

# Bio-Psycho-Social Consequences and Effects in Fall-Efficacy Scale in Seniors Using Exercise Intervention of Motor Learning According to Yoga Techniques

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## I. INTRODUCTION

**Abstract**—The paper declares effects of exercise intervention of the research project “Basic research of balance changes in seniors”, granted by the Czech Science Foundation. The objective of the presented study is to define predictors, which influence bio-psycho-social consequences and effects of balance ability in senior 65 years old and above. We focused on the Fall-Efficacy Scale changes evaluation in seniors. Comprehensive hypothesis of the project declares, that motion uncertainty (dyskinesia) can negatively affect the well-being of a senior in bio-psycho-social context. In total, random selection and testing of 100 seniors (30 males, 70 females) from Prague and Central Bohemian region was provided. The sample was divided by stratified random selection into experimental and control groups, who underwent input and output testing. For diagnostics the methods of Medical Anamnesis, Functional anthropological examinations, Tinetti Balance Assessment Tool, SF-36 Health Survey, Anamnestic comparative self-assessment scale were used. Intervention method called "Life in Balance" based on yoga techniques was applied in four-week cycle. Results of multivariate regression were verified by repeated measures ANOVA: subject factor, phase of intervention (between-subject factor), body fluid (within-subject factor) and phase of intervention × body fluid interaction). ANOVA was performed with a repetition involving the factors of subjects, experimental/control group, phase of intervention (independent variable), and x phase interaction followed by Bonferroni multiple comparison assays with a test strength of at least 0.8 on the probability level  $p < 0.05$ . In the paper results of the first-year investigation of the three years running project are analysed. Results of balance tests confirmed no significant difference between females and males in pre-test. Significant improvements in balance and walking ability were observed in experimental group in females comparing to males ( $F = 128.4$ ,  $p < 0.001$ ). In the females control group, there was no significant change in post-test, while in the female experimental group positive changes in posture and spine flexibility in post-tests were found. It seems that females even in senior age react better to incentives of intervention in balance and spine flexibility. On the base of results analyses, we can declare the significant improvement in social balance markers after intervention in the experimental group ( $F = 10.5$ ,  $p < 0.001$ ). In average, seniors are used to take four drugs daily. Number of drugs can contribute to allergy symptoms and balance problems. It can be concluded that static balance and walking ability of seniors according Tinetti Balance scale correlate significantly with psychic and social monitored markers.

**Keywords**—Exercises, balance, seniors 65+, health, mental and social balance.

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EU population is becoming older, number of people aged 65 years and older is increasing. After the year 2025, there will be almost a quarter of Europe's elderly population over sixty-five years old. The number of seniors over the age of eighty will increase significantly. Therefore, focus on the elderly population from the view of health support and improving seniors' quality of life is an actual challenge for all European states, esp. on activating programs that effectively influenced the healthy life expectancy in the elderly [1]. Also, in Czech Republic, as in EU, is increasing the number of seniors, so called "inverted pyramid" syndrome. In the Czech Republic, around 2.8 million people are living in retirement age [2]. It is therefore inevitable that number of people with impaired ability of balance and associated risk of falls is increasing in society and will increase - together with subsequent health problems and economic consequences.

During aging people expect under social suggestion a loss or a reduction of balance ability, due to decreasing of sensory elements, limited ability to integrate motor senses associated with a reduction or completely loss of balance [3]. Also fear of certain diseases associated with aging (e.g. Diabetes mellitus II. type) causes anxiety from loss of balance ability and risk of falls. Psychogenic dizziness - vertigo is defined as a feeling of movement, which can be assigned to psychiatric disorders (e.g. anxiety, depression). Psychogenic dizziness occurs 15 percent of patients with vertigo who have normal diagnose of balance system. WHO states that ability to maintain balance is the critical factor in falls avoiding and subsequent an injury, particularly evident in seniors [4]. Risk of falling down is one of the main risks in seniors [5], [6].

