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Cardiac Autonomic Modulation and Physical Exercise in Elderly Women with Low Level Cognitive Function

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ABSTRACT

Silva EP, Amorim JCM, Dias-Filho CAA, Castro, MR, Mendes TT, Costa HA, Ferreira AC, Brito-Monzani JO, Ribeiro RM, Mostarda CT, Dias CJ. Cardiac Autonomic Modulation and Physical Exercise in Elderly Women with Low Level Cognitive Function. **JEPonline** 2019;22(3):1-11. This study evaluated the cardiac autonomic modulation after 3 months of exercise in 10 elderly women with low level cognitive function. The subjects were evaluated before and after the 18 wks of physical exercise. The anthropometric and clinical variables showed a significant difference in the body fat (P=0.030), heart rate (P=0.032), and double product (P=0.013). Regarding the variable cognition can be seen that the elderly showed low level cognitive function both pre-exercise and post-exercise. Physical exercise improved the subjects' cardiac autonomic modulation with an increase in the parasympathetic nervous system and a decrease in the sympathetic nervous system. Thus, heart rate was decreased along with double product and body fat. Also, functional capacity was increased in the elderly women with low cognitive function.

Key Words: Cardiac Autonomic Modulation, Elderly Women, Level Cognitive, Physical Exercise

INTRODUCTION

The growth of the elderly population is a worldwide phenomenon. In Brazil, the increase in the elderly is occurring at an accelerated rate (31). The World Health Organization (WHO) states that in 2025 Brazil will move from 10th to the 6th country with the highest number of elderly people in the world. According to the data from the Brazilian Institute of Geography and Statistics (15), this population of adults will reach 26.7% in 2060, due to low mortality and birth rates.

Aging is a complex and natural phenomenon that affects all humans. It is characterized as a dynamic, progressive, and irreversible process related to biological, psychic, and social factors (19). The biological changes are related to the loss of muscle mass and strength, decrease in heart rate, and failure of homeostatic mechanisms. These changes have an impact on the onset of chronic degenerative diseases, fragilities, dependence, and autonomy in old age, which are often associated with a decrease in cognition. However, in the active elderly adults this effect is attenuated (23).

Cognitive functions are negatively affected with aging. The decline begins to occur from the third decade of life, where there is a gradual loss of neurons that may affect the development of some intellectual functions (2). The decrease in cognitive performance occurs due to changes in the neurodegenerative process in the central nervous system (CNS), which results in difficulties in memory, language, and behavioral changes that influence the autonomic nervous system (ANS). The ANS is an important neuromodulator of the cardiovascular and metabolic systems, allowing the central nervous system to maintain homeostasis against acute and chronic changes in physiological and pathological states (21).

The measurement of heart rate variability (HRV) is used to evaluate the influence of the ANS. It is a noninvasive method used to evaluate the modulation of the ANS components, such as the sympathetic nervous system and the parasympathetic nervous system (29). Thus, the central nervous system and the ANS are related to structures in the aging process and the decrease in cognitive performance. In this regard, da Costa Dias et al. (2013) evaluated the autonomic function of individuals with cognitive deficit in the Brazilian population. They reported a decrease in the influence of the parasympathetic nervous system and an exacerbation relative to sympathetic nervous system in individuals with a cognitive deficit (8). Thus, it appears that the regular practice of physical exercises can help to provide a positive effect on cerebral function and cognitive performance in the elderly population, which appears to contribute also to the cardiac autonomic control (11).

The purpose of the present study was to evaluate the cardiac autonomic modulation after 3 months of physical exercise in elderly women with a low level of cognitive function.

METHODS

Population and Sample

The sample consisted of 10 elderly women with an age of 60 yrs or older, who were also participants of the Extension Project "MovimentAção". This aim of the project is to encourage the practice of physical exercises for maintenance of an active and healthy lifestyle in the elderly population of the city of Pinheiro-MA.

Ethical Aspects
This study was approved by the Research Ethics Committee of the Federal University of Maranhão under the code (61856516.5.0000.5087). All subjects signed an Informed Consent Term (TCLE).

Inclusion Criteria
Elderly adults with an age of 60 yrs or older with controlled hypertension and who were participants of the extension project, "MovimentAção" in the municipality of Pinheiro-Ma were considered as subjects for this study. Also, it was important that the elderly women presented a low-level cognitive function according to the Mental State Examination Questionnaire (MMSE) and had the ability to perform all the proposed tests.

