocolo pode ser visualizado no Apêndice A.

Após serem amplamente esclarecidas sobre o propósito deste estudo e os procedimentos aos quais seriam submetidas, as participantes assinaram um Termo de Consentimento Livre e Esclarecido (Apêndice B). Este estudo faz parte de um projeto mais amplo de intervenção com mulheres idosas submetidas ao TP que foi aprovado pelo Comitê de Ética em Pesquisa da Universidade Estadual de Londrina, de acordo com a Declaração de Helsinque.

1.3.2 Delineamento do estudo

Este estudo teve duração de 12 semanas nas quais as participantes foram aleatoriamente alocadas em três grupos, a saber: grupo controle (CON), instruído a manter o padrão de atividade física cotidiano e sem envolvimento em programas de treinamento físico sistematizados ao longo do período de intervenção; grupo pirâmide com zona de repetições restrita (NPR, 12/10/8 repetições); grupo pirâmide com zona de repetições ampla (WPR, 15/10/5 repetições). Ambos os grupos (NPR e WPR) foram submetidos a um período de oito semanas de treinamento com pesos no sistema PR (semanas 3 a 10), com zonas de repetições diferentes e volume equivalente. As primeiras duas semanas (1 e 2) e as duas últimas (semanas 11 e 12) foram utilizadas para realização de medidas antropométricas, testes de força máxima (1RM), exames de absorptometria radiológica de dupla energia (DEXA) e bioimpedância espectral, bem como, para coletas de sangue em jejum.

1.3.3 Medidas antropométricas e de composição corporal

1.3.3.1 Antropometria

A massa corporal foi determinada em uma balança com leitura digital (Balmak, modelo Classe III, São Paulo, SP, Brasil), com escala de 0,1 kg, enquanto a estatura foi medida em um estadiômetro acoplado ao mesmo equipamento, com escala de 0,1 cm. A partir dessas medidas, foi calculado o índice de massa corporal (IMC), por meio da razão entre a massa corporal e o quadrado da estatura, sendo a massa corporal expressa em quilogramas (kg) e a estatura em metros (m).

1.3.3.2 Composição corporal

Exames de DEXA foram realizados em um equipamento da marca Lunar (Prodigy, modelo GE Healthcare, ID 14739, Madison, WI, USA), mediante escaneamento de corpo inteiro. A calibragem do equipamento seguiu as recomendações do fabricante. Tanto a calibragem, quanto as análises, foram realizadas por um técnico do laboratório com experiência nesse tipo de avaliação. As participantes foram submetidas aos exames trajando roupas leves, descalças e sem portar nenhum objeto metálico ou qualquer outro acessório junto ao corpo. As mulheres permaneceram deitadas e imóveis sobre a mesa do equipamento até a finalização da medida. Após a varredura de corpo inteiro, o programa forneceu os dados relativos ao tecido gordo, tecido ósseo e tecido magro e mole, para o corpo todo e regiões específicas (tronco e membros superiores e inferiores). O coeficiente de correlação intraclass (ICC) é de 0,99, com erro padrão de medição (SEM) de 0,7

kg para o tecido magro e mole, ICC de 0,99 e SEM de 0,3 kg para o tecido gordo e ICC de 0,99 e SEM de 0,2 para o tecido ósseo.

Os membros foram demarcados e separados do tronco e da cabeça por linhas padronizadas geradas pelo *software* do próprio equipamento. As linhas foram ajustadas pelo técnico, por meio de pontos anatômicos específicos, conforme manual do equipamento. A massa muscular esquelética total, foi estimada a partir da quantificação do tecido magro e mole apendicular, mediante a utilização da equação preditiva proposta por Kim et al. (KIM et al., 2002), a saber:

$$MME = (1,13 \times ASMM) - (0,02 \times idade) + (0,61 \times sexo) + 0,97$$

Onde MME = massa muscular esquelética. ASMM = massa isenta de gordura e osso apendicular. Sexo: mulher = 0. O ICC do nosso laboratório é de 0,99 e o SEM de 0,5 kg para a MME.

1.3.3.3 Água corporal e vetores da bioimpedância

Para determinação da água corporal total (ACT) e estimativas das frações intracelular (AIC) e extracelular (AEC), bem como, para análise dos vetores da bioimpedância (BIVA) foi utilizado um equipamento de bioimpedância espectral multifrequencial tetrapolar (Xitron 4200, Bioimpedance Spectrum Analyzer, San Diego, Califórnia, USA). As participantes foram posicionadas em decúbito dorsal, em uma maca isolada de condutores elétricos, com as pernas abduzidas num ângulo de 45°. Após a limpeza da pele com álcool, dois eletrodos foram colocados na superfície da mão direita e dois no pé direito, de acordo com os procedimentos

descritos na literatura(SARDINHA et al., 1998). Na tentativa de minimizar possíveis erros de estimativa, as participantes foram orientadas a: (1) urinar cerca de 30 min antes da realização das medidas;(2) abster-se da ingestão de alimentos ou bebidas nas quatro horas precedentes a cada exame; (3) evitar a prática de exercícios físicos vigorosos nas 24h precedentes a cada exame; (4) abster-se do consumo de bebidas alcoólicas e/oucafeinadas por no mínimo 48h antes da realização de cada exame; (5) evitar o uso de bebidas diuréticas ao longo dos sete dias precedentes a cada exame. ICC de 0,98 e SEM de 0.3 L para ACE, ICC de 0,99 e SEM de 0.2 L para ACI e ICC de 0,98 e SEM de 0.3 L para a ACT.

Os dados brutos de resistência (R) e reactância (Xc) na frequência de 50 Hz foram utilizados para calcular o ângulo de fase. Após a padronização pela estatura, para redução do efeito do condutor, foram traçados os vetores de impedância média, por meio das medidas de R/est. e Xc/est. em cada grupo, com suas elipses de confiança de 95% e a análise do deslocamento dos vetores foi realizada com uso do *BIVA software 2002* (PICCOLI, ANTONIO; PASTORI, 2002). ICC de 0,95 e SEM de 15.6 ohms para a R, ICC de 0,96 e SEM de 3.5 ohms para a Xc, ICC de 0,96 e SEM de 0.2 graus para o ângulo de fase.

1.3.4 Força muscular

Para a avaliação da força muscular foram aplicados testes de 1RM em três exercícios, envolvendo os segmentos do tronco, membros inferiores e membros superiores. A ordem de execução dos exercícios testados foi a seguinte: supino vertical, cadeira extensora e rosca *Scott*, respectivamente. As participantes foram instruídas previamente sobre todos os procedimentos e técnicas a serem exigidas nos

testes e em seguida foram submetidas a três sessões de testagens, de acordo com as recomendações da literatura (AMARANTE DO NASCIMENTO et al., 2013). Todos os testes foram realizados no período da manhã, com intervalo de 48 h entre cada sessão. Um aquecimento específico foi adotado antes da realização da primeira tentativa, em cada exercício, com a execução de uma série de 6 a 10 repetições com aproximadamente 50% da carga a ser testada. Dois minutos após o final do aquecimento foi iniciada a primeira tentativa. As participantes foram submetidas a três tentativas em cada exercício, com intervalo de três a cinco minutos entre elas. Para a transição entre os exercícios foi adotado um intervalo fixo de cinco minutos. As participantes foram orientadas para tentarem realizar duas repetições em cada tentativa. Quando uma ou duas repetições eram executadas, a carga era aumentada de 3 a 10% para a próxima tentativa. Por outro lado, a carga era reduzida de 3 a 10% para uma próxima tentativa quando nenhuma repetição era executada. A carga registrada como 1RM em cada exercício foi aquela na qual cada participante só conseguiu realizar uma única repetição máxima. Foram utilizados três avaliadores, sendo designado um avaliador fixo para cada exercício em todos os momentos do estudo. Vale ressaltar que a forma e a técnica de execução de cada exercício foram padronizadas e continuamente monitoradas na tentativa de garantir a eficiência do teste. ICC de 0,99 e SEM de 0,4 kg para o supino, ICC de 0,99 e SEM de 0,9 kg para a extensora e ICC de 0,97 e SEM de 0,5 kg para o roscascott.

1.3.5 Coleta de sangue e análises bioquímicas

Coletas de sangue venoso foram utilizadas para a determinação da glicose em jejum, do perfil lipídico e da proteína C-reativa. Para tanto, um experiente técnico

de laboratório de Análises Clínicas coletou amostras de 14 mL de sangue, após jejum de 12 horas, no período matutino. As amostras foram depositadas em tubos a vácuo, com gel separador sem anticoagulante, e centrifugadas por 10 min a 3.000 g para separação do soro. O plasma e o soro foram aliquotados e armazenados em freezer a -80°C (Indrel®) até a realização das análises. Posteriormente, em um sistema autoanalisador bioquímico DadeBehring Dimension RXL (DadeBehring Inc., Newark, DE, USA), de acordo com métodos consagrados na literatura especializada, seguindo os protocolos recomendados pelos fabricantes, determinou-se as concentrações de proteína C-reativa ultrasensível (PCR-us), colesterol total (CT), lipoproteínas de alta densidade (HDL-C), triglicerídeos (TG) e glicemia (GLI). Para a determinação da lipoproteína de baixa densidade (LDL-C) foi utilizada a equação $LDL-C = CT - (HDL-C + TG/5)$ (FRIEDEWALD et al., 1972).

1.3.6 Hábitos alimentares

Recordatórios alimentares de 24 h foram aplicados três dias, no início e no final do período de intervenção, para o monitoramento dos hábitos alimentares das participantes. Os registros foram obtidos em dois dias da semana útil e um dia no final de semana por uma equipe treinada composta por três nutricionistas. Medidas caseiras padronizadas foram utilizadas para a estimativa da quantidade de alimentos e bebidas consumidas. O consumo energético total e as proporções ingeridas de macronutrientes foram determinadas por meio do programa para avaliação nutricional NutWin, versão 1.5. As participantes foram orientadas a não modificarem seus hábitos alimentares diários durante todo o período de duração do estudo. A ingestão de água foi *ad libitum*.

1.3.7 Programa de treinamento com pesos

O programa de TP foi estruturado de acordo com as recomendações da literatura (ACSM, 2009; GARBER et al., 2011; CADORE et al., 2014), sendo realizado com frequência de três sessões semanais, em dias alternados (segundas, quartas e sextas-feiras), no período da manhã, durante oito semanas.

Uma única programação foi utilizada, incluindo oito exercícios para os diferentes segmentos corporais (tronco, membros superiores e inferiores), que foram executados em ordem alternada por segmento, a saber: supino vertical, *legpress*, remada sentada, cadeira extensora, rosca *Scott*, mesa flexora, tríceps no *pulley* e panturrilha sentada. As diferenças entre os dois grupos submetidos ao TP foram no número de repetições executadas em cada exercício, com o grupo NPR realizando 12/10/8 repetições, respectivamente, em cada série, ao passo que o grupo WPR realizou 15/10/5 repetições, respectivamente.

O intervalo de recuperação estabelecido entre as séries e os exercícios foi de 60 a 120 s. As cargas utilizadas foram compatíveis com o número de repetições estipuladas para as três séries de cada exercício. A progressão em cada exercício ocorreu quando o participante foi capaz de realizar 10 (NPR) ou 7 (WPR) repetições no último conjunto de duas sessões consecutivas. A progressão foi realizada aumentando a carga para os exercícios dos membros superiores e dos membros inferiores em 2-5% e 5-10%, respectivamente, em cada conjunto, na sessão seguinte

de treinamento (ACSM, 2009). As participantes foram orientadas a executar as ações musculares concêntricas e excêntricas em uma razão de 1 : 2, respectivamente.

Todas as sessões de treinamento foram supervisionadas por estudantes de graduação e pós-graduação em Educação Física. Na tentativa de analisar o efeito isolado do TP, as participantes foram orientadas para que durante o período de intervenção não se envolvessem com a prática de nenhum outro programa de treinamento físico.

1.3.8 Análise estatística

Inicialmente, o teste de *Kolmogorov-Smirnov* foi utilizado para a análise da distribuição dos dados. A partir daí as informações foram apresentadas em valores de média e desvio padrão, valores percentuais ou escores-z. O teste de *Levene* foi utilizado para análise da homogeneidade das variâncias. O teste de *Mauchly* foi aplicado para verificar a esfericidade, quando houve violação deste pressuposto, as análises foram ajustadas pela correção de *Greenhouse-Geiser*. Análise de variância (ANOVA) *two-way* para medidas repetidas foi utilizada para comparação entre os grupos e os momentos. O teste para comparações múltiplas de *Bonferroni* foi empregado para a identificação das diferenças específicas nas variáveis em que os valores de F encontrados foram superiores aos do critério de significância estatística estabelecido. O tamanho do efeito foi calculado de acordo com a seguinte equação(COHEN, 1988).

$$M_2 - M_1 / DP$$

Onde M1 representa a média pré-intervenção, M2 a média pós-intervenção, e DP a média dos desvios padrão pré e pós-intervenção. A magnitude do efeito abaixo de 0,20 foi considerada desprezível, entre 0,20 - 0,49 foi considerada pequena, 0,50 - 0,79, moderada e $\geq 0,80$ grande. Para todas as análises estatísticas foi adotado o nível de significância de 5%. As análises foram realizadas com uso do pacote estatístico *STATISTICA* versão 10.

CAPÍTULO 2

Artigo original 1

Effects of ascending pyramid training system performed with wide or narrow repetition zone on muscular strength and hypertrophy in untrained older women

Abstract

The purpose of the present study was to analyze the effects of ascending pyramid training system with different repetition zones on muscular strength and skeletal muscle mass (SMM) in older women. Fifty-nine physically independent and untrained older women (67.5 ± 4.8 years, 67.6 ± 13.3 kg, 1.56 ± 0.1 m, 27.71 ± 4.8 kg/m²) were randomly assigned into one of three groups: a non-exercise control group (CON, n = 20) and two training groups that performed an 8-week resistance training program in an ascending pyramid fashion, whereby one group performed 3 sets in a narrow repetition zone (NPR, n = 20) and other group performed 3 sets in a wide repetition zone (WPR, n = 19) consisting of 12/10/8 repetitions and 15/10/5 repetitions, respectively. The program consisted of 8 whole-body exercises, performed 3 times a week. Dual-energy X-ray absorptiometry was used to estimate fat-free mass (FFM), SMM, upper limbs muscle mass (ULMM) and lower limbs muscle mass (LLMM). Muscular strength was evaluated by one repetition maximum (1RM) test in chest press (CP), knee extension (KE) and preacher curl (PC). Both training groups presented higher ($P < 0.05$) changes compared to CON for FFM, SMM, ULMM, LLMM, CP, KE, and PC, without differences between training groups ($P > 0.05$). The results suggest that ascending pyramid training system in different repetition zones is effective to improve muscular strength and muscle growth in untrained older women.

Keywords: aging, strength training, pyramidal system, resistance exercises, maximum strength, hypertrophy.

2.1 Introduction

Reductions in muscular strength and skeletal muscle mass (SMM) are two of the main age-related impairments (CLARK; MANINI, 2008) that are associated with a decrease in performance of daily life activities and functional autonomy, thus having a negative effect on general health, quality of life, and survival in older persons (CLARK; MANINI, 2008; CLARK; MANINI, 2010; MITCHELL et al., 2012; SANTOS et al., 2016). To counter these deleterious effects, resistance training (RT) has been recommended for older persons given its well-established ability to elicit positive adaptations in muscular strength and SMM (ACSM, 2009; CHODZKO-ZAJKO et al., 2009; GARBER et al., 2011).

The muscular adaptations induced by RT are dependent on manipulating program variables, with training volume and intensity of load widely considered two of the most important variables (ACSM, 2009; SCHOENFELD, 2010). Training volume is affected by the exercises performed, number of sets and repetitions, as well as training frequency, while intensity of load refers to absolute or relative resistance used for a given exercise, velocity of muscular contraction, and amount of rest between sets (ACSM, 2009). Accordingly, some training systems have been proposed by coaches and practitioners as a means to train with higher loads without a drastic reduction in volume. Among the training systems, the ascending pyramid system, due to its inherent characteristic of varying loads and number of repetitions allows exercise performance at higher intensities of load without necessarily causing a drastic loss in the volume from a specific loading zone standpoint, thus maintaining a favorable anabolic environment for increasing strength and muscle hypertrophy.

