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EVALUATING PHYSICAL OUTCOMES IN ELDERLY SPORT AND DANCE ROLLATOR USERS: A SINGLE-ARM PILOT STUDY USING LAB-VIDEO-BASED DANCE INTERVENTION WITH A FOCUS ON INTEGRATING INTER-COMMUNICATION TECHNOLOGY IN ROLLATOR DANCE

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ABSTRACT

The present single-arm pilot study investigates the effects of a video-based dance intervention on physical outcomes in elderly individuals utilizing sports and dance rollators. In addition, the dance videos used in the current study are intended to integrate into the future Intercommunication Technology (ICT)-Rollator for the elderly. The aim is to evaluate the physical outcomes (such as gait, balance, mobility, and hand grip strength) during guided movement training (dance) using a video projected in a laboratory setting. The pilot study involved six elderly rollator users (aged 85 and above). In the initial assessment, subjects were screened for mobility and coordination limitations prior to pre-testing using a four-square-step test and the SF-36 questionnaire. Both pre-testing and post-testing included assessments of mobility, balance, and spatiotemporal gait parameters using the Timed Up-and-Go (TUG) test, Berg Balance Scale (BBS), and the Optogait system, respectively. Hand grip strength was measured using a hand dynamometer and reaction time was measured using a pipe-drop test. Blood pressure was monitored every 15 minutes during the training sessions to prevent adverse events, maintaining an upper range of 140-150/90-96. Adherence rates were measured based on the total duration of activity, calories burned per session, and dropout rates.

Post-session questionnaires were administered to verify the respondents' qualitative evaluations of their degrees of exhaustion, enjoyment, impediments, facilitators, and suggested changes. The intervention included heart rate monitoring, which revealed gradual and slight increases in heart rate intensity and gradual decreases in heart rate ranges (HRR) during the dance sessions. The results indicate improvements in balance, mobility, gait, and adherence rates. Future longitudinal research will further examine the effectiveness of the dance intervention using the ICT-Rollator, comparing it to a control group using a conventional rollator. The ICT-Rollator could be a unique rehabilitation aid for the elderly, offering promising improvements.

Keywords*: intercommunication technology rollator, dance intervention, scoping review, future longitudinal study, home-based technology interventions.*

OCENJEVANJE TELESNIH REZULTATOV PRI STAREJŠIH UPORABNIKIH HODULJ S KOLESI ZA ŠPORT IN PLES: ENOSKUPINSKA PILOTNA ŠTUDIJA O PLESNI INTERVENCIJI, KI TEMELJI NA VIDEOPOSNETKIH, Z VIZIJO INTEGRACIJE MEDKOMUNIKACIJSKE TEHNOLOGIJE PRI HODULJAH S KOLESI ZA PLESNO TERAPIJO

IZVLEČEK

V pričujoči pilotni študiji z eno skupino je bil raziskan učinek plesne intervencije na osnovi videoposnetkov na telesne rezultate pri starejših, ki uporabljajo športne in plesne hodulje s kolesi. Poleg tega so plesni videoposnetki, uporabljeni za intervencijo v pričujoči študiji, vgrajeni v prihodnjo medkomunikacijsko tehnologijo (IKT) za hodulje s kolesi za starejše. Trenutni cilj je oceniti telesne rezultate (kot so hoja, ravnotežje, mobilnost in moč prijema) vodene gibalne vadbe (ples) z uporabo video projekcije v laboratorijskem okolju. V pilotni študiji je sodelovalo šest starejših (85+) uporabnikov hodulj s kolesi. Pri začetni oceni smo pred testiranjem z uporabo testa korakanja v štirih kvadratih in z vprašalnikom SF36 preverili gibalne in koordinacijske omejitve udeležencev. Pred testiranjem in po njem smo preverili parametre gibljivosti, ravnotežja in časovnih ter dolžinskih spremenljivk hoje z uporabo časovno merjenega testa vstani in pojdi (TUG), Bergove lestvice za oceno ravnotežja (BBS) oziroma sistema Optogait. Hkrati smo z ročnim dinamometrom izmerili moč prijema in izvedli test spusta cevi za merjenje odzivnega časa. Poleg tega smo med plesno dejavnostjo vsakih 15 minut merili krvni tlak, da bi preprečili neželene dogodke in ohranili zgornji razpon 140–150/90–96. V tej pilotni študiji smo sodelovanje udeležencev merili na osnovi skupnega trajanja dejavnosti, kalorij, porabljenih na vsakem treningu, in stopnje opustitve. Po vsakem treningu pa smo za sodelujoče pripravili vprašalnik, da bi

