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Original Paper

Biomedical Human Kinetics, 16, 238–246, 2024
DOI: 10.2478/bhk-2024-0025

Effects of a short-term wheelchair yoga intervention on balance in elderly women with neurodegenerative diseases: A preliminary study

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Abstract

Study aim: This study examined effects of practicing of the wheelchair yoga intervention for 4 weeks on static and dynamic balance and physical, mental and social health in elderly female wheelchair users with neurodegenerative diseases.
Material and methods: Elderly females (n = 22, mean age 75.1 ± 5.8 years), users of a wheelchair participated in the 4-week wheelchair yoga intervention program. Medical anamnesis, bioimpedance body composition assessment, Tinetti balance assessment tool, and the RAND 36 Short Form Health Survey (SF-36) were used in the pre – and post-measurements.
Results: Multivariate regression – orthogonal projections to latent structures (OPLS) and non-parametric comparisons revealed significant increase in the dynamic balance, total muscle mass, and the social score after the yoga program. Changes in the Tri-ponderal mass index and several indicators of mental health were the best mediators for the effect of the yoga program on dynamic balance.
Conclusions: Wheelchair yoga intervention program could be a beneficial rehabilitation method for stimulation of neuromotor functions associated with balance control in elderly females – users of a wheelchair due to neurodegenerative diseases.

Keywords: Balance – Females 65 and older – Mobility impairment – Exercise stimuli – Wheelchair yoga – Quality of life

Introduction

Neurodegenerative diseases are progressive diseases characterized by the loss of specific groups of neurons, which in turn determines the clinical picture of the disease. Neuropathological diagnosis takes into account a set of neurohistological changes in different areas of the brain and spinal cord and the detection of specific neuronal and / or glial protein inclusions that are determinative of individual diseases [29]. The prevalence of elderly who use a wheelchair due to neurodegenerative diseases increases with age [41]. Interestingly, the proportion of elderly women with neurodegenerative diseases, requiring a wheelchair, increases with age, as do the areas of life in which their participation is restricted [34, 36]. It was reported that manual wheelchairs are more used in elderly females with neurodegenerative diseases, who live in senior homes [16]. Wheelchair use may result in their physical and social limitations, anxiety, loss of confidence, and fear or depression [9]. In elderly women who use a wheelchair due to neurodegenerative diseases, may impaired not only their mobility and activity, but also health risks, especially due to the potential falls, because the balance control during daily activities may be impaired. It is disturbed here the sensory system, i.e., vestibular, visual, somatosensory [37, 45], further motor functions at a level of the central nervous system [27], and the musculoskeletal system, too [30].

In this context exercise rehabilitation interventions are recommended [6, 9]. The authors suggest intervention programs for users of a wheelchair due to neurodegenerative diseases to improve balance control via stimulation of the sensory, cognitive, and musculoskeletal systems while addressing balance constraints such as orientation in space, changes in direction, and the speed or height of the center of mass during static and dynamic situations. We know, it can be dealt the balance support through a combination of balance and coordination exercises that challenge the postural control systems in multiple dimensions-including

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vertical and horizontal changes of the center of mass, and changing body directions [17]. Moreover, researchs proved positive correlation between daily functioning and muscle strength, body flexibility, and joint mobility in elderly women in wheelchair [44]. The most important determinants of daily functioning were balance, hand grip strength and joint mobility. Theirs study showed also that better scores in balance test and joint mobility implied with higher scores in cognitive functioning of elderly in wheelchair.

The combination of function-oriented challenges while controlling balance stimulating the sensory and neuromuscular control mechanism, as well as muscle strength, body flexibility, and joint mobility, may be realized in elderly through the application of a short-term yoga-based intervention [19, 20]. The results of a 4-week yoga intervention indicated that participants' body fat percentage and systolic blood pressure decreased, balance and range of motion on shoulder flexion and abduction improved. It is important to note that other similar exercise intervention studies for elderly with positive effects on for balance development and body composition lasted only 4 weeks [12, 14]. Significant improvements of balance control in frail older women after 4 weeks of visual feedback-based balance training were reported [35]. Balance changes can be effectively assessed in the ambulatory rehabilitation care setting, using a combination of physical tests and questionnaires that do not require costly instrumentation [31].