A previous study from our laboratory (RIBEIRO et al., 2016a) with older women investigated the effect of the ascending pyramid system on muscular strength

and hypertrophy, and it was observed that this load-management system induced similar adaptations than when the load remained constant through the sets of a given exercise (RIBEIRO et al., 2016a). However, one possible reason for the lack of the superiority of the pyramid system may be because the repetition range applied in the pyramid condition (12/10/8 RM) was too narrow to promote different stresses compared to constant (8-12 RM) and thus induce differential adaptations. Therefore, we cannot rule out the possibility that a pyramid approach using a wide repetition zone, thereby allowing a higher metabolic and mechanical stimulus, may induce superior results.

The purpose of the present study was to analyze the effects of ascending pyramid system with different repetition zones on muscular strength and SMM in older women untrained. We hypothesized that both conditions would be effective to induce increase in muscular strength and SMM, and that the pyramid system performed in a wide zone of repetitions would elicit greater improvements compared to the narrow zone of repetition. The rationale for this hypothesis is based on a greater variation of the stimulus, thus allowing higher metabolic (in the first set) and mechanical stress (in the final set).

2.2 Methods

2.2.1 Participants

Fifty-nine untrained older women (67.5 ± 4.8 years, 67.6 ± 13.3 kg, 1.56 ± 0.1 m, 27.71 ± 4.8 kg/m²) were selected for participation in this study. Recruitment was carried out through newspaper, television programs and radio advertisements, and home delivery of leaflets in the central area and residential neighborhoods. All participants completed health history questionnaires and met the following inclusion criteria: physically independent, free from cardiac dysfunction, not receiving hormonal replacement therapy, and not performing any regular physical exercise for more than once a week over the six months preceding the beginning of the study. Participants passed a diagnostic, graded exercise stress test with 12-lead electrocardiogram reviewed by a cardiologist and were released with no restrictions for participation in this study. Adherence to the program was established with a minimum participation of 85% of the total sessions. After meetings with volunteer groups, those with the necessary prerequisites completed an initial interview and signed the Informed Consent approved by the Ethics Committee of the local University. This investigation was conducted according to the Declaration of Helsinki.

2.2.2 Experimental Design

The study was carried out over a period of 12 weeks, with 8 weeks dedicated to the RT program, and 4 weeks for data collection. Pre- and post-intervention testing was carried out at weeks 1-2 and 11-12, respectively, and comprised anthropometric, body composition and maximal dynamic strength measurements. The RT program was carried out during weeks 3-10. Physical education professionals supervised all sessions. Subjects were instructed not to

perform any other type of physical exercise throughout the study period. Participants were randomly assigned to one of three groups: control group (CON, n = 20), instructed not to engage in any physical exercise training program during the period of the intervention and to maintain their eating and physical activity patterns, and two different systems of pyramid training: a narrow zone of repetitions (NPR, n = 20) in which participants performed 3 sets of 12/10/8 repetitions or a wide zone of repetitions (WPR, n = 19) in which participants performed 3 sets of 15/10/5 repetitions.

2.2.3 Muscular strength

Maximal dynamic muscular strength was determined by the one repetition maximum test (1RM) on bench press (BP), knee extension (KE), and preacher curl (PC). Testing for these exercises was preceded by a warm-up set (6–10 repetitions) using approximately 50% of the estimated load used in the first attempt of the 1RM test. This warm-up was also used to familiarize the subjects with the testing equipment and lifting technique to reduce the effects of learning and establish reproducibility in the exercise. The testing procedure was initiated 2 min after the warm-up. Participants were instructed to try to accomplish two repetitions with the imposed load in three attempts. A 3 to 5 min rest period was afforded between each attempt. The 1RM was recorded as the last load lifted in which the participant was able to complete only one single maximal repetition. Execution for each exercise was standardized and continuously monitored to ensure reliability. Experienced researchers supervised all 1RM testing sessions for greater participant safety and integrity. Verbal encouragement was given throughout each test. Three 1RM sessions were performed separated by 48 h (AMARANTE DO NASCIMENTO et al., 2013). The highest load achieved among the 3 sessions was used for analysis in the exercise. The sum of the weights lifted in the three exercises was considered the total strength. The intraclass

correlation coefficient (ICC) from our lab for these tests is ≥ 0.96 with a standard error of measurement (SEM) of ≤ 2.0 kg.

2.2.4 Body composition

Fat-free mass (FFM), lower limb muscle mass (LLMM), upper limb muscle mass (ULMM) measurements were carried out using a dual energy X-ray absorptiometry (DXA) scan (Lunar Prodigy, model NRL 41990, GE Lunar, Madison, WI, USA). Before scanning participants were instructed to remove all objects containing metal. Calibration and scans were performed according to the manufacturer's instruction manual. Both calibration and analysis were carried out by a skilled laboratory technician. Analyses during the intervention were performed by the same technician who was blinded to intervention time point. The SMM was calculated from the appendicular lean soft tissue estimated by DXA using the equation proposed by Kim et al. (KIM, J. et al., 2002). Previous test-retest scans of eight older women resulted SEM of 0.7 kg and ICC of 0.99 for FFM and SEM of 0.5 kg and ICC of 0.99 for SMM.

2.2.5 Resistance training program

The RT program was performed three times a week, with an interval of 48 h between training sessions and was carried out over a period of 8 weeks. Training took place in the morning and was based on recommendations for RT in older population to improve muscle hypertrophy and strength (ACSM, 2009; CHODZKO-ZAJKO et al., 2009). Physical education professional supervised personally all participants throughout each training session in order to reduce deviations from the study protocol and to ensure subject safety. Subjects performed RT using a combination of free weights and machines.

The RT protocol consisted of a whole-body program with 8 exercises performed in the following order: chest press, horizontal leg press, seated row, knee extension, preacher curl, leg curl, triceps pushdown, and seated calf raise. Participants performed either 3 sets of 12/10/8 repetitions (NRP) or 15/10/5 repetitions (WPR) with incrementally higher loads for each set (ascending pyramid system). The participants were instructed to inspire during the eccentric phase and exhale during the concentric phase of the exercise and to maintain the velocity of muscular contraction at a ratio of 1:2 (concentric and eccentric phases, respectively). The rest interval ranged between 60-120 s for sets and exercises. The supervisors adjusted the loads of each exercise according to the subject's ability and improvements in exercise capacity throughout the study in order ensure that subjects were using as much resistance as possible while maintaining proper technique. Progression in each exercise occurred when the participant was able to perform 10 (NRP) or 7 (WPR) repetitions in the last set by two consecutive sessions. Progression was accomplished by increasing the load for the upper limb and lower limb exercises by 2-5% and 5-10%, respectively, in each set, in the next training session (ACSM, 2009).

2.2.6 Dietary intake

A dietitian oriented the participants to complete a food record on 3 nonconsecutive days (2 week days and one weekend day) at weeks 1–2, and 11–12. Participants were given specific instructions regarding the recording of portion sizes and quantities to identify all food and fluid intake. Total dietary energy, protein, carbohydrate, and fat content were calculated using nutrition analysis software (Avanutri Processor Nutrition Software, Rio de Janeiro, Brazil; Version 3.1.4). All participants were asked to maintain their normal diet throughout the study period.

2.2.7 Statistical analysis

Data are presented as mean, standard deviations, z-scores, and percentage of changes. The Kolmogorov-Smirnov test was used to check normality. The baseline comparisons were performed by one-way analysis of variance (ANOVA). Adjusted Greenhouse-Geisser corrections were used for any violations of sphericity by Mauchly's test. The 2-way ANOVA for repeated measures was conducted for comparisons between and within groups over time. Bonferroni post-hoc test was conducted to identify the mean differences when the F-ratio was significant. The effect size (ES) was calculated to verify the magnitude of the differences by Cohen's *d* where an ES of ≥ 0.20 – 0.49 was considered as small, 0.50 – 0.79 as moderate and ≥ 0.80 as large (COHEN, 1992). The differences between pre- to post-training were calculated, transformed in z-scores, and means for each variable as compared by one-way ANOVA. For all statistical analyses, significance was established at $P < 0.05$. Analyses were performed with SPSS software version 22.0 (SPSS Inc., Chicago, IL, USA).

2.3 Results

There were no significant main effects or interactions for daily relative energy and macronutrients within and between groups over time ($P > 0.05$).

Table 2.1 displays the general characteristics of the participants at baseline. No significant differences were observed between groups ($P > 0.05$).

Tabela 2.1 General characteristics of the participants at baseline.

	CON (n = 20)	NPR (n= 20)	WPR (n = 19)	P-value
Age (years)	66.8 ± 3.9	68.9 ± 5.8	66.6 ± 4.7	0.25
Body mass (kg)	68.6 ± 16.4	66.1 ± 11.1	68.0 ± 11.5	0.81
Height (cm)	157.4 ± 6.2	153.9 ± 6.5	156.6 ± 6.5	0.16
BMI (kg/m ²)	27.5 ± 5.4	27.96 ± 4.8	27.7 ± 4.3	0.96

Note. CON = control group; NPR = Narrow repetition zone group; WPR = wide repetition zone group; BMI = body mass index. Data are expressed as mean and standard deviation.

Figure 2.1 depicts the baseline and post-intervention scores and percentage changes from pre- to post-training for FFM, SMM, LLMM and ULMM by group. There was a significant interaction ($P < 0.05$), in which both training groups presented significantly higher changes than CON for FFM (NPR = +1.87% [+0.7 kg]; WPR = +3.17% [+1.2 kg]; CG = -1.37% [-0.5 kg]), SMM (NPR = +4.71% [+0.8 kg]; WPR = +8.40% [+1.5 kg]; CG = -4.54% [-0.9 kg]), LLMM (NPR = +4.70% [+0.6 kg]; WPR = +6.19% [+0.7 kg]; CG = -3.76 % [-0.5 kg]), and ULMM (NPR = +4.44% [+0.2 kg]; WPR = +5.26% [+0.2 kg]; CG = -6.62% [-0.3 kg]), without differences between the training groups. Figure 2.2, Panel A, depicts the individual percentage changes from pre- to post-training in SMM for each group.

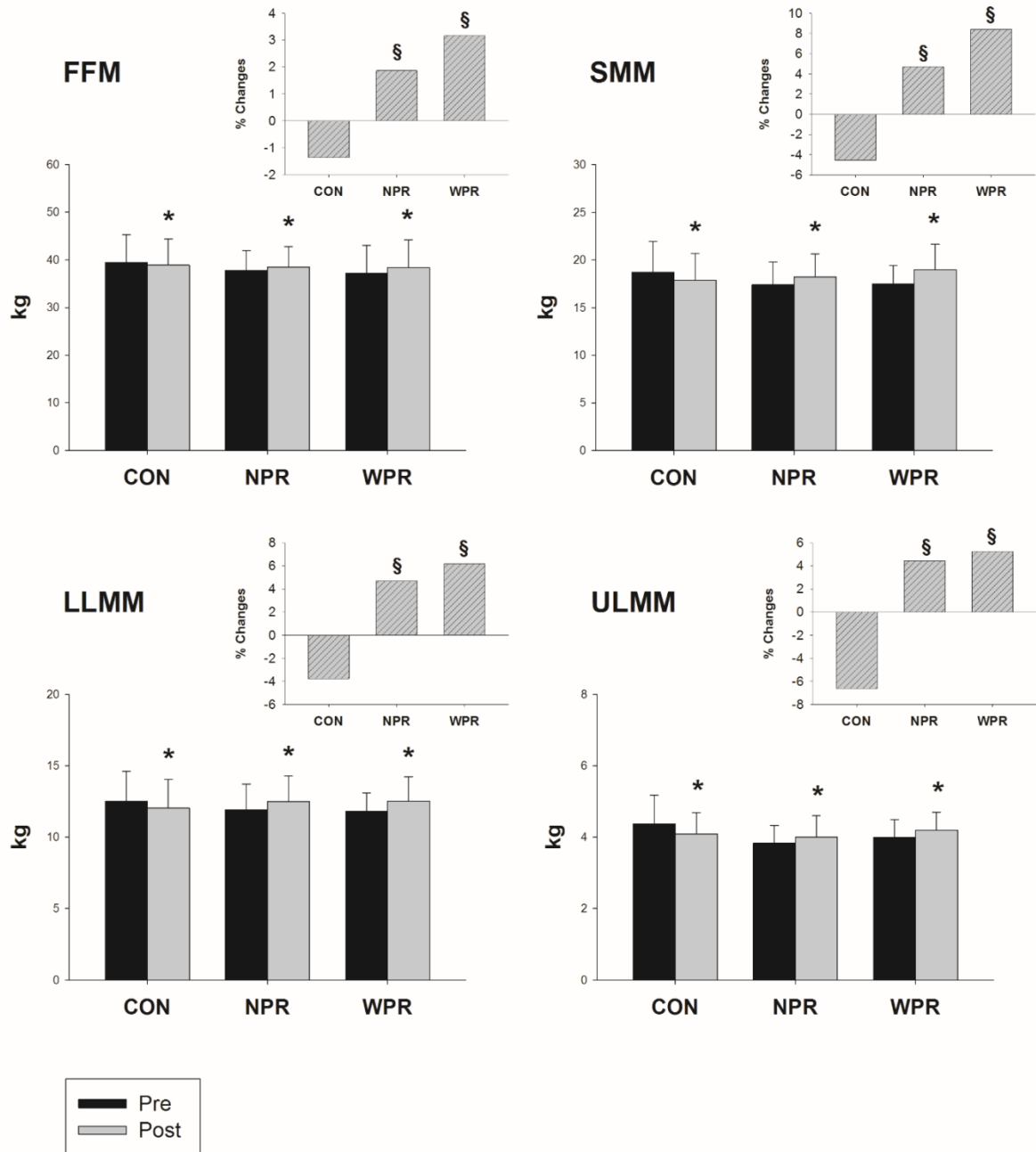


Figure 2.1 Pre- to post-intervention scores and percentage changes of fat-free mass (FFM), skeletal muscle mass (SMM), lower limb muscle mass (LLMM) and upper limb muscle mass (ULMM) by group (control, CON, n = 20; narrow zone repetition, NPR, n = 20; wide zone of repetition, WPR, n = 19). * $P < 0.05$ vs pre-. § $P < 0.05$ vs. CON.

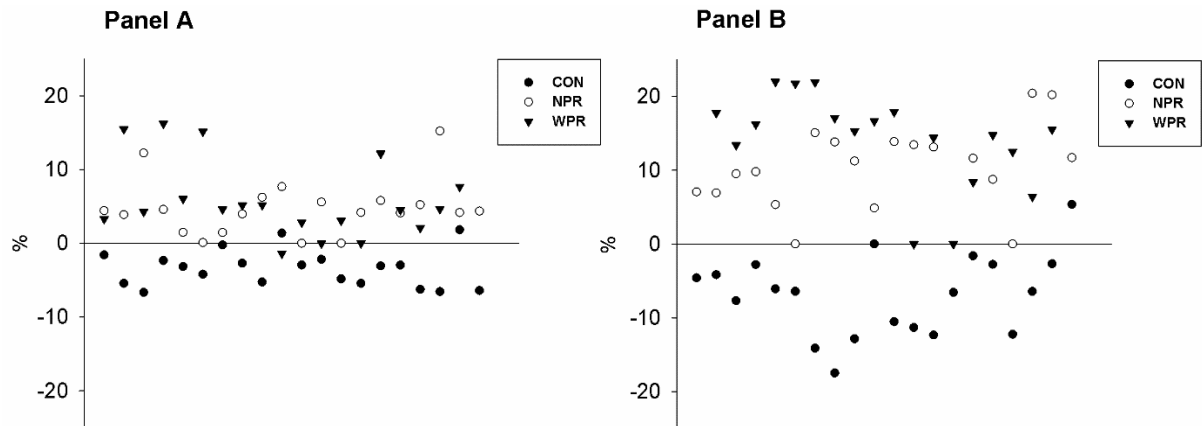


Figure 2.2 Individual percentage changes for skeletal muscle mass and total strength (Panels A and B, respectively) after 8-week intervention period by group (control, CON, $n = 20$; narrow zone repetition, NPR, $n = 20$; wide zone of repetition, WPR, $n = 19$).