preverili kvalitativne ocene anketirancev o stopnji izčrpanosti, užitku pri dejavnosti, ovirah, olajševalnih dejavnikih in potrebnih spremembah. Intervencija je vključevala spremljanje srčnega utripa, ki je pokazalo postopno in rahlo povečanje intenzivnosti srčnega utripa in postopno zmanjšanje razponov srčnega utripa (HRR) med plesnimi dejavnostmi. Rezultati kažejo izboljšano ravnotežje, mobilnost, hojo in stopnjo sodelovanja. Prihodnje longitudinalne raziskave bodo nadalje preučile učinkovitost plesne intervencije z uporabo IKT-hodulj s kolesi in jo primerjale s kontrolno skupino z običajnimi hoduljami s kolesi. IKT-hodulje s kolesi so lahko edinstveni pripomoček za rehabilitacijo starejših, ki omogoča tudi obetavne izboljšave.

***Ključne besede**: hodulja s kolesi z medkomunikacijsko tehnologijo, plesna intervencija, pregled področja uporabe, prihodnja longitudinalna študija, tehnološke intervencije na domu.*

INTRODUCTION

Physical rehabilitation is essential for the elderly, as age increases the risk of developing chronic diseases, exacerbates symptoms, decreases cardiovascular fitness, and limits physical mobility (Langhammer, Bergland, & Rydwik, 2018). Implementing comprehensive preventive measures, such as physical activity interventions, behavioral changes concerning physical activity, lifestyle modifications, and promoting a healthy lifestyle, significantly reduces the risks. This subsequently enhances the quality of life of older adults. The inclusion of physical activity in their daily lives has been demonstrated to improve rehabilitation results (Langhammer et al., 2018).

Furthermore, Xiong, Ye, Wang, and Zheng (2021) conducted a systematic review exploring the effects of physical activity on brain health, cognitive health, and motor abilities in the elderly. Their findings indicate that physical activity not only restores and maintains cognitive function and metabolic control, but also positively affects brain health by reducing the risk of dementia, depression, and stress. The findings from previous studies suggest that multimodal dance may also have positive effects on grey matter decline and the prevention of neurodegenerative diseases in the elderly (Müller et al., 2016). At the same time, a study discovered research has shown that a six-month sports dance intervention in seniors aged 63 to 80 years had a positive impact on structural brain changes, cognitive and motor performances, and the molecular mechanism of brain-derived neurotrophic factor (BDNF) (Rehfeld, 2015).

According to a study by Meulenberg et al. (2023), dance training holds promise for enhancing balance, mobility, and gait in Parkinson's patients. It suggests that dance therapies may improve quality of life and motor skills. However, further research is needed to fully understand and optimize the benefits of dance training for these populations. According to the above study, dance may be more advantageous than pure aerobic-physical interventions for healthy aging, because it combines physical activity with cognitive, coordination, and aerobic training in a social-emotional setting. Additionally, a meta-analysis by Yuan et al. (2022) revealed that dance enhances mobility and general fitness in older individuals with cognitive impairment.

Older adults with limited physical health are more likely to experience falls due to mobility limitations and balance deficits. Various dance interventions have been explored by the studies to improve mobility and balance in the elderly, including low-impact aerobic dance, dance-based aerobic exercise, Turkish folklore dance, ballroom dancing, contemporary dance, salsa dance training, and creative dance (De Oliveira et al., 2020). Research has shown the beneficial

effects of dance-based therapies, such as yoga, Pilates, tai chi, and aerobics (Nagano, Sparrow, & Begg, 2022), can be beneficial for improving balance and reducing falls in senior citizens. The evidence shows that dance interventions can significantly enhance balance and mobility in older adults, highlighting the need for structured dance intervention programs (Bahramian et al., 2023).

