

Review paper

THE INFLUENCE OF DANCE-BASED ACTIVITIES ON RECOVERY AND IMPROVEMENT OF MOTOR FUNCTIONS IN POST-STROKE PATIENTS: A SYSTEMATIC REVIEW

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Jelena Nikolić

Faculty of Special Education and Rehabilitation, University of Belgrade, Serbia

Fadilj Eminović

Faculty of Special Education and Rehabilitation, University of Belgrade, Serbia

Ljiljana Šimpraga

Medical College of Vocational Studies - Belgrade, Serbia
Faculty of Special Education and Rehabilitation, University of Belgrade, Serbia

Angelka Pešterac Kujundžić

Medical College of Vocational Studies - Belgrade, Serbia
Faculty of Special Education and Rehabilitation, University of Belgrade, Serbia

Abstract: Stroke is a clinical syndrome, and one of the leading causes of death and disability, occurring under the influence of a large number of risk factors. The symptoms of a stroke are in correlation with the size, time and location of the lesion. Rehabilitation, which involves the application of conventional and supplementary methods, relates to the assessment of the ability, the level of damage of the affected functions, and an adequately designed rehabilitation program. The use of dance, as a rehabilitation procedure in post-stroke patients, requires listening and active participation of an individual with a specific motor reaction to the stimulus. The primary aim of this article is to demonstrate the importance and effects of the application of dance in the rehabilitation process in post-stroke patients, with a special emphasis on the process of improving motor skills and

¹ ✉ def.jelenanikolic@gmail.com

functions. In accordance with the set criteria and purpose of study, scientific research papers were collected and analysed from the PubMed/MEDLINE, Science Direct and Oxford Academic databases, all published in the period between 2010 and 2019, and all indicating the importance of the application of dance when treating post-stroke conditions. The obtained results suggest that dance, which is basically a sports-recreational activity, when applied for therapeutic purposes in persons after stroke, contributes to the development and recovery of motor abilities, balance, mobility, endurance, coordination, motor skills, stance, walking and precision. Also, dancing is of great importance for the improvement of the functioning of the whole organism, which directly or indirectly affects the recovery of motor functions and the overall welfare of an individual.

Key words: *motor recovery, motor abilities, motor skills, rehabilitation, stroke*

INTRODUCTION

Different modern lifestyle patterns, excessive exposure to stress and risk factors, such as unhealthy diet, irregular and insufficient physical activity, alcohol and cigarette consumption, gender are just some of the variable and invariable risk factors that lead to stroke. In addition, age is another factor that could affect the appearance of this medical syndrome (Arsić, 2015). The incidence of acute stroke is variable across countries and ranges from 100 to 300 new cases per 100 000 inhabitants yearly and the tendency of growth with higher age (Mandić, 2014). Stroke is defined by the World Health Organization as ‘a clinical syndrome consisting of rapidly developing clinical signs of focal (or global in case of coma) disturbance of cerebral function lasting more than 24 hours or leading to death with no apparent cause other than a vascular origin’ (Aho, Harmsen, Hatano, Marquardsen, Smirnov & Strasser, 1980). According to the pathology, which is in the base of focal brain damage, we can differentiate ischemic and haemorrhagic brain attack (stroke). Except that it is a syndrome with very high mortality rate, an equally serious concern is the fact, that this is a clinical syndrome resulting with high rates of disability, cognitive disturbances of various severity (Pavlović, 2016), as well as functional disability (Arsić, Konstantinović, Eminović & Pavlović, 2016). In addition, due to the focal damage of the central nervous system and loss of certain functions, weakness and limitations can affect one half of the body (complete or partial- hemiplegia or hemiparesis), inability to perform basic activities of daily living, speech disorders, vision, hearing, swallowing, sphincter control (Matović, Glinac & Šarić, 2010), as well as changes in motor functions of an individual, their mobility, stability, performance of motor skills, process of motor learning, planning and performance of movement, which are in correlation with the size, time and location of the lesion.

