NEUROMOTOR TRAINING ON GAIT PATTERN AND MOBILITY OF ANKLES IN OLDER PEOPLE

Treinamento neuromotor no padrão de marcha e na mobilidade de tornozelos em idosos

Entrenamiento neuromotor del patrón de marcha y movilidad de tobillos de mayores

Original Article

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ABSTRACT

Objective: To analyze the effect of neuromotor training on gait pattern and mobility of ankles in older people. **Methods:** A cross-sectional non-randomized controlled study conducted in Rio Negrinho, Santa Catarina, from May to September 2015 with a sample of 26 older women divided into control group (CG=15) and neuromotor training group (NETG=11). The gait pattern was assessed through the Cerny Protocol and the mobility of ankles through goniometry. The CG performed regular physical activity including warm-up, stretching and strengthening of major muscle groups and cool-down. The NETG performed a neuromotor training as a 10-station circuit including warm-up, neuromotor training, cool-down and repetition of the circuit three times, remaining one minute at each station and keeping a 30-second interval between the stations. The exercise difficulty level increased after the sixth week. Both groups performed the activity for 12 weeks (twice a week for 45 minutes). The analysis was performed using the t-test with a significance level of $p<0.05$. **Results:** A significant improvement was observed in dorsiflexion of both ankles (right ankle $p=0.00$ and left ankle=0.02) and in both groups; however, the gait pattern did not present a significant improvement after the neuromotor exercise training (speed $p=0.55$; time to ambulation $p=0.6$). **Conclusion:** The neuromotor training maintained the gait pattern (speed and time to ambulation) and the mobility of ankles of the older women assessed.

Descriptors: Aged; Gait; Movement.

RESUMO

Objetivo: *Analisar o efeito do treinamento neuromotor no padrão de marcha e a mobilidade de tornozelos em idosos.* **Métodos:** *Ensaio controlado não aleatorizado, de corte transversal, realizado em Rio Negrinho, Santa Catarina, no período de maio a setembro de 2015, com amostra de 26 idosas divididas em grupo controle (GC=15) e grupo treinamento neuromotor (GTN=11). A avaliação do padrão de marcha ocorreu através do Protocolo de Cerny e a mobilidade de tornozelos, através da goniometria. O GC realizou atividade física regular composta por aquecimento, exercícios de alongamento e fortalecimento muscular de grandes grupos musculares de membros e desaquecimento. O GTN recebeu treinamento neuromotor em forma de circuito composto por 10 estações, com aquecimento, treinamento neuromotor, desaquecimento e repetição do circuito em 3 vezes, com permanência de 1 minuto em cada estação e 30 segundos de intervalo entre elas, com progressão de dificuldade dos exercícios após a sexta semana. Ambos os grupos realizaram a atividade por 12 semanas (2 vezes semanais, com duração de 45 minutos). Análise ocorreu pelo do teste T, adotando um nível de significância de* $p<0,05$. **Resultados:** *Houve melhora significativa em dorsiflexão de ambos os tornozelos (direito* $p=0,00$ *e esquerdo=0,02) e em ambos os grupos; já no padrão de marcha, não houve melhora significativa após treinamento neuromotor (velocidade* $p=0,55$*; tempo de deambulação* $p=0,6$*).* **Conclusão:** *O treinamento neuromotor beneficiou a manutenção do padrão de marcha (velocidade e tempo de deambulação) e a mobilidade articular de tornozelos em idosas avaliadas.*

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RESUMEN

Objetivo: *Analizar el efecto del entrenamiento neuromotor del patrón de marcha y movilidad de tobillos de mayores.* **Métodos:** *Ensayo controlado no aleatorizado, de corte transversal realizado en Rio Negrinho, Santa Catarina, entre mayo y septiembre de 2015 con una muestra de 26 mayores divididas en grupo controle (GC=15) y grupo de entrenamiento neuromotor (GEN=11). La evaluación del patrón de la marcha se dio a través del Protocolo de Cerny y la movilidad de los tobillos a través de la goniometría. En el GC se realizó actividad física regular con calentamiento, ejercicios de estiramiento y de fuerza muscular para los grandes grupos musculares de los miembros y desaceleración. El GEN recibió entrenamiento neuromotor en forma de circuito formado por 10 estaciones con calentamiento, entrenamiento neuromotor, desaceleración y repetición del circuito 3 veces con permanencia de 1 minuto en cada estación y 30 segundos de intervalo entre ellas con progresión de dificultad para los ejercicios después de la sexta semana. Ambos los grupos realizaron la actividad durante 12 semanas (2 veces a la semana, con duración de 45 minutos). El análisis se dio a través del teste T, adoptando un nivel de significancia de p<0,05.* **Resultados:** *Hubo mejora significativa para la dorsiflexión de ambos los tobillos (derecho p=0,00 y izquierdo=0,02) y en ambos los grupos; no hubo mejora significativa después del entrenamiento neuromotor (velocidad p=0,55; tiempo de deambulación p=0,6) en el patrón de la marcha.* **Conclusión:** *El entrenamiento neuromotor benefició la manutención del patrón de la marcha (velocidad y tiempo de deambulación) y la movilidad articular de los tobillos de las mayores evaluadas.*