Holistic research attention to the bio-psycho-social consequences of balance ability in seniors has not been observed in European milieu. Predominance of American, Canadian, Australian research focused into balance tests development from 20 – 25 years ago is leading to impression that balance disorders in seniors occur most in USA, Canada compared to EU countries [7]-[10]. Recognition that prevalence of imbalance is psycho-behavioural disorder in many countries is in same range as in USA, Canada, have important implications for psychological and educational care of seniors [11]-[13]. Gillespie concluded, that approximately 30% of people over 65 years old experiences at least one fall per year, when in institutional care the percentage of such seniors is higher. One fall of ten ends with a fracture. One fifth of falls requires hospital medical care [14]. Any fall can

develop health problems affecting physical, psychological and social quality of life.

From a public health perspective, it is important to be considered new scientifically validated research. Without basic research of structural contexts, we will hardly understand inequalities in senior age. Holistic point of view on balance means to go against the current trend and to deal with specific structural contexts. Research projects on the mentioned holistic approach to the balance risks in senior age in Czech Republic are completely missing. The study [15] deals with stability of seniors in relation to hearing defects and damage of vestibular system. Other works of physicians [16] deal with balance of seniors in context of post-operation states as a criterion of rehabilitation process. These projects especially consider biomechanical aspect of problem. Focus of presented project is to research balance in its holistic understanding.

## II. OBJECTIVES, HYPOTHESES

The purpose of the research project is to identify characteristics of elderly persons who develop a fear of falling and to investigate the association of this fear with changes in self-reported physical, emotional, psychological and social well-being over time, to acquire new knowledge of the fundamental principles of phenomena "balance" in the bio-psycho-social context and observable facts. The research team, based on theoretical foundations, has established several research goals that are intended to describe the bio-psycho-social marks of balance ability and balance promotion in seniors 65 years old and above.

### A. Objectives

1. Basic research of balance changes of seniors in actual holistic perspective of bio-psycho-social contexts.
2. Monitoring of the seniors' balance changes depending on four weeks period of wellness interventions.
3. Prediction and implementation of bio-psycho-social correlations.

We aim to evaluate changes in a balance of seniors (males and females, 65 years old and more) from the bio-psycho-social viewpoint, after four-week balance training in respect of anthropometric and anamnestic data. A by-product of our project is the special tool, authorised by team as "Anamnestic Self-Assessment" focused on self-assessment of emotional and social balance ability monitoring.

### B. Hypotheses

- H1 Motion uncertainty (dyskinesia) can negatively affect the well-being of a senior in social context.
- H2 Participation in the exercise intervention program "Live in Balance" can positively influence somatic balance markers.

## III. MATERIAL, PROCEDURE, ETHICS, METHODS

The research project is aimed on males and females aged 65 years and above. The research group will include in total 500 persons in senior age. In the paper results of the first year

investigation in the frame of the three years running project "Basic Research of Balance Changes in Seniors - GACR ID 17-25710S" (2017-2019) are presented. In this first year 2017 total random selection and pre/post testing of 100 seniors 65+ (30 males aged 75-81, average age 78.4; 70 females aged 76-81, average age 78.7) from Prague and the Central Bohemian region was provided. Seniors were selected from senior homes, retirement homes and senior clubs in this region. The cohort of seniors was divided by stratified random selection method into experimental and control groups, who underwent input and output anthropometric monitoring, equilibrium testing and testing of psycho-social indicators of balance.

The ethical condition for a person involving in the research procedure represented the informed consent of the person.

During the presented research study, following methods were used.

Functional anthropological examination selected from classic anthropometry methods, which are non-invasive, all-terrain available and inexpensive, using anthropometric instruments as anthropometer, digital personal scale, spreading calliper, sliding calliper, plastic metric tape, Harpenden calliper, hand dynamometer - type Collin, monitoring the following parameters:

- Body height, body weight, BMI.
- Chest circumference across mesosternale, waist circumference, abdominal circumference, gluteal circumference, arm circumference relaxed, calf circumference maximal, biepicondylar, width of humerus, biepicondylar width of femur, width of wrist, width of ankle; thickness of seven selected skinfolds - calliper measurement type Harpenden (biceps, triceps, suprailiac, abdominal, subscapular, anterior thigh, calf medial).
- Dynamometry - grip strength of right and left hand, measured by manually dynamometer (type Collin).
- Body Composition Analysis using In-Body 230.