The muscular strength values at pre- and post-intervention according to groups are presented in Table 2.2. A significant interaction ($P < 0.05$) was observed for the 3 exercises analyzed, in which the training groups similarly increased their scores, while CON decreased its scores after the intervention period. Figure 2.2, Panel B, depicts the individual percentage changes from pre- to post-training in muscular strength for each group.

Tabela 2.2 One repetition maximum scores (kg) at pre- and post-intervention according to groups. Data are expressed as mean and standard deviation.

	CON (n = 20)	NPR (n= 20)	WPR (n = 19)	Interaction <i>P</i> -value
Chest press				
Pre	40.4 ± 8.1	36.1 ± 4.9	40.5 ± 7.3	
Post	39.4 ± 8.2*	39.4 ± 7.3*	45.2 ± 7.3*	< 0.001
Δ%	-2.4	+9.1	+11.5	
Knee extension				
Pre	45.0 ± 9.1	39.0 ± 7.9	44.1 ± 9.4	
Post	40.7 ± 9.5*	44.1 ± 8.6*	50.3 ± 9.4*	< 0.001
Δ%	-9.5	+13.1	+14.1	
Preacher curl				
Pre	19.9 ± 3.6	20.0 ± 2.6	18.3 ± 2.9	
Post	17.4 ± 3.6*	22.3 ± 3.7*	21.6 ± 3.7*	< 0.001
Δ%	-12.4	+11.4	+17.9	
Total strength				
Pre	105.3 ± 17.2	95.1 ± 13.4	102.8 ± 16.8	
Post	97.6 ± 18.2*	105.8 ± 15.8*	117.0 ± 18.0*	< 0.001
Δ%	-7.3	+11.3	+13.8	

Note. CON = control group; NPR = Narrow repetition zone group; WPR = wide repetition zone group; Total strength = sum of the weights lifted in the three exercises. **P*< 0.05 vs. pre.

Table 2.3 presents the effect size values for training groups as well as the difference between training groups. A difference of small magnitude was observed for SMM, LLMM, and PC, favoring the WPR. For the other parameters investigated, the differences between groups did not reach meaningful values.

Tabela 2.3 Effects sizes values according to groups.

	NPR (n = 20)	WPR (n = 19)	Differences
Fat free mass	0.17	0.20	-0.03
Skeletal muscle mass	0.34	0.77	-0.43
Lower limb muscle mass	0.31	0.56	-0.25
Upper limb muscle mass	0.34	0.42	-0.08
Chest press	0.67	0.64	0.03
Knee extension	0.65	0.66	-0.01
Preacher curl	0.88	1.13	-0.25
Total strength	0.80	0.84	-0.04

Note. CON = control group; NPR = Narrow repetition zone group; WPR = wide repetition zone group.

The z-scores of the percentage changes from pre- to post-intervention for each parameter investigated are presented in Table 2.4. A significant ($P < 0.05$) difference was observed for training groups when compared to CON, in which both NPR and WPR presented higher positive variation than CON. Although WPR presented the highest positive variation means for all outcomes analyzed, the differences to NPR did not reach statistical significance ($P > 0.05$).

Tabela 2.4 Z-scores of the percentage changes from pre- to post-training period (8 weeks) according to group.

	CON (n = 20)	NPR (n= 20)	WPR (n = 19)	P-value
Fat free mass	-0.67 ± 0.7	0.24 ± 0.6*	0.66 ± 1.1*	< 0.01
SMM	-0.65 ± 0.5	0.25 ± 0.3*	0.59 ± 1.4*	< 0.01
LLMM	-0.54 ± 0.4	0.16 ± 0.3*	0.54 ± 1.5*	< 0.01
ULMM	-0.70 ± 1.0	0.45 ± 0.7*	0.49 ± 0.6*	< 0.01
Chest press	-0.93 ± 0.5	0.31 ± 0.8*	0.64 ± 0.9*	< 0.01
Knee extension	-1.10 ± 0.7	0.50 ± 0.6*	0.60 ± 0.6*	< 0.01
Preacher curl	-1.07 ± 0.5	0.34 ± 0.5*	0.76 ± 0.8*	< 0.01
Total strength	-1.19 ± 0.4	0.47 ± 0.5*	0.73 ± 0.6*	< 0.01
Composited z-score	-0.91 ± 0.3	0.39 ± 0.4*	0.67 ± 0.8*	< 0.01

Note. CON = control group; NPR = Narrow repetition zone group; WPR = wide repetition zone group; SMM = skeletal muscle mass, LLMM = lower limb muscle mass, ULMM = upper limb muscle mass, Composited z score = (skeletal muscle mass z-score + total strength z-score) / 2. * $P < 0.05$ vs. control group. Data are expressed as mean and standard deviation.

2.4 Discussion

The main and novel results of our study showed that both pyramid systems produced significantly greater results compared to a non-training control, with statistically similar changes between WPR and NPR noted in all outcomes studied. However, there were several differences identified between conditions that, although not rising to a level of predetermined statistical probability, nevertheless may be considered meaningful from a practical standpoint. To the authors' knowledge, this is the first study to compare muscular adaptations in RT pyramid system using a narrow versus wide range of repetitions.

With respect to changes in body composition, increases in SMM for WPR were almost double that for NPR (1.5 kg vs. 0.8 kg, respectively), although results did not reach statistical significance. The relative ES difference for this outcome was 0.43,

which borders small to moderate effect. As shown in Figure 2.2, Panel A, the observed differences appear to be due to a greater number of high responders in WPR. Moreover, these differences were primarily the result of greater increases in lower limb muscle mass, where the relative ES difference was 0.25. Although no previous studies have directly compared pyramid system with differing repetition ranges, several studies have used a daily undulating periodization protocol to investigate the effects of training with wide versus narrow repetition ranges. In a cohort of female collegiate tennis players, Kraemer et al. (KRAEMER et al., 2003) found that wide repetition range (4-6RM on Day 1; 8-10RM on Day 2; 12-15RM on Day 3) produced significantly greater absolute increases in FFM compared to a narrow repetition range (8-10RM) as assessed by the 3-site skinfold technique over a 9 months' study period (3.3 kg vs. 1.6 kg, respectively). Recently, Schoenfeld et al. (SCHOENFELD et al., 2016) randomized young, resistance-trained men to train with either a narrow repetition range (8-12RM) or a wide repetition range (2-4 RM per set on Day 1; 8-12 RM per set on Day 2; 20-30 RM on Day 3). Although similar statistical increases were shown for muscle thickness for the biceps, triceps, and quadriceps as measured by b-mode ultrasound, the ES for the upper limbs indicated a potential hypertrophic superiority for the group using a wider repetition range. Results of these studies are difficult to reconcile given the wide-ranging differences in populations and methods between studies, but the totality of findings would seem to indicate a potential benefit to wider variations in repetition ranges for maximal increases in muscle mass. Emerging research indicates that lighter load training promotes greater increases in type I muscle fibers while heavier load training promotes greater increases in type II muscle fibers (NETREBA et al., 2007; NETREBA et al., 2013; VINOGRADOVA et al., 2013). It is therefore possible that

benefits of a wider repetition range may be related to more complete development across fiber types. This hypothesis warrants further study.

Total strength changes across exercises tested for 1RM were similar between training conditions, with WPR producing a 13.8% increase and NPR producing an 11.3% increase. Perusal of Figure 3, Panel B, appears to indicate superiority for WPR, with a majority of subjects showing greater strength increases compared to NPR. These results can be largely attributed to greater increases in 1RM for the preacher curl favoring WPR compared to NPR (17.9% vs 11.4%, respectively), with a small relative ES difference of 0.25. As mentioned, no previous studies have compared muscular adaptations using different pyramid loading schemes. However, several studies have investigated strength outcomes in wide versus narrow repetition ranges using a daily undulating periodization approach. In the study by Kraemer et al. (KRAEMER et al., 2003), the wider repetition range produced greater increases in the leg press, bench press, and shoulder press. Alternatively, Schoenfeld et al. (SCHOENFELD et al., 2016) found similar strength-related changes between wide and narrow repetition ranges, although the ES favored the wider range in the bench press. Despite somewhat equivocal evidence, the totality of findings suggests a potential strength-related benefit to employing a wide repetition range.

Our study had several limitations that are worthy of note. First, the study period of 8 weeks was of rather short duration. It remains to be determined whether results would differ over a longer timeframe. Second, the use of DXA, while well-established as a valid instrument to estimate body composition, lacks the sensitivity to detect subtle changes in muscle mass compared to direct imaging modalities such as computed tomography and magnetic resonance image (LEVINE et al., 2000; MADEN-WILKINSON et al., 2013). For greater clarity, future studies should endeavor to

investigate the topic using direct imaging modalities. The study is specific to untrained, older women and results cannot be generalized to other populations including children, young adults, men, and those with resistance training experience.

On the other hand, our study was conducted with randomized clinical trial design with control group, which strengthens our findings regarding the effects of training. The muscular strength was evaluated through three exercises, allowing the understanding of the effects on upper limbs, lower limbs and trunk, an advantage in relation to most studies involving RT, in which strength is evaluated in only one body segment. In addition, familiarization with the muscle strength assessment protocol allows recognition of the test equipment and lifting technique to reduce learning effects and establish reproducibility in exercise. Another relevant point is that in addition to the SMM analysis, which provides an overview of the effects of the intervention, evaluation of upper and lower limb muscle mass can provide important data about the localized effects of RT. Finally, it is worth mentioning that the training conducted with individualized supervision of the elderly allows a greater control of the training variables and the technique of performing the exercises, reducing the risk of injuries.

As practical implications of our study, the results provide insights on the effectiveness and safety of the use of the PR system with different repetition zones as a simple and dynamic alternative to the traditional RT-prescription system for untrained elderly women. Future studies should attempt to investigate whether outcomes may be mechanistically altered by differences in fiber-type adaptations across repetition ranges.

2.5 Conclusion

The study showed that ascending pyramid training system employing both a wide and narrow repetition range is effective in promoting increases in strength and

muscle mass in untrained older women. Although no statistically significant differences were noted between systems, underlying analysis of effect-sizes suggests a potential benefit to performing a wider range of repetitions.

CAPITULO 3

Artigo original 2

Effects of ascending pyramid training system performed with wide or narrow repetition zone on body fat and metabolic parameters in untrained older women

ABSTRACT

The purpose of this study was to analyze the effects of ascending pyramid training system performed with wide or narrow repetition zone on body fat and metabolic biomarkers in older women. Fifty-eight untrained older women (67.0 ± 5.1 years, 66.6 ± 12.8 kg, 1.55 ± 0.1 m, 27.5 ± 4.8 kg/m²) were randomly assigned in three groups: a non-exercise control group (CON, $n = 19$) and two training groups that performed an 8-week resistance training program in an ascending pyramid fashion, whereby one group performed 3 sets in a narrow repetition zone (NPR, $n = 20$) and other group performed 3 sets in a wide repetition zone (WPR, $n = 19$) consisting of 12/10/8 repetitions and 15/10/5 repetitions, respectively, with incrementally higher loads for each set. Dual-energy X-ray absorptiometry was used to estimate total body fat (TBF), android body fat (ABF), and gynoid body fat (GBF). Glucose, total cholesterol, triglycerides, HDL-C, LDL-C, and C-reactive protein (CRP) concentrations were determined by biochemical analysis. There were significant group by time interactions for all variables analyzed ($P < 0.05$). Both training groups presents significant reductions ($P < 0.05$) in BF, ABF, GBF, glucose, total cholesterol, triglycerides, LDL-C, CRP and increase in HDL-C, without differences between groups. Results suggest that ascending pyramid training system is effective to improve in body fat and metabolic biomarkers in untrained older women, regardless of a wide or narrow repetition zone.

Keywords: strength exercise; blood biomarkers; elderly

3.1 Introduction

Menopause and aging are processes associated to increase and redistribution of body fat in women (FENG et al., 2008; KUK et al., 2009). After menopause, women experience a process of transition between the reduction in adiposity on limbs and increase in visceral and ectopic fat (FENG et al., 2008). Increases in visceral adiposity is associated with dyslipidemia, insulin resistance, diabetes type 2 (STACHOWIAK; PERTYŃSKI; PERTYŃSKA-MARCZEWSKA, 2015), and metabolic syndrome (FOX et al., 2007). In addition, adipose tissue is a relevant source of pro-inflammatory adipocytokines such as leptin, resistin, tumor necrosis factor-alpha (TNF- α), elevating inflammatory markers such as C-reactive protein (CRP) (LEE et al., 2009). These changes increase the risk for development of coronary artery disease, atherosclerosis, and death (LIM; MEIGS, 2013; LIU; LI, 2015).

Resistance training (RT) is an important non-pharmacological strategy to attenuate the deleterious effects associated with aging and obesity (HURLEY; HANSON; SHEAFF, 2011; WESTCOTT, 2012). Increments in SMM induced by RT and reduction of adipose tissue were directly associated with increments in resting metabolic rates (WESTCOTT, 2012), increased energy expenditure and metabolic activity of muscle tissue (CAMPBELL et al., 1994). The effectiveness of RT in inducing these adaptations is directly related to the type of stimulus and the manipulation of the variables of volume and intensity of the training (ACSM, 2009). The RT-derived stimuli may be of mechanical, metabolic predominance or the interaction between them (FLECK; KRAEMER, 2014). RT variables of volume corresponds to the number of exercises, sets and repetitions performed, as well as training frequency, whereas the intensity is related to absolute or relative resistance used for a given exercise, velocity of muscular contraction, and amount of rest between sets. The manipulation of the

variables can occur through the periodization of the training in a linear, reverse linear and undulating (FLECK; KRAEMER, 2014). In linear model of periodization, the training starts with high volumes and low intensity inverse over time (approximately 4 weeks), the reverse linear model of periodization occurs in opposite direction. Already, in undulating periodization the variation occurs in blocks of weeks or every day (FLECK; KRAEMER, 2014). The pyramidal training system was tested as a strategy to undulating periodization in each session to vary the stimuli within and the manipulation of the volume and intensity of the training aiming to potentiate the adaptive responses (CHARRO et al., 2010; CHARRO et al., 2012; HEAVENS et al., 2014; RIBEIRO et al., 2016a; RIBEIRO et al., 2016b; ANGLERI; UGRINOWITSCH; LIBARDI, 2017).

Despite the effectiveness of the pyramidal training system in producing beneficial adaptations in different health parameters, the amplitude in the number of repetitions in each set present in the studies has been small and remained within a repetition zone very similar to the traditional RT system (8-12 repetitions). Therefore, the purpose of this study was to analyze the effects of ascending pyramid training system with narrow and wide zone of repetitions on body fat and metabolic biomarkers in older women. We hypothesized that both repetition zones of pyramid system would be effective in inducing reduction of body fat and improvements in metabolic and inflammatory parameters, and that the pyramid performed in a wide repetitions zone would result in greater improvements over the narrow repetitions zone. The justification for this hypothesis is based on a greater variation of the stimulus, thus allowing greater metabolism (in the first set) and mechanical stress (in the final set).

3.2 Methods

3.2.1 Participants

Fifty-eight physical independent older women (67.0 ± 5.1 years, 66.6 ± 12.8 kg, 1.55 ± 0.1 m, 27.5 ± 4.8 kg/m²) were selected for participation in this study. Recruitment was carried out through newspaper, television programs and radio advertisings, and home delivery of leaflets in the central area and residential neighborhoods. All participants completed health history questionnaires and met the following inclusion criteria: be physically independent, free from cardiac dysfunction, not receiving hormonal replacement therapy, and was not performing any regular physical exercise for more than once a week over the six months preceding the beginning of the study. Participants passed a diagnostic, graded exercise stress test with 12-lead electrocardiogram reviewed by a cardiologist and were released with no restrictions for participation in this study. Adherence to the program was established with a minimum participation of 85% of the total sessions. Fifty-four elderly women reached the end of the intervention, 3 gave up for personal reasons and 1 did not reach 85% of the frequency of the training sessions established and were included in the intent-to-treat analyzes. After meetings with volunteer groups, those with the necessary prerequisites completed an initial interview and signed the Informed Consent approved by the Ethics Committee of the local University. This investigation was conducted according to the Declaration of Helsinki.

