Exergames and their benefits in the perception of the Quality of Life and Socialization on institutionalized older adults

Heitor Cardoso
Alexandre Bernardino
Institute for Systems and Robotics,
Instituto Superior Técnico, University
Lisboa, Portugal
heitor.cardoso@tecnico.ulisboa.pt
alex@isr.tecnico.ulisboa.pt

Mafalda Sanches
Luísa Loureiro
Domus Vida Estoril
José de Mello Residências e Serviços
Lisboa, Portugal
mvsanches@jmellors.pt
mlloureiro@jmellors.pt

***Abstract*— Benefits of augmented reality games in physical and cognitive dimensions have been demonstrated before but not many works have addressed the social dimensions which are quite important for the overall quality of life. The objective of this work is to assess the impact of a recently developed platform for senior exercise with augmented reality games (exergames) in the perception of quality of life and socialization of older adults institutionalized in nursing homes. We describe a 3 months study with 18 participants (85.28 ± 6.02 years) divided into three groups of different functional abilities (Group-1 n=6, Group 2 n=5, Group 3 n=7), with a weekly session of exergames of approximately 90 to 120 minutes. Our study shows significant improvements under World Health *Quality of Life Scale* in domains like Social Relations and also in Friends Satisfaction domain of the *Satisfaction with Social Support Scale*. Differences between groups were also found regarding Satisfaction with Social Activities. Some positive and significant correlations were found between the number of group sessions attendance and the perceived quality of Social Relations and System Usability. We, thus, conclude that our exergame sessions have several benefits for quality of life perception and social relations.**

Keywords*— *Exergames, Institutionalized Older Adults, Quality of Life, Socialization.

I. INTRODUCTION

The World Health Organization (WHO) [1] refers that in 2018 about 125 million people are aged 80 years or older. From 2015 to 2050 the proportion of the world's population over 60 years will increase from 12% to 22%, almost doubling. Aging often brings diseases or geriatric syndromes that contribute to loss of functioning and autonomy in daily life activities. This results in the institutionalization of a significant fraction of the population, that becomes more separate from their families and friends, with a consequent reduction in social relations and significant impact in their perception of the Quality of Life (QoL).

Quality of Life is a multidimensional and subjective concept [7] embracing many dimensions from physical, functional, psychological and social well-being [5] and mood, emotions, health and occupational dimensions [6]. In fact, the WHO developed a scale in order to assess domains that they affirm to be the main contributors to QoL perception [8]. To improve QoL, [2] suggests the importance of being physical [3] and cognitive active [4], aiming autonomy during daily life activities. Authors such as [9], assessed the associations between physical activity, cognitive performance with QoL and depression risk in institutionalized older adults. They found that participants who need any assistance or a device to walk have a 50% greater risk of depression symptoms. Another result showed that physical fitness, especially upper limb muscle strength was associated with QoL.

These studies confirm the benefits of physical activity for QoL but focus mainly on the physical, cognitive and psychological dimensions. Few studies address the social dimensions, despite their importance in QoL. One of these studies [24], suggests that social benefits of exercise could arise indirectly via physical and functional improvements that allow the participants to enjoy other social events in their daily life. However, in their study, because exercise sessions were individual, they could not find significant direct social benefits. Instead, in our study, we use a group exercise paradigm to verify the direct influence of exercise sessions in the perception of the Quality of Life social dimensions.

To keep a person engaged in regular physical activity it is important to understand which factors can influence intrinsic motivation. This was analyzed in [11], that developed the self-determination theory. This theory proposes to consider *autonomy*, *competence* and *relatedness* as important dimensions to assess the basic psychological needs for performing physical exercise. The first, *autonomy*, can be described as the desire to be the source of one's own behavior, reflecting a prior "acceptance" and "involvement" in a chosen behavior. The *competence* dimension reflects a desire to effectively interact with the environment and obtain satisfaction when demands are successfully achieved. The need for *relatedness* suggests the feeling of belonging to a particular group or social context.

