

# Comparison of two stretching techniques on the balance and mobility of older women

Claudinara Botton Dal Paz<sup>a</sup>, Liliana Laura Rossetin<sup>b</sup>, Clynton Lourenço Correa<sup>c</sup>,  
Anna Raquel Silveira Gomes<sup>b,d</sup>

<sup>a</sup>Universidade Regional Integrada do Alto Uruguai e das Missões – URI-FW, Frederico Westphalen, RS, Brazil.

<sup>b</sup>Universidade Federal do Paraná – UFPR, Curitiba, PR, Brazil.

<sup>c</sup>Universidade Federal do Rio de Janeiro – UFRJ, Rio de Janeiro, RJ, Brazil.

<sup>d</sup>Departamento de Prevenção e Reabilitação em Fisioterapia, Universidade Federal do Paraná – UFPR, Curitiba, PR, Brazil.

**Abstract:** Objective: This study aimed to compare the effects of static stretching (SS) and Hold-Relax (HR) on the flexibility, balance, mobility, and cadence of sedentary healthy community older women. Method: Twenty-nine older women (68 ± 11 years) were divided into three groups: Control (CG, n=8); SS (SSG, n=10) and HR (HRG, n=11). CG participated in health education lectures. SSG and HRG performed 8 sessions, maintained for the 60s in each session, twice a week, during 4 consecutive weeks. In order to warm-up, they walked and did recreational activities for 10 minutes and, then they performed stretching exercises for the hamstring muscles, on both lower limbs. Before and after 4-week follow-up, the following variables were assessed: flexibility by a photogrammetry method, balance with the Berg Balance Scale; mobility using the Timed up and go and cadence by counting the steps per minute. Parametric results were analyzed by ANOVA *post hoc* Tukey and non-parametric with *Kruskal-Wallis* ( $p \leq 0.05$ ). We also calculated the Minimal Detectable Change (MDC) for all variables. Results: We found an increase in the flexibility in the SSG (73 ± 8° vs 56 ± 7°,  $p=0.00003$ ) and HRG (71 ± 11° vs 56 ± 8°,  $p=0.00003$ ). However, only the SSG reached the MDC on mobility and the HRG on cadence. Conclusion: Both stretching techniques, SS, and HR, improved hamstring flexibility. However, mobility and cadence were enhanced only by SS and HR, respectively, as a meaningful clinical change.

**Keywords:** *Aged, Muscle Stretching Exercises, Postural Balance.*

## Comparaç o de duas t cnicas de alongamento sobre o equil brio e mobilidade em idosas da comunidade

**Resumo:** Objetivo: Este estudo teve como objetivo comparar os efeitos das t cnicas de Alongamento Est tico (AE) e Manter-Relaxar (MR) sobre a flexibilidade, equil brio, mobilidade e cad ncia em idosas h gidas sedent rias da comunidade. M todo: Participaram 29 idosas (68 ± 11 anos) divididas em 3 grupos: Controle (GC, n=8); AE (GAE, n=10) e MR (GMR, n=11). O GC participou de palestras educativas. O GAE e GMR realizaram 8 sess es de AE e MR, respectivamente, mantidos por 60 segundos em cada sess o, duas vezes por semana, durante quatro semanas consecutivas. Inicialmente foram realizados 10 minutos de aquecimento, por meio de caminhadas e atividades recreacionais, e em seguida exerc cios de alongamento para os m sculos isquiotibiais (IT), bilateralmente. Foram realizadas avalia es antes e ap s quatro semanas, das seguintes vari veis: flexibilidade dos IT por meio de fotogrametria; equil brio com a Escala de Equil brio de Berg; mobilidade utilizando-se o *Timed up and Go* e a cad ncia pela contagem dos passos por minuto. Resultados param tricos foram analisados com a ANOVA *post hoc*

Tukey e não paramétricos com o *Kruskall-Wallis* ( $p \leq 0,05$ ). Foi calculado o *Minimal Detectable Change* (MDC) para todas as variáveis. Resultados: Verificou-se aumento da flexibilidade no GAE ( $73 \pm 8^\circ$  vs  $56 \pm 7^\circ$ ,  $p=0,00003$ ) e GMR ( $71 \pm 11^\circ$  vs  $56 \pm 8^\circ$ ,  $p=0,00003$ ). No entanto, somente o GAE superou o MDC na mobilidade e o GMR na cadência. Conclusão: Conclui-se que tanto a técnica AE quanto MR aumentaram a flexibilidade dos IT. Porém, somente o AE incrementou a mobilidade e o MR a cadência, de forma clinicamente significativa.