There is a general consensus that balance focused exercise interventions for people with chronic diseases and disabilities represents an important rehabilitation method not only for optimizing of the balance control functions, but concurrently for maintaining of social integration of elderly [18, 22]. Reduced opportunities for participation in social and community activities were shown in women used wheelchair [43]. Wheelchair users experience lower levels of social participation relative to elderly individuals who do not use a wheelchair [3]. In this study the authors declare a rate of participation in exercise intervention of elderly senior houses-dwelling wheelchair users was 8.3%, comparing to participation of 88.9% elderly individuals senior houses-dwelling, who did not use the wheelchair. Individual's participation in exercise interventions in elderly may stimulate their motivation and self-efficacy [2]. Participation in a balance focused exercise intervention was found to correlate significantly with reduction of depressive symptoms in elderly females [15].

We know of a study showing the effectiveness of yoga based on a chair, but to the best of our knowledge, there is no published study which has systematically consolidated the evidence of balance effects in elderly female wheelchair users with neurodegenerative diseases after the wheelchair yoga intervention [23]. In our study, we assumed that switching from a wheelchair to a chair causes anxiety and fear of exercise for people who use a wheelchair on a daily basis and have problem with balance and maintaining a habitual upright body posture.

Simultaneously, based on some evidences mentioned above, that the intensive wheelchair yoga intervention focused on stimulation of the balance, flexibility, muscle and respiratory functions in linking to psychic relaxation benefits not only balance abilities itself but concurrently may optimize the social integration of the monitored elderly female wheelchair users with neurodegenerative diseases. Thus, the purpose of the presented study was to examine effects of the wheelchair yoga for 4 weeks on static and dynamic balance in elderly female wheelchair users with neurodegenerative diseases.

Material and methods

In this study we use the methodology and experience from the project GACR ID 15-25710S "Basic Research of Balance Changes in Seniors" (2017-2019, prolonged to 2021). Our preliminary study follows the project which was supported by the Czech Science Foundation. Simultaneously, the research methodology from the abovementioned project was 105 used in this study.

Participants

The research study included 22 females, mean age 75.1 ± 5.8 years, were recruited from senior homes on the base of voluntary participation. The inclusion criteria were female users of a wheelchair due to neurodegenerative diseases, in the age 65 and older , living in senior house, not suffering from any sign of the exclusion criteria, with a skill to stand up, sit down, gait push the wheelchair 4–5 m, were included in the study.

The exclusion criteria were other disorders and diseases according to the White Book on Physical and Rehabilitation Medicine in Europe: (i) paraplegia, cerebral palsy, hemiparesis, (ii) amputations (iii) human to human infectious diseases and bacillus carrier, (iv) all acute-stage diseases and conditions in which destabilization of health state can be reasonably expected, (v) cachexia of various etiologies, (vi) malignant tumors, (vii) active attacks or phases of psychoses and mental disorders with asocial manifestations or with reduced communication, (viii) 2nd and 3rd degree of urinary incontinence and stool incontinence [10].

The overview of diagnoses of the selected participants was as follows:

- Multiple sclerosis (5 participants)
- Neuromuscular respiratory or cardiac disease (7 participants)
- Parkinson's disease (4 participants)
- Rheumatoid arthritis (6 participants)

Written informed consent to participation in the study was obtained. Participants were informed about the assessments and intervention, but not about the purpose of the study. The Ethical committee of the research institution of the College of Physical Education and Sport PALESTRA in Prague (protocol code: GACR_01_2019) expressed full agreement with the research aims and procedures. The research conformed to the requirements stipulated in the Declaration of Helsinki.