To fulfill these needs, our approach proposes group exercise sessions through exergames (video games that demand physical exercise to interact) with cultural motifs that trigger past memories, in order to promote relatedness and engagement. Since Social Relations seem to be an important domain, this study also analyses which social support tends to be the main contributor to QoL. We used the *Satisfaction with Social Support Scale*, which analyses the person's perceived satisfaction with friends, family and social activities that they do together [12].

Our work is framed on a collaborative project [31] that aims to promote exercise among the older population for physical rehabilitation and prevention of sedentary behavior.

The developed exergames [13], are adjustable and configurable to account for physical limitations of the elderly and to provide functional fitness training. They are inspired by Portuguese tradition in order to capture attention and promote engagement among older adults. Together with the exergames, we have developed a transportable interactive gaming platform [14] that combines augmented reality through virtual content projections on the floor and simultaneously measures vital signs and manages parameters such as balance, posture, agility, and aerobic activity. Other objectives were to study mechanisms and strategies of promotion, motivation to physical exercise and to provide therapists with a state-of-the-art tool for therapy sessions. We deployed this platform and the exergames in an elderly institution in Lisbon region in Portugal.

II. Related Work

Researchers have been showing interest in using exergames to intervene not only in physical exercise but also in the cognitive component. For example, in Dementia [15] used exergames to attempt to slow cognitive decline by preserving functioning, while [16] verified improvements in everyday memory functioning and patient's mood with cognitive training software. However, according to [17, 18, 19], more evidence is needed to observe a consistently link between videogames and cognitive benefits, but the use of video games to cognitive training in dementia could be a promising field to explore, by taking advantage of simulations of daily life activities under virtual environments.

An area that has also attracted the attention of researchers is socialization among the players while playing video games. Authors like [20], said that exergames provide new opportunities to socialize through intergenerational integration in families, and [21] showed that is possible to promote social activity in sheltered care and nursing housing with commercial Wii equipment. In a social perspective, [22] suggest that social interaction requires all players to have a balanced chance of winning or reaching the objectives with fair rules in the core mechanics, and to match players with approximate skills or allow some advantage to less skilled gamers in order to restore competitiveness. [23], adopted the Canonical Action Research model on their study with sessions of 2 hours per week along 6 months. They divided the participants according to a functional level (excluding frail subjects) with an average attendance of 14 gamers per session. They used this model to dynamically adapt the best intervention strategies with the participants, in order to keep them integrated with the exergames sessions.

The authors of [24] affirm that QoL is linked with physical, psychological social and environmental aspects of the human being. So, they ran an experiment aiming to assess the influence of commercialized exergames that use Kinect in QoL with older adults on a 6 months intervention of 2 times per week individual sessions of 30 min each. In that study was also used the short version of WHO Quality of Life (WHOQOL-bref) to assess the domains that contribute to the QoL. On their study, they observed a significant improvement under QoL in general and also in the subdomain Environment (home and physical environment satisfaction, leisure activities, etc) after their exergames intervention. However, the physical, psychological and social relations didn't show any significant improvement between the pre - post assessment. In relation to the Social QoL's domain, the authors suggested that the fact there wasn't found any significant differences were probably due to the exergames sessions being performed individually which didn't allow for participants to exchange social interactions. The authors assumed that the physical and functional improvements resulting from the intervention would be enough for the participants to enjoy other social events in their day to day activities.

The previous works show that exergames are widely used among older adults with the purpose of improving various domains of their life, however, a large number of commercial or custom exergaming platforms, which have been utilized by seniors, are not tailored to them [25]. For instance [26] show that commercial exergames used with older adults have problems in requiring body movements for game actions that are not suitable or recommended for the elderly population. In addition, requiring multiple tasks or complex tasks (without the possibility of adaptation) leads to moments of confusion and frustration in older adults. In our work, we use exergames specifically designed for the older population [13] and adaptable to multiple types of physical and cognitive limitations. To extend previous works in the field, we adopt a group sessions paradigm and show the benefits in quality of life improvements.