Tinetti Fall-Efficacy Scale [10] was used as a tool to measure the fear of falling under the definition of fear as "low self-efficacy in the prevention of falls in basic activities of daily life. It is useful in the research of balance ability in terms of its contribution fear of falling into the functional response (worsening) (worsening) reactions in the elderly.

Anamnestic Self-Assessment [6] focused on self-assessment of emotional and social markers of balance, i.e. to determine the level of ability to cope problems in emotional and social context evaluated in 10-point scale.

Item Health Survey - SF 36 represents widely used tool to determine the quality of life related to health, designed to research and monitor the quality of specific population and of general population life as well. In general, the questionnaire SF 36 is sensitive to all problems in areas of physical, mental and social health.

Intervention Method "Life in Balance" [6] applied in the form of four-week intervention programs, consisting of continual regular training of relaxation exercises (with special using of a chair by senior), consisting from units of simple physical exercises (stretching + strengthening + balance), breathing exercises and relaxation exercises. The training units

are realised in form of “controlled physical activities” with transfer to self-regulation. The term "controlled physical activities" is the designation of system carried out to achieve health benefits through professionally guided motor learning. Four-week intensive intervention program period was chosen because it is a period repeatedly confirmed by research to be highly effective in terms of health benefit [17], [18]. Self-regulation techniques are based on a two-phase process, where the first phase presents an undisturbed self-perception (body, breathing, etc.). This can be achieved through active muscle tension, muscle relaxation, breathing manipulation, imagination. The second phase state of disharmony (a sort of "derailment" of psyche under stress) is reversed into a state of harmony, peace, calmness [6]. There are self-regulatory and hetero-regulatory techniques. Using the self-regulatory techniques, a person is educated to deal with a separate release process and lowering the activation, tensions. Using hetero-regulatory techniques is a person under care and guiding of a professional expert. Both types of control techniques will be used and tested.

Statistics carried out in the Institute of Endocrinology in Prague. The differences between stages of the trial for metric variables were evaluated by a repeated measures ANOVA model consisting of subject factor (separating inter-individual variability from that explained by other factors), between-subject factors gender and status (treated vs. untreated subjects), within-subject factor stage of the trial and interactions gender × status, gender × stage of the trial, status

× stage of the trial, gender × status × stage of the trial. The changes in categorical data will be evaluated by log-linear models (frequency analysis) consisting of factors gender, status, beginning of the trial, changes after intervention and interactions between these variables. A simultaneous evaluation of relationships between the effects of intervention on the scores calculated from questionnaire data on the one hand and initial values of these parameters, anthropometric data and further indices on the other hand, will be investigated using a multivariate regression with reduction of dimensionality such as the method of orthogonal projection to latent structure (OPLS) or the bidirectional OPLS (O2PLS). These models are capable of coping with the problem of multicollinearity, which is expectable namely in the anthropometric data.

#### IV. RESULTS AND DISCUSSION

Results of balance tests confirmed no significant difference between females and males in pre-test. After the intervention, a significant improvement in balance and walking ability was observed in experimental group in females comparing to males ( $F = 128.4$ ,  $p < 0.001$ ). In females of control group, there was no significant change in post-test. At the same time, the experimental group of females declared positive changes in posture and spine flexibility in post-tests. The female organism, even in old age, seems to be able to react to balance intervention incentives and to develop flexibility of the spine.