Exclusion Criteria
Any potential subjects with acute respiratory disease, rheumatic diseases, acute myocardial infarction 3 months prior to the study, and failure to perform all the proposed tests were excluded.

Study Design
The subjects were verbally informed about all data collection procedures of the study, as well as the purpose in doing so. All the evaluations (i.e., anamnesis, anthropometric evaluation, questionnaire application, heart rate variability, and 6-min walk test) were performed at the beginning of the interventions through physical exercises and after 18 wks.

Anamnesis and Anthropometric Evaluation
The anamnesis (i.e., the recollection or remembrance of the past) was performed through the collection of personal data, medical history, eating habits, and the practice of physical exercises. During the anthropometric evaluation, the subjects' weight was measured using a digital scale with the subject positioned barefoot in the center of the scale that was previously zeroed. The subjects' height and waist circumference (WC) were measured using a Travan-TR4013 while instructed to remain in the orthostatic position with the face turned forward. The upper limbs were positioned alongside the body with the hands and fingers in the supine position (facing forward) and pointed downwards, respectively. The WC was obtained between the iliac crest and the lateral costal border (midpoint between the hip and the last rib). Body mass index (BMI) was determined using the formula: weight (kg) / height (m^2) (7). In order to verify fat percentage, 7 cutaneous folds (subscapular, mid-axillary, triceps, thigh, supra-iliac, abdomen, and pectoral) were collected using the protocol proposed by Pollock et al. (1993). For these measurements, a plicometer (Sanny) was used.

Questionnaire
The cognitive level of the elderly subjects was determined by using the questionnaire Mini-Mental State Examination (MMSE) that consists of 30 questions grouped into categories that evaluate the following specific cognitive functions: orientation, attention, memory, language, and motor activity. The scores vary from 0 to 30 points and some cut-off points are established according to the one proposed by Brucki et al. (2003) in which the cut-off points varied according to the person's years of study (i.e., 20 points for illiterate, 25 for 1 to 4 yrs of schooling, 26 for 5 to 8 yrs, 28 for 9 to 11 yrs, and 29 for individuals with higher education).

Heart Rate Variability (HRV)

A 12-lead electrocardiogram of the Win Cardio 6.1.1 was used to measure heart rate variability (HRV). The subjects were placed in the supine position for 10 min at rest, with spontaneous and normal respiratory rate (between 9 and 22 cycles·min^{-1}). The analysis was made through the following indices: (a) ***Time Domain:*** RR (the mean of RR intervals), SDNN (RR interval standard deviation), and RMSSD (square root of the mean to squares of the differences between the adjacent RR intervals) were obtained using the Kubios HRV software, version 2.0 (Kubios, Finland); and (b) ***Frequency Domain:*** The Fast Fourier transform (FFT) was used, which measures the low frequency (LF) band, high frequency (HF) band (absolute values of power (ms^2) and standard units (nu)), very low frequency (VLF) representing the sympathetic and vagal modulations, respectively, and the LF/HF ratio (14). The analysis of the HRV in the time domain expresses the results in unit time (milliseconds), measuring each normal RR interval (sinus beats) during a certain time interval, and thus based on statistical methods were calculated the translator indices of fluctuations in the duration of cardiac cycles (30).

Six-Minute Walk Test

The 6-min walk test (6-MWT) was used to analyze functional capacity. The test was performed in the following way: two duly trained evaluators instructed the elderly subjects to walk the longest possible distance on a flat track, rectangular, and signalized for 6 min (9). In the 6-MWT, the instruction is to walk as fast as possible with the participant determining the walking speed (5). The elderly subjects were instructed to discontinue the test if they experienced lower limb pain, tachycardia, and/or any other symptom of discomfort.

Before starting the test, the elderly subjects remained in the resting position for a period of 10 min before the measurement of blood pressure was determined by the auscultatory method (hand stethoscope and sphygmomanometer Premium brand), heart rate was determined by using a heart rate meter (Polar H-10), and perception of effort was determined by the Borg scale scores. After performing the 6-MWT, the elderly subjects stopped the test and then blood pressure, heart rate, and the effort perception scale were determined. Subsequently, to determine the subjects' distance walked, a tape measure was used.

