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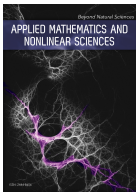

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Benefits of a dance group intervention on institutionalized elder people: a Bayesian network approach

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Abstract

The present study aims to explore the effects of an adapted classical dance intervention on the psychological and functional status of institutionalized elder people using a Bayesian network. All participants were assessed at baseline and after the 9 weeks period of the intervention. Measures included balance and gait, psychological well-being, depression, and emotional distress.

According to the Bayesian network obtained, the dance intervention increased the likelihood of presenting better psychological well-being, balance, and gait. Besides, it also decreased the probabilities of presenting emotional distress and depression. These findings demonstrate that dancing has functional and psychological benefits for institutionalized elder people. Moreover it highlights the importance of promoting serious leisure variety in the daily living of institutionalized elder adults.

Keywords: Bayesian network, dance, institutionalized elder people, healthy ageing, randomized controlled trial.
AMS 2010 codes: 62C12.

1 Introduction

There is a universal consensus on the fact that the population is getting older. This is a sign of success for our society in terms of technological and socio-sanitary advancement, as well as a challenge for sustainable development [1]. The World Health Organization (WHO) estimates that world population over 60 years will increase at nearly double from 12% to 22% by 2050 [2]. As a response to this fact, a global strategy and an action plan on ageing and health have been developed [3] to promote healthy ageing. Similarly, at the European research level framed in the strategy Horizon 2020 [4], the European Commission has developed the European

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Innovation Partnership on Active and Healthy Ageing [5]. Target is to ensure that not only lifespan increases, but also lifestyles become more healthy and active among the elder adults population. To do so, they are embracing a multi-agent strategy in order to nurture the participation of different stakeholders as patient associations, non-profit organizations, academics, professionals, companies, health authorities and policymakers.

As a way to find consensus between academic and policy circles, the WHO proposes a definition of the term *healthy ageing* as *"the process of developing and maintaining the functional ability that enables well-being in older age"* [7, p. 28]. In this sense, it has been consistently acknowledged that institutionalized elder people present a higher risk of poor functional ability and well-being than community dwelling elder people [8]. Hence, this stresses the need for developing interventions that make nursing homes more user-friendly in order to maintain health during aging.

Healthy ageing promotion embraces the wide range of interventions aiming to increase opportunities for physical and mental health, active and social participation, and security. To that effect, dance has been proposed to be a great healthy ageing promoter as it not only represents a form of physical activity that improves mobility and coordination, but in addition, it encourages appreciation of aesthetics, fun, enjoyment, social interaction, and a sense of community [9–11]. Past reviews have summarized evidence for dance interventions to significantly improve elder adults' functional fitness status by increasing aerobic power, muscular strength, flexibility, endurance, balance and gait, as well as reducing the risk of falls and cardiovascular deficits [12, 13]. However, the majority of the research on dance interventions has focused only on the physical benefits, leaving the psychological ones understudied. Hence, the present paper aims to study the effects of an adapted classical dance intervention on the psychological and functional status of institutionalized elder people.

Apart from a classical statistical analysis, we construct a simple Bayesian network (BN) that will help us to illustrate graphically the relationships between the variables. It permits us to provide an alternative quantification of the strength of causation of the intervention on the test variables. With both approaches, we not only confirm that the intervention had a positive impact, but we also provide further information to explain it.

2 Matherial and Methods

BNs permit to handle uncertainty according to probability theory. We first introduce some preliminaries on BN modeling and the proposed structure for the network that will be considered later.

2.1 Bayesian Network Model

Let us consider a finite set $\mathbf{X} = \{X_1, X_2 \dots X_n\}$ of discrete random variables and P a joint probability distribution over the variables in $\mathbf{X}$. A *Bayesian network* (BN) is a directed acyclic graph that encodes a joint probability distribution over the set of random variables $\mathbf{X}$. Formally, a BN for $\mathbf{X}$ is a pair $B = (G, \Theta)$ where G is the graph whose vertexes are the random variables $X_1, X_2 \dots X_n$, and the Θ represents the set of parameters that qualify the network. The graph encodes independence assumptions: each variable X_i is independent of its non-descendants given its parents in G, the parameters. Here Θ consists of a set of parameters $\theta_{x_i|\Pi_{x_i}} = P_B(x_i|\Pi_{x_i})$ for each possible value x_i of X_i and Π_{x_i} of Π_{X_i}, where Π_{X_i} denotes the set of parents of X_i in G. A Bayesian network B defines a unique joint probability distribution over $\mathbf{X}$ given by:

$$P_B(X_1, X_2, \dots, X_n) = \prod_{i=1}^{n} P_B(x_i|\Pi_{x_i}) = \prod_{i=1}^{n} \theta_{x_i|\Pi_{x_i}}. \tag{1}$$