TABLE I  
 EFFECTS OF STAGE AND INTER INDIVIDUAL VARIABILITY ON BALANCE

Variable	Stage		ANOVA, Factors			
	Means with 95% confidence limits		Stage		Subject	
	1	2	F-statistic	p-value	F-statistic	p-value
Dynamometry	13.6 (13.2, 14.1)	13.7 (13.3, 14.1)	-0	0.934	5.3	<0.001
Self – Assessment E	52.5 (51.4, 53.5)	52.5 (51.4, 53.5)	0.8	0.371	4.7	<0.001
Self – Assessment S	35.8 (34.7, 37)	35.2 (34.1, 36.3)	0.3	0.572	9.5	<0.001
Body Height	157 (156, 157)	157 (156, 157)	0.2	0.687	277.5	<0.001
Body Weight	74.6 (74.5, 74.7)	74.5 (74.4, 74.6)	0.1	0.739	4706.4	<0.001
BMI	29.8 (29.3, 27.8)	29.7 (29.6, 29.8)	1.8	0.196	672.7	<0.001
Fat Percentage	27 (26.7, 29.9)	26.4 (25.6, 27.1)	0.9	0.346	18.3	<0.001
Tinetti Balance Test Score	5.35 (4.61, 6.12)	5.48 (4.73, 6.25)	0	0.867	2.5	0.01

(n = 100 seniors 65+; 30 males aged 75-81, average age 78.4; 70 females aged 76-81, average age 78.7)

Analyses of data found significant improvement in social balance marker “non-conflict” in males and females of experimental group in post-test comparing to control group ( $F = 10.5$ ,  $p < 0.001$ ), see Tables I and II and Fig. 1. Analysed results show that seniors who completed 4-week intervention have mastered the ability to relax and unblock social tensions. Analyses of data indicate significant improvement in social balance marker “non-conflict” in males and females of experimental group in post-test comparing to control group ( $F = 10.5$ ,  $p < 0.001$ ). Motoric behaviour of each senior 65+ is basically determined of the body movements, or rather the lack of such movements. To support the motor learning process for persons in senior age 65+ and improve the effectiveness of balance by linking with a motion process.

Environmental harmony is a big theme in the research of balance changes in senior 65+. Senior lives in a social context, and his well-being depends a lot on the harmony and harmony of his interpersonal relationships in daily life activities. Therefore, harmonizing processes balance development should also touch on this site (coping, altruism, affiliation) of human action.

Mental balance is closely related to the ability to concentrate. The restlessness of human needs a lot of energy because he has to think about many things simultaneously. Senior operates in a hurry and in more mistakes, which is retrospectively reflected on his mental state. Confusing behaviour and restlessness lead to problems with static and dynamic balance in old age. Yoga techniques allow a

continuous development of concentration, which improves positively on the physical balance and the ability to better handle external psycho-social disruptions. On the basis of the research study results, it was confirmed that the reverse

process works, where psycho-social calming and good concentration improve significantly on the physical balance ability in monitored seniors.

TABLE II  
RELATIONSHIPS BETWEEN TINETTI BALANCE TEST SCORE AND PREDICTORS FOR THE 1ST PREDICTIVE COMPONENT AS EVALUATED BY O2PLS MODEL

	Variable	Predictive Component			R <sup>a</sup>
		Component loading	t-statistics		
Relevant Predictors (matrix X)	Blood Pressure	-0.276	-6.02	-0.480	**
	Operations	0.151	1.52	0.263	
	Allergy	0.363	2.98	0.611	*
	Endomorph Component	-0.126	-1.13	-0.212	
	Dynamometry	0.333	2.35	0.580	*
	Self – Assessment S	0.215	2.23	0.347	*
	Tiredness	-0.331	-2.75	-0.582	*
(matrix Y)	Tinetti Balance Test Score	1.000	6.31	0.644	**
Explained variability		41.5% (33% after cross validation)			
R <sup>2</sup> Component loadings expressed as a correlation coefficient with predictive component, *p<0.05, **p<0.01					

(n = 100 seniors 65+; 30 males aged 75-81, average age 78.4; 70 females aged 76-81, average age 78.7)

TABLE III  
RELATIONSHIPS BETWEEN TINETTI WALK TEST SCORE AND PREDICTORS, AS EVALUATED BY MULTIPLE REGRESSION

Relevant Predictors (matrix X)	Variable	Predictive component	
		Regression coefficient	t-statistics
	TINNETI Walk Test Score	-0.404	-15.42*
	Fat Percentage	-0.177	-4.82*
Explained variability		21.4% (15.2% after cross validation)	
*p<0.05			