The aim of the rehabilitation process of post-stroke patients, which is often necessary to modify (Mandić, 2014), is a correction of abnormal patterns of behaviour and providing adequate performance, as well as re-training the person to be operational in their social environment. The effectiveness of the rehabilitation process depends on different factors, such as motivation, premorbid factors, factors related to damage, the beginning of the restoration of lost functions, the person's age, their personality structure, the general state of the organism. The plasticity of the brain (neuroplasticity), represents a good basis for the rehabilitation process, especially for the motor learning process and motor recovery (Li, 2017; Park & Lee, 2016), which can be grouped into two categories: local CNS process (early recovery) and CNS reorganization (later recovery) (Ruiz Olaya & Lopez Delis, 2015; Sharma, Classen & Cohen, 2013). Brunnstrom empirically described stereotypical stages of motor recovery: (1) flaccidity; (2) appearance of spasticity; (3) increased spasticity with synergistic voluntary movement; (4) synergic movement patterns and reduced spasticity; (5) more complex movements with reduced spasticity; (6) spasticity disappears; and (7) full recovery of normal function with coordinated voluntary movements (Li, 2017). Apart from the urgent, medication therapy, medical rehabilitation holds particular significance for the final results of this clinical syndrome, and this includes the increasingly common use of complementary and supportive methods and techniques of rehabilitation. Using dance as a rehabilitation method based on the combination of motor activities and music, is significant for the overall wellbeing of the individual. Dance is a form of physical activity, which is sustainable because it is "entertaining", and important for increasing the flexibility, muscle strength and tone, endurance, balance and spatial awareness (Alpert, 2010). The aforementioned author points out that dance contains a series of repetitive movements, which are of great importance for the development of the mobility of the extremities and the whole organism. During the implementation of dance, for therapeutic approaches, specific attention must be paid to its characteristics, intensity and content.

Based on theoretical assumptions, and by collecting and analysing the existing research, the aim of this review paper is to present the importance and effects of dance-based therapy in the process of rehabilitation, for improving and recovery of motor skills and functions in post-stroke patients.

METHOD

All collected and analysed scientific data had to be in accordance with the purpose and aim of this article. Analysed papers were selected by researching electronic databases (PubMed / MEDLINE, Science Direct and Oxford Academic), as well as after analysing the references of selected papers concerning the set topic, published in entirety. For this purpose a method of selection was used.

In order to cover the bibliography more precisely, the criteria set for the purposes of the research were: research papers published in their entirety, with at least one research variable referring to the use of dance in the rehabilitation process of persons after stroke and recovery of motor functions and/or skills. The scope of the analysed papers was limited to six research papers, published in their entirety in the period between 2010 and 2019. The following keywords were used to search for the papers: stroke, dance, dance-based therapy, motor recovery, motor abilities, and motor skills. The applied methods for the selection of articles included: the selection method, the description method, the systematization method, the analysis method, the synthesis method, and the comparison method.

RESULTS

Illustration 1. *Data collection process*



Illustration 1 shows the process of collecting data from research articles. In accordance with the aim and the set criteria of this article, six articles were selected, all indicating the influence of dance on the recovery of motor functions and skills in post-stroke patients (Table 1).

Table 1. *An overview of the collected and analysed research studies*

First author	Sample characteristics			Assessed elements	Conclusion	
	N	Groups	Age			Gender
Thornberg, 2013	17	1	38-78	7 F 10 M	Performance of specific movements according to rhythm, Performance of motor tasks	Conducted therapy based on movement performance according to the music rhythm, applied for ten weeks, once a week, contributes to the process of learning new movements, body awareness, finding alternatives for performing a movement, coordination and simultaneous movement in post-stroke patients.
Demers et al., 2015	9	1	AS 63.7 ± 11.7	7 F 2 M	Participation, Balance, Endurance, Rhythm, Quality of movements, Learning activities	Using modified dance lessons for four weeks (twice a week), contributes to the recovery of post-stroke patients, as well as the improvement of balance, movement quality, endurance, and development of social skills.