3.2.2 Experimental Design

The study was carried out over a period of 12 weeks, with 8 weeks dedicated to the RT program, and 4 weeks for data collection. Pre- and post-training

testing was carried out at weeks 1-2 and 11-12, respectively, and comprised anthropometric, body composition, maximal dynamic strength measurements and metabolic biomarkers. The RT program was carried out during weeks 3-10. Physical education professionals supervised all sessions. Subjects were instructed not to perform any other type of physical exercise throughout the study period. Participants were randomly assigned in three groups: control group (CON), instructed not to engage in any physical exercise training program during the 8 weeks of the intervention and to maintain their eating and physical activity patterns; narrow repetitions zone pyramid (NPR) performed either 3 sets of 12/10/8 repetitions; and wide repetition zone pyramid (WPR) 3 sets of 15/10/5 repetitions, respectively, with incrementally higher loads for each set.

3.2.3 Anthropometry

Body mass was measured to the nearest 0.1 kg using a calibrated electronic scale (Balmak, Laboratory Equipment Labstore, Curitiba, Paraná, Brazil), with the participants wearing light workout clothing and no shoes. Height was measured with a stadiometer to the nearest 0.1 cm with subjects standing without shoes. Body mass index was calculated as the ratio of body mass in kilograms by the square of height in meters

3.2.4 Body composition

Total body fat (BF), android body fat (ABF) and gynoid body fat (GBF) were carried out using a dual energy X-ray absorptiometry (DXA) scan (Lunar Prodigy,

model NRL 41990, GE Lunar, Madison, WI). Before scanning participants were instructed to remove all objects containing metal. Calibration and scans were performed per the manufacturer's instruction manual. Both calibration and analysis were carried out by a laboratory technician. Analyses during the intervention were performed by the same technician who was blinded to intervention time point. Previous test-retest scans of eight older women resulted in intraclass correlation coefficient (ICC) of 0.99 and standard error of measurement (SEM) of 0.9 kg BF, SEM of 0.3 kg and ICC of 0.99 for ABF, SEM of 0.41 kg and ICC of 0.99 for GBF.

3.2.5 Biochemical analysis

Serum levels of high-sensitivity C-reactive protein (CRP), glucose (GLU), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and triglycerides (TG) were determined after 12 h fasting by a laboratory technician. The blood was taken from the antecubital vein. The participants were instructed not to perform vigorous exercise for the preceding 24 h, and to avoid alcohol or caffeinated beverages 72 h before collection. Measurements were performed by standard methods in a specialized laboratory at the University Hospital. Samples were deposited in vacuum tubes with a gel separator without anticoagulant, and were centrifuged for 10 min at 1008 x g for serum separation. Thereafter, the CRP, TG, and HDL-C concentrations were determined. The LDL-C was calculated using the following equation (FRIEDEWALD; LEVY; FREDRICKSON, 1972): $LDL-C = TC - (HDL-C + TGL/5)$. The analyses were carried out using a biochemical auto-analyzer system (Dimension RxL Max - Siemens Dade Behring) according to established methods in the literature consistent with the manufacturer's recommendations.

3.2.6 Dietary intake

A dietitian oriented the participants to complete a food record on 3 nonconsecutive days (2 week days and one weekend day) at weeks 1–2, and 11–12. Participants were given specific instructions regarding the recording of portion sizes and quantities to identify all food and fluid intake. Total dietary energy, protein, carbohydrate, and fat content were calculated using nutrition analysis software (Avanutri Processor Nutrition Software, Rio de Janeiro, Brazil; Version 3.1.4). All participants were asked to maintain their normal diet throughout the study period.

3.2.7 Resistance training program

The RT program was performed three times a week, with an interval of 48 h between training sessions and was carried out over a period of 8 weeks. Training took place in the morning and was based on recommendations for RT in older population to improve muscle hypertrophy and strength (ACSM, 2009; CHODZKO-ZAJKO et al., 2009). Physical education professional supervised personally all participants throughout each training session in order to reduce deviations from the study protocol and to ensure subject safety. Subjects performed RT using a combination of free weights and machines.

The RT protocol consisted of a whole-body program with 8 exercises performed in the following order: chest press, horizontal leg press, seated row, knee extension, preacher curl, leg curl, triceps pushdown, and seated calf raise. Participants performed either 3 sets of 12/10/8 repetitions (NRP) or 15/10/5 repetitions (WPR) with incrementally higher loads for each set (ascending pyramid system). The participants were instructed to inspire during the eccentric phase and exhale during the concentric phase of the exercise and to maintain the velocity of muscular contraction at a ratio of 1:2 (concentric and eccentric phases, respectively). The rest interval ranged between 60-120 s for sets and exercises. The supervisors adjusted the loads of each exercise

according to the subject's ability and improvements in exercise capacity throughout the study in order ensure that subjects were using as much resistance as possible while maintaining proper technique. Progression in each exercise occurred when the participant could perform 10 (NRP) or 7 (WPR) repetitions in the last set by two consecutive sessions. Progression was accomplished by increasing the load for the upper limb and lower limb exercises by 2-5% and 5-10%, respectively, in each set, in the next training session (ACSM, 2009).

3.2.8 Total load of training

At each training session, the loads and the number of repetitions performed during each set of the 8 exercises were recorded. The total training load was calculated by the sum of all loads lifted in all sessions.

3.2.9 Statistical analysis

Data are presented as mean, standard deviations, z-scores, and percentage of changes. Adjusted analyzes Greenhouse-Geisser corrections were used when it was identified the violation of sphericity by Mauchly's test. The 2-way analysis of variance (ANOVA) for repeated measures was conducted for dietary intake, body composition, and biochemical analysis. Bonferroni post-hoc test was conducted to identify the mean differences when F-ratio was significant. A comparison between total load of PR groups by student dependent t-test was performed. The effect size (ES) was calculated to verify the magnitude of the differences by Cohen's d where an ES of 0.20–0.49 was considered as small, 0.50–0.79 as moderate and 0.80 as large(COHEN, 1988).For all statistical analyses, significance was established at $P < 0.05$. Analyses were performed with SPSS software version 22.0 (SPSS Inc., Chicago, IL, USA).

3.3 Results

The older women who did not complete the intervention were maintained in the analyses as intention to treat and measurements values obtained in the baseline were repeated in the post-intervention. No significant differences ($P > 0.05$) were found between the general characteristics of the subjects in baseline (Table 3.1).

Tabela 3.1 General characteristics of the sample.

	CON (n = 19)	NPR (n = 20)	WPR (n = 19)	<i>P-value</i>
Age (years)	65.3 ± 4.0	68.9 ± 6.0	66.6 ± 4.7	0.10
Bodymass (kg)	67.2 ± 17.3	64.7 ± 9.1	68.0 ± 11.5	0.71
Height (cm)	156.1 ± 6.7	153.5 ± 6.4	156.6 ± 5.3	0.27
BMI (kg/m ²)	27.3 ± 5.7	27.6 ± 4.5	27.7 ± 4.3	0.98

CON =control group; NPR = narrow pyramid system; WPR = wide pyramid system; BMI = body mass index.

There were no significant main effects or interaction group by time ($P > 0.05$) for daily relative energy and macronutrients within and between groups over time (Table 3.2).

Tabela 3.2 Dietary intake at pre- and post-intervention according to group.

	CON (n = 19)	NPR (n = 20)	WPR (n = 19)	Interaction <i>P-value</i>
Carbohydrate (g.kg⁻¹.d⁻¹)				
Pre	3.40 ± 1.1	2.99 ± 1.0	3.03 ± 1.0	
Post	3.36 ± 1.3	3.01 ± 1.0	3.14 ± 0.9	0.55
Protein (g.kg⁻¹.d⁻¹)				
Pre	1.06 ± 0.3	0.89 ± 0.4	0.88 ± 0.2	
Post	1.02 ± 0.3	0.95 ± 0.4	0.92 ± 0.2	0.09
Lipids (g.kg⁻¹.d⁻¹)				
Pre	0.70 ± 0.2	0.65 ± 0.3	0.67 ± 0.2	
Post	0.73 ± 0.2	0.63 ± 0.3	0.68 ± 0.2	0.63
Energy (kcal.kg⁻¹.d⁻¹)				
Pre	25.40 ± 7.8	21.38 ± 7.6	21.90 ± 5.7	
Post	24.34 ± 6.9	20.90 ± 8.0	22.20 ± 5.5	0.38

Note. CON = control group; NPR = narrow pyramid system; WPR = wide pyramid system. Data are expressed as mean and standard deviation.

The total load in WPR was significantly higher ($P < 0.05$) than in NPR (13728.5 ± 950.9 kg vs. 12534.3 ± 926.1 kg, WPR and NPR, respectively).

Table 3.3 depicts the body composition scores pre- and post-intervention according to group. A significant group by time interaction was found for all body composition variables ($P < 0.05$). In training groups, there were a significant decrease ($P < 0.05$) in body fat (NPR = -1.0 kg vs. WPR = -1.3 kg), android body fat (NPR = -0.1 kg vs. WPR = -0.3 kg) and gynoid body fat (NPR = -0.3 kg vs. WPR = -0.3), with no statistical differences between the two groups ($P > 0.05$).

Tabela 3.3 Participant's scores at pre- and post-intervention according to group.

	CON (n = 19)	NPR (n= 20)	WPR (n = 19)	Interaction <i>P-value</i>
Body Fat (kg)				
Pre	26.7 ± 11.6	26.0 ± 7.5	29.2 ± 7.9	
Post	27.7 ± 11.8	25.0 ± 7.4*	27.9 ± 7.5*	
Δ%	+4.1	-3.9	-4.4	0.02
Effect size	+0.09	-0.13	-0.16	
Android fat (kg)				
Pre	2.3 ± 1.1	2.4 ± 0.6	2.8 ± 1.0	
Post	2.7 ± 1.4*	2.3 ± 0.6*	2.6 ± 0.8*	
Δ%	+18.3	-3.8	-9.9	< 0.01
Effect size	+0.38	-0.15	-0.28	
Ginoid fat (kg)				
Pre	4.8 ± 1.6	4.8 ± 1.3	5.1 ± 1.3	
Post	4.9 ± 1.9	4.5 ± 1.3*	4.8 ± 1.2*	
Δ%	+3.0	-6.2	-5.7	0.03
Effect size	+0.09	-0.23	-0.22	

Note. NPR, narrow repetitions zone pyramid, WPR, wide repetition zone pyramid. * $P < 0.05$ to pre-intervention. Data are expressed as mean and standard deviation.

The metabolic biomarkers parameters are depicted in figure 3.1. A significant group by time interaction was found for all variables ($P < 0.05$), except for total cholesterol ($P > 0.05$). In both training groups there were found significant reductions ($P < 0.05$) in blood glucose (NPR = -7.7 mg.dL^{-1} vs. WPR = -9.9 mg.dL^{-1}), triglycerides (NPR = -19.3 mg.dL^{-1} vs. WPR = -21.1), LDL-C (NPR = -27.3 mg.dL^{-1} vs. WPR = -19.1 mg.dL^{-1}) and CRP (NPR = -0.6 mg.dL^{-1} vs. WPR = -0.5 mg.dL^{-1}) concentrations, whereas HDL-C increased (NPR = $+5.6 \text{ mg.dL}^{-1}$ vs. WPR = 4.6 mg.dL^{-1}), no differences between then ($P > 0.05$). No significant difference was observed in total cholesterol ($P < 0.05$).

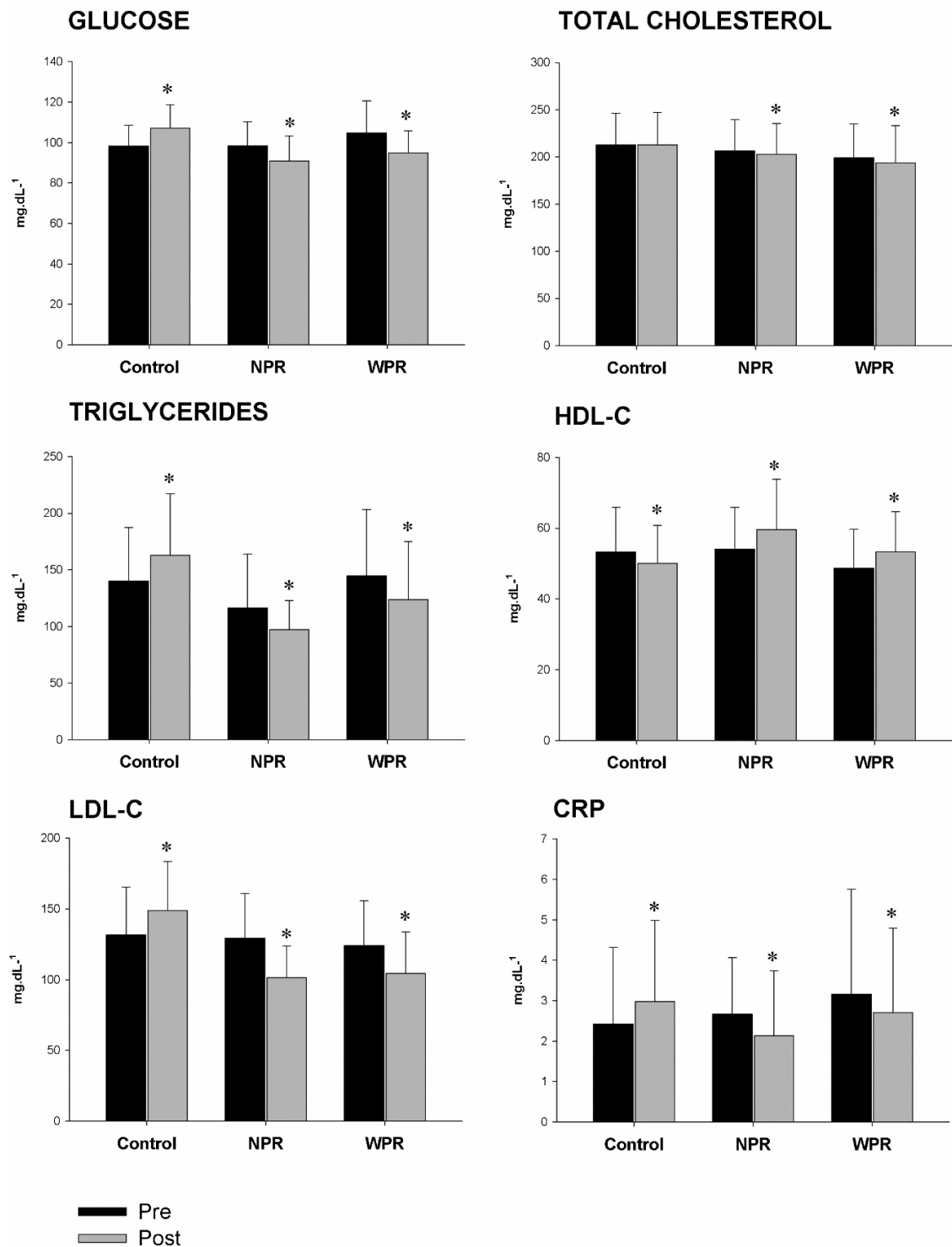


Figure 3.1 Biochemical parameters at pre- and post-intervention according to group. NPR = narrow repetition zone pyramid, WPR = wide repetition zone pyramid, HDL-C = high density lipoprotein cholesterol, LDL-C = low density lipoprotein cholesterol, CRP = C-reactive protein. * $P < 0.05$ vs. pre. Group by time interaction ($P < 0.05$) was revealed for all variables, except to total cholesterol ($P = 0.8$).