These networks permit to summarize a number of conditional dependence relations graphically. The graph structure can also be used to represent cause-effect relationships through the edges and their directions between pairs of nodes. The structure can be determined by different algorithms such as expectation-maximization algorithm, evolutionary algorithms, Gibbs sampling-based algorithms, or expert knowledge, see [14, 15]. In the case under consideration, due to the nature of the experimental study, we employed expert criteria to propose the

structure displayed in Figure 1. As it will be seen later, the dance intervention will increase the probabilities of presenting higher psychological well-being and a better balance and gait, as well as to decrease the probabilities of presenting depression and emotional distress in institutionalized elder people.

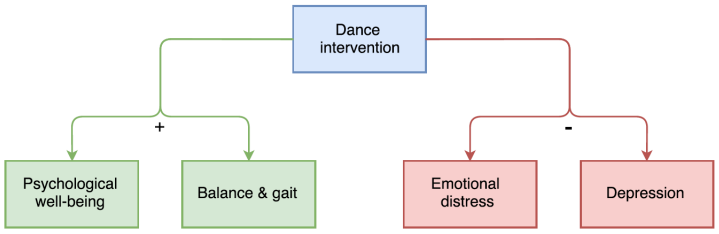

Fig. 1 Bayesian network of the dance intervention effects.

2.2 Participants

A total of 26 elder adults institutionalized in a nursing home "City of Valencia" in Valencia (Spain) participated in the study. Their mean age was 81,5 (SD = 6.5), and 69.2% of them were women. The average of their years of schooling was 9.27 (SD = 5.09). In order to be included in the study, participants must be permanent residents of the nursing home and present a functional status that enabled them to participate in the dance intervention with no serious risk for their health. Participants with any severe functional limitation either physical or psychological were excluded.

2.3 Materials

The benefits of the intervention will be measured according to the following four dimensions:

- *Psychological Well-Being* was measured using the Spanish adaptation of the 54-item version Ryff's Psychological Well-Being Scale [16, 17]. It is a 6-point Likert-scale ranging from 1 ("Totally disagree") to 6 ("Totally agree") with items formulated both in positive (e.g. *"In general, I feel I am in charge of the situation in which I live")* and negative (e.g. *"I gave up trying to make big improvements or changes in my life a long time ago")*, although for the analyses negative items were inverted. The Cronbach's α obtained for the reliability of the scale was .89, showing good internal consistency.

- *Emotional Distress* was measured using the Spanish validated version [18] of the 28-item General Health Questionnaire [19, 20]. It is a 5-point Likert-scale ranging from 0 (*"Not at all"*) to 4 (*"Much more than usual"*) (e.g. *"Have you found everything getting on top of you?"*). The Cronbach's α obtained for reliability of the scale was .96, showing excellent internal consistency.

- *Depression* was measured using the Spanish adaptation of the Geriatric Depression Scale (GDS) [21, 22] as it is designed specifically for rating depression in the elder people. It is a questionnaire of 30 dichotomous questions (yes/no) both direct (e.g. *"Have you dropped many of your activities and interests?"*) and reverted (e.g. *"Are you basically satisfied with your life?"*), these latter ones were inverted for the analyses. The Cronbach's α obtained for the reliability of the scale was .91. showing good internal consistency.

- *Balance and gait* were assessed using the Performance Oriented Mobility Assessment tool [23]. Scoring is done on a 3-point scale ranging from 0 to 2, where 0 represents the most impairment and 2 the best

performance. The maximum overall score is 28 as a result of combining the Gait Scale (12 points max.) and the Balance Scale (16 points max.). The Cronbach's α obtained for the reliability of the overall scale was .95, showing excellent internal consistency.

2.4 Design and procedure

We developed a randomized controlled trial with two times of assessment and data gathering. The present investigation was favorably informed by the Human Research Ethics Committee of the University of Valencia, since meets the fundamental principles established in the Declaration of Helsinki and the Council of Europe Convention on Human Rights, and the established requirements in Spanish legislation in the field of biomedical research, the protection of personal rights and bioethics are respected.

The flowchart of the design and procedure followed is displayed in Figure 1. Potential participants were selected by the psychologist and the physician of the nursing home. The inclusion and exclusion criteria followed for the selection of the participants have been described above in the paragraph concerning the participants.

