Chapter

Robot Therapy Program for Patients with Dementia: Its Framework and Effectiveness

Kyoko Osaka, Ryuichi Tanioka, Feni Betriana, Tetsuya Tanioka, Yoshihiro Kai and Rozzano C. Locsin

Abstract

Robot therapy uses humanoid and animal-like robots. The robot therapy for older adults is expected to affect the therapeutic goals, including physical condition, cognitive function, and provide joy. By interaction with humanoid or animal-like robot, the older adults who are not physically active may have the improvement of their physical condition, such as hugging, stroking, talking with them, and participating in any activity involving the robot. The typical examples show that animal therapy has almost the same effectiveness as robot therapy among older people. It is clarified that robot therapy can be expected to have a healing effect on patients, improve motivation for activity, and increase the amount of activity, like animal therapy. Furthermore, it was essential to consider the intermediary role of nurses for connecting the robot and older adults and their role, even if the robot is not sophisticated enough to be useful as a humanoid nurse robot for rehabilitation and dialogue with older adults. Thus, robot therapy could be considered another important intervention in the challenging health and innovative care practices needed in the care of older persons. This chapter explains the robot therapy program for patients with dementia from the viewpoint of its framework and effectiveness.

Keywords: robot therapy, animal therapy, older adults, dementia, intermediary role

1. Introduction

In Japan, the number of older adults requiring medical and nursing care is increasing, constituting a super-aged society [1]. This trend is exacerbated by the decrease in the active working population and is accompanied by a declining birth rate [2]. This situation in Japan and other countries, including for current and future rehabilitation services, increases the demand for nursing care of older adults. With that as a result, nursing staff shortages are becoming more serious [3, 4]. Therefore, it is necessary to bridge the gap between human resources and demand for services in health care. In addition, the number of patients with dementia is also increasing especially among the older adult population who need more engaged medical and nursing care [5].

There are plenty of reports on the benefits of animal therapy, which began in the USA in the 1970s [6]. One study conducted in patient with schizophrenia found that showed cortisol level was significantly reduced after participating in an animal assisted therapy session, which could indicate that interaction with the therapy dogs reduced stress [7]. Another study reported that measuring actigraphy increased sleep duration (min) when visitors were accompanied by a dog rather than the robot seal or soft toy cat [8]. Another study reported that animal therapy is associated with decreased impulsivity, aggression, and anxiety, and increased sociability [9].

Meanwhile, several studies have suggested that the robots used in robot therapy can improve the cognitive level and reduce the Behavioral and Psychological Symptoms of Dementia (BPSD) in patients [10, 11]. However, none of the studies have tested the robots on a large sample, meaning that their findings have limited generalizability [12]. Yokoyama reported the caregiver must play an intermediary role during robot therapy for older people with dementia [13]. For such therapy to be effective, it must be evaluated from the perspective of the user (an older adult with dementia) and the caregiver (a nurse or other professional caregiver).

Osaka and other studies [14–16] analysed Heart Rate Variability (HRV) and accelerometer data in two-second increments and showed real-time results. As such, changes in autonomic activity and the intensity of physical exercise could be determined during the implementation of robot therapy. This device sensor was designed to be small size and thus carry only minimal burden for older persons. Another advantage was that it could transmit data to a computer wirelessly, allowing the tested subjects to move freely. It is also possible for an observer to supplement the data by recording through the participant observation of the relationship between the older person and the caregiver during the intervention.

Limited study on robot therapy in older adults with dementia has assessed the intervention objectively and comprehensively by using participant observation and HRV and accelerometer data. The study by Osaka et al. [14] is valuable in that it provides objective data to those involved in caring for older adults with dementia (caregivers and health care professionals involved in rehabilitation), thereby allowing them to review their interventional approaches in relation to standard. Moreover, if it can be demonstrated that low-cost robot therapy is effective, then the study will offer valuable data for developing policies on cost-effective robotics in dementia care.

This chapter explains the robot therapy program for patients with dementia from the viewpoint of its framework and effectiveness.