3.4 Discussion

To our knowledge, this is the first study to compare variations in the repetition zones of the ascending pyramid training system on body composition and metabolic biomarkers in older women. The main findings of our study were that ascending pyramid training system promoted significant improvements in body composition and metabolic biomarkers in untrained older women, independently of repetition zones used.

In this study, the body fat loss in the training groups were similar (-1.0 kg in the NPR and -1.3 kg in the WPR). This result corroborates with data reported a recent study conducted in our laboratory (RIBEIRO et al., 2016b), with another cohort of untrained older women, in which the ascending pyramid and traditional training systems induced similar reductions in body fat. Some studies have analyzed the effects of daily undulating periodization on body fat and the results are controversial (KRAEMER et al., 2003; DE LIMA et al., 2012; CONLON et al., 2016). In Kraemer et al. (2003) study, the reduction of BF was statistically similar among young female tennis athletes who underwent 9 months of non-periodic RT regimes (-2.1 kg) and daily undulating periodization (-3.8 kg). Conlon et al. (2016) also reported a similar reduction on BF in untrained older subjects after 22 weeks of RT in non-periodized training regimens (-4.3 kg), undulatory block periods (-3.0 kg) and daily undulating periodization (-4.1 kg). On the other hand, de Lima et al. (2012) reported higher BF reductions in young untrained women who performed RT in linear periodization (-2.5 kg%) than those who performed daily undulating periodization (-1.6 kg). Due to the enormous differences between the protocols, intervention time, population evaluated and measures used in the studies, there is no way to reach a consensus about the most effective model. In addition, in our study the analyses of regional fat revealed

significant increases only in android fat in the CON group. On the other hand, fat region lost in android and gynoid regions were homogeneous and without statistical differences between the training groups. Longer RT intervention periods can result in reduction of up to 35% of android fat, every 10% of total fat lost (HUNTER et al., 2002).

Reduction of body fat induced by RT was associated with decrease in glucose and LDL-C in elderly women (TOMELERI et al., 2016). In our study, both training groups had similar decreases of glucose concentration with moderate effect size (NPR = -0.65 and WPR = -0.63). Although the glucose does not seem to be affected by the RT system acutely (CHARRO et al., 2010), the reduction induced by the continuous practice of training was a long-awaited response, considering the glycolytic demands for energy production associated with the exercise model (LAMBERT; FLYNN, 2002). Another important aspect associated with the reduction of RT-induced blood glucose is the improvement in action and insulin resistance (RYAN et al., 2001). Regarding the lipid profile, in the present study no significant alterations in total cholesterol were reported, which is common, considering the antagonist of its fractions (LDL-C and HDL-C). On the other hand, in CON group were found elevation of LDL-C and triglycerides and reduction of HDL-C, whereas in the PR groups statistically similar alterations were observed with reduction of LDL-C and triglycerides and increases in HDL-C. Ribeiro et al. (2016b) also, reported statistically similar improvements independently of RT system, however, reductions in LDL-C were of large magnitude in the TR group (ES, -0.86) and moderate in the PR group (ES, -0.76). In contrast, Conlon et al. (CONLON et al, 2016) reported that the daily variation in volume and intensity of training with daily undulating periodization may induce superior adaptations on blood lipids with moderate improvements (ES, -0.57) compared to the block periodization (ES, 0.00) and non-periodization (ES, 0.22). The effect-sizes

observed in the PR groups for the triglycerides were similar (ES, -0.4, NPR and WPR), however, in LDL-C were ES, -0.9 (larger) and -0.6 (moderated) in NPR and WPR, respectively. Although the mechanisms by which RT induces improvements in these variables are still not entirely clear and the training system seems to have little impact on adaptations. However, overall, the benefits of RT for the prevention of cardiovascular and metabolic problems are clear.

Evidence shows that CRP is not only an inflammatory marker but an important risk factor associated with numerous aging-related diseases including hypertension, cardiovascular disease, diabetes mellitus, and kidney disease (TANG et al., 2017). RT is an effective intervention model in the improvement of inflammatory indicators such as CRP (DE SALLES et al., 2010). Our results reveal that after 8 weeks of intervention, there were increases in CRP of the CON group but RT induces a similar reduction in the PR groups. Previous studies from our laboratory had already reported improvements in CRP, regardless of training system (RIBEIRO et al., 2016b), in older obese women (TOMELERI et al., 2016) and more pronounced the longer the training time (RIBEIRO et al., 2015). In addition, adaptive responses in CRP induced by RT seem to be associated with baseline levels in older women, where subjects with normal levels of CRP have minor changes compared to subjects with high baseline levels (RAMEL et al., 2015).

Some limitations of this study need to be highlighted. The 8-week intervention period may be considered short in order to differentiate the adaptive responses to the different systems. Studies with longer duration should be conducted to analyze possible differences. Despite the evaluation of food consumption, the lack of control over the subjects' diet was an important factor for the study. Although DXA is well established as a valid measure for determining body composition, subtle

changes in body adiposity and changes in visceral fat are not detected as in imaging equipment such as computed tomography and magnetic resonance imaging. For greater clarity, future studies should endeavor to investigate the topic using direct imaging modalities. The study is specific to untrained, older women and results cannot be generalized to other populations including children, young adults, men, and those with resistance training experience.

On the other hand, our study was conducted with randomized clinical trial design with control group, which strengthens our findings regarding the effects of training. Another important point to note was that in addition to total body fat, we evaluated the android and gynoid portions, providing evidence of redistribution of body fat induced by RT. Finally, it is important mentioning that the training conducted with individualized supervision of the elderly allows a greater control of the training variables and the technique of performing the exercises, reducing the risk of injuries.

3.5 Conclusion

The study revealed that the pyramid ascending system performed with narrow and wide zone of repetitions promotes improvements in body composition and metabolic profile in older women. Although we have not identified significant statistical differences between repetition zones utilized, the results demonstrate the effectiveness of the PR system as a valid strategy in reducing the risk factors for development of cardiovascular and metabolic diseases in older women.

CAPITULO 4**Artigo original 3**

Effects of ascending pyramid training systems performed with wide or narrow repetition zone on bioimpedance vectors and phase angle in untrained older women

Abstract

The purpose of the present study was to analyze the effects of ascending pyramid training system performed with wide or narrow repetition zone on bioimpedance vectors analysis (BIVA) and phase angle (PhA) in untrained older women. Fifty-five older women (67.3 ± 4.4 years, 66.5 ± 12.6 kg, 1.55 ± 0.1 m, 27.6 ± 5.0 kg/m²) were randomly assigned into one of three groups: non-exercise control group (CON, $n = 18$) and two training groups that performed an 8-week resistance training program, consisted of 8 whole-body exercises, performed 3 times a week in an ascending pyramid fashion, whereby one group performed 3 sets in a narrow repetition zone (NPR, $n = 19$, repetitions = 12/10/8) and other group performed 3 sets in a wide repetition zone (WPR, $n = 18$, repetitions = 15/10/5). Dual-energy X-ray absorptiometry was used to estimate lean soft tissue (LST) and fat mass (FM). Bioimpedance spectroscopy was used to accessing the resistance (R), reactance (Xc) and PhA. BIVA analysis was conducted by Piccoli's RXc graph method. Both training groups showed higher improvements ($P < 0.05$) in R, Xc and PhA, compared to CON and increases in PhA were statistically higher ($P < 0.05$) in the WPR (ES = 1.02) compared to NPR (ES = 0.58). The results suggest that the ascending pyramid training system performed with wide or narrow repetition zone is effective to induce improvements in BIVA vectors and PhA, and that the WPR elicits higher increments in PhA than the NPR in untrained older women.

Keywords: aging, strength training, resistance training system, BIVA, phase angle.

4.1 Introduction

Bioelectrical impedance (BIA) is one of the non-invasive, inexpensive and simple method to monitor cellular volume (LUKASKI, 2013). The principle of BIA is based on the body's responses to a series of alternating electric currents (KUSHNER, 1992). The electric current flows through the ions and impeded by the viscosity of the environment, represented by resistance (R) and due to the dielectric and electromagnetic properties of tissue interfaces and cell membranes, part of this current is stored in the cells and represented by reactance (X_c), which indicates the opposition to electric current or electric tension (PICCOLI et al., 1994). The storage of the electric charge causes the current to be behind the voltage, creating a phase shift and phase angle (PhA) is calculated taking the arc tangent value of the ratio of X_c versus R (BAUMGARTNER; CHUMLEA; ROCHE, 1988). To avoid the error associated with the use of predictive equations of BIA equipment, the studies that have used the analysis of the bioelectrical impedance vectors (BIVA) and PhA have increased (LUKASKI, 2013). BIVA consists of the graphical representation of the relationship between R and X_c normalized by the height of the individual (PICCOLI et al., 1994).

The BIVA and PhA has been widely used to monitor changes in hydration and nutritional status in different populations (BUFFA et al., 2010; NORMAN et al., 2012; ALVES et al., 2015; CAMINA MARTIN et al., 2015; SLEE; BIRC; STOKOE, 2015). In addition, vector displacement and PhA analysis has been used to aid diagnosis (BUFFA et al., 2010; MARINI et al., 2012) and prognosis (NORMAN et al., 2012) in different clinical approaches. Sex, ethnicity, age and BMI directly influence the distribution pattern of BIVA vectors and PhA (PICCOLI; PILLON; DUMLER, 2002; BOSY-WESTPHAL et al., 2006). The PhA decreases with aging, influenced by the reduction of muscle mass reflected in the reduction of X_c and increase in body fat,

reflecting increases in R (NORMAN et al., 2012). Resistance training (RT) can be a strategy to reverse, mitigate and improve the adverse effects of aging in muscle mass and body fat (PHILLIPS, 2007; RIBEIRO et al., 2015). RT can induce changes in the cellular volume of skeletal muscle tissue, which is a highly hydrated tissue due to variations in metabolic demand, cell membrane potential and blood supply, and these alterations are associated with muscle hypertrophy and reduced adiposity (USHER-SMITH; HUANG; FRASER, 2009).

Besides, BIVA and PhA vectors can serve performance indicators (MICHELI et al., 2014) and are influenced by the intensity of training and modality practiced (KOURY; TRUGO; TORRES, 2014). Recently the effects of 12 and 24 weeks of RT on the BIVA and PhA vectors were evaluated in older women, revealing that 24, but not 12 weeks, promoted vector migration, with significant increases in Xc and PhA, indicating improvements in the integrity of the membrane and cellular health (FUKUDA et al., 2016). This was the first study to evaluate the effects of RT on BIVA vectors, however, other recent studies have reported improvements in PhA after short-term (8 - 12 weeks) RT interventions (DOS SANTOS et al., 2016; SOUZA et al., 2016; RIBEIRO et al., 2017c; RIBEIRO et al., 2017b).

Physical exercise induces increased cellular hydration and function, due to cell swelling (HAUSSINGER; LANG; GEROK, 1994; HÄUSSINGER, 1996). Predominantly metabolic stimuli result in increased extracellular fluids, whereas mechanical stimuli result in increased intracellular fluids (SJOGAARD; ADAMS; SALTIN, 1985). Apparently, cellular swelling due to the metabolic and mechanical effects of RT can induce different adaptive responses in the function and volume of cellular hydration. Considering this hypothesis, our group recently compared the traditional (constant loads) and pyramidal (progressive loads) RT systems on PhA in

older women (RIBEIRO et al., 2017b). The hypothesis was that the variation of the stimuli, due to the progression of loads, could result in superior adaptive responses in relation to the use of constant loads. Both systems promoted increases in PhA, with no statistically significant differences between systems (RIBEIRO et al., 2017b). Although the study provides important evidence on the effectiveness of RT for improvements in the cellular health of older women, the lack of pyramidal training system superiority may be because the repeat interval performed (12/10/8 RM) was too narrow to promote stimuli compared to the system with constant loads (8-12 RM) and thus induce differential adaptations. In addition, BIVA vectors have not been evaluated and to date there is no evidence on the influence of load variation on the adaptive responses of these variables.

Therefore, the purpose of the present study was to analyze the effects of ascending pyramid training system performed with wide or narrow repetition zone on classical bioelectrical impedance vector analysis (BIVA) and phase angle (PhA) in older women. We hypothesized that both repetition zones would be effective to induce improvements in BIVA vectors and increase in PhA, and that the ascending pyramid training system performed in a wide zone of repetitions would elicit greater improvements compared to the narrow zone of repetition. The rationale for this hypothesis is based on a greater variation of the stimulus, thus allowing higher metabolic (in the first set) and mechanical stress (in the final set).

4.2 Methods

4.2.1 Participants

Fifty-five physically independent older women (67.3 ± 4.4 years, 66.5 ± 12.6 kg, 1.55 ± 0.1 m, 27.6 ± 5.0 kg/m²) were selected for participation in this study.

Recruitment was carried out through newspaper, television programs and radio advertisings, and home delivery of leaflets in the central area and residential neighborhoods. All participants completed health history questionnaires and met the following inclusion criteria: physically independent, free from cardiac dysfunction, not receiving hormonal replacement therapy, and not performing any regular physical exercise for more than once a week over the six months previous the beginning of the study. Participants passed a diagnostic, graded exercise stress test with 12-lead electrocardiogram reviewed by a cardiologist and were released with no restrictions for participation in this study. Adherence to the program was established with a minimum participation of 85% of the total sessions. After meetings with volunteer groups, those with the necessary prerequisites completed an initial interview and signed the informed consent term. This study was conducted according to the Declaration of Helsinki and approved by the Ethics Committee of the local University.

4.2.2 Experimental Design

The study was carried out over a period of 12 weeks, with 8 weeks dedicated to the RT program, and 4 weeks for data collection. Pre- and post-intervention testing was carried out at weeks 1-2 and 11-12, respectively, and comprised anthropometric, body composition and maximal dynamic strength measurements. The RT program was carried out during weeks 3-10. Physical education professionals supervised all sessions. Subjects were instructed not to perform any other type of physical exercise throughout the study period. Participants were randomly assigned to one of three groups: control group (CON, n = 18), instructed not to engage in any physical exercise training program during the period of the intervention and to maintain their eating and physical activity patterns, and two different

systems of pyramid training: a narrow zone of repetitions (NPR, $n = 19$) in which participants performed 3 sets of 12/10/8 repetitions or a wide zone of repetitions (WPR, $n = 18$) in which participants performed 3 sets of 15/10/5 repetitions.

4.2.3 Body composition

Lean soft tissue (LST) and fat mass (FM) measurements were carried out using a dual energy X-ray absorptiometry (DXA) scan (Lunar Prodigy, model NRL 41990, GE Lunar, Madison, WI). Before scanning participants were instructed to remove all objects containing metal. Calibration and scans were performed according to the manufacturer's instruction manual. Both calibration and analysis were carried out by a skilled laboratory technician. Analyses during the intervention were performed by the same technician who was blinded to intervention time point. Previous test-retest scans of eight older women resulted in standard error of measurement (SEM) of 0.6 kg and intraclass correlation coefficient (ICC) of 0.99 for LST and SEM of 0.90 kg and ICC of 0.99 for FM.

4.2.4 Bioimpedance spectroscopy

A phase-sensitive bioimpedance spectroscopy (Xitron Hydra, model 4200, Xitron Technologies, San Diego, CA, USA) was used to obtain whole-body resistance (R) and reactance (X_c) at a single frequency (50 kHz). PhA was calculated taking the arc tangent value of the ratio of X_c versus R . Classic BIVA values were calculated relative by height (R/H and X_c/H). Total body water (TBW) and his fractions intracellular (ICF) and extracellular (ECF) fluids were obtained by the bioimpedance spectroscopy commercial software. Before each test, the analyzer was calibrated by measuring, modeling, and computing volume on a provided verification module. The calibration

test result is based on the default ECF and ICF resistivity coefficients. Participants were instructed to lie in a supine position for about 10 min (serving as an equilibration period). After cleaning the skin with alcohol, four electrodes were positioned on the surface of the right hand and right foot, according to conventional procedures established in the literature. SEM of 0.3 l and ICC of 0.98 for ECF, SEM of 0.19 l and ICC of 0.99 for ICF and SEM of 0.4 l and ICC of 0.98 for TBW, SEM of 15.6 ohms and ICC of 0.95 for R, SEM of 3.5 ohms and ICC of 0.96 for Xc, SEM of 0.2 degrees and ICC of 0.96 for PhA.