III. Instruments

For this study were used the following instruments:

- *Sociodemographic Questionnaire* regarding code number identity, age, gender, study inclusion date, nº of sessions, schooling, marital status, time of institutionalization, last occupation and dominant hand.
- *Mini-Mental State Examination* (MMSE), for cognitive inclusion criteria. This screening exam allows assessing cognitive dimensions such as orientation, memory, attention, language and visuoconstructive abilities. The cut points to exclude the participant from this study due cognitive impairments were based on Mini-Mental Scale max score *s*: $s \leqq 15$ if the subject is uneducated, $s \leqq 22$ if the subject if the participant has between 1 and 11 years of schooling and $s \leqq 27$ for more than 11 years of education [27].
- The *Barthel Index* was used for groups inclusion criteria (perform exergames while stand or seated) is one of the most widely used rating scales for the measurement of activity limitations in patients with neuromuscular and musculoskeletal conditions in an inpatient rehabilitation setting. Several authors have proposed guidelines for interpreting Barthel scores. Shah et al. suggested that scores of 0-20 indicate "total" dependency; 21-60 "severe" dependence; 61-90 "moderate" dependence; 91-99 "slightly" dependence and 100 indicates independent.
- *World Health Organization Quality of Life* (WHOQOL-bref) composed of 26 items, where the first two questions assess the Auto-Perception of Quality of Life and Satisfaction with Health. The other 24 items represent four fields of assessment domains, such as Physical health domain (sleep, energy, mobility, medical treatment to function in daily life, level of satisfaction with their capacity for work), Psychological domain (concentrate, self-esteem, body image, spirituality, frequency of positive or negative feelings), Social Relationships (satisfaction with personal relationships, social support systems and sexual satisfaction) and Environment domain (safety and security, home and physical environment satisfaction, finance, information, leisure activity, accessibility and transportation satisfaction) (Skevington et al., 2004). The WHOQOL-bref has 5 Likert

points, that will fit in different domains. This scale is often used under the elderly population with good accuracy in quality of life perception evaluation.

- The *Satisfaction with Social Support Scale* (SSSS) was developed to measure the perception and satisfaction of the existing Social Support as [12]. The SSSS has 15 items wherein a 5 point Likert scale has to check which answer fits is opinion ("strongly agree", "mostly agree", "do not agree or disagree", "strongly disagree", and "strongly disagree") with a total score between 15-75, where a higher score corresponding to better social support. [28] suggests that no cutoff points can be considered as deficit due to the fact that people's perception of satisfaction with social support (low or high) doesn't exactly indicate a deficit. These 15 items will generate 4 sub-dimensions, such as: "Satisfaction with friends," to measure the satisfaction with the friends; "Intimacy" that measures the perception of the existence of intimate social support; "Family Satisfaction" measures satisfaction with existing family social support and finally "Social Activities" measures the satisfaction with the performed social activities.

- *Basic Psychological Needs in Exercise Scale* (BPNES, [29] assesses, along 12 items, the intrinsic psychological motivation that is crucial for participants to engage in exercise programs. This assessment scale combines 3 factors: Autonomy, Competence and Relatedness. The response format is a 5 Likert point from 1 ("Strongly Disagree") to "5" ("Strongly Agree").

- *System Usability Scale* (SUS) provides a single reference score for participants' view of the product's usability or service with 10 items and a 5-point Likert scales numbered from 1 ("Strongly disagree") to 5 ("Strongly agree"). Assessing Usability is an important part of the development of a product or service, by promoting cooperation between the developers and the end user during the prototyping process, design, and validation. It was used in order to measure the usability and feasibility of this interactive system approach under institutionalized elderly adults.