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Subramaniam et al., 2015	11	1	AS 60.75	6 F 6 M	Balance, Motor activity, Gait characteristics, Functional recovery	Using virtual dance lessons for six weeks (20 sessions) in post-stroke patients, is important for the improvement of the reaction time, agility, the level of physical activity, the response time to stimuli and the speed of movement performance. The used methods are moreover significant for the improvement of gait characteristics and reducing the risk of falls.
Dursun et al., 2016	45	2	1. AS 47.75 (±15.5) 2. AS 49.21 (±12.7)	1. 10 F 16 M 2 12 F 7 M	Muscle tone, Motor recovery, Mobility Static and dynamic balance	Applying modified tango for four weeks (five times a week), combined with the rehabilitation program and injections of Botulinum Toxin A, leads to the improvement of muscle tone, mobility, static and dynamic balance, and motor recovery.
Wolff et al., 2017	4	1	50-86	1 F 3 M	Gait, Balance, Transfer, Precision of movements, Coordination	Using dance for three years (once a week), contributes to the improvement of the motion quality, development and improvement of the elementary, and complex movements of the limbs, mobility in general, gait patterns and transfer.
Patterson et al., 2018	20	1	AS 62.4	9 F 11 M	Spatiotemporal parameters of gait, Balance	Using dance for ten weeks (twice a week), contributes to improving the balance, but not the spatiotemporal parameters of gait.

Legend: N - number of participants, AS - mean, F - female, M - male

A research study, conducted by Thornberg (2013), which included 17 examinees of both genders, aimed at determining the reasoning behind the participation of post-stroke patients in a treatment based on dance, rhythm, and music. The treatments were conducted once a week within ten weeks. Data has been collected by means of semi-structured interviews carried out for the assessment of examinees' participation in therapy, understanding, and learning motor tasks. The phenomenographic method was used to estimate the reasoning behind the participation, the changes in motor task performances, and motor functioning. The obtained results show that the therapy and its complexity contribute to the adaptations to changes in the body and the process of learning new movements. Also, the results show that this type of therapy contributes to finding alternative ways of performing motor tasks, as well as coherent body awareness. A combination of music, motion, and rhythm in therapeutic approaches in post-stroke patients increase the level of simultaneous and coordinated performances of movements.

In their pilot study, Demers and McKinley (2015) strive to determine the feasibility of a modified dance intervention as an adjunct therapy designed

for people with subacute stroke. The therapeutic procedure included nine participants, involved in a biweekly 45-min dance intervention, over four weeks, as well as in occupational and physical therapy (45 minutes per day). A combination of the elements of jazz dance and merengue, activities were focused on the development of flexibility, balance, endurance, upper and lower extremity function, and the quality of performed movements. The dance instructor completed an unstandardized observation grid for each participant, containing the following elements: participation and social interaction (interaction with other participants, ability to follow instructions), balance (use of external support, loss of balance), endurance (portion of the dance class performed in sitting/standing position, rest period needed), rhythm (ability to follow the music rhythm), quality of movements (use of the impaired limbs, fluidity and smoothness of movement, ability to reproduce dance steps), and memorization of the routine (with or without model) (Demers and McKinley, 2015, p. 3125). An assessment of abilities and functions was done the week prior and following the dance intervention. Using descriptive and comparative methods, it has established a difference between scores on the Berg Balance Scale (BBS), obtained on the initial and final assessment. For all participants with low BBS initial score, the BBS score improved after therapy. According to the participants' responses, and positive feedback, it was pointed to the improvement of motor abilities, as well as the total level of recovery.

An examination of the effects of a virtual reality-based dance training paradigm in improving the balance control and physical activity levels in persons with chronic hemiparesis caused by stroke, was the aim of a research conducted by Subramaniam and Bhatt (2015). During six weeks, 11 participants of both genders participated in a dance therapy. In the first two weeks, the treatment consisted of five sessions per week, the following two weeks it involved three sessions per week, and the last two weeks there were two sessions per week. The average time spent in rehabilitation ranged from one hour and twenty-five minutes to one hour and forty minutes for all participants. The assessment of balance control, physical activity, and functional measures was carried out one week before the intervention, on the 10th training session and one week after the intervention. Voluntary balance control was assessed using the Limits of Stability (LOS) test protocol, while the reactive balance control was assessed using the Motor Control test (MCT) protocol, of the Equitest (Computerized Dynamic Posturography) based on the evaluation of the participants' abilities to quickly recover balance control after an unexpected external imbalance. Changes in the level of physical activity were recorded using the Omran HJ-321 Tri-Axiz Pedometer. Standardized clinical outcome measures were used to assess functional recovery through balance control (Berg Balance Scale, BBS), risk of falls (Timed Up and Go Test, TUG) and fear of falling (Fall Efficacy Scale, FES). After using one way analysis of