Instruments of assessment

Medical anamneses

The standardized medical anamnesis protocol was applied by the physician to assess the female's health state and assess, if she meets the inclusion criteria, i.e. age 65 and older, neurodegenerative disease, using of the wheelchair, skill to stand up, sit down, gait push the wheelchair 4-5 m. Finally, the physician carried out the medical decision to include the female in the study.

Assessment of body composition

Body height was measured using the Tanita Leicester, Height Measure device (Invicta Plastics, Leicester, United Kingdom) with an accuracy of 0.1 cm. A tetrapolar multi-frequency bioelectrical impedance device InBody 230 (InBody, Seoul, South Korea) was used to assess body weight, BMI, body fat percentage and total muscle mass. The tri-ponderal mass index was calculated which yields valid results even for very short and very tall persons [8].

Balance assessment

To assess static and dynamic balance, the Tinetti balance assessment tool, clinical performance-oriented exam was used [39]. According to this tool, static balance was assessed on the basis of observation of an individual's bodily behavior during sitting and standing positions and their changes which are defined by nine items. Dynamic balance was judged by eight items that involve characteristics of an individual´s gait. The participant was asked to walk push the wheelchair 4–5 m with or without assistance [25]. The particular items of static and dynamic balance are rated on the 2-point or the 3-point scales. The maximal total scores are 16 and 12 points for static balance and dynamic balance, respectively. The higher the score, the better the performance.

RAND 36 Short Form Health Survey (SF-36)

This survey (SF-36) is a valid and reliable indicator of overall health status [42], and it is widely used all over the world today. It is comprised of 36 items that assess eight categories: physical functioning (10 items), physical role of functioning (4 items), emotional role of functioning (3 items), social role of functioning (2 items), mental health (5 items), vitality (4 items), body pain (2 items), and general health perceptions (5 items). Responses across the items are scored on the two- to six-point scales. One item (question 2) covers a change in health status over the past year. Therefore, participants in the present study were not assessed on this item. The method was reported to have a reliability of r = 0.65 to 0.94 across the scales, with a median of 85, very good internal consistency and item-discriminant validity [28].

Procedure

The pre-measurements started with medical anamnesis provided by a physician, followed with assessment of body composition provided by an anthropologist, followed by the test of balance with the use of the Tinetti balance assessment tool provided by a physiotherapist. After 15 minutes break a participant completed the RAND 36 with the possible assistance of a research team member. After the pre-measurements the 4-week wheelchair yoga intervention followed. We adopted yoga exercises based on a wheelchair practice chair. Thanks to this, the participants did not have any discomfort due to changing from the wheelchair to the chair. One week after finishing the intervention, the post-measurements were performed in the identical schedule.

Intervention

The intervention was focused on stimulation of balance functions through the wheelchair yoga exercises without contraindications to the participants. Exercises were focused on balance control, breathing, flexibility, muscle strength, and the ability to move in sitting in a wheelchair or in standing by a wheelchair [24]. During the 4-week intervention, once per week a main training lesson was carried out, followed by practicing of learned exercises throughout the same week. Each participant received an educational sheet, which contains a simple guide and a symbolic attribute for the concrete intervention week. The week program also includes the motto: Week 1 "You are never alone"; Week 2 "Change is always possible"; Week 3 "Movement is life"; Week 4 "Enjoy life and every moment". The main training lesson, lasting 60 minutes, was conducted under the guidance of a coach in the groups of 5-6 participants. In addition to the coach, 2 coach assistants helped participants to complete exercises easily and correctly and motivate them to repeat the learned exercises daily for 20-30 minutes during the week (Attachment: sample author's wheelchair yoga exercise program).