4.2.4 Resistance training program

The RT program was performed three times a week, with an interval of 48 h between training sessions and was carried out over a period of 8 weeks. Training took place in the morning and was based on recommendations for RT in older population to improve muscle hypertrophy and strength (ACSM, 2009; CHODZKO-ZAJKO et al., 2009). Physical education professional supervised personally all participants throughout each training session in order to reduce deviations from the study protocol and to ensure subject safety. Subjects performed RT using a combination of free weights and machines.

The RT protocol consisted of a whole-body program with 8 exercises performed in the following order: chest press, horizontal leg press, seated row, knee extension, preacher curl, leg curl, triceps pushdown, and seated calf raise. Participants performed either 3 sets of 12/10/8 repetitions (NRP) or 15/10/5 repetitions (WPR) with incrementally higher loads for each set (ascending pyramid system). The participants were instructed to inspire during the eccentric phase and exhale during the concentric phase of the exercise and to maintain the velocity of muscular contraction at a ratio of

1 : 2 (concentric and eccentric phases, respectively). The rest interval ranged between 60-120 s for sets and exercises. The supervisors adjusted the loads of each exercise according to the subject's ability and improvements in exercise capacity throughout the study in order ensure that subjects were using as much resistance as possible while maintaining proper technique. Progression in each exercise occurred when the participant was able to perform 10 (NRP) or 7 (WPR) repetitions in the last set by two consecutive sessions. Progression was accomplished by increasing the load for the upper limb and lower limb exercises by 2-5% and 5-10%, respectively, in each set, in the next training session (ACSM, 2009).

4.2.5 Volume load

The loads and the number of repetitions performed during each set of the 8 exercises were recorded in all training session. The training volume of each exercise was calculated as the sum of the volume (loads used multiplied by the number of repetitions performed) of all three sets for each exercise. The total volume per session was calculated as the sum of training volume of all 8 exercises. The weekly volume load was calculated by the sum of total volume reached in the 3 sessions performed in the week.

4.2.6 Statistical analysis

The Kolmogorov-Smirnov test was used to checked normality. Data are presented as mean, standard deviations, and percentage of changes. The baseline and percentage changes comparisons were performed by one-way analysis of variance (ANOVA). Adjusted Greenhouse-Geisser corrections were used for any violations of sphericity by Mauchly's test. The 2-way ANOVA for repeated measures

was conducted for comparisons between and within groups over time. Adjusted Greenhouse-Geisser corrections were used for any violations of sphericity by Mauchly's test. Fisher's post-hoc test was conducted to identify the mean differences when the F-ratio was significant. The mean vector displacement was compared with BIVA software (PICCOLI; PASTORI, 2002) using Hotelling's T^2 test. The effect size (ES) was calculated to verify the magnitude of the differences by Cohen's d where an ES of ≥ 0.20 – 0.49 was considered as small, 0.50 – 0.79 as moderate and ≥ 0.80 as large (COHEN, 1988). For all statistical analyses, significance was established at $P < 0.05$. Analyses were performed with SPSS software version 22.0 (SPSS Inc., Chicago, IL, USA).

4.3 Results

No significant differences were observed in baseline scores between groups ($P > 0.05$) for age (CON = 66.8 ± 3.3 years; NPR = 68.0 ± 4.6 years; WPR = 67.0 ± 4.6 years), body mass (CON = 1.56 ± 0.1 m; NPR = 1.54 ± 0.1 m; WPR = 1.56 ± 0.1 m), weight (CON = 65.8 ± 14.8 kg; NPR = 66.3 ± 11.6 kg; WPR = 67.5 ± 11.6 kg), and BMI (CON = 27.0 ± 5.6 kg/m²; NPR = 28.1 ± 5.0 kg/m²; WPR = 27.6 ± 4.4 kg/m²).

Figure 4.1 depicts the weekly volume load by RT group. There was significant group by time interaction ($P < 0.05$), with higher increments of total volume load in WPR (WPR = 123.643 kg and NPR = 135.249 kg, total volume load) was observed.

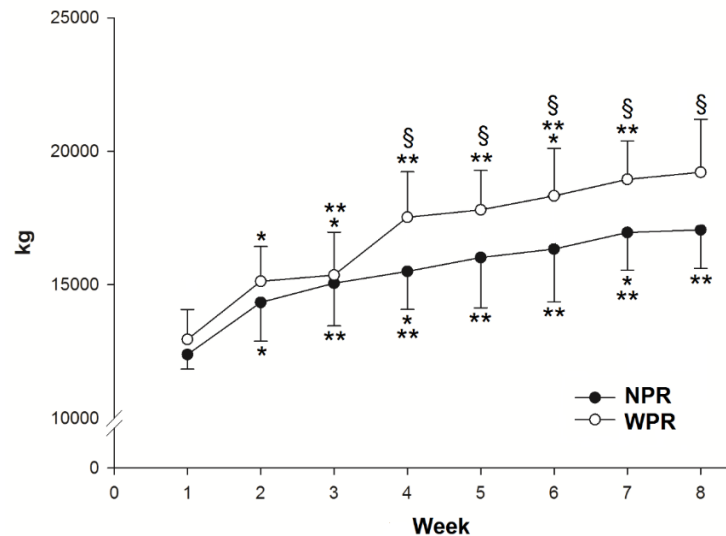


Figure 4.1 Weekly volume load in 8 weeks at pyramidal system in the narrow repetition zone (NPR, $n = 19$) or wide repetition zone (WPR, $n = 18$) in older women. * $P < 0.05$ vs. previous week. ** $P < 0.05$ vs. two previous weeks. § $P < 0.05$ vs. NPR.

Body composition information is presented in Table 4.1. Significant interactions ($P < 0.05$) were found for body fat (NPR = - 0.94 kg; WPR = - 1.73 kg; CON = 0.53 kg), LST (NPR = 0.73 kg; WPR = 1.25 kg; CON = -0.71 kg), TBW (NPR = 0.32 L; WPR = 0.54 L; CON = - 0.75 L), ECF (NPR = - 0.33 L; WPR = - 0.79 L; CON = 0.25 L), ICF (NPR = 1.02 L; WPR = 1.33 L; CON = -1.0 L), R (NPR = -13.49 ohm; WPR = - 26.91 ohm; CON = 8.91 ohm); Xc (NPR = 2.42 ohm; WPR = 3.29 ohm; CON = -2.48 ohm), R/H (NPR = -8.55 ohm/m; WPR = - 27.03 ohm/m; CON = 6.01 ohm/m) and Xc/H (NPR = 1.38 ohm/m; WPR = 2.13 ohm/m; CON = -1.58 ohm/m), without differences between training groups.

Tabela 4.1 Body composition at pre- and post-intervention according to group.

	CON (n = 18)	NPR (n = 19)	WPR (n = 18)	Interaction P-value
Body fat (kg)				
Pre	25.8 ± 9.9	27.4 ± 8.9	28.9 ± 8.0	< 0.01
Post	26.4 ± 10.1*	26.5 ± 9.0*	27.1 ± 7.6*	
Δ%	+2.1	-3.4	-6.0	
ES	+0.05	-0.10	-0.22	
LST (kg)				
Pre	38.1 ± 5.2	38.5 ± 4.6	37.1 ± 6.1	< 0.01
Post	37.4 ± 5.2*	39.2 ± 4.7*	38.3 ± 5.9*	
Δ%	-1.9	+1.9	+3.4	
ES	-0.14	+0.16	+0.20	
TBW (L)				
Pre	28.8 ± 5.4	29.3 ± 3.7	28.0 ± 3.6	0.03
Post	28.0 ± 5.4*	29.6 ± 3.6	28.5 ± 3.8*	
Δ%	-2.6	+1.1	+1.9	
ES	-0.14	+0.09	+0.15	
ECF (L)				
Pre	13.2 ± 2.0	12.9 ± 1.4	13.2 ± 1.6	< 0.01
Post	13.4 ± 2.0*	12.6 ± 1.2*	12.5 ± 1.7*	
Δ%	+1.9	-2.6	-6.0	
ES	+0.13	-0.24	-0.49	
ICF (L)				
Pre	15.6 ± 3.5	16.0 ± 2.5	14.7 ± 2.3	< 0.01
Post	14.6 ± 2.8*	17.1 ± 2.6*	16.0 ± 2.7*	
Δ%	-6.4	+6.4	+9.0	
ES	-0.29	+0.41	+0.58	
R (ohm)				
Pre	572 ± 72	564 ± 45	574 ± 56	0.01
Post	581 ± 72	551 ± 51*	548 ± 62*	
Δ%	+1.6	-2.4	-4.7	
ES	+0.12	-0.30	-0.48	
Xc (ohm)				
Pre	56 ± 7	54 ± 5	55 ± 5	< 0.01
Post	54 ± 7*	56 ± 6*	58 ± 6*	
Δ%	-4.4	+4.5	+6.0	
ES	-0.36	+0.47	+0.66	
R/H (ohm/m)				
Pre	366.3 ± 40.1	366.7 ± 23.4	367.4 ± 32.0	< 0.01
Post	372.4 ± 42.6	358.2 ± 28.8*	340.3 ± 38.5*	
Δ%	+1.6	-2.3	-7.4	
ES	+0.15	-0.37	-0.84	
Xc/H (ohm/m)				
Pre	36.0 ± 4.2	34.9 ± 3.1	35.0 ± 3.1	< 0.01
Post	34.4 ± 4.4*	36.2 ± 3.7*	37.2 ± 3.6*	
Δ%	-4.4	+4.0	+6.1	
ES	-0.38	+0.45	+0.70	

Note. CON = control group, NPR = narrow repetition zone group, WPR = wide repetition zone group, LST = lean soft tissue, TBW = total body water, ECF = extracellular fluids, ICF = intracellular fluids, R = resistance, Xc = reactance, R/H = ratio between resistance and height, Xc/H = ratio between reactance and height, ES = effect size. Data are expressed in mean and standard deviation.

The mean differences in R/H and Xc/H vector with 95% confidence ellipses by groups were depicted in figure 4.2. Significant displacement ($P < 0.01$) were observed for CON ($T^2 = 14.5$), NPR ($T^2 = 40.0$) and WPR ($T^2 = 84.1$) group, in which the 95% confidence ellipses did not cross the origin.

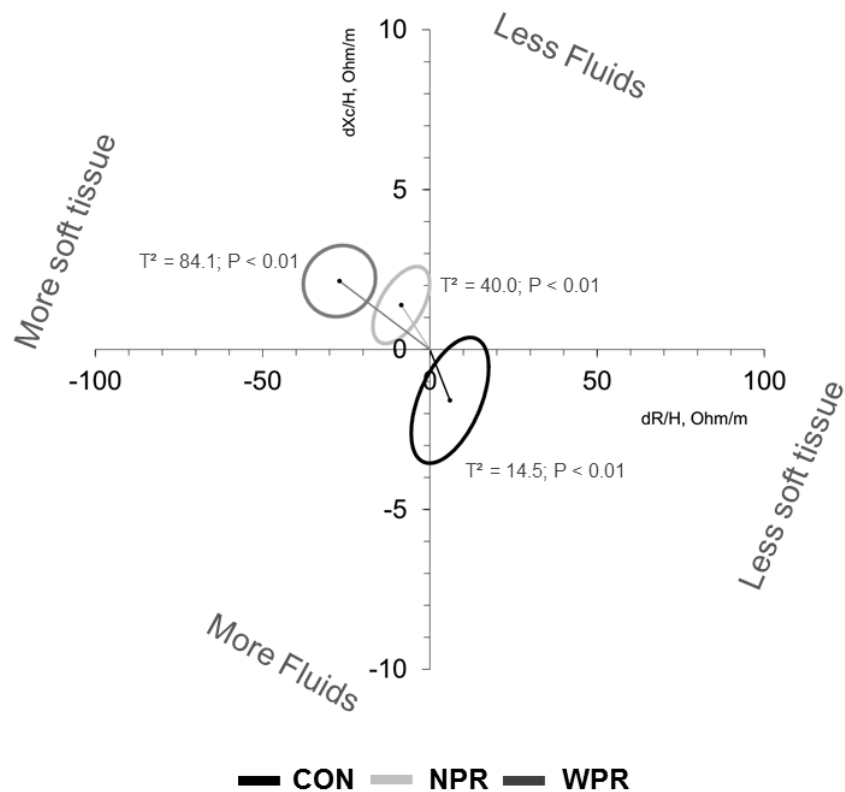


Figure 4.2 Impedance vector displacement and the 95% confidence ellipses for control (CON, $n = 18$), narrow repetition zone (NPR, $n = 19$) and wide repetition zone (WPR, $n = 18$) groups.

Figure 4.3 depicts the mean impedance vectors with 95% confidence ellipses baseline to post-intervention by groups. The vector migration was statistically significant only in the WPR group ($T^2 = 13.0$; $P < 0.01$), indicating that the upward displacement occurred due to the greater reduction in R / H.

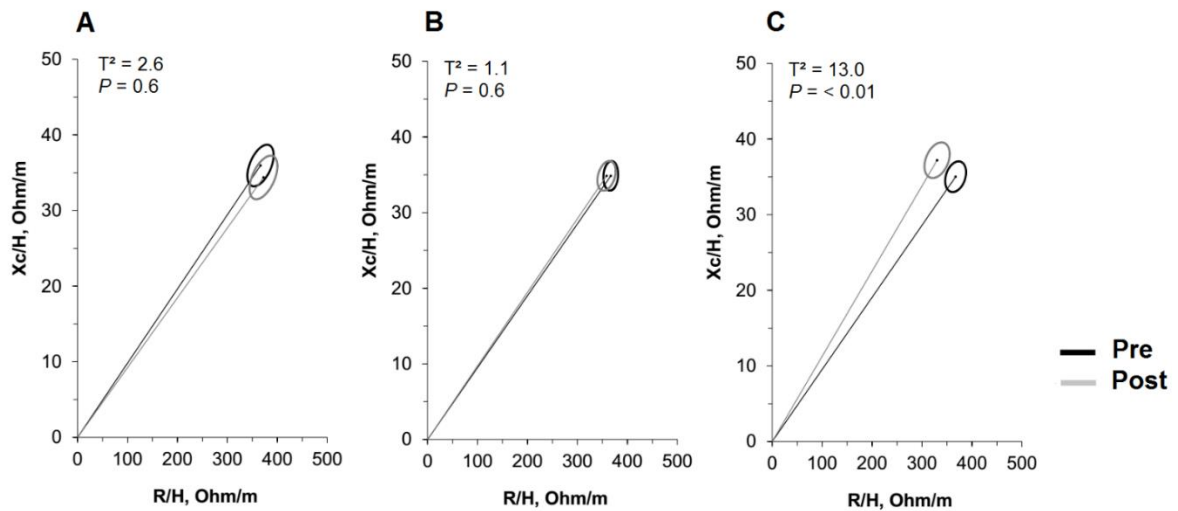


Figure 4.3 Mean impedance vectors with 95% confidence ellipses for control (Panel A), narrow repetitions zone (Panel B) and wide repetitions zone (Panel C) groups at pre- and post-intervention.

Figure 4.4 depicts the percentage changes pre- to post-intervention on PhA by group. The PhA were similar between groups on baseline (CON = 5.63 ± 0.6 ; NPR = 5.45 ± 0.6 ; WPR = 5.47 ± 0.6). There was a significant interaction ($P < 0.05$), in which WPR presented higher increase in PhA than NPR and CON (PhA post-intervention = 6.08° [+11.2 %]; 5.80° [+6.4 %]; 5.30° [-1.6 %], respectively).