**Palavras-chave:** *Idoso, Exercícios de Alongamento Muscular, Equilíbrio Postural.*

## 1 Introduction

Musculoskeletal changes related to aging are characterized by decreased muscle mass and strength, increased muscle-tendon stiffness, decreased mobility, impaired gait and gait dysfunction (HOLLAND et al., 2002). The maintenance of the levels of flexibility and neuromuscular control are important for the balance, gait and functional capacity of the elderly people (HOLLAND et al., 2002; GALLON et al., 2011).

Stretching is important to prevent the decline of flexibility and to improve range of motion (ROM), torque, functionality and gait parameters (GALLON et al., 2011; RODACKI et al., 2009). Static stretching (SS) is the most commonly used technique, effective for ROM gain. It is simple to perform and it has a lower risk of injury, recommended for the elderly population (FELAND et al., 2001). The Proprioceptive Neuromuscular Facilitation (PNF) stretching, based on voluntary muscle contraction, performed in combination with muscle stretching, promotes muscle relaxation and, subsequently, it increases ROM, as well as improve neuromuscular aspects (FELAND et al., 2001; FELAND; MYRER; MERRILL, 2001).

The most part of the studies reported the acute effect of stretching (immediately or a few hours after) or the combination of stretching with other types of exercises (FELAND et al., 2001; FERBER; OSTERNIG; GRAVELLE, 2002; ZAKAS et al., 2005; BIRD et al., 2009). A study using the hold-relax (HR) PNF technique pointed out that this was more effective than SS for acute effects on the IT muscle flexibility gain in male athletes aged 55-64 years old (FELAND; MYRER; MERRILL, 2001). However, the effects of HR stretching training on the flexibility, balance, and gait of sedentary elderly women are not known. Thus, the objective of this study was to analyze the effects of the SS and HR techniques on the flexibility of the hamstrings muscles, mobility, balance, and cadence of the gait of sedentary elderly women of the community.

## 2 Method

This study was a randomized clinical trial conducted at the Hospital das Águas do Prado Hospital of Vicente Dutra-RS. It was approved by the Research Ethics

Committee Involving Human Beings (CEPEH) of the University of Paraná (UNIPAR), Umuarama-PR (CAAE 0008.0.375.000-10). The participants were invited verbally and after accepting to participate in the study, they signed the Informed Consent Term (TCLE).

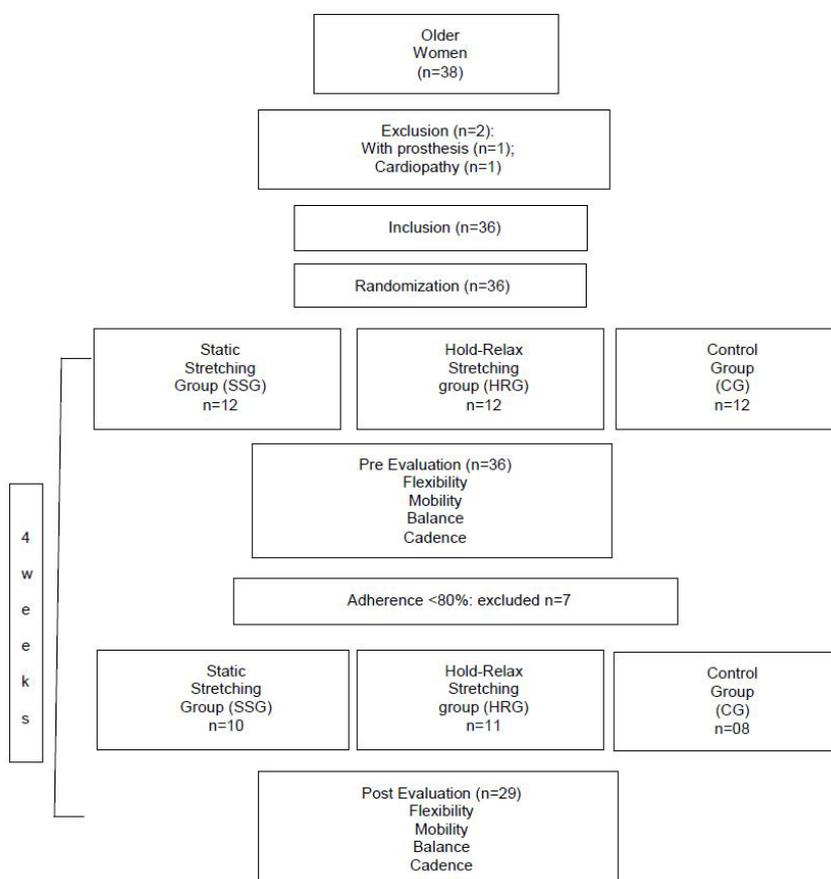
The sample calculation was performed using the G\*Power 3.1 program and the sample was estimated in 10 individuals per group, considering: effect size: 0.6; error  $\alpha$ : 0.03 and power ( $1-\beta$ ): 0.85, with a significance level of 5%.

