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DYNAMIC COMPONENTS OF POSTURAL CONTROL IN WOMEN AGED 60–74 YEARS WITH DIFFERENT RATES OF AGEING

Taisiya P. Moroz*, Aleksandr V. Demin*, Dimitar Jovanovski**, Mati Pääsuke**

*Northern (Arctic) Federal University named after M.V. Lomonosov (Arkhangelsk, Russian Federation)
**University of Tartu (Tartu, Estonia)

This article presents the results of the study into the dynamic components of postural control in women aged 60–74 years with different rates of ageing. The research involved women with low (*n* = 83) and normal (*n* = 85) rates of ageing. To assess the dynamic components of postural control we used the computer-aided stabilometric complex Balance Master. In Sit-to-Stand test women with normal rate of ageing showed decreased rising index and increased sway velocity. These data suggest reduced adaptive abilities as well as changes in the neurophysiological mechanisms of holding posture at quick rising from a seated position in women with normal rate of ageing compared to those with low rate of ageing. The Walk Across test revealed increased step width and reduced gait speed in women with normal rate of ageing. No statistically significant differences were found between the groups in Tandem Walk test, which indicates that no changes take place either in the adaptation abilities or neurophysiological mechanisms of postural control in women 60–74 years old with normal rate of ageing. We suggest that the preservation of effective coordination during walking in older women will have a positive effect on their life expectancy. Further, in Step/Quick Turn test, prolonged turn time to the left and to the right as well as increased turn sway were observed in older women with normal rate of ageing compared to those with low rate of ageing. These data suggest reduced adaptive abilities and changes in the neurophysiological mechanisms of complex motor acts in women with normal rate of ageing.

Keywords: *older women, rate of ageing, walk, stabilometry.*

It is a fact that senescence entails a gradual development of changes limiting the adaptive capacity of the body, whereas premature ageing involves partial or total acceleration of ageing, resulting in the person's being ahead of the average age of his/her age group [1]. Many researchers have noted that changes in premature ageing occur throughout the body, affecting many organs and systems, including changes in the parameters of postural control [2]. It is known that normal ageing is characterized by a certain shift and a sequence of age-related changes corresponding to the biological and adaptive regulatory abilities of the human body. Normal rate of ageing in older women is a borderline between physiological and premature ageing, whereas slow and low rate of ageing in older women can be regarded as the basis of "optimal ageing" producing a positive effect on

Corresponding author: Taisiya Moroz, *address:* 3 proezd Badigina, Arkhangelsk, 163045, Russian Federation, *e-mail:* t.moroz@narfu.ru

the processes of successful and active ageing [3]. The aim of this study was to evaluate the dynamic components of postural control in women aged 60–74 years with different rates of ageing.

Materials and methods. A group of 168 healthy community-dwelling women aged 60–74 years volunteered to participate in this study. The sample was divided into 2 groups by rate of ageing (RA): normal rate of ageing (NRA) (n = 85) and low rate of ageing (LRA) (n = 83). To calculate RA we used a formula for determining the biological age (BA) and appropriate biological age (ABA) according to the 3rd version of V.P. Voitenko's method [4]. The following formula was applied: RA = BA – ABA [2]. According to Voitenko's classification, low rate of ageing is –10 years or less, while normal rate of ageing ranges from +4.9 to –4.9 years [2]. The study criteria excluded women registered in mental hospitals and those with strokes, cognitive impairments, chronic traumas or neurodegenerative diseases in past medical history. Moreover, all the women at the time of the survey were mobile and able to walk without assistance.

In addition, the subjectively experienced age (SEA) of the women was determined by asking how old they felt. This parameter depends on life intensity, eventfulness and satisfaction, as well as on experiences and the perceived degree of self-fulfilment of the ageing person and his/her socioeconomic status [5].

Motor performance was assessed using the computer-aided stabilometric complex Balance Manager. The following tests were conducted [6]:

Sit-to-Stand (STS). This test quantifies the patient's ability to rise from a seated to a standing position. Key components of this task include shifting the body centre of gravity (COG) forward from an initial position over the seat to a location centred over the base of support, followed by extension of the body to an erect stand while maintaining the centred COG position. The measured parameters are weight transfer time, rising index (force exerted to rise), sway velocity during the rising phase, and left/right symmetry of the rising force.

Walk Across (WA). This test quantifies characteristics of gait as the patient walks across the length of the force plate. The test characterizes steady state gait by having the patient begin well behind and continuing beyond the force plate. The measured parameters are step width, step length and speed.

Tandem Walk (TW). This test quantifies characteristics of gait as the patient walks heel to toe from one end of the force plate to the other. The measured parameters are step width, speed, and endpoint sway velocity.

Step/Quick Turn (SQT). This test quantifies turn performance characteristics as the patient takes two forward steps, quickly turns 180° and returns to the starting point. The measured parameters are the time to execute the turn and the sway velocity during the turn execution.

The statistical analysis was carried out using SPSS 22.0 software. Due to the fact that not all the samples showed normal distribution parameters, the parameters were evaluated in groups and presented as a median (Me) and percentile 25–75 (Q1–Q3). To compare the groups and analyse the data we applied non-parametric methods (the Mann–Whitney U test to compare two independent samples). Statistical significance was set at $p < 0.05$.