(n = 100 seniors 65+; 30 males aged 75-81, average age 78.4; 70 females aged 76-81, average age 78.7)

The authors in [6] presented cool-down effect using walking, and other low-intensity exercises. These activities permit the gradual circulatory readjustments, and allow the dissipation of body heat. They prevent the pooling of the blood in extremities and the rapid fall in blood pressure after vigorous exercise which can trigger dizziness and possible fainting. Comparing this definition with the data analyses from our study, compare, it is possible to state similar findings in walk progress and correlations between balance improvements with walking ability as a less intense exercise (i.e. short walks), see Table I.

The applied exercise intervention program “Live in Balance” represents according the presented results, an appropriate defence in case of neurotic tendencies and overloading of the psychophysiological potential of seniors in the form of tiredness correlated significantly negatively as the relevant predictive component  $p < 0.05$ , see Table II.

On the base of the result analyses of Fat Percentage results significant correlation  $p < 0.05$  between the components of fat Percentage/Endomorph Component and Tinetti Walk Test, see Tables II and III. These components respond favourably and rapidly in combination with equilibrium ability, coordination and mental balance. We can speak about

development of vitality and functional independence in monitored seniors 65+. Lower Fat Percentage in body correlates with Balance and influenced positively markers of bio-psycho-social balance. These components respond favourably and rapidly to training and in combination with coordination, balance and reaction time they form a vital ingredient of functional independence in people with chronic conditions. From the analysed data results, it can be the applied exercise intervention program recommended to apply in the balance management and compensation for the burden of various kinds, because the applied exercises have a holistic influence on physical, mental and social balance, see Table III, Fig. 1. Therefore, a great importance for seniors has also the energy balance in eating and moving, because seniors’ organism atrophied soon by physical inactivity and loses its vital. Further, we can discuss the question of “kinesis-protection”, the level of burden in aging with disability due to optimal physical development, as well as the question of sedatives and medicaments applied in seniors due different symptoms, including anxiety and maladaptive behaviour. Better understanding of the determinants of exercise behaviour is beginning to emerge. Data analyses declared also that monitored seniors use in average four drugs daily, without gender difference. There was no monitored senior who did not take at least one drug. Each second senior took anti-allergy medications, food supplements or vitamins.

From the point of view of rate of allergies in seniors it was found in average 1 allergy per person, without sex significant difference. Quite high number of drugs contributes to allergy symptoms and to balance problems. In this context in solving the research project an international cooperation is realised with the Canadian expert RNDr. Ludmila Vacek, PhD, a member of Board of “Global Spa and Wellness Summit” in Canada in the fields of Seniors Wellness, Exercise Physiology and Exercise Epidemiology. She will supervise the evaluation of the project in the project results in the second year of

investigation. The wellness area and its research perspective may in a way pragmatically influence the quality of life from childhood to seniority [6].

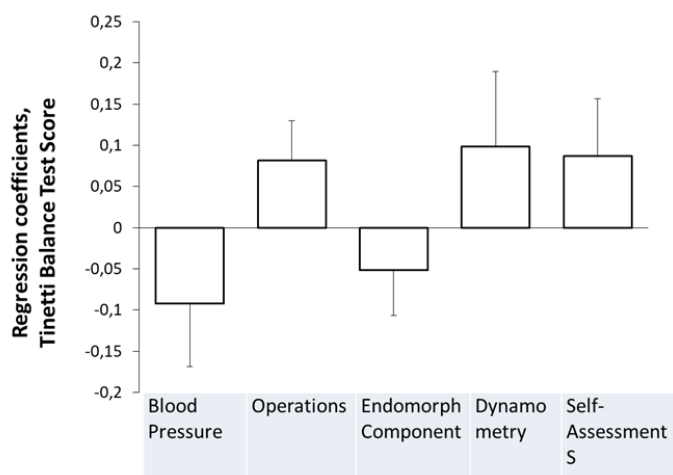


Fig. 1 Correlations of seniors balance with blood pressure, operations, body fat, dynamometry and Self-Assessment Social Score (n = 100 seniors 65+; 30 males aged 75-81, average age 78.4; 70 females aged 76-81, average age 78.7)