Protocol of Physical Exercises

The intervention protocol was initiated with the purpose of promoting health and physical exercise in the elderly subjects. The protocol was organized in accordance with the recommendations of the World Health Organization (22) and the paper by Kraemer et al. (18) with respect to the American College of Sports Medicine (ACSM). The WHO suggests that physical exercise should be at least 150 min of moderate-intensity exercise or 75 min of vigorous intensity per week. ACSM and WHO recommend that the resisted exercises for the elderly population should include large muscle groups, ranging from 8 to 10 exercises. So, the intervention program was contemplated as follows. Aerobic and resistance exercises were performed with a focus on resistance training and muscular strength, flexibility, agility, balance, and motor coordination. Low-cost equipment such as disposable plastic bottles filled with water to facilitate load measurement, ropes, cones, broomsticks, rubber bands, rubber balls, bows, and mats were also used.

The exercise sessions included: (a) ***the Initial Moment:*** consisted of monitoring blood pressure with joint preheating and dynamics in group (15 min); (b) ***the Conditioning***

Moment: consisted of aerobic exercises (dance and guided walking), cognitive exercises (perceptive games), and resistance exercise (resistance and muscular strength, flexibility, agility, balance, coordination, and postural reorganization) (40 min); and (c) ***the Cooling Moment:*** consisted of relaxation and stretching exercises (5 min). Evaluations were made at the beginning of the physical exercise interventions and after 18 wks of training. Three weekly sessions with duration of 60 min each were performed by the subjects.

Statistical Analysis

BioEstat 5.0 software was used to analyze the data. To compare the initial and final values, normality test of Shapiro-Wilk followed by Student's paired *t*-test was performed. The data are presented as mean ± standard deviation. An alpha level of $P<0.05$ was considered statistically significant.

RESULTS

Table 1 presents the values of the anthropometric and clinical variables in the 10 elderly subjects with a mean age of 70.2 ± 7.33 yrs, where 5 subjects were diagnosed with arterial hypertension. However, their blood pressure was controlled by use of medication. With regards to the subjects' cognitive level, it can be observed that the elderly women presented a low level of cognitive function in both the pre-exercise and the post-exercise conditions.

Table 1. Anthropometric and Clinical Variables of Elder Women Subjects.

	Pre–Exercise (n = 10)	**Post–Exercise** (n = 10)	**P**
Weight (Kg)	61.02 ± 12.18	60.47 ± 11.40	0.378
BMI ($kg \cdot m^{-2}$)	26.50 ± 4.91	27.35 ± 4.97	0.125
Height (cm)	151.7 ± 4.67	151.7 ± 4.67	1.000
Body Fat (%)	19.146 ± 8.20	16.697 ± 6.61	0.030*
WC (cm)	84.85 ± 11.01	83 ± 11.47	0.178
SBP (mmHg)	127.5 ± 7.07	116.25 ± 11.88	0.051
DBP (mmHg)	76 ± 13.50	79 ± 5.68	0.217
HR ($beats \cdot min^{-1}$)	77.25 ± 10.10	72.429 ± 5.41	0.032*
DP ($mmHg \cdot beats \cdot min^{-1}$)	9.7438 ± 1.39	8.6486 ± 0.88	0.013*
Scholarly Level	7 ± 4.55	7 ± 4.55	1.000
Cognition	22.62 ± 2.39	22.25 ± 2.82	0.399

BMI = Body Mass Index; **SBP** = Systolic Blood Pressure; **DBP** = Diastolic Blood Pressure; **HR** = Heart Rate; **DP** = Double Product; **WC** = Waist Circumference; * = $P<0.05$

There were no statistical differences (P>0.05) in the subjects' weight, body mass index (BMI), height, waist circumference (WC), diastolic blood pressure (DBP), and systolic blood pressure (SBP). However, there were statistical differences (P<0.05) in body fat, heart rate (HR), and double after the training protocol.

Given the distance covered from pre- and post-physical exercises, the data shows an improvement in functional capacity of the elderly subjects. Table 2 shows the results of the 6-min walk test.

Table 2. Six-Minute Walk Test of the Elderly Subjects.