Exclusion criteria included women unable to perform the exercises and/or evaluations of this study, using orthoses and prostheses, neurodegenerative diseases, dementia, uncontrolled systemic arterial hypertension, cardiac diseases, fractures, stroke, cancer, vestibular dysfunctions, hearing or visual impairment. Inclusion criteria were female, above 57 years old, sedentary, healthy and adherence in at least 80% of the interventions and 100% in the pre and post evaluations. The criterion for classifying the older as sedentary was not to perform the regular physical exercise for at least one year in the period before the beginning of the study.

Thirty-eight women participated in the study. Considering the inclusion and exclusion criteria, 36 women were randomly divided into three groups: control (CG,  $n=12$ ), who received health educational lectures; Static stretching group (SSG,  $n=12$ ); Hold and relax stretching group (HRG,  $n=12$ ).

However, there were 07 women who did not attend at least 80% of the interventions. Thus, 29 older women ( $68 \pm 11$  years) completed the study, divided as follow: SSG ( $n=10$ ,  $66 \pm 8$  years,  $73 \pm 13$  kg and  $156 \pm 7$  cm); HRG ( $n=11$ ,  $69 \pm 6$  years,  $63 \pm 9$  kg and  $164 \pm 5$  cm) and CG ( $n=8$ ,  $68 \pm 5$  years,  $79 \pm 15$  kg and  $164 \pm 6$  cm). The CG held educational lectures. The study consisted of 29 older women ( $68 \pm 11$  years), that took part of the SSG ( $n=10$ ,  $66 \pm 8$  years,  $73 \pm 13$  kg and  $156 \pm 7$  cm); HRG ( $n=11$ ,  $69 \pm 6$  years,  $63 \pm 9$  kg and  $164 \pm 5$  cm) and CG ( $n=8$ ,  $68 \pm 5$  years,  $79 \pm 15$  kg and  $164 \pm 6$  cm). The CG held educational lectures (Figure 1).

There were assessments before and after 4 weeks, both performed by a single evaluator, at the same



**Figure 1.** Flowchart of the study participants.

time of day, lasting approximately one hour. The post evaluation was performed the following day after the last intervention. The variables evaluated were hamstring flexibility (IT); balance; mobility and cadence.

## 2.1 Flexibility of IT

The photogrammetry was performed by quantifying the muscle-tendon shortening of the knee flexors in degrees (SARRAF; DEZAN; RODACKI, 2005). The images were collected by a digital camera (KODAK, M863), according to the evaluation protocol described by Carregaro, Silva and Gil Coury (2007). Major trochanter and lateral epicondyle of the femur and fibula malleolus were identified and 3 spherical markers of 10 mm were used, adhered to the garment at each point. The participants wore clothing adhered to the body to facilitate marking and avoiding movement of the stitch during the test. The demarcation of these points was used to propitiate the reconstruction of the model using the formed segments.