variance (ANOVA), significant differences were found between the intervals of assessment in change in balance control (response time ($F(2,20)= 6.659$, $p < 0.05$), movement velocity ($F(2,20)= 15.313$, $p < 0.01$) and maximum movement excursion ($F(2,20)= 3.863$, $p < 0.01$)). The level of physical activity, using regression analysis and estimated on the basis of the increase in the number of steps during sessions, was significantly enhanced over time ($R^2 = 0.0528$, $p < 0.05$). Significant differences between the initial and final assessment were observed in the functional outcome scores on BBS, TUG, and FES ($p < 0.01$).

“Can a combination of therapeutic dance, conventional rehabilitation program and botulinum toxin A (BTX-A) injections, improve the walking ability and balance in post-stroke patients?” Dursun and associates (Dursun et al., 2016) tried to answer this question in their research. A total of 45 examinees were divided into two groups: an experimental group - included into adapted tango classes and a conventional rehabilitation program combined with BTX-A injections ($N= 26$), and a control group ($N= 19$) - included into a conventional rehabilitation program combined BTX-A injections. One week to 10 days after the BTX-A injection both the patient in tango and control groups received a standard 45-minute rehabilitation program five times a week for three weeks (Dursun et al., 2016, p. 126). After the rehabilitation program, the participants from the experimental group are included into dance lessons (adapted tango), whereas the patients from the second group were included in recreational activities, according to their needs, for 30 minutes per day. The baseline and post-treatment muscle tone were evaluated using the Modified Ashworth Scale (MAS), the Brunnstrom approach was used in the evaluation of post-stroke motor recovery, while the functional mobility, balance ability, and static and dynamic balance abilities were assessed using BBS and TUG. According to the author’s explanations, a comparison of pre- and post-treatment MAS, BBS and, TUG test results within each group was performed using the paired samples t-test. The comparisons between the tango and control groups were performed using the independent t-test and, the comparisons between tango and control groups were performed using the independent t or χ^2 tests. After the treatment, a significant progress was noted in all assessed areas, within both groups of participants. Retrospectively, a statistically significant difference was found between the groups on all tests ($p < 0.05$), in favour of the experimental group.

Wolff and associates (Wolff, Santos Delabary & Hass, 2017) observed the effects of dance on the physical, emotional and social functioning of persons after stroke. In a case study which involved four persons of both genders, with hemiparesis caused by stroke, the authors analysed the effect of dance lessons conducted for one hour per week, for a period of three years. The activities were planned according to the initial assessed somatic status of the participants and included different forms of dances. The dance lessons

included a series of different dance techniques, including exercises for gait, balance, weight transfer and the movement of legs and arms with precision and coordination, individual movement quality, progressing from simple to more complex movements, from slow movements to progressively faster, in addition to building body awareness. Individual semi-structured interviews were audio-recorded and used for assessment. The questions and themes of the interview were related to the participants' perception of the changes to their body, as well as to changes in physical, social or emotional aspects of wellbeing after dance classes. The obtained information was classified, categorized and interpreted with the Bardin technique of content analysis. With qualitative analysis, based on the observation of the participants' individual and contextual characteristics and obtained responses, the authors established that dance contributes to the improvement of functions in all parts of the body, especially upper and lower extremities, as well as to the improvement of balance, gait, agility, speech functions, and emotional and social wellbeing.