	Pre – Exercise (n = 10)	**Post – Exercise** (n = 10)	**P**
Distance Covered (m)	354.67 ± 44.88	408.28 ± 50.84	0.003*

* = P<0.05

The indices of heart rate variability are presented in Table 3 through the time domain and frequency domain variables. In the time domain, the variable RMSSD showed statistical difference. Variables in the frequency domain showed significant reductions in low-frequency component (LFnu) and a significant increase in the high-frequency component (HFnu).

Table 3. Heart Rate Variability (HRV) of the Elderly Subjects.

	Pre – Exercise (n = 10)	**Post – Exercise** (n = 10)	**P**
Time Domain			
RR (ms)	898.94 ± 116.23	889.68 ± 140.30	0.435
SDNN (ms)	28.93 ± 16.13	24.83 ± 9.40	0.205
RMSSD (ms)	17.23 ± 6.18	22.56 ± 2.70	0.049*
Frequency Domain			
VLF (ms^2)	350.67 ± 412.16	222.15 ± 173.80	0.195
LF (ms^2)	403.48 ± 775.44	87.82 ± 68.51	0.117
HF (ms^2)	140.18 ± 84.11	130.92 ± 39.53	0.341
LF (nu)	48.48 ± 23.36	31.31 ± 12.98	0.031*
HF (nu)	41.80 ± 19.70	54.80 ± 16.50	0.045*
LF/HF	2.44 ± 3.57	0.67 ± 0.40	0.078

RR = Heart Beats Interval; **SDNN** = Standard Deviation of RR Intervals; **RMSSD** = Square Root of Squared Mean of the Differences between Adjacent RR Interval; **VLF** = Very Low Frequency band; **LF (ms^2)** = Low Frequency Band in Absolute Power Values; **HF (ms^2)** = High Frequency Band in Absolute Power Values; **LF (nu)** = Low Frequency Band in Normalized Units; **HF (ns)** = High Frequency Band in Normalized Units; **LF/HF** = Sympathovagal Balance; * = P<0.05

The cardiac autonomic modulation showed an improvement represented by the index RMSSD in time domain that presents parasympathetic predominance. There was also an increase in the frequency domain represented by the high-frequency band in normalized units (HFnu) that presents parasympathetic predominance and a reduction of the low-frequency band (LFnu) that presents sympathetic predominance.

DISCUSSION

This study evaluated the cardiac autonomic modulation in elderly women with a low cognitive function before and after a 3-month physical exercise program. The main finding of this study was the increase of vagal modulation (as demonstrated in the values of RMSSD that presents parasympathetic predominance) high-frequency band in units normalized (HFnu) with parasympathetic predominance, and a decrease in the value of low-frequency band in normalized units (LFnu) with sympathetic predominance. Also, there was an improvement in cardiovascular efficiency as demonstrated with the decrease in heart rate and double product. Overall, the decrease in body fat helped to increase the subjects' functional capacity.

The present study found similar results to the research by Buchheit et al. (6) who reported that the elderly people practitioners of a regular physical exercise program presented higher HRV indexes and mainly of vagal indices. Similarly, Albinet et al. (1) evaluated heart rate variability and cognitive function in elderly subjects during 12 wks of aerobic training and stretching. They verified improvement in the vagal parameter of HRV, thus showing the role of aerobic exercise as a positive influence on important cardiac and cerebral factors.

Conversely, Forte et al. (16) analyzed that effects of 16 wks of a dynamic resistance training program on elderly women. They reported that the training protocol did not present modifications in the parameters of cardiac autonomic modulation evaluated in the time and frequency domains(16,17). It is possible that the negative findings on HRV occurred due to the low stimulation of physical training. Thus, if the low stimulation hindered modifications in the heart autonomic control, it would confirm that HRV changes during exercise and recovery post-exercise occur according to the intensity and physiological impact of the exercise (24).

Seals and Dinenno (26) and Tapanainen et al. (27) indicate that the reduction in heart rate variability is related to autonomic dysfunction and risk in the clinical development of cardiovascular and metabolic diseases in middle-aged adults and elderly (26,27). Hence, the findings in the present study corroborate with the literature observing that regular practice of physical exercises promotes greater regulation and delay of the aging process, increases functional capacity, and stimulates the parasympathetic nervous system through muscarinic receptors (13).