The older women remained on a bench and the evaluated lower limb was raised passively by the evaluator, with the application of a slow and gradual force, with the knee extended until the moment of discomfort in the posterior region of the knee, the opposite limb being fixed and extended on the bench (FELAND et al., 2001; ZAKAS et al., 2005). The measured angle was obtained between the straight line formed by the raised lower limb (thigh and leg) and the horizontal plane (bench), quantified with the angular dimension tool of the software Corel Draw 12. Values greater or equal to 65° indicate flexibility and less than 65° indicated reduced flexibility. Precautions were taken during the test: visual control of hip tilt and rotation, instructions for the participant to relax, and standardization of slow rate of elevation of the assessed limb.

## 2.2 Balance

The balance was analyzed through the Berg Balance Scale (BSE) (MIYAMOTO et al., 2004), to evaluate the participant's functional balance ability. This scale was performed with participants wearing

glasses and/or hearing aids prostheses commonly used. The maximum score is 56 points, and in this study, it was considered a value equal or lower than 36 as a risk of 100% falls (MIYAMOTO et al., 2004; ABREU; CALDAS, 2008).

### 2.3 Mobility

The Timed up and Go (TUG) test (PODSIADLO; RICHARDSON, 1991) was used to evaluate the mobility of the participants, which consists of getting up from a chair without the help of the arms and walking at a comfortable and safe pace in a distance of 3m, turn around and return and sit. It was performed once for familiarization and the second time for timing. The following scores were considered for the TUG: 60-69 years old: 8.1; 70-79 years old: 9.2s; 80-99 years old: 11,3s (PODSIADLO; RICHARDSON, 1991; ALEXANDRE et al., 2012; BOHANNON, 2006). The score was 8.1, for 3 older women who were 57-59 years old.

### 2.4 Cadence of gait

The participant was evaluated with a digital camera (KODAK, M863), individually guided to walk at a usual, safe and comfortable pace, from the beginning to the end of a marked 20-meter track in a straight line on a flat surface, covered ground. The rate of gait was evaluated by counting the number of steps per minute, according to the general parameters of gait in free-speed walking, by normal females of different ages (EDWARDS; THOMPSON, 1996).

### 2.5 Stretching protocols

They were performed on alternate days, twice a week, for four consecutive weeks, totaling eight interventions with the same evaluator. In each session, a 10-minute warm-up was performed with walking and ludic activities (WOODS; BISHOP; JONES, 2007). Then, the stretching exercises were performed for the IT muscles in both lower limbs. The duration of each stretching session was approximately 30 minutes.

For the SS, the elderly remained in a supine position, with the spine aligned and one of the lower limbs extended, fixed by a strip, with 0° of hip and knee flexion. Then, the patient performed hip flexion with the knee extended from the contralateral lower limb, at the maximum tolerable range of motion of each participant, but not with pain (FERBER; OSTERNIG; GRAVELLE, 2002). Next, the physical educator passively maintained this position for 60s (FELAND et al., 2001). Only one repetition (60s) of the SS was performed.

For HR stretching, the participant was in the supine position with the lower limb to be stretched in flexion, adduction and external thigh rotation, knee extended, dorsal flexion with inversion of the foot until reaching the maximum tolerable range of motion, but not with pain. Next, the older woman performed an isometric contraction with the movements opposite to those described previously, that is, extension, abduction, internal rotation of the thigh, extended knee, plantar flexion with eversion of the foot. After 10s, the relaxation of the lower limb was followed by 20s of passive stretching through the movements of the initial position, that is, flexion, adduction and external rotation of the thigh, extended knee, dorsal flexion with inversion of the foot. From this possible new ROM, the older woman was asked to do again isometric contraction of the same movements described previously (extension, abduction, internal thigh rotation, extended knee, plantar flexion with foot inversion). The HR stretching was repeated twice, totaling 60s (30s each HR stretching).

### 2.6 Statistical analysis

Descriptive statistics by mean and standard deviation (SD) were used. For analysis of normality, Shapiro-Wilk, and homogeneity the Levene's test were used. Data with normal and homogeneous distribution were evaluated through analysis of factorial variance (ANOVA) followed by post hoc Fisher, for comparison between groups. For the non-parametric data, the comparisons were performed by the Kruskal Wallis test. These analyses were performed in Statistica software (version 7.0<sup>®</sup>) and adopted a level of significance of 95% ( $p < 0.05$ ). Minimal Detectable Change (MDC) was calculated for the analysis of the minimal change needed to be considered clinically significant. For the determination of the MDC, the following formula was used:  $MDC = 1.96 \cdot \sqrt{2} \cdot SEM$ , SEM is equal to the standard deviation  $\cdot \sqrt{1 - ICC}$ . SEM corresponds to the Standard Error of Measurement and the ICC to the Intraclass Correlation Coefficients. The ICC was calculated using the SPSS program (version 17<sup>®</sup>).