Patterson and associates (Patterson, Wong, Nguyen & Brooks, 2018), examined the effects of dance on the changes in spatiotemporal gait parameters and balance. The research encompassed 20 participants, included in 60-min dance lessons (ballet, jazz, folk, contemporary and ballroom dances), twice a week, for ten weeks. All lessons included activities such as warm-up, choreography in sitting or standing position, circular exercises with gradual increase in skills and the complexity of choreography. Initial and final assessment included the assessment of spatiotemporal gait parameters (using a pressure-sensitive mat, whereby the gait parameters were examined through the velocity, cadence, step length, step ratio, stance ratio, and swing ratio) and balance (using the Mini-Balance Evaluation Systems Test (MiniBESTest)), examined through anticipatory control, compensatory control, sensory orientation, and gait dynamic. The paired t-test was used to evaluate the scores obtained on the pre-test and post-test assessments. Statistical analysis and the analysis of the obtained results revealed significant differences between the results obtained in the pre- and post- balance test (Mini-BESTest total $p < 0.005$) and subscale dynamic of gait ($p < 0.0001$). By assessing the gait parameters, the obtained results show that dance did not lead to significant changes in the spatiotemporal gait parameters.

DISCUSSION

The human brain is capable of distinguishing music from noise, responding to rhythm, repetition, tones, and melodies. The auditory nerve transmits the signals of music and other sounds to the auditory cortex in the temporal lobe, while the nerve networks in different parts of the brain be-

ar primary responsibility for decoding and interpreting different properties of music (Simon, 2015). The existence of auditory-motor pathways (e.g. via reticulospinal connections), can influence threshold excitability of motor neurons, creating the primary effect of music on the segmental motor system, via auditory input (Thaut & McIntosh, 2014). The vestibular system is one of the most fundamental systems accountable for the emergence of the motor response. Specifically, while listening to music, the perception of auditory signals activates a large number of centres in the brain. During the cognitive processing of the audio signals, there is a simultaneous activation of descendent pathways, which transmit information to the muscle effectors, resulting in the presence of rhythmical movements in the limbs. Movements performed while dancing can be important for the improvement of abilities and skills in post-stroke patients.

Dance, which is basically a sports-recreational activity, leads to the development and recovery of different motor abilities and skills (Table 1). The analysed research studies indicated the positive influence of dance on: motor learning process (learning new motor tasks) (Thornberg, 2013; Demers et al., 2015), mobility and motor recovery process (Subramaniam & Bhatt, 2015; Dursun et al., 2016), all aspects of balance (Demers et al., 2015; Subramaniam & Bhatt, 2015; Dursun et al., 2016; Wollf et al., 2017; Patterson et al., 2018). The positive effects of dance on gait parameters and ability were observed in all studies except the one conducted by Patterson and associates (Patterson et al., 2018), which indicated that dance did not lead to the improvement of spatiotemporal gait parameters. The limitations of the analysed studies were reflected in: a relatively small sample size, different duration of dance therapy within various participant groups, as well as the influence of the other therapeutic procedures.

Conducting a research aimed at examining the effect of various complementary or supportive therapeutic procedures contributes to scientific research, the expansion of knowledge and the improvement of diagnostic, therapeutic, and educational activities. Continuous and relevant data collection contributes to the development of standards and methodologies in work and treatment of post-stroke and disability populations, as well as to the overall strengthening of functional capacities, personality structure, and welfare of the community.

CONCLUSION

The analysed research has shown that dance as a therapeutic method contributes to the recovery of motor abilities and functions of post-stroke patients. After stroke, neuroplasticity changes are associated with functional re-

covery and depend on the extent of implemented activities. Dance represents an activity that requires the activation of residual motor capacities, and their active participation in the performance of movements, which can be simple (elementary), complex, of varying tempo, intensity, and rhythm, in line with the individual characteristics of each person. Having in mind that movement is a fundamental tool of expression, in combination with accurately planned, programmed and adapted activities, the processes of motor learning and behaviour, restoration, restitution and compensation of damaged functions are encouraged.

The importance of this systematic review article is oriented toward contributing to the creation of a general viewpoint on the influence and value of dance during the recovery of persons after stroke. However, in our country and around the world, a small number of research studies have been conducted to be able to answer certain questions. This fact represents a proper foundation for a comprehensive consideration of these problems in further studies.

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