In this sense, de Vilhena and Junqueira (12) show that the main neurotransmitter responsible by the cognitive functions and nervous transmission of the parasympathetic branch after exercise is acetylcholine. Thus, physiological changes can improve both the cardiovascular and cerebral systems, although the mechanisms that assess cognition and physical exercise are not well established in the literature (20).

Thus, the present study shows that 18 wks of physical training was sufficient to reduce body fat rates in elderly women with a low cognitive level, which is consistent with the findings by

Sanal et al. (25). They concluded that physical exercises improved the physical and metabolic health of subjects in any age group. Therefore, the body fat percentage reduction influences the peripheral vascular resistance reduction, facilitating a better venous return, which is also associated with a decrease in the sympathetic nervous system stimulation.

Another important finding in the present study is the decrease in heart rate and double product, which supports the study performed by Terra et al. (28) who observed a decrease in heart rate and double product in physically active elderly. It is important to mention that these findings occurred due to the vagal stimulation on the sinoatrial rhythm that induced an increase in the RR intervals and a decrease in the contraction force of cardiac muscle. Also, the decrease in the subjects' double product demonstrates a lower cardiovascular risk (28). These results argue that physical training is an important non-pharmacological treatment that plays an important function in the improvement of sympathetic balance and plasma levels of catecholamines (3,4).

CONCLUSIONS

The physical exercise improved the cardiac autonomic modulation with an increase in the parasympathetic autonomic nervous system and a decrease in the sympathetic autonomic nervous system. Thus, there was a decrease the heart rate, body fat, and double product, which is consistent with the results of the 6-min walk test that indicated an increase in functional capacity in the elderly women with a low level of cognitive function.

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REFERENCES

1. Albinet CT, Boucard G, Bouquet CA, Audiffren M. Increased heart rate variability and executive performance after aerobic training in the elderly. ***Eur J Appl Physiol.*** 2010; 109(4):617-624.

2. Antunes HK, Santos RF, Cassilhas R, Santos RV, Bueno OF, Mello Md. Exercício físico e função cognitiva: Uma revisão. ***Rev Bras Med Esporte.*** 2006;12(2):108-114.

3. Aubert AE, Seps B, Beckers F. Heart rate variability in athletes. ***Sports Med.*** 2003; 33(12):889-919.

4. Besnier F, Labrunee M, Pathak A, Pavy-Le Traon A, Gales C, Senard J-M, et al. Exercise training-induced modification in autonomic nervous system: An update for cardiac patients. ***Ann Phys Rehabil Med.*** 2017;60(1):27-35.

5. Britto RR, de Sousa LAP. Teste de caminhada de seis minutos uma normatização brasileira. ***Fisioterapia em movimento.*** 2017;19(4).

6. Buchheit M, Simon C, Viola AU, Doutreleau S, Piquard F, Brandenberger G. Heart rate variability in sportive elderly: Relationship with daily physical activity. ***Med Sci Sports Exerc.*** 2004;36(4):601-605.

7. Charro M, Bacurau R, Navarro F, Pontes Junior F. Manual de avaliação física. São Paulo: Phorte, 2010.

8. da Costa Dias FL, da Silva RMFL, de Moraes EN, Caramelli P. Perfil clínico e autonômico de pacientes com doença de Alzheimer e demência mista. ***Revista da Associação Médica Brasileira.*** 2013;59(5):435-441.

9. da Cunha MJ, dos Santos DB, Valmorbida LA, et al. Análise do teste de caminhada de seis minutos em idosos de uma instituição de longa permanência. ***X Salão de Iniciação Científica PUCRS.*** 2009.

10. da Silva WQA, Fontes EB, Forti RM, Lima ZL, da Silva Machado DG, Deslandes AC, et al. Affect during incremental exercise: The role of inhibitory cognition, autonomic cardiac function, and cerebral oxygenation. ***PloS one.*** 2017;12(11):e0186926.

11. de Medeiros Rêgo ML, Cabral DAR, Fontes EB. Déficit cognitivo na insuficiência cardíaca e os benefícios da atividade física aeróbia. ***Arq Bras Cardiol.*** 2018;110(1): 91-94.

12. de Vilhena Toledo MA, Junqueira LF. Cardiac autonomic modulation and cognitive status in Alzheimer's disease. ***Clin Auton Res.*** 2010;20(1):11-7.