In the current pilot study, the elderly rollator users received the dance intervention utilizing a sport and dance rollator. This study incorporates social cognitive theory, which posits that group training sessions allow participants to learn through observation of their peers and the environment, thereby enhancing their self-efficacy and motivation to dance (Bandura, 1977). Over extended periods, this intervention may modify the behaviors of both elderly individuals with chronic conditions and healthy older adults, enhancing or maintaining their physical fitness (Bandura, 1977).

The current intervention is also based on flow theory by Chen and Tang (2023), which emphasizes complete immersion with no distractions, as dance with good music can facilitate the enjoyment and loss of self-consciousness. The dance intervention upholds clear objectives and provides immediate feedback based on blood pressure data, allowing elderly participants to relax through breathing exercises and modify their actions in real-time. Furthermore, the intervention maintains a balance between skill and challenge throughout the duration, tailoring the movements to the participants' fitness and fatigue levels.

Ammar et al. (2021) explored the use of digital technology to encourage physical activity and a healthy lifestyle among the elderly during pandemic-related confinement. This study discussed how digital tools and interventions could reduce the negative effects of isolation, support active lifestyles, and enhance mental well-being in elderly adults during physical limitations and reduced social interaction (Ammar et al., 2021). However, the elderly have low engagement in physical activity due to a lack of facilities, mobility issues, living arrangements, levels of education, and financial constraints. Additionally, numerous studies have also failed to consider the psychological status of the elderly during rehabilitation (Biering, 2019).

Furthermore, a preliminary scoping review conducted before the pilot study found no technology-based physical activity interventions that could provide mobility assistance during dancing. Very few inventions have focused on socialization for the elderly while performing physical activities with the aid of technology, and only a limited number of studies have provided high-quality feedback to users during activities. Research has shown that integrating technology into dance programs reduces the risk of falls and improves physical and cognitive functions in the elderly (Franco et al., 2020). According to research, both

conventional and technology-aided dance interventions provide safe means of improving gait, balance, and mobility in the elderly, thereby enhancing their quality-of-life. The dance intervention in the current study involves a warm-up that includes active mobilization exercises accompanied by music, followed by basic joint motions, dancing in patterns or circles, and dance moves that enhance lower limb strength, all delivered through videos.

The future goals of this pilot study are to provide psychological support through social inclusion platforms and opportunities for physical activity. The project also aims to combine interactive games, strength training, gait training, balance training, and guided movement dance training. The ICT-Rollator will assist and provide physical activity training programs, regardless of the participant's location. Therefore, the primary objective of the present pilot study is to assess the influence of interventional dance films on the participants' level of commitment and physical results (such as gait, balance, mobility, and hand grip strength) during guided movement training (dance), employing a projected video in a lab environment.

METHODS

Study Design and Participants

Otto von Guericke University Magdeburg, Germany, recruited elderly participants for this single-arm, lab-based study through a newspaper advertisement. Initially, six patients, five of whom were women and one man, all aged 85 or older, participated in the pilot trial. However, the participation of one subject was subsequently terminated for confidential reasons. The remaining five participants received intervention for five sessions and one extra group session. Due to the limited availability of rollators, two participants were simultaneously trained to ensure their care and safety while dancing.

The elderly subjects initially exhibited marked immobility and inactivity during four square-step tests, where all participants made considerable errors. Furthermore, the SF36 questionnaire also highlighted their initial low functional mobility levels. The elderly participants were notable for their low levels of mobility and activity. They came from a variety of backgrounds, reflecting a wide range of life experiences, medical histories, and activity levels. One participant had a history of stroke but had completely recovered ten years

before the start of the pilot study, which allowed for a thorough analysis of the intervention's effects.

Before and after the interventions, all 5 participants were tested and screened using the Timed Up-and-Go (TUG) test for mobility, the hand dynamometer for hand grip strength, the Berg Balance Scale (BBS) for balance, and the Barthel Index for quality of life.

Study Procedures

Figure 1: A) Optogait Measurement System; B) Hand Dynamometer; C) Polar; D) Sphygmomanometer; E) Test for Reaction Time

Figure 2: Intervention of Pre-Recorded Dance Videos Using a Projector

Preparation Phase: The participants provided their written consent. We granted the participants access to the Barthel Index after obtaining their consent, to assess their various histories of falls, surgeries, and strokes. The SF36 questionnaire and four-square step test were used as a pre-screening tool to understand functional mobility and coordination status.