They were then informed about the program by the psychologist in charge of the assessments and the facilitation of the dance intervention and asked for voluntary participation. Participants that voluntarily accepted to participate signed the informed consent and were acquainted with the possibility to leave the program at any stage if they did no longer want to continue with no compromise.

All participants were assessed at the entry-level and then assigned randomly (with envelopes containing the group code) to the experimental group or the control one. Both experimental and control group had a final size of 13 participants each. The participants in the experimental group attended dance lessons while the participants in the control group were assigned to the waiting list and took the usual leisure activities of the center: cognitive training, arts and crafts, table games, cinema, etc. All participants were assessed again after the intervention. Participants were assessed individually in an isolated room during the time periods scheduled as free time. For the sake of equity among all the participants, after the post-intervention assessment, the participants of the control group were given the opportunity to attend the dance intervention.

The dance intervention consisted on dance group lessons of ballet adapted to characteristic old people physical functional limitations. The dance lessons were complemented with brief group dynamics at the beginning and the end of the sessions to work on physical and psychological self-awareness and self-regulation both at the individual and group levels. The facilitator was a trained psychologist and retired professional ballet dancer. The duration of the intervention was of a total of 18 sessions of 45 minutes each with a frequency of 2 times per week during 9 weeks. The intervention was conducted in the time scheduled for leisure activities but in the area normally employed for physical and active group activities.

3 Data analysis

It will be split in two parts: one with classical statistical analysis and a second with a Bayesian network. We used SPSS for descriptive sample statistics, and discretization of the study variables.

3.1 Statistical Analysis

Since no assumption could be done concerning the distribution of the values on any of the variables of the study, we have used the Wilcoxon unpaired test for evaluating the results of the intervention. Mean, standard deviations, and the p-values of the study variables before the intervention (initial time) and after it (final time) are displayed in Table 1. We also include the detail of the effects on each subdimension:

Looking at the p-value at the initial time we cannot conclude that there was a significative difference in any of the variables of study in both groups. In contrast, after the intervention there has been a significative difference between both groups in depression (GDS), in all items about psychological well-being except in autonomy, in the general health situation (GHQ-28), and in balance and gait (POMA), see Table 1.

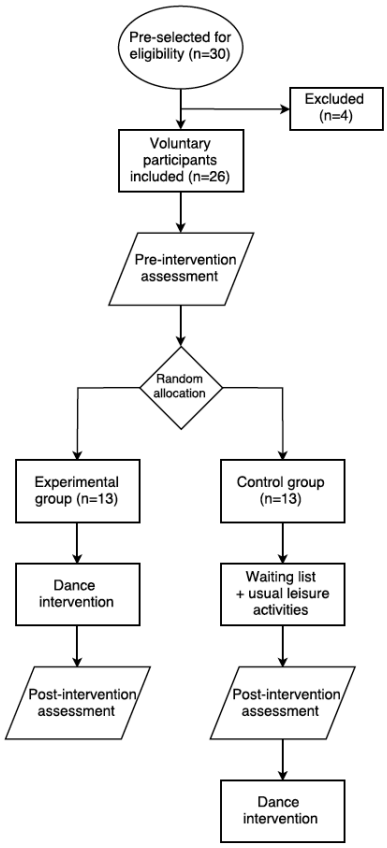

Fig. 2 Flowchart of the study design and procedure.

3.2 Data analysis with a Bayesian network

A BN does not need that the joint distribution follows a specific parametric distribution. It is also consistent in probabilistic associations between the variables. In fact, it is not necessary to maintain the joint distribution in memory for doing Bayesian inference. Besides, it also let us evaluate many structure function interactions without explicitly consider the multiple comparison problem.

For analyzing the BN, the first step was to discretize the variables in the line of [24]. For the variable "type of group", the experimental group was codified with 1 and the control group with 0. As the variables were initially measured following a scale, we computed the histograms and frequencies for each variable in order to discretized them.

Then, we randomly divided the data into two sets: the training set (80%) and the test set (20%). We used the software Netica[a] for computing the conditional probabilities based on the network model and the training test [25]. Netica provides three different values for validating the network based on the test set: the *Logarithmic loss*, *Quadratic loss*, and *Spherical payoff*. Logarithmic loss values vary between 0 and infinity, being 0 the best goodness of fit possible. Quadratic loss values range between 0 and 2, where 0 represents the best execution of the network. Finally, spherical payoff values vary between 0 and 1, being 1 the perfect fit of the theoretical model with data. For further information, we refer the reader to [25, 26].