Descriptores: *Anciano; Marcha; Movimiento.*

INTRODUCTION

Population aging is a global phenomenon that is manifesting quickly and differently in the countries, bringing major challenges for public policies to ensure the continuity of economic and social development process with equity between the age groups in the sharing of resources, social rights and responsibilities and to promote active and healthy aging for the control of chronic noncommunicable diseases[1].

The Brazilian population, according to the latest census (2010), was 190,755,199 million people. The number of older people was 20,590,599 million, approximately 10.8% of the total population. According to epidemiological projections, Brazil will rank sixth worldwide in terms of absolute numbers by 2015[2,3].

The gradual decrease in functional capacity is directly related to the aging process and bears a direct linear relationship to age. Several physical capacities are affected, such as: decreased muscle strength, flexibility, agility, coordination, joint mobility and balance[4-6]. The dependence for the performance of activities of daily living (ADL) tends to increase from 5% among individuals aged 60 to circa 50% among those aged 90 years and over[7].

Gait efficiency may be impaired with age due to changes such as the shortening and decrease in step height, widened base of support, reduction of gait speed and the knee and hip extension, as well as increased stance phase and the double support time. As a result, older people develop a gait pattern that requires greater energy expenditure, which could trigger a decline in activities performed and consequently a decrease in muscle strength, contributing to alterations of the motor function[8].

Alterations in dynamic balance and agility resulting from the aging process have been minimized through exercises targeted to these physical valences. A neuromotor training applied to 100 older people aged 75-80 years who underwent 40 sessions lasting 50 minutes three times a week showed improvements in balance and agility[9].

Functional exercises can also be indicated and present evidence of improvement in muscle strength and power with a view to improving balance and independence of older people[10]. Low-intensity functional exercises are able to improve the physical fitness of older people, making them more independent[11].

Regular physical activity containing warm-up flexibility exercises, muscle strengthening exercises for the lower limb and trunk, balance exercises, various ball games and cool-down exercises with stretching presented improvement in static balance, functional mobility and physical functioning subdomains, vitality and general health-related quality of life among older people[12].

The training of the controlling mechanisms of static and dynamic balance increases older people's confidence, improving their functional capacity and hence joint mobility and gait performance[13].

Falls are a public health problem among older people due to the mortality, morbidity rates and the social and economic costs involved. Furthermore, it is known that falls are important factors that lead to an increase in the level of dependence among older people because they affect their functional capacity[14].

The World Health Organization defines healthy aging as the development and maintenance of functional capacity that allows well-being during advancing age. Health promotion for the older population includes awareness campaigns, implementation and execution of regular physical activity through muscle strengthening strategies, muscle stretching, aerobic conditioning and balance optimization[15].

This issue was chosen due to the importance of applying systematized physical exercises to older people as a tool for the development of active aging. The neuromotor training is among the recommended exercises as it incorporates skills that stimulate the proprioceptive receptors present in the body, providing improved physical performance, balance, gait and joint mobility of the lower limbs. The study can contribute to the expansion of theoretical and practical application of neuromotor training programs geared to older people in the private or public sectors.

The aim of the present study was to analyze the effect of neuromotor training on gait pattern and mobility of ankles in older people.

METHODS

This is a cross-sectional non-randomized controlled study conducted in Rio Negrinho, Santa Catarina, from May to September 2015.