Pre-testing Phase: The Pre-testing was conducted to assess the subjects' physical readiness for the dancing intervention and to gauge its effects from pre-testing to post-testing. The TUG test and the Optogait system were used during the pre-testing phase to analyze the mobility and spatiotemporal gait parameters. The TUG test is a validated tool for assessing mobility in elderly women aged 80-93 (Zarzeczny et al., 2017). The BBS, which is also validated for assessing balance in the elderly, was also fitted to analyze each elderly subject's balance during the pre-testing phase (Pereira, Maia, & Silva, 2013). Hand grip strength was measured using a hand dynamometer, and reaction time was measured using a pipe with measurements (Figure 1). Pre-testing and assessments of the physical capabilities of the elderly were done before the dance intervention.

Intervention Phase: The first session consisted of live dance sessions with simple steps. After each intervention session, a post-session questionnaire was administered to gather participants' qualitative evaluations of their degrees of

exhaustion, enjoyment, impediments, facilitators, and suggested changes. On the second day, the subjects received the dancing intervention using a projector and pre-recorded videos. These pre-recorded videos are intended to be integrated with the Rollator's intercommunication technology. The current study objective is to assess how pre-recorded, customized dance videos affect physical outcomes in the elderly.

During each session, the POLAR heart rate monitor was placed on the chest before the intervention began and will be taken off after the intervention. The purpose was to keep track of the participants' levels of activity during the entire intervention, as well as their minimum, average, and maximum heart rates. During all the dance intervention sessions, blood pressure was measured before, every 15 minutes during, and after the intervention to avoid adverse events and avoid training above the limit of 140-150/90-96 blood pressure. The video-based dance intervention was employed in the 2nd, 3rd, 4th, and 5th sessions (Figure 2). The final session consisted of a group dance session without videos, held in a sports hall to support participants' psychological well-being and reduce feelings of isolation.

Post-testing Phase: All tests administered during pre-testing were repeated during post-testing.

Intervention Duration: The intervention lasted four weeks. The senior rollator users were given sufficient recovery time between the two sessions per week. Each session lasted approximately one hour (60 minutes), with a 5-minute break every 15 minutes. Training was provided to two participants simultaneously.

Intervention Feasibility

The feasibility and utility of the intervention were evaluated based on the total duration of activity levels for each session recorded via POLAR. Additionally, the total number of calories burned throughout each session, and their minimum, average, and maximum heart rates were measured. The number of intervention dropouts was also assessed. Quality of life assessments were also carried out before and during the sessions. To ensure participants' safety and prevent falls, three supervisors were present, standing three meters from the seniors during each session. To avoid the high risk of falls and medical emergencies, blood pressure was monitored every 15 minutes.

Statistical Analysis

The pilot study involved a small sample size (N = 5). Descriptive statistics (mean and standard deviations) were used to visualize the HRR and average heart rate (AHR) intensities for all sessions. Given the small sample size and to prevent outliers in the data, medians were used to illustrate the differences between gait cycle time, BBS scores, gait speed, TUG test duration, stride length, and cadence from pre-testing to post-testing. No inferential statistics were conducted in the current pilot study.

RESULTS

The median and interquartile range (IQR) values for balance, mobility, and gait variables are presented in Figure 5 and Table 2. The BBS scores increased from a median of 34 (IQR 20) pre-testing to a median of 41 (IQR 33) post-testing. Similarly, the time taken for the TUG test decreased significantly, from a median of a median of 47 (IQR 15.375) to a median of 19.29 (IQR 7.28). Gait speed increased from a median of 0.385 (IQR 0.3725) to a median of 0.695 (IQR 0.115), while cadence improved from a median of 41.005 (IQR 57.0725) to a median of 100.67 (IQR 37.7375). The median and IQR values show mobility, balance, and gait improvements in the current pilot study.

Figures 3 and 4 show the comparison of HRR and AHR intensities across five training sessions. Table 1 presents the mean and standard deviations of fluctuations in HRR and heart rate intensity for all five sessions.