2. Definition of terms

2.1 Animal therapy

The American Veterinary Medical Association (AVMA) defined Animal Assisted Therapy (AAT) as one of the Animal Assisted Intervention (AAI) [17]. There are various animals are used for AAT, such as canines, felines, and equines, depending on purpose of treatment, but the most frequently used animal for AAT is the dog [18]. The AAI for older people can be expected to have the effect of suppressing the decline in cognitive functions and improving the peripheral symptoms (depression, agitation, aggression) and insomnia associated with dementia [10].

2.2 Robot therapy

The number of robot therapy articles for rehabilitation or recreation that include communication is increasing. Considering the entity of a care robot, several definitions are recently offered [19]. However, there is no consensus about their findings. The devices and applications in those studies have yet to be integrated into widespread clinical use [20]. Robot therapy functions include providing therapy, educate, enable communication, and so on [21]. A pilot study showed that by interacting with Paro, a seal-like robot, the communication and interaction skills, and activity participation of older people improved [22]. Another study reported that the use of Paro is associated with improvement in emotional state and social interaction and reduce the challenging behaviours among older people [23]. Research showed that robot therapy has the same effect on people as animal therapy [21]. The effects of robot therapy and animal therapy influence the physical, cognitive, and mental conditions of the users, especially the older people.

3. Theoretical framework

The Model for the intermediary Role of nurses in Transactive relationships with Healthcare robots (MIRTH©) [24] explains the engagement processes that are characteristic activities of older adults with dementia, the nurse as mediator, and the communication robot (**Figure 1**). Healthcare robots' function in transactive relationships among patients and nurses. The nurses' role as intermediaries is integral to facilitating the interaction between these robots and the older adult patients who are in transactive relationships. The effects of the intermediary role are especially prominent with low-fidelity robots in use today. The functional abilities of the nurse as intermediary include knowledge of advancing technologies regarding robots that foster quality care.

Nurses as intermediaries should: (1) have an accurate awareness of each of the functions of robot performance and the usefulness of each function relevant to patient care situations; (2) create relationships with healthcare robots so that they can promote the health and safety of older adults while increasing their enjoyment through physical and social activities; and (3) seek safe, secure, and competent ways to facilitate using healthcare robots for healthcare. In essence, intermediaries

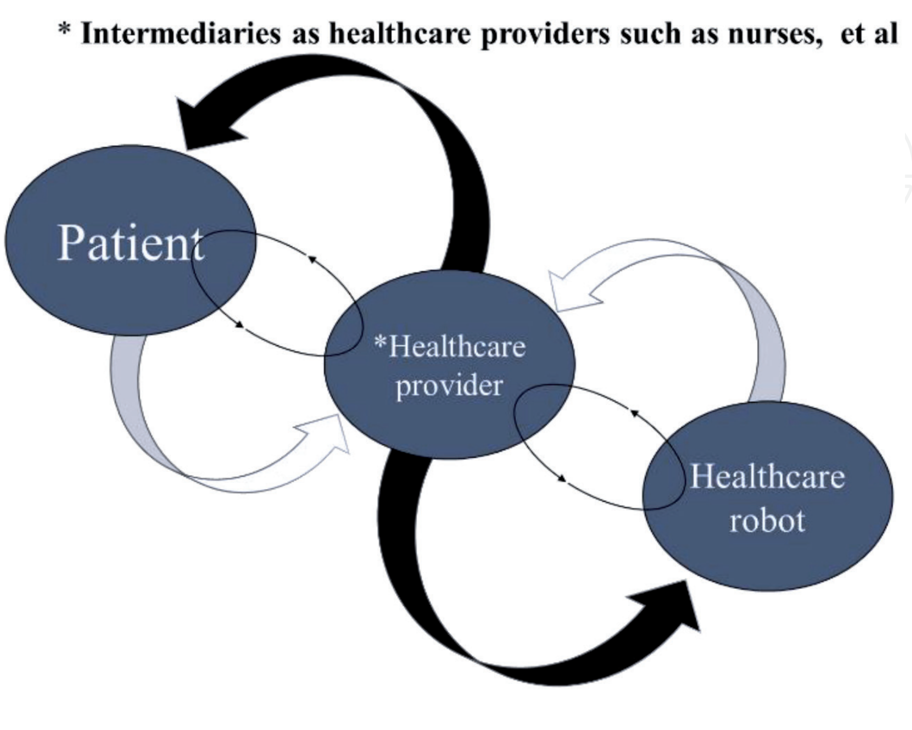

Figure 1.
Illustration of MIRTH©.

should prepare the environment for using healthcare robots. In doing so older adults can use healthcare robots for complicated operations, with the nurse as intermediary monitoring the effective use of robots and identifying clinical problems while working with healthcare institutions to address preventable healthcare problems.