Mean, standard deviations, and Pearson correlation coefficients of the study variables at time 1 are displayed in Table 2, as well as those from time 2 in Table 3. As it can be seen in the tables, there was no correlation before

[a] https://www.norsys.com/

Table 1 *Mean, standard deviations, and p-values of the study variables before (time 1) and after the intervention (time 2) for the intervention (INTERV.) and control (CONTROL) groups*

	Time 1			Time 2		
	INTERV.	CONTROL	p-values	INTERV.	CONTROL	
	M/SD	M/SD	p-values	M/SD	M/SD	p-values
RPWBS (total)	202.77 / 12.60	201.46 / 5.35	0.7385	186.85 / 12.54	227.38 / 16.31	<10-4*
- Autonomy	5.69 / 3.97	38.15 / 3.87	0.08645	39 / 5.13	35.46 / 3.93	0.1272
- Positive relations w/ others	37.62 / 5.11	37.38 / 4.33	1	42.62 / 6.73	34.47 / 3.78	0.0014*
- Self-acceptance	33.15 / 2.38	34.84 / 2.79	0.1274	35.69 / 3.30	33 / 2.08	0.0370*
- Environmental competence	35.85 / 2.91	35.15 / 3.78	0.7954	40.15 / 4.48	31.15 / 6.20	0.003*
- Purpose in life	29.62 / 5.28	27.23 / 4.00	0.1965	34 / 2.80	25.46 / 4.24	<10-4*
- Personal growth	30.85 / 5.28	28.69 / 2.93	0.129	35.92 / 4.09	27.31 / 3.35	0.0001*
GHQ-28 (total)	22.23 / 11.72	22.84 / 10.51	0.837	9.54 / 5.35	33.77 / 15.90	<10-4*
- Somatization	4.46 / 3.71	4.54 / 2.93	0.7751	1.38 / 1.50	7.92 / 4.29	<10-4*
- Anxiety & insomnia	7,23 /4,34	5.85 / 4.29	0.2994	2.54 / 1.94	9.08 / 5.45	0.0006*
- Social disfunction	8.62 / 3.57	9.62 / 2.29	0.423	4.46 / 2.15	12.46 / 3.80	<10-4*
- Severe depression	2.92 / 3.68	2.85 / 2.67	0.7343	1.15 / 2.12	4.31 / 3.82	0.0089*
GDS	12.54 / 6.12	12.53 / 5.03	0.9589	5.23 / 3.22	16.07 / 6.69	0.0003*
POMA	17.34 / 8.72	16.08 / 6.72	0.521	22.62 / 7.78	11.38 / 5,75	0.003*
- Balance	11.62 / 4.52	10.46 / 3.80	0.29	13.54 / 3.67	7.69 / 3.40	0.0016*
- Gait	5.77 / 4.59	5.62 / 3.20	0.9376	9.08 / 4.21	3.69 / 2.59	0.0029*

Notes: M = mean, SD = standard deviation, EG = experimental group, CG = control group,
RPWBS = Ryff's Psychological Well-Being Scale , GHQ-28 = General Health Questionnaire (28 items),
GDS = General Depression Scale, POMA = Performance Oriented Scale.

$*$ = correlation is significant at level $p < .001$

the intervention between the type of group and any of the study variables, whereas after the intervention the type of group is significantly correlated with all the variables studied. As expected, the intervention increased the levels of psychological well-being $(r = .823,\ p < .001)$ and balance and gait $(r = .649,\ p < .001)$, as well as decreased the levels of depression $(r = .728,\ p < .001)$, and emotional distress $(r = .732,\ p < .001)$. As to the validation of the model, the goodness of fit statistics of the BN show a valid correspondence between the theoretically proposed model and the data for all the study variables.

Table 2 *Mean, standard deviations, and Pearson correlations (bilateral) of the study variables before the intervention (time 1)*

	RPWBS	GHQ-28	GDS	POMA
Group (EG vs CG)	.070	.018	.000	.087
RPWBS	–	-.261	-.364	.287
GHQ-28	–	–	.733*	-.230
GDS	–	–	–	-.064

Notes: M = mean, SD = standard deviation, EG = experimental group, CG = control group,
RPWBS = Ryff's Psychological Well-Being Scale , GHQ-28 = General Health Questionnaire (28 items),
GDS = General Depression Scale, POMA = Performance Oriented Scale.