## 3 Results

The results of the flexibility presented normal distribution, considered parametric ( $p > 0.05$ , Shapiro-Wilk). Non normal distribution was found in the following variables: mobility, balance, and cadence. Therefore, non-parametric ( $p < 0.05$ , Shapiro-Wilk) were considered. Only mobility did not show homogeneity ( $p = 0.02$ , Levene).

Both SS and HR improved flexibility compared to pre-intervention (Table 1).

No statistically significant difference was found in mobility, balance, and cadence (Tables 2 and 3).

**Table 1.** Evaluation of the flexibility of the hamstrings in degrees (°) by means of photogrammetry.

Groups	Evaluated limb	Pre-Evaluation (°)	Post-Evaluation (°)
CG	LRL	62 ± 8	66 ± 4
SSG	LRL	56 ± 7	73 ± 8*
HRG	LRL	56 ± 8	71 ± 11*

CG: control group; SSG: static stretching group; HRG: hold-relax stretching group; LRL: lower right limb. The results are a mean ± standard deviation. \*When compared to the pre-evaluation (ANOVA,  $p=0.00003$ ).

**Table 2.** Assessment of mobility in seconds, through the Timed up and Go (TUG) and assessment of balance through the Berg balance scale (BSE).

Variable	CG	SSG	HRG
Pre TUG	17 ± 4	19 ± 4	15 ± 2
Post TUG	17 ± 5	14 ± 3	12 ± 2
Pre BSE	51 ± 5	52 ± 3	52 ± 2
Post BSE	50 ± 5	53 ± 2	54 ± 2

The results are a mean ± standard deviation. CG: control group; SSG: group submitted to static stretching; HRG: hold-relax stretching group.

**Table 3.** Evaluation of gait cadence (steps/min).

Groups	Pre-evaluation (steps/min)	Post-evaluation (steps/min)
CG	95 ± 9	100 ± 10
SSG	97 ± 5	100 ± 5
HRG	97 ± 15	106 ± 14

The results are a mean ± standard deviation. CG: control group; SSG: group submitted to static stretching; HRG: hold-relax stretching group.

**Table 4.** Minimal Detectable Change (MDC) values.

CG	MEAN PRE/POST	ICC	SEM	MDC	PRE/POST
FLEX	6.28	0.76	3.08	4.86	-3.12
TUG	4.185	0.84	1.69	3.6	0.5
BSE	5.235	0.97	0.92	2.66	0.37
CAD	9.82	0.16	9.02	8.32	-5.63
SSG	MEAN PRE/POST	ICC	SEM	MDC	PRE/POST
FLEX	7.26	0.67	4.19	5.67	-16.50*
TUG	3.9	0.68	2.2	4.11	5.10*
BSE	2.98	0.88	1.04	2.82	-0.8
CAD	7.84	0.29	6.59	7.11	-2.3
HRG	MEAN PRE/POST	ICC	SEM	MDC	PRE/POST
FLEX	9.54	0.64	5.76	6.65	-15.73*
TUG	2.37	0.05	2.31	4.21	3.27
BSE	2.66	0.8	1.19	3.03	-1.55
CAD	14.68	0.7	8	7.84	-9.55*

BSE: Berg balance scale; TUG: Timed up and Go; CAD: cadence; FLEX: IT flexibility; ICC: intraclass correlation coefficients; SEM: Standard Error of Measurement; PRE-POST: difference between the values of the Pre-evaluation and the Post-evaluation; CG: control group; SSG: group submitted to static stretching; HRG: hold-relax stretching group; MDC: Minimal Detectable Change. M ± SD: results are a mean ± standard deviation. \*Differences between pre and post exceeding the MDC.