The MIRTH© model has five assumptions:

It is the responsibility of nurses as professionals to practice nursing grounded in discipline-related knowledge of nursing. The most important attribute in nursing is the relationship expressed as caring. Robot performance requires an intermediary for their effective and safe use [14, 15]. This assumption expresses the importance of the functions of intermediaries in robot-human situations. The intermediary is inextricably linked with the patient and the healthcare robot;

- Robots are used for rehabilitation, recreation, and caring of older adults [16]. This assumption describes the variety of functions of robots specifically for older persons;

- High-quality care with robot-human relationship is guided by ethical and moral standards of nursing [25]. With human beings as patients and robots as integral to human health care, this relationship must be linked with considerations of beneficial effects founded on justice and goodness;

- Technologies of health and nursing are elements for caring [26].

- The utility of advancing technologies founded on competent expressions of caring provides opportunities for innovating human caring practices;

- Nursing is both a discipline and a profession [27].

It is the responsibility of nurses as professionals to practice nursing grounded in discipline-related knowledge of nursing. The interactive engagement, the lived experience of the caring between patients and nurses, gives meaning to the nursing relationship, the most important attribute in Nursing.

Framework for robot therapy program.

It has been reported that therapies using animals have a healing effect on patients and an improvement in motivation for performing activities [28, 29]. Park et al. performed a meta-analysis on animal assisted and pet robot interventions which suggested that AAI and Pet Robot Intervention (PRI) significantly reduce depression in patients with dementia. It report, nine studies were analysed and seven of them showed confirming results. The outcome measurements used scales such as functional tests and depression scales. In the two studies, pulse oximetry, pulse rate or galvanic skin response (GSR) (electric skin response) were combined and evaluated as physiological indicators [10].

Intervention therapies using animals for hospitalized patients is not uncommon. Studies by Osaka and others [14–16] suggest that robot therapy is expected to have a more healing effect on patients and improve motivation for activities for older people by using an expensive humanoid robot such as Pepper from an inexpensive communication robot.

Figure 2 shows the framework of the effectiveness using robot therapy by Osaka. Robot therapy uses humanoid and animal-like robots. The robot therapy is expected to affect the therapeutic goals, including physical effect (e.g., relaxation, motivation), physiological effect (e.g., improvement of vital signs), and social effect (e.g., stimulation of communication among inpatients and caregivers) [30].

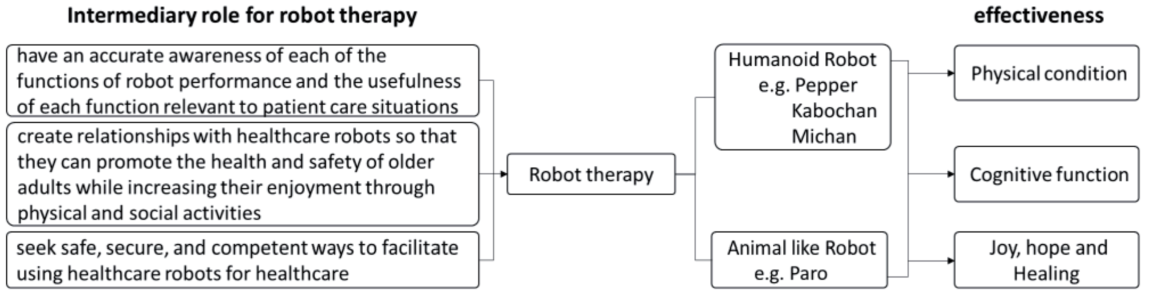

Figure 2.
The framework for robot therapy program.