$*$ = correlation is significant at level $p < .001$

Table 3 *Mean, standard deviations, and Pearson correlations (bilateral) of the study variables after the intervention (time 2)*

	RPWBS	GHQ-28	GDS	POMA
Group(EG vs CG)	.823*	-.728*	-.732*	.649*
RPWBS	–	.744*	-.834*	.663
GHQ-28	–	–	.857*	-.583*
GDS	–	–	–	-.562
POMA	–	–	–	–

Notes: M = mean, SD = standard deviation, EG = experimental group, CG = control group, RPWBS = Ryff's Psychological Well-Being Scale , GHQ-28 = General Health Questionnaire (28 items), GDS = General Depression Scale, POMA = Performance Oriented Scale.

$*$ = correlation is significant at level $p < .001$

Both goodness of fit statistics and the percentages of mutual information of the studied variables (i.e., the influence of the type of group on the rest of the studied variables) are displayed in Table 4. Regarding these percentages, and considering the direction of the correlations obtained and already discussed in the previous paragraph, we can infer that the intervention had a positive influence on the levels of psychological well-being and balance and gait of 46.3% and 16.4% respectively, whereas at the same time had a negative influence on the levels of depression and emotional distress of 46.3% and 19.6%, respectively.

Table 4 Bayesian network's validation and percentage of mutual information between Group and the rest of the variables

	LL	QL	SP	%
Group (EG vs CG)	0.6931	0.5	0.7071	
Psycological Well-Being	0.6966	0.5035	0.7047	46.3
Emotional Distress	0.3448	0.1701	0.9247	46.3
Depression	0.6131	0.4201	0.7634	19.6
Balance & Gait	0.8194	0.625	0.62	16.4

Notes: LL = Logarithmic loss, QL = Quadratic loss, SP = Spherical payoff

4 Discussion

The aim of the present study was to explore the effects of a dance intervention on the psychological and functional status of institutionalized elder people and to illustrate it through a BN. As expected, while both groups were initially equivalent, after the intervention the groups functional and psychological outcomes were different. Participants that attended the dance lessons presented better psychological well-being, balance, and gait, in combination with lower levels of emotional distress and depression. According to the BN tested, the dance intervention increased the likelihood of presenting better psychological well-being and balance and gait in 46.3% and 16.4% respectively. Similarly, the intervention decreased the probabilities of presenting emotional distress and depression in 46.3% and 19.6% respectively. These results are consistent with the ones found by Hui, Chui and Woo [27] with community-dwelling elder people.

The added value of conducting the BN is that it allows estimating the probabilities of the dance intervention benefits and not only the linear correlation between the variables. In addition, it is especially useful in cases with small data such as our case, showing a good prediction accuracy even with rather small sample sizes.

The main limitation of the present study is that, although participants were randomly allocated in the groups, both experimental and control groups were composed of elder adults living in the same institution. Consequently,

while the participants in the experimental group were doing a new activity the participants in the control group were doing the same leisure activities they were already doing. Hence, the psychological benefits found associated with the dance group intervention could be confounded by the novelty effect [28]. In other words, it is possible that the increase in psychological well-being and the decrease in the levels of emotional distress and depression are caused by the fact of doing a new, fun, social engaging and stimulating activity different than the activities they were already doing routinely rather than because of the dance intervention itself. Besides, we also have to point out the improvements could also be due as a result of doing more physical exercise rather than for the dance intervention itself

Nevertheless, the results of this study highlight the positive effect of dance group lessons as a form of physical and serious leisure activity to promote institutionalized elder adults well-being. These findings should be interpreted in light of other proposals about the positive impact of promoting variety and serious leisure in the daily living environment of elder adults to promote healthy ageing. [29,30]. [31] defined serious leisure as a "*systematic pursuit of an amateur, hobbyist, or volunteer activity that participants find so substantial and interesting that, in the typical case, they launch themselves on a career centered on acquiring and expressing its special skills, knowledge, and experience*" (p.3). In this line, [32] reviewed the existing empirical evidence and provided support for serious leisure to be therapeutic and contribute to physical, social, emotional and cognitive health. She also identified the protective factors linked to serious leisure: meaningful and/or intrinsically interesting, provision of social connection, competence and self-efficacy development, experiences of challenge and absorption, feelings of control and self-determination, disengagement from and buffering of stressors and negative events, and ability to provide continuity after experiencing disability or a traumatic event (as institutionalization may be).

To conclude, the importance of studying and introducing new practices and interventions, rather than exclusively the pharmacological ones, not only to prevent diseases and mortality but also to foster independence and psychological well-being of institutionalized elder people has been clearly stressed.

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