IV. METHODOLOGY

Five of the exergames developed in the project were tested in this work: *Grape Stomping*, based on the Douro region of Portugal, is a game that recreates a grape maceration activity for wine production that promotes aerobic endurance; *Rabelos VR* is a game inspired in the Portuguese city of Porto that simulates the historic Rabelos boats used to transport wine downriver and aims at upper limbs force training; the *Toboggan Ride*, inspired on the historic two-seater wicker sleds from the city of Funchal, is aimed at training static balance and trunk muscle strength; the Exerfado is a game inspired on traditional Portuguese music "Fado" aims at lower limbs muscular strength training. Another exergame, without cultural motifs but very popular among users, is *Exerpong*. It consists on a ball than bounces at walls and on a paddle controlled by the player. The paddle is moved laterally by body movements of the player that should prevent the ball from leaving the game area and direct it to colorful blocks on the game zone to gather points. This game can be used to train agility, upper and lower limbs strength.

A sample of 18 participants (85.28 ± 6.02 years, gender F=12, M=6), were divided into 3 groups, suggested by the residence's therapists based on Barthel index score. Group-1 (G1: n=6, F=5, M=1) includes participants with high levels of autonomy and functionality, that perform the exergames standing. With more physical impairments Group-2 (G2: n=5, F=0, M=5) and Group-3 (G3: n=7, F=7, M=0) performed the exergames while seated. Participants were assessed with the cognitive screening exam (Mini-Mental State) to exclude any subject with cognitive impairments in learn the rules of the exergames, and had to understand the exergames instructions in one group session or by observing the others playing. The physical inclusion criteria considered are:

- to have at least one functional arm;
- to have postural trunk control to be able to sit;
- enough sight accuracy to perceive the interactive multimedia projection on the floor.

The participant's balance was taken into consideration during the selection of the participants' groups (group play in stand or sitting position). Following [22] in order to promote an optimal social interaction during the group sessions, the players were matched by similar physical skills. For example, in the Rabelos VR game, the objective of catching the wine barrels deployed on the banks of the river is more accurately while played in stand mode. So, for participants that cannot grab the barrels or cannot move laterally because playing seated, the need of catching barrels was ignored and the game obstacles were removed. Also, the Exerfado game can only be played while standing, so the participants with physical limitations were grouped together so they have a balanced chance of winning or reaching the objectives.

The study took 3 months with weekly sessions. There were 11 exergame sessions and 2 assessment sessions, one in the beginning and the other in the end. Due to the high number of occupational activities where the participants were engaged, it was only possible to run one group session per week for each group, with a duration of 90 ~120 minutes. The used platform for exergames projection was PEPE [14] that projects the exergames interactive content in the floor through an ultra-short throw video projector while a body motion capture sensor (Kinect V2) detects the body joints required for the videogame interaction. The used exergames allow playing in standing or seating mode, fitting the needs of both groups.

Initially, the institution's therapists were interviewed with respect to the physical and cognitive capabilities of their population. Once passed in the screening test, the participants were asked to respond to a sociodemographic questionnaire as well as to some other already mentioned assessment scales. They were assessed two times after the screening with the battery of tests described in Section IV, one at the beginning of the study (before the exergames session), and at the end of the study (3 months later).

The group sessions were run in two different settings. G1 performed the exergames in the multi activities room of the institution, a wide room with enough space for the playing area and to arrange a semicircle around the floor projection where other participants (see Fig.1), or even other residents not participating in the study, could watch the games. This allowed social interaction among residents, even with those who were not part of the experience. Groups 2 and 3, which had reduced mobility and need for careful supervision, performed the exergames sessions in a private room (physiotherapy gym), where only the participants and some therapists were present for social interactions (see Fig.2).

Each participant performed one exergame for 3 minutes and, after game score visualization, the participant returned to his/her chair and gave the turn to another player. This process was repeated until 4 or 5 (depend if was played stand or

seated) of the exergames library were performed or the session time expired. Like in [23], this study has similarities with the Action Research model, especially with group 2 and 3 (the less autonomous participants).

The exergames were initially designed for a standing playing position, thus, we had to adapt/configure the exergames settings and interaction mechanics for the sitting mode. The first sessions for each group were mainly to find the best playing configurations, i.e. to adjust the game difficulty (velocity, number of distractors, obstacles, players positions, etc.). If a more appropriate interaction solution emerged during the sessions (ex. by therapist advice), it would then be adopted even if just for a single participant.