When comparing the differences between the pre- and post-evaluation of the mobility and the flexibility of the SSG, they exceeded the minimum detectable change (MDC), confirming the clinical improvement of these outcomes (Table 4). Also, the HRG showed improvement in flexibility and cadence, surpassed the MDC and also indicating clinical improvement (Table 4).

## 4 Discussion

The SS and HR protocols used in this study performed twice a week were enough to increase the flexibility of the hamstrings muscles of older women. Initially, the participants had a ROM value of less than 65°, indicating reduced flexibility. It can be attributed to the aging process and sedentarism of the participants, as well as to the biarticular muscles (IT), which are more susceptible to shortening (HOLLAND et al., 2002; WOODS; BISHOP; JONES, 2007).

The possible causes of the reduction of flexibility may be due to the decrease in the length of the muscular fascicles and the pennation angle; a decrease in the compliance of the articular structures, favoring the greater resistance to deformation, by the increase of the collagen, that results in greater articular stiffness (HOLLAND et al., 2002; FELAND et al., 2001; FERBER; OSTERNIG; GRAVELLE, 2002; WOODS; BISHOP; JONES, 2007; NARICI; MAGANARIS, 2007).

In this study, the improvement of flexibility was observed after both stretching techniques, as

it was also observed by other authors who analyzed community dwelling older women (BATISTA et al., 2008, 2009). In this study, when performed SS, in a closed kinetic chain, seven repetitions of 60s twice a week for 4 weeks, it was found an increase in the IT ROM (BATISTA et al., 2008, 2009). In this way, it may be suggested that gains in IT flexibility can be obtained with only 1 repetition of 60s of SS or 2 repetitions of 30s of HR, in open kinetic chain, twice a week, for 4 weeks, as detected in this study in sedentary community dwelling older women.

When comparing the acute effects of different durations of stretching (one 60s repetition, two 30s repetitions, four 15s repetitions) in community dwelling older women, the 1 repetition of 60s protocol was more effective for increasing ROM (ZAKAS et al., 2005). This result indicates that the response to stretching is directly proportional to the duration of the stretching stimulus (ZAKAS et al., 2005). However, the results of this study showed that both 1 repetition of 60s of SS and 2 repetitions of 30s of HR were equally sufficient for increasing flexibility. In another study, improvement in IT flexibility was also found after a repetition of SS or HR. However, it was maintained for only 32s in athletes aged 65 years or older (FELAND et al., 2001). Thus, it may be suggested that for senior athletes the volume of 32s of stretching is enough, however, for sedentary elderly women with ROM limitation, 60s were required to increase flexibility.

This study shows that the regular practice of SS or HR, according to the protocol adopted, is equally effective for the IT flexibility gain of sedentary community older women. However, the mobility, balance and cadence outcomes did not show a statistically significant difference. It can be considered that the tests used were not sensitive to identify possible variations in these outcomes.

In a systematic review of gait assessment, Hamacher et al. (2011) pointed out that gait length and gait velocity are difficult parameters to differentiate fallers from non-fallers elderly people. These authors further suggest that oscillation time and support time should be considered for gait analysis in the elderly population (HAMACHER et al., 2011).

In a prospective study to evaluate the spatiotemporal parameters of gait in the elderly women showed that both gait velocity and other gait parameters analyzed (cadence, step length, balance time and support time) did not significantly predict recurrent falls. These authors suggest that future studies should investigate the gait of the elderly in "real life" situations, such as walking over obstacles or concomitant execution of cognitive and motor

tasks (for example, talking, calculating or carrying objects) (MOREIRA; SAMPAIO; KIRKWOOD, 2015). It is possible that the more challenging tasks may require more of the physiological and cognitive systems, therefore, being more clinically sensitive.

In this study, the minimum detectable change (MDC) was calculated to verify the clinical effect of stretching techniques. Thus, both the SS and the HR induced flexibility gains, not only statistically significant but clinically important, although no difference was found between the stretching techniques with the control group.

The clinical effect of SS on mobility and HRG on cadence was detected. Other studies also found an improvement in the mobility of elderly women who underwent SS exercises twice a week, but in the closed kinetic chain, making seven repetitions of 60s (BATISTA et al., 2008, 2009).