13. Dong JG. The role of heart rate variability in sports physiology. ***Exp Ther Med.*** 2016; 11(5):1531-1536.

14. Electrophysiology. Heart rate variability: Standards of measurement, physiological interpretation, and clinical use. ***Circ.*** 1996;93(5):1043-1065.

15. Estatística IBGE. Censo demográfico 2010: Características urbanísticas do entorno dos domicílios. ***Instituto Brasileiro de Geografia e Estatística Rio de Janeiro,*** 2010;1-175.

16. Forte R, De Vito G, Figura F. Effects of dynamic resistance training on heart rate variability in healthy older women. ***Euro J Appl Physiol.*** 2003;89(1):85-89.

17. Kanegusuku H, Queiroz AC, Silva VJ, de Mello MT, Ugrinowitsch C, Forjaz CL. High-intensity progressive resistance training increases strength with no change in

cardiovascular function and autonomic neural regulation in older adults. ***J Aging Phys Act.*** 2015;23(3):339-345.

18. Kraemer WJ, Adams K, Cafarelli E, Dudley GA, Dooly C, Feigenbaum MS, et al. American College of Sports Medicine position stand. Progression models in resistance training for healthy adults. ***Med Sci Sports Exerc.*** 2002;34(2):364-380.

19. Litvoc J, Brito FCd. Envelhecimento prevenção e promoção da saúde. ***Envelhecimento prevenção e promoção da saúde.*** 2004;226.

20. Lubans D, Richards J, Hillman C, Faulkner G, Beauchamp M, Nilsson M, et al. Physical activity for cognitive and mental health in youth: A systematic review of mechanisms. ***Pediatrics.*** 2016;138(3):e20161642.

21. Mostarda C, Wichi R, Sanches IC, Rodrigues B, Angelis K, Irigoyen MC. Hipertensão e modulação autonômica no idoso: Papel do exercício físico. ***Rev Bras Hipertens.*** 2009;16(1):55-60.

22. Organization WH. Global recommendations on physical activity for health: ***World Health Organization,*** 2010.

23. Pimenta FAP, Bicalho MAC, Romano-Silva MA, de Moraes EN, de Rezende NA. Doenças crônicas, cognição, declínio funcional e Índice de Charlson em idosos com demência. ***Revista da Associação Médica Brasileira.*** 2013;59(4):326-34.

24. Saboul D, Balducci P, Millet G, Pialoux V, Hautier C. A pilot study on quantification of training load: The use of HRV in training practice. ***Euro J Sport Sci.*** 2016;16(2):172-181.

25. Sanal E, Ardic F, Kirac S. Effects of aerobic or combined aerobic resistance exercise on body composition in overweight and obese adults: Gender differences. A randomized intervention study. ***Eur J Phys Rehabil Med.*** 2013;49(1):1-11.

26. Seals DR, Dinenno FA. Collateral damage: Cardiovascular consequences of chronic sympathetic activation with human aging. ***Am J Physiol-Heart Circ Physiol.*** 2004; 287(5):H1895-H905.

27. Tapanainen JM, Thomsen PEB, Køber L, Torp-Pedersen C, Mäkikallio TH, Still A-M, et al. Fractal analysis of heart rate variability and mortality after an acute myocardial infarction. ***Am J Cardiol.*** 2002;90(4):347-352.

28. Terra DF, Mota MR, Rabelo HT, Bezerra LMA, Lima RM, Ribeiro AG, et al. Redução da pressão arterial e do duplo produto de repouso após treinamento resistido em idosas hipertensas. ***Arquivos Brasileiros de Cardiologia.*** 2008;91(5):299-305.

29. Túbero GS. Variabilidade da frequência cardíaca, funções cognitivas e nível de atividade física em pacientes com doença de Alzheimer, 2014.

30. Vanderlei LCM, Pastre CM, Hoshi RA, de Carvalho TD, de Godoy MF. Noções básicas de variabilidade da frequência cardíaca e sua aplicabilidade clínica. ***Revista Brasileira de Cirurgia Cardiovascular.*** 2009;24(2):205-217.

31. Veras R. Envelhecimento populacional contemporâneo: Demandas, desafios e inovações. ***Revista de Saúde Pública.*** 2009;43:548-554.

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