Multifactorial approach to prevent the risk of falls in seniors represents a conceptual latest approach considering the bio-psycho-social determinants of falls in seniors, whose purpose is to reduce the impact of risk factors [19], [20]. We examine balance of the balance dysfunction in the elderly based on knowledge of aging process in relation to the bio-psycho-social aspects of balance ability and of individual physical skills. Falls exponentially increase with age-related biological change, therefore a pronounced number of persons over the age of 80 years will trigger substantial increase of falls and fall injury at an alarming rate [21], [22]. As accent [23], [24], the ability to move freely is an important factor that determines the quality of life of the elderly population. This is one of the most common geriatric problems that threaten independence and self-sufficiency in seniors. Instability with its major consequences – falls – is becoming a major problem in health care and economic costs.

## V. CONCLUSIONS

The planned objectives of the research study were fulfilled. Analysed results from the first year of the running three years Research Project “Basic Research of Balance Changes in Seniors - GACR ID 17-25710S” show that seniors who completed 4-week intervention have mastered the ability to relax and unblock social tensions.

The Hypotheses H1: Motion uncertainty (dyskinesia) can negatively affect the well-being of a senior in social context - was verified. Emotional volatility reflected in social imbalance. Furthermore, it can be stated that the base of analysed data of the actual level of seniors’ equilibrium correlates significantly negatively with blood pressure, number of operations, body fat, low level of muscle strength

(dynamometry) and with a social imbalance. In senior age 65+, social imbalances are reflected in emotional and social imbalance, but it is possible through relatively short one-month intervention and to improve quality of balance expressed in the Self-Assessment Social Score, which includes just the desirable needed qualities as strength promotion, resilience, resistance in aging.

The Hypotheses H2: Participation in the exercise intervention program “Live in Balance” can positively influence somatic balance markers – was verified. In the experimental group of female seniors, significant positive changes were found in posture and spine flexibility in post-tests. It seems that female organism even in senior age can react better to incentives of intervention in balance and spine flexibility. The basic point of the exercise intervention program is the equilibrium development and especial “feeling of equability”. Thanks to it, it was possible to aware of imbalance state in daily life of seniors.

We can conclude that senior, who can relax, can easily to observe, when tension arises and can help self to remove the tension. Similarly, the development of balance allows seniors to perceive imbalance in a bio, psycho or social context. An imbalance is a signal that it is necessary to “centre” self. Efforts to educate and lead a person to the right way of behaviour, which creates a balance and restores immunity and natural defences is known from antiquity and ancient Asian medicine. We can conclude that researchers and experts should not deal with the stability of seniors in relation of hearing or another somatic impairment damage to the kinetic system only. To consider only the clinical biomechanical and organic aspect cannot solve the problem of balance changes in seniors.

Physical imbalance is affecting emotional imbalance, when senior loses confidence, not only physical, but also self-confidence and emotional volatility reflected in social imbalance. This holistic concept shows us the hypothesis that physical imbalance (dyskinesia) may negatively affect well-being of man in the bio-psycho-social context. Holistic interconnectedness of the processes can return well-being state of man through exercise intervention program and positively affects overall balance, reflected in motoric, emotional and social contexts. Holistic approach to balance is the main epistemological moment of the presented project.

Yoga exercises are slow provided, which corresponds well to seniors and their ability to motor learning in the age over 65. Also, the synchrony of movement with breathing leads to an optimal pace and rhythm of exercise, using all parts of the body, including fingers and face muscles. Yoga-based exercise intervention is effective in mental balance increasing and in overall bio-psycho-social resilience in aging. Our research has proven that the “Live in Balance” intervention program can be applied very well and easily in the seniors 65+ old. Adequate exercises, equilibrium development is possible be realised in age of seniors 65+, including persons with disability and should be understand as a necessity of senior daily life, but may correlate to the individual state of senior 65+.

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