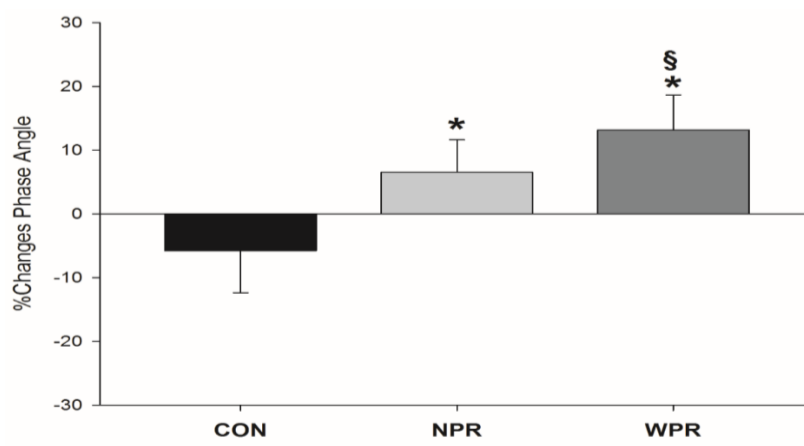


Figure 4.4 Percentage changes on phase angle after 8 weeks of intervention at control (CON, $n = 18$), narrow repetition zone (NPR, $n = 19$) and wide repetition zone (WPR, $n = 18$) groups. * $P < 0.05$ vs. CON. § $P < 0.05$ vs. NPR.

4.3 Discussion

The main novelty this study was that pyramid system performed with both narrow and wide repetitions zone is effective to improve BIVA and PhA, although the WPR has resulted in higher increases of PhA in untrained older women.

The RT seems to induce significant displacement in BIVA vectors associated with improvements in integrity and health of cells (FUKUDA et al., 2016). In the present study, in both training groups there was similar and statistically significant upward displacement of the BIVA vectors (Figure 1), indicating increases in soft tissues, which can be confirmed by the LST values obtained by DXA (LST = +0.7 kg and +1.25 kg, NPR and WPR, respectively), while in the CON group the displacement indicated soft tissue reduction (LST = -0.7). In the CON and NPR groups the R/H and Xc/H components contributed in an equally way to the vector migration, already in WPR group, the migration occurred due to the greater reduction of the R/H component (Figure 2). These results are evident when compared the effect-size of R/H (-0.84, large effect) and Xc/H (0.70 moderated effect) on post-intervention on WPR. Performance sets with high number of repetitions (+15 repetitions) and reduced loads (<50% 1RM) induce metabolic overload and accumulation of substrates as blood lactate (BUIRAGO et al., 2012; FINK; KIKUCHI; NAKAZATO, 2016). The accumulation of intramuscular lactate has been associated to trigger mechanisms regulating the volume of cellular hydration, which can be amplified by the accumulation of metabolites from exercise (SCHOENFELD, 2013). The accumulation of metabolites changes the extracellular environment, making it more acidic and increasing the ionized substrates (e.g. Na⁺ and Cl⁻), which alter the osmolarity, moving the water through the sarcolemma of the cell membranes and inducing the cellular swelling (USHER-SMITH; HUANG; FRASER, 2009).

Furthermore, in untrained individuals the primary responses to RT are neural adaptations and increased protein synthesis (DAMAS et al., 2015), processes associated with changes in cellular hydration, especially increases on intracellular fluids (RIBEIRO et al., 2014). Cellular swelling is an important process of regulation on cellular function and can be stimulated by anabolic processes such as hormonal changes, oxidative stress, and nutrient metabolisms (HAUSSINGER, 1996). In the present study, performed RT in WPR system resulted in higher effect-sizes in Xc/H and ICF (ES, 0.58 and 0.70, respectively) compared to NPR (ICF = 0.41 and Xc/H = 0.45). These changes indicate a possible improvement in the integrity of the cell membrane, increasing the capacitance of the cells. It is possible that cellular swelling in response to RT induces increased pressure on the cell membrane, which in turn recognizes these changes as threats to cell integrity and leads to increased signaling and processes to enhance cell ultrastructure's (SCHOENFELD, 2010). Improvements in cell integrity, structures and function, may reflect changes in PhA. In healthy older women, the reference values for PhA are between 5 to 6 degrees (BOSY-WESTPHAL et al., 2006). The PhA of our sample were within the population mean in all groups (CON = 5.63°, NPR = 5.45°, WPR = 5.47°) and our analysis reveal that in both training groups the increases in PhA were significantly higher in relation to the CON group and in the WPR the increments were statistically superior than NPR (ES = 1.08 vs. 0.58, WPR and NPR, respectively). In the available literature, there are few studies on the adaptive responses of PhA to RT (DOS SANTOS et al., 2016; FUKUDA et al., 2016; SOUZA et al., 2016; RIBEIRO et al., 2017c; RIBEIRO et al., 2017b). However, it is possible to state that PhA is sensitive to RT (DOS SANTOS et al., 2016; FUKUDA et al., 2016; SOUZA et al., 2016; RIBEIRO et al., 2017b) and that apparently, the adaptive responses are independent of sex (RIBEIRO et al., 2017c).

In our recent study comparing the systems with constant training loads and a system with variation of loads to each set during 8-weeks of training the PhA were statistically similar in CG ES, 0.30 and PR ES, 0.35(RIBEIRO et al., 2017b). The results of the present study indicate that the realization of the ascending pyramidal system with greater amplitude between sets can maximize the metabolic effects in the first sets, as discussed above, and the mechanical effects in the last sets, resulting in a greater anabolic potential. The realization of sets with 5 RM has already been shown to induce increases in PhA in older women (FUKUDA et al., 2016).

Our study has several limitations that deserve attention. The training period was 8 weeks and may be considered short for adaptations associated with RT. In addition, the study was conducted with older, untrained women and the results should not be extrapolated to other populations. Finally, the absence of biomarkers of lipid peroxidation, protein oxidation and metabolic stress limit the understanding of possible mechanisms associated with the observed results. On the other hand, our study was conducted with randomized clinical trial design with control group, which strengthens our findings regarding the effects of training. Another important point was the use of BIVA to understand the adaptive responses of PhA to the RT system. Finally, it is important mentioning that the training conducted with individualized supervision of the elderly allows a greater control of the training variables and the technique of performing the exercises, reducing the risk of injuries.

Practically, the results of the present study provide subsidies on the effectiveness and safety of the ascending pyramidal system as an alternative to the traditional training system for prescribing for untrained older subjects.

4.4 Conclusion

Our results suggest the effect of ascending pyramid training system with wide and narrow repetition zones in to induce benefic changes in both BIVA and PhA of older women, and that performing a wide repetition zone results in higher increments in PhA than the narrow repetition zone.

CAPÍTULO 5

Considerações finais

5.1 CONCLUSÕES

De acordo com o nosso conhecimento, este foi o primeiro estudo no qual os efeitos de duas zonas de repetições do sistema piramidal foram analisados em diversas variáveis relacionadas à saúde em mulheres idosas não-treinadas.

As informações produzidas ao longo dos três artigos apresentados indicaram que, independente da zona de repetições utilizadas, o sistema de TP piramidal foi eficaz para o aumento da força muscular, melhoria de componentes da composição corporal e de biomarcadores relacionados à saúde. Entretanto, o treinamento com zona de repetições ampla (15/10/5 repetições) permitiu maiores incrementos de cargas e maior intensidade do que o treinamento com zona de repetições restrita (12/10/8 repetições). Adicionalmente, o treinamento com zona de repetições ampla parece induzir melhoras na saúde celular superiores ao treinamento com zona de repetições restrita.

Diversos aspectos metodológicos do nosso estudo merecem ser destacados. Este estudo foi conduzido com a presença de grupo controle e alocação dos sujeitos de forma aleatorizada, reduzindo o viés amostral e possibilitando identificar de forma mais clara o efeito do TP. A análise da força muscular em mais de um exercício permitiu a identificação de alterações segmentares na força muscular (membros superiores, inferiores e tronco). A análise segmentada da massa muscular e compartimentalizada da gordura corporal possibilitaram visualizar respostas adaptativas de maior magnitude na massa muscular de membros inferiores e na adiposidade na região central do corpo.

Entretanto, os resultados apresentados devem ser interpretados com uma certa cautela, tendo em vista algumas limitações deste estudo. Embora a análise com o DEXA esteja bem estabelecida como uma medida válida para determinar a

composição corporal, mudanças discretas na adiposidade corporal e na gordura visceral podem ser melhor discriminadas por exames de tomografia computadorizada e ressonância magnética. Considerando que a amostra investigada foi composta por mulheres idosas não-treinadas, os resultados encontrados não devem ser generalizados para outras populações, incluindo crianças, jovens adultos, homens e aqueles com experiência em TP.

De forma prática, os resultados observados sugerem que o sistema piramidal crescente é uma estratégia segura e efetiva de prescrição de TP para mulheres que estão iniciando e/ou que estão retomando a prática, sendo uma boa alternativa ao sistema tradicional devido a maior dinâmica das sessões de treinamento, em virtude da diversidade de estímulos, o que pode favorecer a adesão e a aderência por parte da população idosa.

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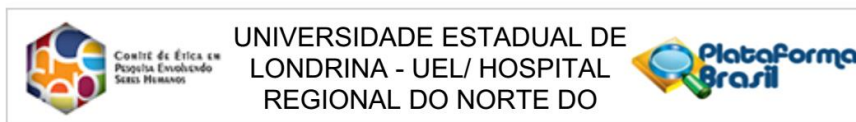
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ANEXOS

ANEXO A – Comitê de ética em pesquisa envolvendo seres humanos



PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: IMPACTO DO TREINAMENTO COM PESOS EM DIFERENTES FREQUÊNCIAS SEMANAIS, DESTREINAMENTO E RETREINAMENTO SOBRE BIOMARCADORES DE SAÚDE, COMPOSIÇÃO CORPORAL, DESEMPENHO MOTOR E INDICADORES DE QUALIDADE DE VIDA EM MULHERES IDOSAS.

Pesquisador: EDILSON SERPELONI CYRINO

Área Temática:

Versão: 2

CAAE: 48815515.0.0000.5231

Instituição Proponente: CEFE - Departamento de Educação Física

Patrocinador Principal: MINISTERIO DA CIENCIA, TECNOLOGIA E INOVACAO

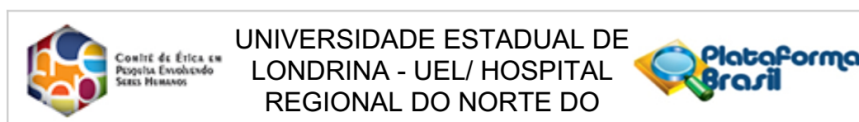
DADOS DO PARECER

Número do Parecer: 1.306.507

Apresentação do Projeto:

Introdução: O processo de envelhecimento tem um impacto negativo sobre diversos indicadores de saúde e qualidade de vida, sobretudo, em pessoas que adotam comportamentos sedentários. Por outro lado, muitos estudos observacionais e experimentais têm revelado efeitos benéficos para a saúde associados a prática de exercícios com pesos em idosos. **Objetivo:** Analisar o impacto do treinamento com pesos em diferentes frequências semanais, do destreinamento e do retraining sobre biomarcadores de saúde, composição corporal, desempenho motor e indicadores de qualidade de vida em mulheres idosas. **Métodos:** Aproximadamente 60 mulheres idosas serão acompanhadas ao longo de 58 semanas em dois grupos experimentais (um com frequência de duas e outro com frequência de três vezes por semana ao treinamento com pesos) de pessoas sedentárias com excesso de peso/obesidade será adotado. O estudo será dividido em quatro etapas com duração de 12 semanas cada, separadas por blocos de duas semanas para medidas e avaliação do processo (linha de base, após 12 semanas de treinamento, após 12 semanas de destreinamento, no final de 12 e de 24 semanas de retraining). Medidas antropométricas e hemodinâmicas, composição corporal, registros alimentares, desempenho motor, bioquímica sanguínea e indicadores de

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Continuação do Parecer: 1.306.507

qualidade de vida serão obtidos nos diferentes momentos do estudo. Resultados esperados: Considerando os riscos para a saúde associados ao comportamento sedentário e os possíveis benefícios do treinamento com pesos em idosos, espera-se que as informações a serem produzidas neste estudo forneçam subsídios importantes para a

saúde de mulheres idosas e que permitam uma tomada de decisão mais segura sobre a prescrição deste tipo de treinamento, a partir de diferentes frequências semanais, considerando que a falta de tempo é considerada uma das principais barreiras relatadas para a falta de adesão e aderência a prática de exercícios físicos em diferentes populações.

Objetivo da Pesquisa:

Objetivo Primário: Analisar o impacto do TP em diferentes frequências semanais, do destreinamento e do retreinamento sobre biomarcadores de saúde, composição corporal, desempenho motor e indicadores de qualidade de vida em mulheres idosas.

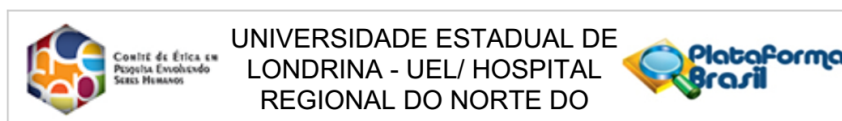
Objetivo Secundário: Estabelecer relações entre as possíveis modificações na quantidade de água corporal intracelular e a massa muscular/massa livre de gordura

induzidas pelo TP; Identificar as modificações no comportamento hemodinâmico induzidas pelo treinamento e destreinamento em idosos; Verificar possíveis modificações na força muscular e na composição corporal de forma segmentar.

Avaliação dos Riscos e Benefícios:

O projeto apresenta riscos mínimos, relacionados com os possíveis desconfortos decorrentes das medidas antropométricas e de força muscular, coleta de sangue para medidas bioquímicas, além do eventual constrangimento a algumas das questões do instrumento de qualidade de vida. É possível, também, que no início do programa de treinamento as participantes sintam dores musculares após as sessões de exercícios. Contudo, profissionais de Educação Física serão responsáveis por adotar medidas de segurança e se responsabilizarão por eventuais problemas nas áreas que lhes competem. Com relação à coleta de sangue, será realizada por profissionais capacitados do Hospital Universitário desta Universidade, os quais, da mesma forma, serão responsáveis pela segurança e suporte em eventuais problemas causados durante o procedimento. Benefícios: Espera-se que as participantes do estudo se beneficiem dos resultados positivos que a prática de exercícios orientados pode gerar nesta faixa etária, sendo que, mediante os resultados positivos, o treinamento também será ofertado ao grupo controle.

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Continuação do Parecer: 1.306.507

Comentários e Considerações sobre a Pesquisa:

O processo de envelhecimento tem um impacto negativo sobre diversos indicadores de saúde e qualidade de vida, sobretudo, em pessoas que adotam comportamentos sedentários. Por outro lado, muitos estudos observacionais e experimentais têm revelado efeitos benéficos para a saúde associados a prática de exercícios com pesos em idosos. A prática regular de programas de TP pode melhorar a aptidão neuromuscular, a composição corporal, a sensibilidade à insulina, os níveis de glicose sanguínea, a pressão arterial, além de prevenir o desenvolvimento de inúmeras disfunções crônico-degenerativas.

Considerações sobre os Termos de apresentação obrigatória:

Folha de Rosto, Parecer favorável da Entidade coparticipante e TCLE foram apresentados e estão em conformidade com as exigências do CEP/UEL. Demais documentos apresentados também estão em conformidade com as exigências do CEP/UEL.

Recomendações:

Substituir no TCLE, o endereço do CEP/UEL para: Comitê de Ética em Pesquisa Envolvendo Seres Humanos da Universidade Estadual de Londrina, situado junto ao LABESC – Laboratório Escola, no Campus Universitário, telefone 3371-5455, e-mail: cep268@uel.br.

Conclusões ou Pendências e Lista de Inadequações:

Não há.

Considerações Finais a critério do CEP:

Prezado (a) Pesquisador (a),

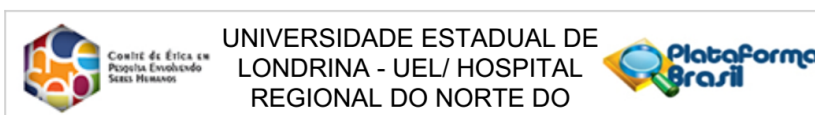
Este é seu parecer final de aprovação, vinculado ao Comitê de Ética em Pesquisas Envolvendo Seres Humanos da Universidade Estadual de Londrina. É sua responsabilidade imprimi-lo para apresentação aos órgãos e/ou instituições pertinentes.