Data analysis

The Wilcoxon paired test was used to assess significance of post-intervention changes in the dependent variables – the Tinetti static, dynamic and total balance

scores, the measures of body composition, and the item scores of the RAND 36. The relationships between the three Tinetti balance scores after finishing of the intervention and their potential mediators, i.e., the measures of body composition, and the scores of the RAND 36, as well as changes of the three Tinetti balances scores and potential mediators (predictors) including their changes during the intervention were assessed using a multivariate regression – orthogonal projections to latent structures (OPLS) to estimate relevance and statistical significance of the potential mediators. An ordinary multiple regression was employed for the assessment of specific contribution (uncorrelated with other mediators) for individual mediators [1, 40]. The OPLS is effective in coping with the problem of severe multicollinearity within the matrix of mediators (high intercorrelations) where the ordinary multiple regression fails to correctly evaluate such data. The relevance of individual variables was tested by variable importance statistic (VIP) and only relevant variables improving predictivity of the model (with significant VIP ($p < 0.05$)) were included. Statistical software SIMCA v. 12 from UMETRICS (Umeå, Sweden) was used for OPLS and the ordinary multiple regression analysis. Due to non-Gaussian data distribution and non-constant variance in most mediators, the original continuous variables for OPLS analysis were transformed by power transformations prior to further processing to attain data symmetry and homoscedasticity. Statistical software Statgraphics Centurion 18 from Statpoint (The Plains, Virginia, US) was used for the power transformations.

Results

Post-intervention changes

Significant increase in the Tinetti total balance scores was found, accompanied by significant increase in the dynamic balance score, although no significant change in the static balance score. Muscle mass also significantly increased with the applied yoga program. Of the variables of physical, mental and social functioning only social functioning score significantly enhanced (Table 1).

Mediators of positive change in the dynamic balance score

39.5% of variance in the pre-post change of the Tinetti dynamic balance score was explained by 5 explanatory variables (mediators) see Table 2. The variance of the yoga-induced change in the dynamic balance score explained by these explanatory variables decreased to 28.1% when cross-validation among the explanatory variables was considered. After elimination of co-linearity among the relevant explanatory variables, the change in the dynamic balance score was best explained by two RAND items of the individual´s vitality (RAND 9g and 9i), one Rand item of mental health (RAND 9h) and the pre-post change of the Tri-ponderal mass index.

Explanatory variables (mediators, explanatory variables) of positive change in the total balance score 53.0 % of variance in the pre-post change of the Tinetti total balance score was explained by sixteen explanatory variables (mediators), see Table 3. The variance of the change in the total balance score explained by the relevant explanatory variables decreased to 45.0% when cross-validation among the explanatory variables was considered. After elimination of co-linearity among the relevant explanatory variables, the change in the total balance score was best explained by fifteen explanatory variables. After elimination of co-linearity among the relevant explanatory variables, several measures from the RAND and their pre-post changes were identified as the explanatory variables (mediators) of the change in total balance score. Specifically, it concerned four measures of mental functioning and their changes – the RAND item 9f and pre-post changes of the RAND items 9f, 9d and 9h, further the measure of vitality – the RAND 9a and its pre-post change, the measure of social functioning – RAND item 6, and finally the measures of general health perception – RAND item 11a and the pre-post change of RAND item 11b.

Interestingly, variables of the physical status domain also showed to be significant explanatory variables, namely the lower hypertension and lower taking of medication predicted a higher increase in the Tinetti total balance score.

Table 1. Significant post-intervention effects changes of the dependent variables and potential mediators

Variable	Pre	Post	Mean ± SD	p-value
Social functioning score	42.37	45.78	3.46 ± 7.04	0.001
Total muscle mass [kg]	16.21	17.62	1.42 ± 0.67	0.034
Tinetti dynamic balance score	10.26	10.59	0.36 ± 0.66	0.020
Tinetti total balance score	23.72	24.38	0.77 ± 1.41	0.028

Table 2. Relationships between Tinetti dynamic balance score and explanatory variables for the 1st predictive component as evaluated by OPLS model after the intervention