The sample consisted of older women aged 65-75 years enrolled in the *Programa de Hipertensão Arterial e Diabetes - HiperDia* (Hypertension and Diabetes Program) of the Municipal Health Secretariat of Rio Negrinho, Santa Catarina. Participants included sedentary individuals and people who did regular physical activity twice a week. Invitation posters were placed on the walls of primary health care centers of the city and oral invitation was carried out during the monthly meetings of HiperDia Program. Participants of the monthly meeting of HiperDia make up a total of 60 older people, 6 of whom are men. Of the 54 older women, 15 did regular physical activity and 39 were sedentary. After explaining the study procedures, 11 sedentary older women agreed to participate. Exclusion criteria involved older individuals with: disability, with the need to use assistive device for gait; neurological sequelae; severe visual impairment; or any other disorder that could interfere with the performance of the neuromotor training exercises.

The neuromotor training group (NETG) had 11 sedentary older women and the control group (CG) comprised 15 older women who did regular physical activity twice a week in the *Grêmio Esportivo Vila Nova* (Villa Nova Sports Center) in the same city.

The initial assessment included anamnesis and assessment of gait pattern and mobility of ankles. Information were collected in the anamnesis through questions about demographic data, education level, use of medicines, and history of falls in the last year. Gait pattern and mobility of ankles were reassessed after 12 weeks of neuromotor training.

Two researchers carried out the anamnesis and gait pattern assessment according to established protocols and only one researcher performed the ankle goniometry because this test is examiner-dependent. Assessments took place in the morning on days that were pre-scheduled by the researchers.

Gait pattern analysis was performed using the Cerny protocol[16] and the following variables were analyzed: total gait time, linear speed of gait. This protocol is used to analyze the gait in the sagittal plane on a 16m-runway distributed as follows: 1 - initial area of 5.0m length; 2 - central area of 6.0m length; 3 - final area of 5.0m length. Time was not recorded in the first and final 5 meters. The total gait time was only recorded in the 6m-central area.

The mobility of ankles was assessed through goniometry of active movements of dorsiflexion and plantar flexion. Assessment of dorsiflexion occurred with the patient sitting with the knees flexed and the feet in anatomical position. The stationary arm of the Carci® goniometer was placed parallel to the lateral aspect of the fibula and the movable arm of the goniometer was placed parallel to the lateral aspect of the fifth metatarsal and the axis on the ankle joint parallel to the lateral aspect of the lateral malleolus. The assessment of plantar flexion occurred with the patient lying supine with feet in anatomical position. The stationary arm of the goniometer was parallel to the lateral aspect of the fibula, the moveable arm was parallel to the lateral aspect of the fifth metatarsal and the axis was placed on the ankle joint parallel to the lateral malleolus[17]. In both movements, the researcher requested maximum amplitude and the movable arm of the goniometer was moved for the registration of the joint range, which was measured in degrees.

The control group kept regular physical activity twice a week, with a Physical Education professional controlling their attendance. The exercises included muscle strengthening, balance and muscle stretching exercises. There was also a period for warm-up and cool-down exercises, and the session lasted 45 minutes. The CG received initial assessment in the same period as the neuromotor training group and reassessment occurred after 12 weeks.

The neuromotor training occurred over 12 weeks twice a week following the methodology based on previous studies[18-20]. Each session lasted 45 minutes with the following phases: warm-up for five minutes with metabolic exercises of upper and lower limbs, neuromotor training lasting 35 minutes and cool-down for 5 minutes with stretching and breathing exercises. The neuromotor training[21] was performed as a 10-station circuit (Chart 1). The participants repeated the circuit three times, remaining one minute at each station and keeping a 30-second interval between them. The circuit contained self-explanatory captions with arrows, footprints and numbers for a simple and didactic presentation that helped the participants to perform the exercises. One researcher monitored the first 5 exercises and another researcher monitored the last 5 exercises.

The degree of difficulty increased over the training from the sixth week with the addition of sensory stimulations such as repetition of colors, numbers and objects and associated movements of the trunk and head while performing the tasks, being interspersed in each station[21].

Statistical analysis was performed in SPSS version 21.0 using descriptive, exploratory and inferential analyses with a significance level of $p < 0.05$. Results are presented as mean (M), standard deviation (SD), relative frequency (%) and absolute frequency. Data normality was tested by the Shapiro-Wilk test and the homogeneity of data was assessed using the Levene test. The comparison between groups occurred through the independent samples t test because the sample data are normal and homogeneous between the groups.

After explanation of the study procedures, the participants provided their consent to participate in the research according to Resolution No. 466/12 of the National Health Council. Data collection started after approval by the Ethics Committee of the University of Contestado – Mafra Campus (Opinion No. 1.022.531/2015).

RESULTS

The present study included 26 older women divided into two groups: control group (CG) with 15 participants and Neuromotor Training Group (NETG) with 11 participants who received the neuromotor training.