On the other hand, the improvement in the cadence observed after the regular practice of the HR technique, may be related to the gain in IT flexibility, since other studies have reported that the mean amplitude and cadence pace have a significant association with ankle and hip flexibility and it should be considered in the analysis of the overall gait performance in the elderly people (GAJDOSIK et al., 2005; RODACKI et al., 2009; MOREIRA; SAMPAIO; KIRKWOOD, 2015; KERRIGAN et al., 2001). Also, reduced flexibility may be associated with an increased risk of falls in the elderly people, especially as a result of the loss of mobility in the hip and ankle, and may lead to changes in gait pattern (KERRIGAN et al., 2001).

Improvement in gait velocity was still observed in elderly individuals who underwent training with SS, 3 repetitions of 45s each in the closed kinetic chain for hip and ankle muscles for eight weeks (CHRISTIANSEN, 2008). In the present study, it was observed that with only 60s of stretching performed in open kinetic chain, twice a week for 4 weeks, it was possible to improve the mobility of sedentary elderly women.

The results of this study provide important contributions to prevention and therapy in the elderly population, especially regarding the prescription of stretching exercises. It was possible to observe that each technique had different effects, which contribute to the targeting of the exercise prescription, according to the objective to be achieved.

This study shows some limitations, such as the inclusion of elderly women from 57 years old (n=5). Thus, it is suggested for future studies inclusion of elderly women aged 65 and over, to follow the

international standard, or 60 years old in Brazil, for the individual to be considered older. Also, it is suggested the evaluation of the kinematics of the gait concomitant with electromyography analysis and skeletal muscle architecture, to investigate the mechanisms involved in neuromuscular and functional adaptation, induced by static stretching and hold-relax techniques. Furthermore, new research was needed to verify the maintenance time of the outcomes evaluated in the present study and with a greater number of elderly women in each group to increase the extrapolation power of the data obtained.

## 5 Conclusion

The outcomes of this study allow concluding that both stretching, static (SS) and hold-relax (HR) techniques are enough for increasing IT flexibility. However, while SS might be recommended to enhance mobility; HR should be prescribed to improve gait cadence for healthy sedentary community dwelling women.

## References

ABREU, S. S. E.; CALDAS, C. P. Velocidade da marcha, equilíbrio e idade: um estudo correlacional entre idosas praticantes e idosas não praticantes de um programa de exercícios terapêuticos. *Revista Brasileira de Fisioterapia*, Rio de Janeiro, v. 12, n. 4, p. 324-330, 2008.

ALEXANDRE, T. S. et al. Accuracy of Timed Up and Go Test for screening risk of falls among community-dwelling elderly. *Revista Brasileira de Fisioterapia*, São Carlos, v. 16, n. 5, p. 381-388, 2012.

BATISTA, L. H. et al. Efeitos do alongamento ativo excêntrico dos músculos flexores do joelho na amplitude de movimento e torque. *Revista Brasileira de Fisioterapia*, São Carlos, v. 12, n. 3, p. 176-182, 2008.

BATISTA, L. H. et al. Active stretching improves flexibility, joint torque, and functional mobility in older women. *American Journal of Physical Medicine and Rehabilitation*, São Carlos, v. 88, n. 10, p. 815-822, 2009.

BIRD, M. L. et al. Effects of resistance-and flexibility-exercise interventions on balance and related measures in older adults. *Journal of Aging and Physical Activity*, Launceston, v. 17, n. 4, p. 444-454, 2009.

BOHANNON, R. W. Reference values for the timed up and go test: a descriptive meta-analysis. *Journal of Geriatric Physical Therapy*, Storrs, v. 29, n. 2, p. 64-68, 2006.

CARREGARO, R. L.; SILVA, L. C. C. B.; GIL COURY, H. J. C. Comparação entre dois testes clínicos para avaliar a flexibilidade dos músculos posteriores da coxa. *Revista Brasileira de Fisioterapia*, São Carlos, v. 11, n. 2, p. 139-145, 2007.

CHRISTIANSEN, C. L. The effects of hip and ankle stretching on gait function of older people. *Archives of Physical Medicine and Rehabilitation*, Denver, v. 89, n. 8, p. 1421-1428, 2008.

EDWARDS, S.; THOMPSON, A. J. *Neurological physiotherapy: a problem solving approach*. New York: Churchill Livingstone, 1996.