		OPLS, Predictive component				Multiple regression		
	Variable	Component loading	t-statistics	R[a]		Regression coefficient	t-statistics	
Relevant explanatory variables (X)	RAND item 3h wheelchair mobility several blocks	0.263	1.84	0.394		0.193	1.81	
	RAND item 9g feel worn out	–0.448	–2.79	–0.671	*	–0.153	–2.20	*
	RAND item 9h felt happy	0.418	9.22	0.626	**	0.166	2.63	*
	RAND item 9i felt tired	–0.428	–4.46	–0.643	**	–0.152	–3.21	**
	Tinetti dynamic balance score	0.413	2.74	0.619	*	0.173	1.77	
	Ä Tri-ponderal mass index	–0.507	–3.16	–0.760	**	–0.186	–2.79	*
(Y)	Ä Tinetti dynamic balance score	1.000	2.20	0.628	*			
Explained variability		39.5% (28.1% after cross-validation)						

[a]R…Component loadings expressed as correlation coefficients with predictive component, *p < 0.05, **p < 0.01, for details see Data analysis.

Table 3. Relationships between Tinetti total balance score and explanatory variables for the 1st predictive component as evaluated by OPLS model after the intervention

		OPLS, Predictive component				Multiple regression		
	Variable	Component loading	t-statistics	R[a]		Regression coefficient	t-statistics	
Relevant explanatory variables (X)	Hypertension	–0.156	–1.99	–0.386	*	–0.053	–2.85	*
	Surgery	0.142	1.39	0.352		0.061	1.55	
	Medication	–0.197	–2.50	–0.488	*	–0.079	–1.92	*
	RAND item 3f bending, kneeling, or stooping	–0.221	–2.40	–0.549	*	–0.079	–2.33	*
	RAND item 3j bathing or dressing yourself	–0.208	–3.08	–0.518	**	–0.067	–2.23	*
	RAND item 6 physical health or emotional problems interfered with social activities	0.250	5.72	0.636	**	0.061	4.32	**
	RAND item 9a felt full of pep	0.270	8.34	0.668	**	0.061	4.80	**
	RAND item 9f felt downhearted and blue	–0.240	–2.81	–0.595	*	–0.064	–2.28	*
	RAND item 9g feel worn out	–0.203	–1.50	–0.506		–0.056	–2.37	*
	RAND item 9i felt tired	–0.298	–3.67	–0.741	**	–0.088	–3.72	**
	RAND item 11a get sick easier than others	0.118	1.45	0.304		0.076	2.45	*
	Ä RAND item 9a felt full of pep	–0.347	–5.28	–0.859	**	–0.080	–2.58	*
	Ä RAND item 9d felt calm and peaceful	–0.351	–4.03	–0.876	**	–0.091	–3.31	**
	Ä RAND item 9f felt downhearted and blue	0.294	3.11	0.730	**	0.085	3.70	**
	Ä RAND 9h felt happy	–0.339	–5.65	–0.839	**	–0.075	–2.39	*
	Ä RAND item 11b felt healthy as anybody other	–0.306	–4.39	–0.768	**	–0.079	–3.18	**
(Y)	ÄTinetti total balance score	1.000	7.41	0.728	**			
Explained variability		53,0% (45,0% after cross–validation)						

aR…Component loadings expressed as correlation coefficients with predictive component, *p<0.05, **p<0.01

Discussion

The obtained results documented the significant increase in the total and dynamic balance score in monitored participants after the wheelchair yoga intervention, but not in static balance score. It seems that level of wheelchair skills is likely associated with dynamic and total balance abilities of wheelchair users as it is reported [26] and it allows in a short term to reach a greater potential mobility and independence of the female elderly wheelchair users with neurodegenerative diseases [38].

The multimodal wheelchair yoga intervention approach significantly improved dynamic and total balance score in monitored female elderly wheelchair users with neurodegenerative diseases. According to the results, the improvement in the total and dynamic balance score after the wheelchair yoga intervention does not correlate significantly with age. It follows that participants within the whole age range benefited from the applied intervention program. It can be assumed, that the improvements might be due to the included easy yoga exercises without contraindications into the wheelchair yoga intervention what facilitates the neuromotor process with and without visual control [4, 33]. The improvements in balance control were corroborated by the participants noting that they were more balance confident when performing regular daily activities during the applied intervention.