Results. The analysis of parameters of real age showed (*Table 1*) that all quartiles in women with

Table 1

AGE CHARACTERISTICS IN OLDER WOMEN WITH NRA AND LRA (Me (Q1–Q3))

Parameters	Normal rate of ageing (NRA), n = 85	Low rate of ageing (LRA), n = 83	p
Real age, years	64 (61–67)	65 (63–70)	0.031
SEA, years	62 (59–65)	60 (55–65)	0.055
RA, years	–2 (–3…0)	–13 (–15…–11)	< 0.001

NRA were lower than in women with LRA (p = = 0.03). These results suggest that the prevalence of NRA will have a negative impact on life expectancy in women older than 60 years. In SEA, a statistical trend was identified (p = 0.055). It was found that women with LRA aged 60–74 years feel 5 years younger, whereas women with NRA feel, on the average, only 2 years younger.

In Sit-to-Stand test (*Table 2*), the rising index in women with NRA was lower (p = 0.003) and sway velocity was higher (p = 0.011) compared to women with LRA. According to the results, women 60–74 years old with NRA demonstrate reduced adaptive abilities as well as changes in the neurophysiological mechanisms of holding posture at quick rising from a seated position.

In Walk Across test, all quartiles of step width were higher (p < 0.001) and all quartiles of speed (p = 0.029) were lower in women with NRA compared to women with LRA. In addition, the analysis of step length showed statistical trends ($p \leq 0.060$). Thus, according to the Walk Across test, an increase in step width and a decrease in speed were suggested in the group of women with NRA.

No statistically significant differences ($p > 0.05$) were found between the measured groups in the parameters of Tandem Walk test (*Table 3*). These data suggest no changes in adaptation abilities or neurophysiological mechanisms of postural control in women aged 60–74 years with NRA. We can assume that the preservation of effective complex coordination during walking in older women will have a positive effect on their life expectancy. Conversely, we consider the deterioration of these test parameters to be an indicator of premature ageing that can have a negative impact on women's mobility in old age.

Table 2

SIT-TO-STAND AND WALK ACROSS TEST PARAMETERS IN OLDER WOMEN WITH NRA AND LRA (Me (Q1–Q3))

Parameters	Normal rate of ageing (NRA), n = 85	Low rate of ageing (LRA), n = 83	p
Sit-to-Stand			
Weight transfer time, s	0.44 (0.34–0.56)	0.47 (0.35–0.62)	0.238
Rising index, %	15 (12–19)	18 (14–23)	< 0.001
Sway velocity, deg/s	3.9 (3.2–4.5)	3.3 (2.8–4.1)	< 0.05
Walk Across			
Step width, cm	14.1 (11.9–16.1)	12.4 (9.7–14.4)	< 0.001
Step length, cm	56.1 (48.7–60.4)	58.3 (52.0–63.1)	0.060
Speed, cm/s	82.4 (75.1–88.8)	86.0 (77.8–95.2)	< 0.05

In Step/Quick Turn test, turn time to the left (p < 0.001) and to the right (p < 0.001) was longer and turn sway to the left (p < 0.001) and to the right (p < 0.001) was greater in women with NRA compared to women with LRA. These results show a decrease in adaptive abilities and functions of the neurophysiological mechanisms of complex motor acts in older women with NRA. Thus, women aged 60–74 years with NRA are characterized by lower performance of simple and complex motor acts compared to women of the same age with LRA, which can be used as additional criteria for the evaluation of age-related changes.

Discussions. It is known that SEA in elderly and senile age can be considered as an evaluation criterion of their successful ageing [2]. In this regard, our results suggest that NRA in women

Table 3

TANDEM WALK AND STEP/QUICK TURN TESTS PARAMETERS IN OLDER WOMEN WITH NRA AND LRA (Me (Q1–Q3))

Parameters	Normal rate of ageing (NRA), *n* = 85	Low rate of ageing (LRA), *n* = 83	*p*
Tandem Walk			
Step width, cm	7.5 (6.3–9.7)	7.3 (6.1–8.7)	0.118
Speed, cm/s	28.3 (22.9–34.0)	30.0 (25.2–35.9)	0.101
Endpoint sway velocity, deg/s	5.6 (4.4–6.2)	4.9 (3.9–6.5)	0.175
Step/Quick Turn			
Turn time left, s	1.8 (1.18–2.45)	1.29 (1.01–2.01)	< 0.001
Turn time right, s	1.57 (1.17–2.19)	1.24 (0.8–1.61)	< 0.001
Turn sway left, deg/s	30.2 (23.8–38.8)	24.8 (19.9–32.9)	< 0.001
Turn sway right, deg/s	30.5 (21.3–37.2)	23.3 (19.0–30.8)	< 0.001

aged 60–74 years will have a negative impact on the process of successful ageing as opposed to LRA. In addition, these data suggest that the lack of changes in simple walking and complex coordination during walking will have a positive effect on successful ageing of women.