FELAND, J. B. et al. The effect of duration of stretching of the hamstring muscle group for increasing range of motion in people aged 65 years or older. *Physical Therapy*, Brigham, v. 81, n. 5, p. 1110-1117, 2001.

FELAND, J. B.; MYRER, J. W.; MERRILL, R. M. Acute changes on hamstring flexibility: PNF vs static stretch in senior athletes. *Physical Therapy in Sports*, Brigham, v. 2, n. 4, p. 186-193, 2001.

FERBER, R.; OSTERNIG, L.; GRAVELLE, D. Effect of PNF stretch techniques on knee flexor muscle EMG activity in older adults. *Journal of Electromyography and Kinesiology*, Newark, v. 12, n. 5, p. 391-397, 2002.

GAJDOSIK, R. L. et al. Effects of an eight-week stretching program on the passive-elastic properties and function of the calf muscles of older women. *Clinical Biomechanics*, Missoula, v. 20, n. 9, p. 973-983, 2005.

GALLON, D. et al. The effects of stretching on the flexibility, muscle performance and functionality of institutionalized older women. *Brazilian Journal of Medical and Biological Research*, Curitiba, v. 44, n. 3, p. 229-235, 2011.

HAMACHER, D. et al. Kinematic measures for assessing gait stability in elderly individuals: a systematic review. *Journal of the Royal Society*, Berlin, v. 8, n. 65, p. 1682-1698, 2011.

HOLLAND, G. J. et al. Flexibility and physical functions of older adults: a review. *Journal of Aging and Physical Activity*, Tennesse, v. 10, n. 2, p. 169-206, 2002.

KERRIGAN, C. D. et al. Reduced hip extension during walking: healthy elderly and fallers versus young adults. *Archives of Physical Medicine and Rehabilitation*, Boston, v. 82, n. 1, p. 26-30, 2001.

MIYAMOTO, S. T. et al. Brazilian version of the Berg balance scale. *Brazilian Journal of Medical and Biological Research*, São Paulo, v. 37, n. 9, p. 1411-1421, 2004.

MOREIRA, B. S.; SAMPAIO, R. F.; KIRKWOOD, R. N. Spatiotemporal gait parameters and recurrent falls in community-dwelling elderly women: a prospective study. *Brazilian Journal of Physical Therapy*, Belo Horizonte, v. 19, n. 1, p. 61-69, 2015.

NARICI, M. V.; MAGANARIS, C. N. Plasticity of the muscle-tendon complex with disuse and aging. *Exercise and Sport Sciences Reviews*, Cheshire, v. 35, n. 3, p. 126-134, 2007.

PODSIADLO, D.; RICHARDSON, S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. *Journal of the American Geriatric Society*, Montreal, v. 39, n. 2, p. 142-148, 1991.

RODACKI, A. L. et al. Transient effects of stretching exercises on gait parameters of elderly women. *Manual Therapy*, Curitiba, v. 14, n. 2, p. 167-172, 2009.

SARRAF, T.; DEZAN, V. H.; RODACKI, A. L. F. Diferenças entre medidas qualitativas e quantitativas durante testes de comprimento músculo-tendíneo dos flexores do quadril uni e bi-articulares. *Revista Brasileira de Fisioterapia*, São Carlos, v. 9, n. 2, p. 195-202, 2005.

WOODS, K.; BISHOP, P.; JONES, E. Warm-up and stretching in the prevention of muscular injury. *Sports Medicine*, Tuscaloosa, v. 37, n. 12, p. 1089-1099, 2007.

ZAKAS, A. et al. Acute effects of stretching duration on the range of motion of elderly women. *Journal of Bodywork and Movement Therapies*, Thessaloniki, v. 9, n. 4, p. 270-276, 2005.

---

### **Author's Contributions**

Claudinara Botton Dal Paz, Clynton Lourenço Correa and Anna Raquel Silveira Gomes were responsible for designing, project, analyzing and interpreting data. Claudinara Botton Dal Paz, Liliana Laura Rossetin, Clynton Lourenço Correa and Anna Raquel Silveira Gomes were responsible for the writing of the article, critical review of the intellectual content and final approval of the version to be published. All authors approved the final version of the text.

### **Funding Source**

CNPq.