The mean age of the NETG was 70.4 ± 3.95 years and the mean age of the control group was 67.9 ± 3.51 years. There was no significant difference between groups regarding age (p=0.43). The mean body mass index was 25.7 in the NETG and 26.3 in the CG.

The sociodemographic characteristics of the participants of this study are shown in Table I.

There was no significant difference in the parameters assessed in the gait pattern between the groups (Table II).

In general, the plantar flexion range of motion in both ankles in the control group was already higher than that of the neuromotor training group at initial assessment. There was a significant difference between the groups at the post-test of dorsiflexion in both ankles in both groups (Table III). Minimum and maximum values of plantar flexion in both ankles were 10º and 44º, respectively; as for dorsiflexion, the minimum and maximum values were 6º and 24º, respectively.

Chart 1 - Neuromotor training circuit.

NEUROMOTOR TRAINING	
STATIONS	EXERCISE
1	Exercises standing on one foot “airplane”
2	Backward gait using heels only
3	Gait on unstable surface (mattress)
4	Gait using the anterior one-third of the feet only
5	Narrow base gait on circumferential path
6	Crouched gait
7	Side steps
8	Forward gait with legs spread apart and total feet support
9	Forward gait with legs crossed and total feet support
10	Forward and backward gait on a straight line

Source: Adapted from Costa et al. (2009)[21].

Table I - Sociodemographic characteristics. Mafra, Santa Catarina, 2015.

Variable	CG (n=15)			NETG (n=11)	
	n	%		n	%
Occupation					
Seamstress	1	6.66	Teacher	1	9.09
Meat clerk	1	6.66	Assistant	1	9.09
Housewife	1	66.6	Seamstress	1	9.09
Bookkeeper	1	6.66	Domestic worker	2	18.18
Day laborer	1	6.66	Housewife	5	45.45
Hodwoman	1	6.66	Day laborer	1	9.09
Education					
Primary	12	80		10	90.90
Secondary	2	13.33		-	-
Higher	1	6.66		1	9.09
Marital status					
Married	5	33.33		4	36.36
Single	-	-		1	9.09
Widowed	10	66.66		6	54.54
Pathologies					
Diabetes mellitus	3	20		4	25
Hipertension	10	66.66		8	50
Cardiopathy	2	13.33		4	25

CG: control group; NETG: neuromotor training group.

Table II - Gait pattern. Mafra, Santa Catarina, 2015.

Gait pattern	GROUPS		p-value*
	CG (n=15)	NETG (n=11)	
Speed (m/s)			
Pre	0.93±0.21	0.98±0.22	0.55
Post	0.97±0.22	1.03±0.24	0.53
Time to ambulation (seconds)			
Pre	6.68±1.30	6.37±1.55	0.58
Post	6.39±1.24	6.10±1.54	0.60

Results are described as mean ± standard deviation. CG: control group and NETG: neuromotor training group. *Independent *t* test.

Table III - Joint mobility of ankles. Mafra, Santa Catarina, 2015.

Goniometry (degrees)	GRUPOS		p-value*
	GC (n=15)	GTN (n=11)	
Right plantar flexion			
Pre	33.20±6.17	26.45±10.21	0.04*
Post	34.20±6.37	29.91±13.30	0.28
Left plantar flexion			
Pre	34.60±6.13	27.45±9.66	0.03*
Post	35.13± 6.19	30.18±11.68	0.17
Right dorsiflexion			
Pre	19.07±3.53	16.91±4.41	0.17
Post	19.67±2.92	16.73±3.25	0.02*
Left dorsiflexion			
Pre	18.67±2.58	13.18±4.40	0.01*
Post	18.93±1.98	13.55±4.27	0.00*

Results are described as mean ± standard deviation. CG: control group and NETG: neuromotor training group.

Regarding gait time, the value found in the initial assessment of the variable in the control group was higher (6.68s) than that of the neuromotor training group (6.37s).

DISCUSSION

The results of the present research show that regular physical activity and neuromotor training help to maintain the good performance of gait and mobility ankles in older people.

The practice of regular physical activity beneficially affects the changes resulting from the aging process and helps to maintain the functions; this may help to maintain and/or improve strength, flexibility, coordination and balance, which are essential physical fitness elements for keeping functional capacity of older people[22].

There is a non-linear decline in balance, muscle strength and gait with aging, which justifies the need to preserve the factors that contribute to greater functional independence. The maintenance of muscle strength of the lower limbs, a safe and efficient gait and a good balance can positively affect the health and functional independence of older people because when they have a balance dysfunction, a poor gait and reduced muscle strength, the risk of falls and fractures increases[23].