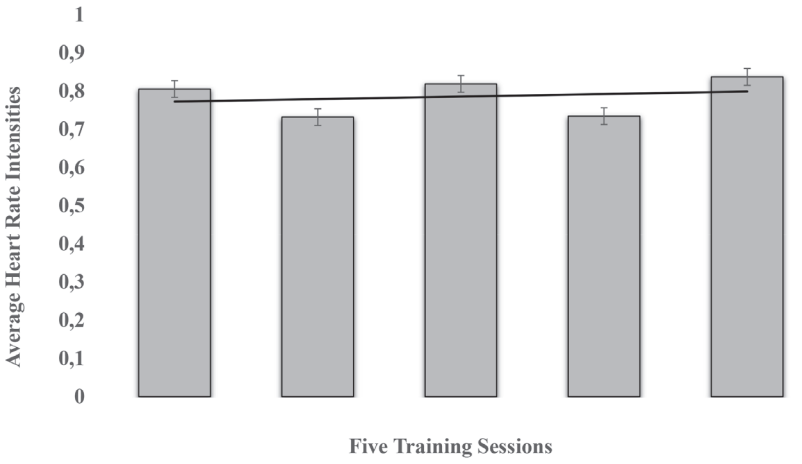

Figure 3: Comparison of Average Heart Rate Ranges (HRR) Between the Five Training Sessions

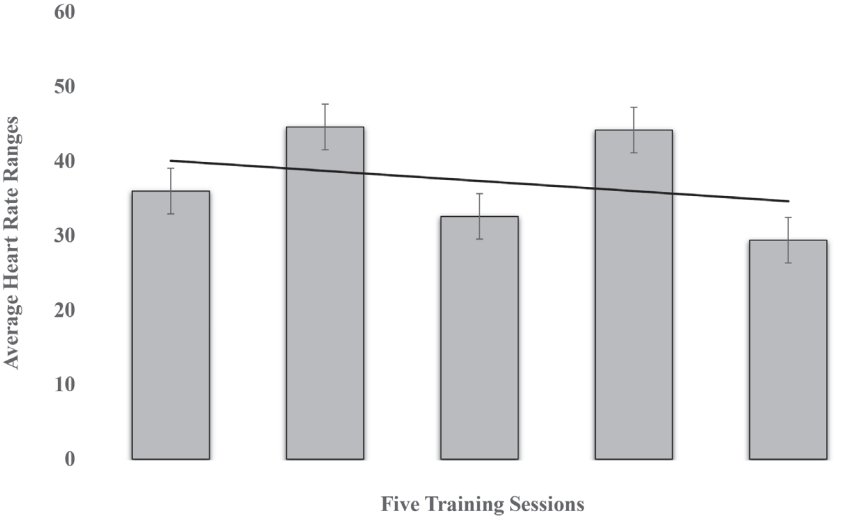

Figure 4: Comparison of Average Heart Rate (AHR) Intensities Between the Five Training Sessions

Table 1. Mean and Standard Deviation of HRR and Heart Rate Intensities:

Number of Sessions	Heart Rate Range		Heart Rate Intensity	
	Mean	SD	Mean	SD
Session1	36	12.24	0.80	0.05
Session 2	44.6	13.64	0.73	0.10
Session 3	32.6	11.09	0.81	0.07
Session 4	44.2	12.72	0.73	0.11
Session 5	29.4	10.50	0.84	0.06