Coordenação CEP/UEL.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_552637.pdf	23/10/2015 21:28:29		Aceito
Declaração de Pesquisadores	CARTA_RESPOSTA.docx	23/10/2015 21:27:57	EDILSON SERPELONI	Aceito
Declaração de Pesquisadores	luciano.pdf	23/10/2015 19:47:46	EDILSON SERPELONI	Aceito

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Continuação do Parecer: 1.306.507

Declaração de Pesquisadores	rodrigo.pdf	23/10/2015 19:43:45	EDILSON SERPELONI	Aceito
Declaração de Pesquisadores	decio.pdf	23/10/2015 19:27:00	EDILSON SERPELONI	Aceito
Projeto Detalhado / Brochura Investigador	Projeto.doc	23/10/2015 19:24:45	EDILSON SERPELONI CYRINO	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_2015.doc	23/10/2015 19:23:38	EDILSON SERPELONI CYRINO	Aceito
Folha de Rosto	foto2.pdf	28/08/2015 15:33:21	EDILSON SERPELONI	Aceito
Declaração do Patrocinador	Termo.pdf	24/08/2015 09:52:48	EDILSON SERPELONI	Aceito
Outros	Parecer Edilson Serpeloni Cyrino.pdf	11/08/2015 21:23:19		Aceito

Situação do Parecer:

Aprovado

Necessita Apreciação da CONEP:

Não

LONDRINA, 03 de Novembro de 2015

Assinado por:
Alexandrina Aparecida Maciel Cardelli
(Coordenador)

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APÊNDICES

APÊNDICE A - Arquivo de saída do G*Power para o cálculo amostral

F tests – ANOVA: Repeated measures, within-between interaction

Analysis: A priori: Compute required sample size

Input:	Effect size f	=	0.24
	α err prob	=	0.05
	Power (1- β err prob)	=	0.80
	Number of groups	=	3
	Number of measurements	=	2
	Corr among rep measures	=	0.5
	Nonsphericity correction ϵ	=	1
Output:	Noncentrality parameter λ	=	10.3680000
	Critical F	=	3.2199423
	Numerator df	=	2.0000000
	Denominator df	=	42.0000000
	Total sample size	=	45
	Actual power	=	0.8004756

APÊNDICE B - Termo de consentimento livre e esclarecido

Título da pesquisa:

“EFEITO DE DIFERENTES ZONAS DE REPETIÇÕES DO SISTEMA PIRAMIDAL CRESCENTE SOBRE A FORÇA MUSCULAR, A COMPOSIÇÃO CORPORAL E BIOMARCADORES SANGUÍNEOS EM MULHERES IDOSAS NÃO-TREINADAS”

Prezada Senhora:

Gostaríamos de convidá-la para participar da pesquisa **“Efeito de diferentes zonas de repetições do sistema piramidal crescente sobre a força muscular, a composição corporal e biomarcadores sanguíneos em mulheres idosas não-treinadas”**, a ser realizada no município de Londrina/PR. O objetivo desta pesquisa é analisar os efeitos de diferentes sistemas de treinamento com pesos sobre indicadores metabólicos, fisiológicos, neuromusculares e morfológicos em mulheres idosas.

Todas as avaliações serão realizadas por profissionais previamente treinados para tal finalidade. A assinatura deste termo permitirá que você participe das seguintes atividades: (1) Programa de treinamento com pesos com duração de 8 semanas que será acompanhado por profissionais e estudantes de Educação Física; (2) Preenchimento de questionários sobre histórico de saúde; (3) Medidas de massa corporal, estatura, força muscular, pressão arterial, frequência cardíaca em repouso e atividade física habitual; (4) Avaliação da composição corporal pelos métodos de impedância bioelétrica (teste com duração de ~30 s: deitado em um colchonete, dois pequenos eletrodos serão colocados na mão e pé direito e transmitirão uma pequena corrente elétrica que indicará a quantidade de água [procedimento indolor e sem qualquer tipo de risco]), DEXA (teste com duração de aproximadamente sete minutos: deitada em uma mesa no próprio equipamento, sem portar qualquer tipo de objeto metálico, vestindo apenas roupas leves [shorts e top]). O equipamento fará um escaneamento do corpo todo para determinação da massa livre de gordura, massa gorda e massa óssea [procedimento indolor e sem qualquer tipo de risco]); (5) Coleta de sangue venoso em jejum de 12 h feita por um técnico capacitado e habilitado para a avaliação de indicadores metabólicos; (6) Avaliação nutricional por meio da

aplicação de registros alimentares de três dias; (7) Avaliação da aptidão neuromuscular por meio de testes de uma repetição máxima (teste realizado em três exercícios para os segmentos de membros superiores, inferiores e tronco, que consiste na realização de três tentativas com o objetivo de levantar a maior quantidade de peso possível em apenas uma repetição para determinação da força muscular máxima).

Gostaríamos de esclarecer que a participação é totalmente voluntária. A participante pode recusar-se a participar/desistir a qualquer momento sem sofrer prejuízo algum. As informações serão utilizadas somente para fins de pesquisa e todos os documentos e amostras utilizados serão identificados por um código numérico sem identificação nominal para preservar a identidade da participante. Lembramos que não será cobrada taxa alguma por estas avaliações. Da mesma forma, não será paga quantia alguma as participantes.

Ao final do estudo, comprometemo-nos a retornar com os resultados de todas as avaliações, que serão entregues as participantes. Espera-se com essa pesquisa, proporcionar informações que possam favorecer a melhoria da saúde e qualidade de vida de mulheres idosas por meio da prática de treinamento e associação com aspectos nutricionais, além de possibilitar a melhoria de parâmetros morfológicos, fisiológicos, neuromusculares e metabólicos das participantes. Apesar de considerados mínimos, os possíveis riscos são: desconfortos na coleta sanguínea e cansaço durante os testes físicos. É possível também que alguns grupamentos musculares exigidos nos testes de esforço fiquem doloridos entre 24 e 48 horas após a realização dos mesmos.

Caso você tenha dúvidas ou necessite de maiores esclarecimentos pode contatar o Prof. Dr. Edilson Serpeloni Cyrino, no Laboratório de Metabolismo, Nutrição e Exercício, localizado no Centro de Educação Física e Esporte, da Universidade Estadual de Londrina, pelo telefone (43) 3371-4772 / 9139-4509 ou procurar o Comitê de Ética em Pesquisa Envolvendo Seres Humanos da Universidade Estadual de Londrina, na Avenida Robert Kock, 60 ou no telefone (43) 3371-2490. Este termo deverá ser preenchido em duas vias de igual teor, sendo uma delas, devidamente preenchida, assinada e entregue a você.

Londrina, ____ de _____ de 2015.

Pesquisador Responsável

RG: _____

Eu, _____

(**“Efeito de diferentes zonas de repetições do sistema piramidal crescente sobre a força muscular, a composição corporal e biomarcadores sanguíneos em mulheres idosas não-treinadas”**), tendo sido devidamente esclarecido sobre os procedimentos da pesquisa, concordo em participar **voluntariamente** da pesquisa descrita acima.

Assinatura (ou impressão dactiloscópica): _____

Data: _____

APÊNDICE C - Ficha de registro alimentar

Data ___/___/___ Mom. _____

DESJEIUM ___h___min								
ALIMENTO	TIPO	QUANTIDADE		Outros alimentos - qtde				
Pão/bolacha	<input type="checkbox"/> unidade	<input type="checkbox"/> fatia: Δ f Δ m Δ g						
Leite/ iogurte	<input type="checkbox"/> copo gde(req.)	<input type="checkbox"/> copo americano			<input type="checkbox"/> xic Δ p Δ m Δ g			
Marg./Mant./Req.	<input type="checkbox"/> ptade faca	<input type="checkbox"/> colher de chá						
Café	<input type="checkbox"/> copo americano	<input type="checkbox"/> xícara Δ p Δ m Δ g			<input type="checkbox"/> copo café			
Açúcar	<input type="checkbox"/> colher de sopa	<input type="checkbox"/> colher de sob.			<input type="checkbox"/> colher chá			
Queijo/ presunto	<input type="checkbox"/> fatia fina	<input type="checkbox"/> fatia média			<input type="checkbox"/> fatia grossa			
Cereal	<input type="checkbox"/> colher de sopa	<input type="checkbox"/> colher de sob			<input type="checkbox"/> xic Δ p Δ m Δ g			
Fruta/suco	<input type="checkbox"/> unidade	<input type="checkbox"/> fatia Δ p Δ m Δ g			<input type="checkbox"/> Copo. Δ p Δ m Δ g			
Achocolatado	<input type="checkbox"/> colher de sopa	<input type="checkbox"/> colher de sob			<input type="checkbox"/> colher de chá			

Lanche da manhã ___h___min								
ALIMENTO	TIPO	QUANTIDADE		Outros alimentos - qtde				
Pão/bolacha/bolo	<input type="checkbox"/> unidade	<input type="checkbox"/> fatia: Δ f Δ m Δ g						
Leite/ iogurte/vitamina	<input type="checkbox"/> copo gde(req.)	<input type="checkbox"/> copo americano			<input type="checkbox"/> xic Δ p Δ m Δ g			
Café	<input type="checkbox"/> copo americano	<input type="checkbox"/> xícara Δ p Δ m Δ g			<input type="checkbox"/> copo café			
Salgado	<input type="checkbox"/> unidade	<input type="checkbox"/> peq Δ méd Δ gde						
Açúcar	<input type="checkbox"/> colher de sopa	<input type="checkbox"/> colher de sob.			<input type="checkbox"/> colher chá			
Queijo/ presunto	<input type="checkbox"/> fatia fina	<input type="checkbox"/> fatia média			<input type="checkbox"/> fatia grossa			
Fruta / suco	<input type="checkbox"/> unidade	<input type="checkbox"/> fatia: Δ f Δ m Δ g			<input type="checkbox"/> copo Δ amer. Δ requ.			
Marg./Mant./Req	<input type="checkbox"/> pta. de faca	<input type="checkbox"/> col Δ sopa Δ sob Δ chá						

Almoço ___h___min								
ALIMENTO	TIPO	QUANTIDADE		Outros alimentos - qtde				
Arroz	<input type="checkbox"/> escumadeira	<input type="checkbox"/> colher de sopa			<input type="checkbox"/> colher de servir			
Feijão	<input type="checkbox"/> concha Δ p Δ m Δ g	<input type="checkbox"/> colher de sopa			<input type="checkbox"/> colher de servir			
Salada	<input type="checkbox"/> folha Δ p Δ m Δ g	<input type="checkbox"/> prato Δ p Δ m Δ g			<input type="checkbox"/> colher de sopa/servir			
Legumes	<input type="checkbox"/> colher de sopa/servir	<input type="checkbox"/> legumes			<input type="checkbox"/> xic Δ p Δ m Δ g			
Carne	<input type="checkbox"/> pdç Δ p Δ m Δ g	<input type="checkbox"/> colher de sopa			<input type="checkbox"/> colher de servir			
Massa	<input type="checkbox"/> pegador de macarrão	<input type="checkbox"/> colher de sopa			<input type="checkbox"/> colher de servir			
Molho	<input type="checkbox"/> colher de sopa	<input type="checkbox"/> colher de servir			<input type="checkbox"/> concha Δ p Δ m Δ g			
Sobremesa	<input type="checkbox"/> unidade	<input type="checkbox"/> outro			<input type="checkbox"/> col Δ sopa Δ sob Δ chá			
Fruta/suco	<input type="checkbox"/> unidade	<input type="checkbox"/> fatia Δ p Δ m Δ g			<input type="checkbox"/> copo Δ amer. Δ requ.			
Sal					Óleo:			

Lanche da Tarde ___h___min								
ALIMENTO	TIPO	QUANTIDADE		Outros alimentos - qtde				
Pão/bolacha/bolo	<input type="checkbox"/> unidade	<input type="checkbox"/> fatia: Δ f Δ m Δ g						
Leite/ iogurte/vitamina	<input type="checkbox"/> copo gde(req.)	<input type="checkbox"/> copo americano			<input type="checkbox"/> xic Δ p Δ m Δ g			
Café	<input type="checkbox"/> copo americano	<input type="checkbox"/> xícara Δ p Δ m Δ g			<input type="checkbox"/> copo café			
Salgado	<input type="checkbox"/> unidade	<input type="checkbox"/> peq Δ méd Δ gde						
Açúcar	<input type="checkbox"/> colher de sopa	<input type="checkbox"/> colher de sob.			<input type="checkbox"/> colher chá			
Queijo/ presunto	<input type="checkbox"/> fatia fina	<input type="checkbox"/> fatia média			<input type="checkbox"/> fatia grossa			
Fruta / suco	<input type="checkbox"/> unidade	<input type="checkbox"/> fatia: Δ f Δ m Δ g			<input type="checkbox"/> copo Δ amer. Δ requ.			
Marg./Mant./Req	<input type="checkbox"/> pta. de faca	<input type="checkbox"/> col Δ sopa Δ sob Δ chá						

Jantar ___h___min								
ALIMENTO	TIPO	QUANTIDADE		Outros alimentos - qtde				
Arroz	<input type="checkbox"/> escumadeira	<input type="checkbox"/> colher de sopa			<input type="checkbox"/> colher de servir			
Feijão	<input type="checkbox"/> concha Δ p Δ m Δ g	<input type="checkbox"/> colher de sopa			<input type="checkbox"/> colher de servir			
Salada	<input type="checkbox"/> folha Δ p Δ m Δ g	<input type="checkbox"/> prato Δ p Δ m Δ g			<input type="checkbox"/> colher de sopa/servir			
Legumes	<input type="checkbox"/> colher de sopa/servir	<input type="checkbox"/> legumes			<input type="checkbox"/> xic Δ p Δ m Δ g			
Carne	<input type="checkbox"/> pdç Δ p Δ m Δ g	<input type="checkbox"/> colher de sopa			<input type="checkbox"/> colher de servir			
Massa	<input type="checkbox"/> pegador de macarrão	<input type="checkbox"/> colher de sopa			<input type="checkbox"/> colher de servir			
Molho	<input type="checkbox"/> colher de sopa	<input type="checkbox"/> colher de servir			<input type="checkbox"/> concha Δ p Δ m Δ g			
Sobremesa	<input type="checkbox"/> unidade	<input type="checkbox"/> outro			<input type="checkbox"/> col Δ sopa Δ sob Δ chá			
Fruta/suco	<input type="checkbox"/> unidade	<input type="checkbox"/> fatia Δ p Δ m Δ g			<input type="checkbox"/> copo Δ amer. Δ requ.			
Sal					Óleo:			

Ceia ___h___min								
ALIMENTO	TIPO	QUANTIDADE		Outros alimentos - qtde				
Pão/bolacha/bolo	<input type="checkbox"/> unidade	<input type="checkbox"/> fatia: Δ f Δ m Δ g						
Leite/ iogurte/vitamina	<input type="checkbox"/> copo gde (req.)	<input type="checkbox"/> copo americano			<input type="checkbox"/> xic Δ p Δ m Δ g			
Açúcar	<input type="checkbox"/> colher de sopa	<input type="checkbox"/> colher de sobremesa			<input type="checkbox"/> colher chá			
Queijo/ presunto	<input type="checkbox"/> fatia fina	<input type="checkbox"/> fatia média			<input type="checkbox"/> fatia grossa			
Fruta / suco/vitamina	<input type="checkbox"/> unidade	<input type="checkbox"/> fatia Δ peq Δ méd Δ gde			<input type="checkbox"/> copo Δ amer. Δ requ.			
margarina	<input type="checkbox"/> pta. de faca	<input type="checkbox"/> colher de chá						

Consumo de água no dia							
Litros:	_____	Copo:	<input type="checkbox"/> americano	<input type="checkbox"/> requeijão	<input type="checkbox"/> outros	_____	_____