However, considering the principle of the specificity of the training for the development of gait speed, the specific functionality exercises were superior to the overall strength training, although both trainings have been effective. That said, no physical exercise seems to be better than the practice of their own gait to the development of functional gait performance in older people[24]. Although the neuromotor training in the present research was composed of several exercises, none of them was specifically focused on the direct improvement of gait speed.

There is a positive relationship between physical activity and gait performance in healthy older people. Thus, it is possible to assume that the decline that occurs over the years in certain capabilities that are essential for a good gait performance – for instance, strength, balance, coordination, flexibility and power – can be compensated in different degrees through physical activity[25,26].

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In the initial assessment carried out in the present study, the gait time of the control group was longer (6.68s) than that of the neuromotor training group (6.37s). This is in contrast with a research that compared a weight training group (4.87s) and a sedentary group (5.65s), which showed that sedentary individuals had a longer gait time[27].

A study conducted with healthy older people who received an exercise program consisting of aerobic, balance, coordination, stretching and gait training exercises in order to improve physical performance associated with gait kinematics found a decrease in gait speed after 12 weeks (1.37 m/s ± 0.15 to 1.28 m/s ± 0.28)[28]. In the present study, there was no specific gait training in the neuromotor training, which may have contributed to the fact that the results were not significant regarding the gait pattern of the older women assessed.

There is a linear relationship between age and joint flexibility in older people. A study on the relationship between the age of older people and flexibility of the ankles found statistical difference when comparing the age groups 65-69, 70-74 and 75-79 years with each other and the age groups over 80 years[29]. The findings of the study corroborate the profile of the sample in the present study, as the mean age was 67.93±3.51 years in the control group and 70.45±3.95 years in the NETG.

A review study aimed at assessing gait speed and survival that included 9 cohort studies with a total of 34,485 community-dwelling older people (73.5±5.9 years) found that the mean gait speed was 0.92 m/s and there was a relationship between gait speed and survival and it is directly associated with advancing age[30]. The present research has shown that the results are within the usual values for this age group.

A cohort study[31] conducted with 3,042 community-dwelling older people defined the cutoff point of 1 m/s in a 6-meter distance for gait speed in older people as a predictive value for reported health events regardless of gender and race differences. The values of the gait speed found in both groups of the present study are very close to 1 m/s; therefore, it is important that older people are monitored through systematic assessments of gait pattern and kinematics.

The normal mobility of ankles is closely linked to activities of daily living that require dynamic postural control of the individual and is subjected to constant injuries that will become worse and more noticeable with advancing age, compromising the mobility of this joint[32]. A study conducted with 30 sedentary older women with a mean age of 77.48±6.94 years assessed the amplitude of plantar flexion and dorsiflexion measured bilaterally and showed that the minimum and maximum angles for plantar flexion of the right ankle were 10º and 45º, respectively; the left ankle presented values of 18º and 45º, respectively. Right and left dorsiflexion presented minimum and maximum values of 6º and 20º, respectively[33]. In the present study, minimum and maximum values for plantar flexion in both ankles were of 10º and 44º. Regarding dorsiflexion, the minimum and maximum values were 6º and 24º, respectively.

The association between age and range of motion of the joints has been investigated to determine the limitations imposed by age. An observational study showed that the range of motion of plantar flexion of the ankle found for the age group 65-69 years was 21.67±5.59 degrees, and in the age group 70-74 years, the range of motion was 23.75±7.44 degrees[29]. In the present study, greater values were found for the plantar flexion of ankles (CG=33.20±6.17 and NETG=26.45±10.21 degrees).

Within the context of healthy aging, maintaining high levels of functional skills should be a priority in the process of promoting the health of older people. Public policies aimed at the health of older people assume that a healthy and successful aging requires the provision of opportunities for individuals to choose healthy lifestyles and also be in control of their own health status[34]. It is up to health professionals participate in the process, regardless of the professional environment in which they are inserted. Thus, it will be possible to promote aging as a positive process with respect to musculoskeletal changes that occur in senescence.

A limitation of the present study is its small sample size, which does not allow the generalization of results. Also, new studies should be conducted to assess other aspects of gait pattern in older people using other quantitative tools to assess gait kinematic parameters.

CONCLUSION

The study showed that the neuromotor maintained the gait pattern (speed and time to ambulation) and the mobility of ankles of the older women assessed.

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