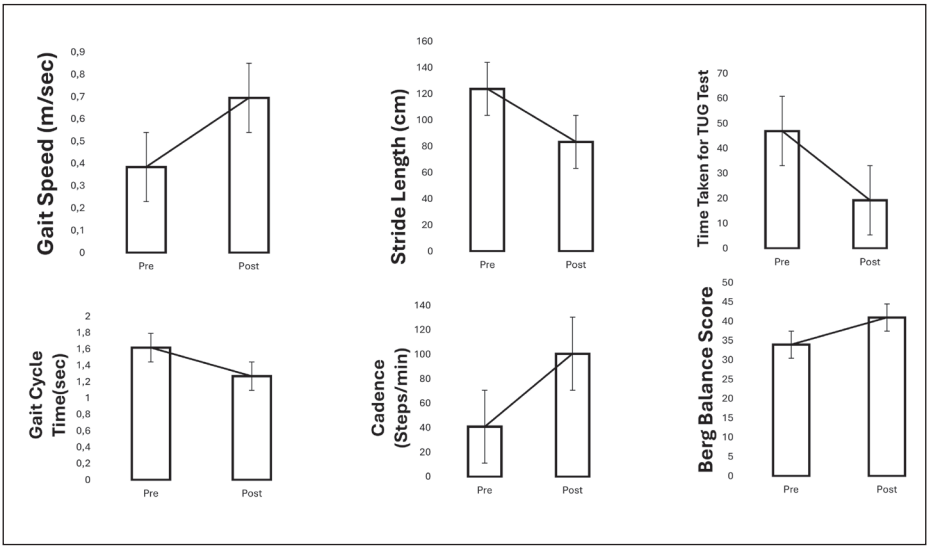

Figure 5: Median differences in BBS, Time taken for TUG test, and Gait variables

Table 2: Median and Interquartile Ranges of Gait Variables, BBS, and Time taken for the TUG Test

Variables	Pre-Testing		Post-Testing	
	Median	Interquartile range	Median	Interquartile range
Berg Balance Scale Score	34	20	41	33
Timed-Up-and-Go Test (sec)	47	15.375	19.29	7.28
Gait Cycle Time (sec)	1.618	1.78825	1.2695	0.61525
Stride Length (cm)	123.8	55.075	83.45	23.4
Gait Speed (m/sec)	0.385	0.3725	0.695	0.115
Cadence (steps/min)	41.005	57.0725	100.67	37.7375

DISCUSSION

The current pilot study focused on evaluating the physical outcomes of elderly individuals after a dance video intervention supported by a dance rollator in a laboratory setting. The results show improvements in mobility, balance, and gait, as assessed using the Timed Up-and-Go (TUG) test for mobility, the Berg Balance Scale (BBS) for balance, and Optogait system for measurement of spatial-temporal parameters of gait before and after the intervention. Previous studies have shown improved mobility in the elderly after dance interventions, assessed through the TUG test. The TUG test is a valuable tool for measuring mobility with high participant attendance rates, supported by a study by Klotzbier, Korbus, Johnen, and Schott (2021). Balance, gait symmetry, and dual-task performance improved after dance intervention assessed by the TUG test in populations with specific health problems (Fontanesi & DeSouza, 2021). Additionally, dance training has been found to improve spatiotemporal gait parameters, balance, and TUG test performance in adults with neurological conditions (Patterson, Wong, Prout, & Brooks, 2018). At the same time, research considering the elderly with Parkinson's disease has shown a positive impact on functional mobility and gait parameters after modified dance intervention (Delabary et al., 2020). Consistent with previous research, our study observed

improvements in mobility and reduced variability according to interquartile ranges from pre-testing to post-testing (Figure 5; Table 2). Notably, during screening before the intervention, all participants exhibited maximum errors (>5) when tested on the four-square-step test. Therefore, the TUG test is a valuable tool for evaluating functional mobility in the elderly.

In the current study, BBS scores improved from pre-testing to post-testing and the variability of scores within the dataset widened. This indicates a broader range of performance among the subjects and explains diverse responses from pre-testing to post-testing. Confirming the results from the current study, previous studies found that Cha-Cha dance training significantly enhanced balance ability in healthy elderly individuals (Li et al., 2022). The qualitative survey conducted after the intervention found that respondents reported feeling more stable when performing domestic tasks, consistent with the improvement in the BBS score from pre-testing to post-testing (Figure 5; Table 2). The enhanced balance performance corroborates findings from earlier studies, suggesting that the dance intervention can effectively improve the balance in the elderly (Hiyamizu, Morioka, Shomoto, & Shimada, 2011). Studies by Pereira et al. (2019) and Moratelli et al. (2022) highlight the benefits of dance for Parkinson's disease, showing improvements in gait and endorsing dance as one of the therapeutic interventions for gait in the elderly. Similarly, our active trial study showed that gait cycle time and stride length decreased. Moreover, gait speed and cadence increased (Figure 5). This is possibly due to enhanced speed and better balance (Hak, Houdijk, Beek, & Van Dieën, 2013).