As indicated by the correlation analysis, the monitored female participants in wheelchair achieved significant positive changes in a short time of 4 weeks. This improvement could have a significant positive impact in the prevention of falls-related injuries, of fall-related fractures of female elderly in wheelchair and therefore has significant potential for balance dysfunction rehabilitation [32]. This is a confirmation of the potential of the applied intervention in the sense of the total balance improvement in elderly females in wheelchair which is in agreement with the study [13], which noting that wheelchair yoga interventions help maintain the balance, fitness and mobility of elderly female wheelchair users.

In this context, statistical analysis of the results revealed the fact that after the wheelchair yoga intervention there was an increasing of muscle mass of the participated elderly female wheelchair users with neurodegenerative diseases. This fact points to the effectiveness of the wheelchair yoga intervention program and the suitability for use and to the monitored group of elderly females used wheelchair, as well as the ability of women to quickly transition to a balance of energy intake and expenditure [7, 11]. It represents a very valuable result for female elderly 65 and older as they are more endangered by fragility comparing to male elderly. These results fully correspond to the results of the studies [46], when authors declare that even simple yoga exercises improve muscular strength and body flexibility, and a progress in exercise sequences and postures influence positively muscle activity, and metabolic processes.

On the base of results, it is evidence that by increasing of the dynamic and overall balance skills of elderly female wheelchair users may be also increased their social integration. Analyzed results show that female elderly wheelchair users with neurodegenerative diseases after the 4-weeks wheelchair yoga intervention have mastered the ability to relax and unblock social tensions. These findings are in line with similar study results [5, 21], which demonstrated that balance development may be developed and manifested in multiple aspects of physical, mental and social functioning in elderly females a cost effective mean and that such exercise intervention may be used as a successful rehabilitation of balance function skills in female elderly wheelchair users with neurodegenerative diseases.

Strengths and weaknesses of the study

To the best of the authors' knowledge, this is the first such study in which wheelchairs were used and its participants were not exposed to discomfort, disturbance of the sense of security and transferring to a chair. Our research shows the effectiveness and adaptability of a daily used wheelchair as an effective one for yoga practice. The authors are aware of the weakness of this study, especially that there is no control group and the study group concern only women. The women's are more willing to participate in experiments, and their participate in physichal activity rate in neurogenerative diseases is more offen then men.

A potential limitation of the study may be the number of the participants. Despite relatively low number of the elderly female participants with neurodegenerative diseases, significant changes were demonstrated after the 4-week wheelchair yoga intervention, and potential positive and negative explanatory variables of balance in elderly females 65 and older in wheelchairs were analyzed. Morover, when assessing dynamic postural stability in general, the use of a stabilization platform is certainly significant. But, this use is very limited due to the current functional status of the patient on wheelchair, and the risk of injury due to a fall. For this reason, a stabilization platform was not used in our study.

Conclusions

1. The balance development is essential for daily activities in elderly female wheelchair users with neurodegenerative diseases. The study verified a four-week intervention based on simple wheelchair yoga exercises without contraindications, feasible and effective for these elderly female wheelchair users. It was found,

that additional benefits except total and dynamic balance development can also be obtained, as confirmed by the results of the study, i.e. increase of the muscle mass and an improvement in social integration.

2. After the four-week wheelchair yoga intervention main explanatory variables with positive effect for the total and dynamic balance, in participated elderly female wheelchair users with neurodegenerative diseases, were tendencies to be able to overcome subjectively perceived sickness, to feel happy and healthy as anybody other. As the negative explanatory variables for the dynamic and total balance score in the monitored females were analyzed hypertension, allergies and number of medicaments.
3. Supporting the balance of wheelchair users through wheelchair yoga exercises may not be difficult and it is possible to be recommended for rehabilitation praxes for elderly female wheelchair users with neurodegenerative diseases.
4. Further study, using a larger sample and including a control group, is needed to fully determine the effect of the wheelchair yoga intervention on elderly female wheelchair users with neurodegenerative diseases.

Conflict of interest: Authors state no conflict of interest.

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Received 02.10.2023
Accepted 24.06.2024