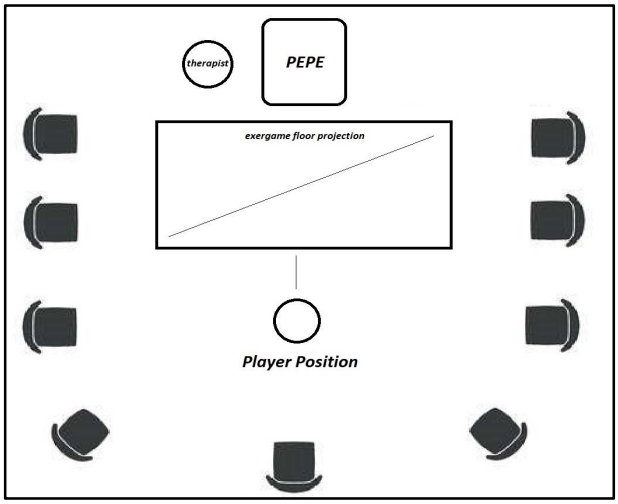

fig.1: Top view: the setting of the Group 1 sessions in the institution's main activities room. Participant plays in stand mode.

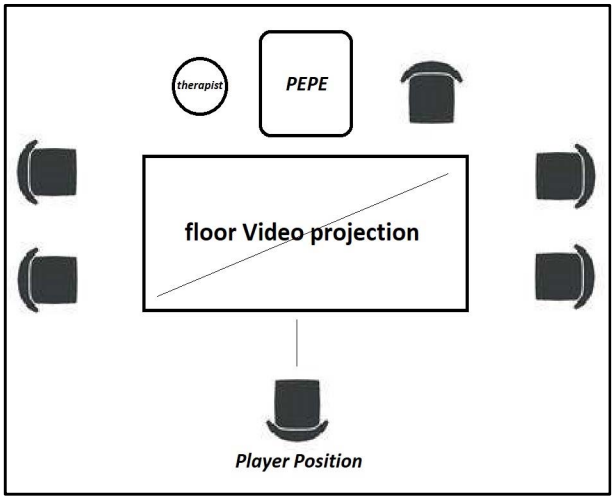

fig.2: Top view: Setting of the Group 2 and 3 sessions in the physiotherapy gym. Participant plays in seated mode.

V. EXERGAMES CONFIGURATION

This section shows the used configurations for the exergames in each participant's groups. Since this study has one physical independent group (G1) and the other two (G2 & G3) with physical limitations, we describe which exergames configurations were adopted in order to allow all the participants to enjoy and play the exergames. From a library of five exergames, just Exerfado was not possible to configure to be played while seated, thus, was only applied to G1.

TABLE I ExerPong configurations per groups

ExerPong	**G1**	**G2 & G3**
Sync Joint	Waist	Right Hand
Ball Size	1.2	1.2
Velocity	2.6 - 3.0	2.6 - 3.0
Paddle increment	10%	10%
Veloc. Increment	10%	10%
Exercise Time	3 min	3 min
Play Mode	Stand	Sit

For the Exerpong game (Table I), G1 performed in stand mode. The exergame paddle was controlled by the participant's waist position while walking laterally from left to right. For G2 and G3, the paddle was controlled with right-hand joint, so the participant could move the paddle from the left to the right edges by simply moving the right arm while seated.

TABLE II - GrapeStomp configurations per groups

Grape Stomp	**G1**	**G2 & G3**
Step	Available	Available
Pull	Disable	Disable
Stepping height	-2	-2
Nº of Players	1 or 2	1 or 2
Grape Int. Timer	3	3
Treadmill Veloc.	2	2
Distractors Freq	0	0
Exercise Time	3 min	3 min
Play Mode	Stand	Sit

For the GrapeStomp exergame (Table II), G1 performed in stand mode, where just the static walk movement was required to simulate the action of stomping the grapes. The G2 and G3 have performed the stomping exercise while seated; the participants had to raise their knees in order to simulate the stomp movement. The simulation act of pulling the baskets to bring the grapes to the inside of the bucket was disabled due to the fact that double task (stomp + pull) seemed to be complex for this group participants. Whenever possible this game was played with two players in competition mode, to motivate participants to perform better (produce more wine) every time they played.