It is known that the ability to quickly rise from a seated position in older adults is a prerequisite for daily activities and can be used as an indicator of physical activity [7]. It can be assumed that women aged 60–74 years with NRA will experience a decrease in physical activity compared to those with LRA. As we know, getting up from a seated position requires more muscle strength of the lower limbs than other motor acts, such as simple or complex walking. In addition, quick rising function depends on the knee joints [8]. What is more, declining muscle strength is known to increase the risk of premature ageing in older people [2, 9].

The results of this study suggest a decrease in the functioning of leg muscles and joints in women aged 60–74 years with NRA. Changing the extensor mechanism of the knee and leg muscle strength can be regarded as a predictor of increased rate of ageing, reduced physical and daily activity in women aged 60 and older, thus having a negative impact on the process of successful ageing. The data allow us to consider high values of Sit-to-Stand test to be a biomarker of LRA. It is known that decreased muscle strength in the lower limbs increases the risk of falls in elderly and senile age [6, 10]. It can be assumed that lower rising index and higher sway velocity in Sit-to-Stand test will increase the risk of falls in older women. Our study confirms the fact that people with NRA run a higher risk of falling compared to people with LRA [5, 11, 12].

The analysis of Step/Quick Turn test results showed that older women with NRA have a decrease in efficiency and accuracy in complex motor acts, which is one of the most important risk factors for falls among older women [6]. Changes in the parameters of this test in older adults may also be a result of reduced visual and vestibular information in balance control, as well as dysfunction of the musculoskeletal system [10]. Women aged 60–74 years with NRA have a higher risk of deteriorated sensory information involved in postural control, as well as dysfunction of back muscles and joints and foot muscles.

We suggested that NRA in older women, regardless of their real age, contributes to more

pronounced changes in the parameters of quick rising from a seated position, walking and complex motor acts. The findings indicate that NRA in older women should be considered as a premorbid condition that increases the risk of changes in the dynamic components of postural control. Evaluation of the rate of ageing in people will predict not only the level of deterioration of their health, but also the scope of medical and psychosocial care they may require.

Conclusions:

• Decreased rising index and increased sway velocity were identified in Sit-to-Stand test in older women with normal rate of ageing as compared to those with low rate of ageing. It indicates a reduction in their adaptive abilities and changes in the state of neurophysiological mechanisms of holding posture at quick rising from a seated position.

• According to the Walk Across test results, elderly women with normal rate of ageing showed an increase in step width and a decrease in speed during normal walk compared to women with low rate of ageing.

• The Step/Quick Turn test results indicate that older women with normal rate of ageing show longer turn time to the left and to the right, as well as increased sway velocity during turning to the left and to the right compared to women with low rate of ageing. These findings demonstrate a reduction in the women's adaptive abilities and functions of the neurophysiological mechanisms of complex motor acts.

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ДИНАМИЧЕСКИЕ КОМПОНЕНТЫ ПОСТУРАЛЬНОГО КОНТРОЛЯ У ЖЕНЩИН 60–74 ЛЕТ С РАЗЛИЧНЫМИ ТЕМПАМИ СТАРЕНИЯ

Т.П. Мороз, А.В. Дёмин*, Д. Йовановски**, М. Паасуке***

*Северный (Арктический) федеральный университет имени М.В. Ломоносова
**Тартуский университет (Эстония)

В статье представлены результаты исследования динамических компонентов постурального контроля у женщин в возрасте 60–74 лет с различными темпами старения. В исследовании приняли участие женщины с медленным (n = 83) и нормальным (n = 85) темпами старения. Для оценки динамических компонентов постурального контроля использовали компьютерный стабилометрический комплекс «Balance Master» производства «NeuroCom» (США). В тесте «вставание из положения сидя» у женщин с нормальным темпом старения наблюдается понижение индекса подъема и увеличение скорости колебания центра тяжести. Полученные данные позволяют говорить о снижении у них адаптационных способностей и об изменении состояния нейрофизиологических механизмов, обеспечивающих удержание позы при быстром вставании из положения сидя. Сравнительная оценка теста «простая ходьба» показала, что у женщин в пожилом возрасте при нормальном темпе старения наблюдается повышение ширины шага, снижение скорости ходьбы. В тесте «тандемная ходьба» в обследуемых группах значимых различий не обнаружено, что свидетельствует об отсутствии изменений в адаптационных способностях и нейрофизиологических механизмах постурального контроля у женщин 60–74 лет с нормальным темпом старения. Мы предполагаем, что сохранение эффективной координации при ходьбе у пожилых женщин будет иметь положительное влияние на продолжительность их жизни. В тесте «быстрый разворот» обнаружено, что у пожилых женщин с нормальным темпом старения наблюдается увеличение времени разворота влево и вправо, а также повышение колебания центра тяжести при разворотах. Полученные данные указывают на снижение у женщин с нормальным темпом старения адаптационных способностей и функций нейрофизиологических механизмов сложных двигательных актов.

Ключевые слова: *пожилые женщины, темп старения, ходьба, стабилометрия.*

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Ответственный за переписку: Мороз Таисия Петровна, *адрес:* 163045, г. Архангельск, проезд Бадигина, д. 3; *e-mail:* t.moroz@narfu.ru