The video-based dance interventions produced positive results for balance and mobility in the elderly rollator user population. Overall, the synthesis of these studies suggests that video-based dance interventions can be a promising approach to enhancing balance in the elderly population. These can be achieved through cognitive-motor training, rhythmic auditory cueing, and engaging in dance activities through video games. Such interventions can potentially improve balance, mobility, and gait parameters in elderly rollator users. contributing to overall well-being and reducing the risk of falls in the elderly.

Furthermore, study research on older women has shown improved better heart rate variability and the cardiac autonomic modulation responses after engaging in a dance protocol, indicating a potential increase in heart rate intensity (Pires et al., 2021). Similarly, waltz dancing has been linked to improved exercise capacity correlating with heart rate changes in heart failure patients (Belardinelli, Lacalaprice, Ventrella, Volpe, & Faccenda, 2008). In the ongoing preliminary study, the HRR gradually decreased (Figure 3; Table 1), and heart rate intensities slightly increased during the five sessions of dance intervention

(Table 1, Figure 4). In the first, second, and third sessions, there is an increased AHR intensity, which may be because participants are gradually pushing themselves harder (Figure 4), and there is a decrease in HRR due to improved movement control (Figure 3). Conversely, the average heart rate intensity in the second and fourth sessions gradually reduced, perhaps due to the participants' interspersed times of lower-intensity movement or rest between routines. Additionally, a wider range of heart rate responses during the second and fourth sessions may signify that participants were engaged in more dynamic and diverse movements. Several dance movements were introduced in the second and fourth sessions. The fact that the participants' AHR either stayed the same or went down slightly across all the sessions shows that they may be adapted to the dancing motions and increased their cardiovascular efficiency. These results indicate that a well-planned dance intervention that includes recovery, variety-oriented, high-intensity, and low-intensity portions can benefit the body's general conditioning and cardiovascular fitness.

The present study had high adherence rates as there were no dropouts and all the subjects attended all five sessions, except for the one dropout before pre-testing. Hand grip strength showed no noticeable difference, likely due to the nature of the dance intervention involving a dance rollator, which the participants used for support throughout the session. This restriction in upper body movement may have limited the impact on hand grip strength and reaction time. While there is substantial research on the benefits of dance interventions for improving balance and mobility in the elderly, further studies should focus on examining heart rate variables during dance training and the effects on gait parameters before and after the intervention in elderly rollator users. Moreover, future studies should explore exercise intervention plans with or without the use of technology to improve upper body strength and activity in elderly rollator users.

Future Study

In future research, a longitudinal study will compare dance and physical rehabilitation training over six months using an ICT-Rollator versus a control group using a standard rollator (Figure 6). Both groups will undergo the same pre-testing and post-testing questionnaires as used in the pilot study. The length of training will be recorded for the control group and the intervention group, and will be uploaded to the ICT-Rollator server. The intervention group will have access to a social inclusion platform, guided movements, fall prevention sensors, and feedback. During the sessions, both visible and audible cues will be provided.

Figure 6: Initial Digitalized Version of Sport and Dance Rollator

Limitations

The analysis in this study is limited to descriptive statistics due to the small sample size. The POLAR values, which also consider heart rate measurements taken during intersession breaks, may have affected the results. Additionally, because of the elderly participants' low fitness levels, the pre-testing conducted without support resulted in very minimal measurement errors for gait testing. Furthermore, the results are preliminary, as the study has a small sample size and limited generalizability, which may impact the conclusions.

CONCLUSION

The ICT-Rollator holds promise as a beneficial tool for the elderly to use for physical activity in every living setting, providing support and protection. It helps prevent falls using fall detection sensors, guides movement with visual and audible cues, and assists in mobility by maintaining an upright posture while moving around. The integration of customized dance videos with the ICT-Rollator in future studies is expected to further improve balance, mobility, and gait. There is a need to conduct a longitudinal study with a larger sample, a control group, and a specific dance intervention program for the elderly with different health conditions. The pilot study demonstrated excellent adherence rates, with no dropouts and all participants completed five training sessions, with no adverse events or reported falls occurring during the pilot study sessions using a sport and dance rollator.

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