TABLE III Rabelos configurations per groups

Rabelos	**G1**	**G2 & G3**
Rowing mode	light	light
Direction	Body position	Trunk rotation
Docks distance	1.25	1.25
Docks odds	100%	100%
Rocks odds	0%	0%
Exercise Time	3 min	3 min
Play Mode	Stand	Sit

In the Rabelos exergame (Table III), G1 performed in stand mode. In order to catch the barrels on river banks, they move laterally to the left or to the right while doing the rowing movement. It was given more reward to the rowing goal, than to the act of catching barrels, due to the small duration of the exercise sessions (3 minutes per game). The G2 and G3 performed the rowing exercise on seated position, where the action of catching the barrels was ignored and also the virtual obstacles (rocks) were removed from the environment due to the lack of control of the lateral position. The institution's physiotherapist also suggests the use of a stick to make the arms move more accurately and to correct arms level.

TABLE IV Toboggan configurations per groups.

Toboggan	**G1**	**G2 & G3**
Brake	20 = disable	20 = disable
Acceleration	4	4
Direction	Moving L/R	Leaning
Pickups Distance	1.25	1.25
Pickups deployments	100%	100%
Obstacles	0%	0%
Exercise Time	3 min	3 min
Play Mode	Stand	Sit

In the Toboggan game (Table IV), Group 1 performed in stand position, and the obstacles were removed so the participants only need to focus on the catchable items (bananas). For this group, the basket lateral position is controlled with lateral walking, in order to catch the bananas. Like for the other exergames, G2 and G3 played while seated. The obstacles were also deactivated. To control the lateral position direction is used the lateral inclination (left and right) of the participant body trunk.

TABLE V ExerFado configurations per groups.

Exerfado	**G1**	**G2 & G3**
Swipe	none	---
Detection	foot	---
Bonus	15%	---
Note Sliding Time	8"	---
Time Between Notes	4"	---

Only Exerfado (Table V) could be played by G1 since it requires a stand position to be played.

VI. Statistical Analysis

Statistical analysis was performed in the data acquired in the battery of tests of Section IV using SPSS v.25 software. Due to the sample size (n=18), the most suitable test of normality is Shapiro-Wilk [30] where the analyzed variables showed that our data derives from a normally distributed population. Two-tailed Paired samples T-Test was executed in order to determine if the mean difference between two variables measured on the same subjects at two different moments is statistically significant (differences between the pre and post exergames intervention). ANOVA was used to find statistical differences between groups and the Pearson Correlation Test was used to understand if there is any correlation between the number attendances to exergames sessions with any other variable. From the sample (n=18), 3 participants of Group_3 had less than 50% of attendance to the groups' sessions. Therefore, they were removed from pre-post intervention means analysis. However, their data was still used to perform the Correlation Analysis between the number of attended sessions (independent variable) with other variables.

VII. Results

In this section, we present the most significant results obtained.

TABLE VI Paired Sample tests

Variable	**Paired Sample Test**			
	N	***Mean***	***p***	***df***
Soc. Relation quality (1)	15	3.64	0.003	14
Soc. Relation quality (2)	15	4.06		
Satisf. w/ Friends (1)	15	18.40	0.044	14
Satisf. w/ Friends (2)	15	19.66		

Table-VI shows significant improvements, from pre(1) to post(2) intervention, in the perception of Social Relations quality and in Satisfaction with Friends at the end of the study. Regarding differences between groups, we ran ANOVA with Bonferroni test (due to normality distribution of the sample) and it was observed that G1 had a higher and significant mean in satisfaction with Social Activities when compared to the G2 (M = 10.00, M = 6.00 respectively, p. 0.001). Between G2 and G3, the groups that performed sitting and in the private room, G3 perceived significant higher scores in the Social Activities domain of the satisfaction with social support scale (G2 M = 6.00 - G3 M = 8.71), as it is possible to observe in Table VII.

TABLE VII Significant differences between groups with the ANOVA test.

Social Activities Satisfaction	**ANOVA**		
	Mean Diff	***p***	***95% Confidence Interval***
Group 1 - Group 2	4.000*	0.001	1.6826 - 6.3174
Group 2 - Group 3	2.750*	0.035	0.1827-5.3173

Group sessions attendance ("*Study Attendance*") showed a positive and significant moderate correlation with Social Relations (*SocRel-who_2*) *r=0.491*, p=.038*, Basic Psychological Needs in Exercise (BPNE) in general (*r=0.656**, p=0.003)*, and also specifically in two subdomains *Autonomy (r=0.646**, p=0.004)* and *Competence (r=0.655**, p=0.003)*. The *System Usability Scale* (M = 77.83, SD = 8.54) that was applied to the participants at the end of the study shows a *mean* higher than 65 (cut point to consider a fitable system according to the authors). Therefore, our approach is suitable for our target population. The *System Usability Scale* showed positive and

significant correlation with *BPNE* in general, also with *Autonomy* and *Competence subdomains*.

Despite no statistically significant differences, we also observed slight improvements between pre and post intervention assessment in *Physical* and *Psychological* domain of *WHOQOL-bref*, also in *Satisfaction with Social Support* in general and *satisfaction* with *family* and *social activities* subdomains.

VIII. Discussion:

The results in Table VI show significant improvements under the quality of life domains, such as *Social Relations* suggesting that participants have improved feelings of satisfaction with personal relationships and social support after 3 months of exergames group intervention. This can be attributed to the fact that during the weekly sessions, the participants have narrowed their friendship ties by sharing advices, challenge and motivate each other, and also share experiences from previously sessions during other day moments outside of sessions. This can be also supported by the other significant improvement in *Satisfaction with Friends* domain from satisfaction with social support scale.

Also, statistically significant differences were found between groups, where G1 and G3 score significantly higher under Social Activities satisfaction (SSSS domain) comparing to G2. The fact that G1 registered the higher score could be probably associated with the fact that they're more physical independent or also due to perform the exergames sessions in the main institution's activity room where more residents have joined the sessions thus increasing the possibilities for social interactions. One possibility for the G2 registered the lower values in this domain, could be due to the fact that most of these group elements (composed only by male elements) returned to their rooms after finish the exergames group sessions, while the other groups took advantage to continue to socialize in the living room.

Regarding correlations, data suggest a positive and significant correlation between the amount of exergames sessions attendance during the 3 months study and variable domains such as Social Relations, Basic Psychological Needs in Exercise (BPNE) in general, and also specifically in two subdomains Autonomy and Competence. The System Usability Scale was also positive and significant correlated with subdomain BPNE Autonomy and Competence.

It was possible to observe slight means improvements at the end of this approach intervention in the quality perception of Physical, Psychological and Environment (domains of quality of life scale - WHO), Satisfaction with Life, Satisfaction with Family Support and Social Activities suggesting that, along the time, positive results could be expected.

The main limitations of this study are two-fold. First, due to resource limitations we had a short time duration to perform the study and we could only perform the group activities once a week with a small number of participants. Second, to more precisely assess the benefits of the exergames, it will be necessary to recruit more users for a control group performing conventional group exercise activities. Future work will address these issues.

IX. Conclusion:

The results of the study show a positive and significant impact under social domains after exercise sessions through exergames with institutionalized older adults. Along the entire intervention, some participants met and talk for the first time, where they shared their opinions, experiences, old memories, motivate and cheer each other during the exergames group sessions. Was possible to observe, at the end of the study, significant improvements under satisfaction with Friends and also satisfaction in Social Relations. This is supported by the positive and statistically significant moderate correlation between the sessions attended and with the increase of satisfaction with the Social Relation as QoL domain. Although not statistically significant, were observed improvements in other dimensions, suggesting the continuity of similar studies, where the participants could attend more sessions per week and during longer periods of time.

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