By interaction with humanoid or animal-like robot, the older adults who are not physically active may have the improvement of their physical condition [31], such as hugging and stroking them, talking with them, and participating in any activity involving the robot.

The intermediary role of the nurse involves mediating and connecting patients with robots. It also involves a focus on ethical and moral issues inherent in nursing situations that include activities by healthcare robots [25]. Specifically, the intermediary person was in charge of connecting the subject with the robot. An intermediary can support older persons to interact well with the robot according to their physical condition. Also, they can provide joy for older adults when interacting with the robot, and among other persons. Moreover, in this interaction, the cognitive function of older persons with dementia may improve as they are able to communicate or have a conversation with robots [32]. Thus, intermediary can ask older adults if they are having fun, and if they feel like they have a companion in their daily life.

In Japan, various robots are produced and introduced for robot therapy in hospitals and other health care facilities. However, the performance and functions of these robots are often of lesser fidelity and functionality than expected by some facilities, thereby preventing their continued use after the initial introduction [33, 34]. The dialogue between healthcare robots and older adults was difficult without an intermediary role because of the difficulty for older adults to understand the robot because of the speed of its speech and tone of vocalization [15]. Oftentimes, because of this robot inefficiency, it is essential to consider instituting the intermediary role of nurses to engage the robot with the older adults. This nurses' role can enhance utility and instigate efficiency even if the robot is not sophisticated enough to be useful for rehabilitation and dialogue with older adults.

4. Method

4.1 Subjects of the study

The subjects of the study were two female older persons who were diagnosed with dementia using the Hasegawa's Dementia Scale-Revised (HDS-R) [35] instrument. Both were in their 80s and met the following inclusion criterion (diagnosed with dementia with a certain score): the HDS-R between the score range of 3-20 points. Exclusion criteria included older people who could not communicate verbally, those who could not interact with dogs and small stuffed toy robots, those who could not wear a portable electrocardiogram, and those who could not consent from their families.

- Subject A received the animal therapy intervention. She was in her 80's and diagnosed with dementia with a HDS-R score of 8 points.

- Subject B received the robot therapy. She was in her 80's and diagnosed with dementia with a HDS-R score of 10 points.

Data collection occurred on a single day, in a single observation period for each person; data collection for animal therapy was on October 10, 2017, and for robot therapy was October 25, 2019.

4.2 Hypothesis

As a prediction of the data comparison results, both animal therapy and robot therapy have the same effect on the physical, mental, and cognitive functions of the older person. Each subject data was extracted from animal and robot therapy, and both effects were compared. Data extraction methods were indicated in **Figures 3** and **4**.

4.3 Ethical consideration

The data collection procedure was performed following the Private Information Protection Law, with approval from the Tokushima University Hospital Ethics Board (approval number 2039) and Mifune Hospital (approval number 20170201-1). The purpose and methods used in the study were explained to all subjects and their guardians. Subjects were assured that their personal information would be protected and would only be used for research purposes, and that anonymity would be maintained in the report.

4.4 Data extraction method

4.4.1 Animal therapy protocol

As described below, a total of 5 minutes of data was extracted before, during, and after the therapy (**Figure 3**). In the animal therapy, the subject was an older person with dementia who was admitted to the facility. Animal therapy was performed by a therapist after music therapy. The animal used was a dog.

4.4.2 Robot therapy protocol

As described below, robot therapy was set to a total of 5 minutes of data before, during, and after the therapy. However, due to data collection constraints, it could not obtain data for 5 minutes during and after the therapy (**Figure 4**). In the robot therapy procedure, the subject was an older person with dementia. The robots used were Kabo-chan (W23×H28×H28 (sitting high), weight 680g) and Mi-chan (W25×D20×H 30 (sitting high) 30cm, weight 390g). These robots can talk, sing, and slightly nod charmingly in response to touch and spoken words. These robots have sensors that are installed in the mouth, head, hands, feet, and main body. These sensors allow the robots to verbally respond to any sounds and movements.

4.5 Procedure of data analysis

4.5.1 Analysis of autonomic nervous activity

Heart Rate Variability (HRV) data were assessed at various frequency bands using an HRV software tool (MemCalc/Bonaly Light: GMS, Tokyo, Japan).

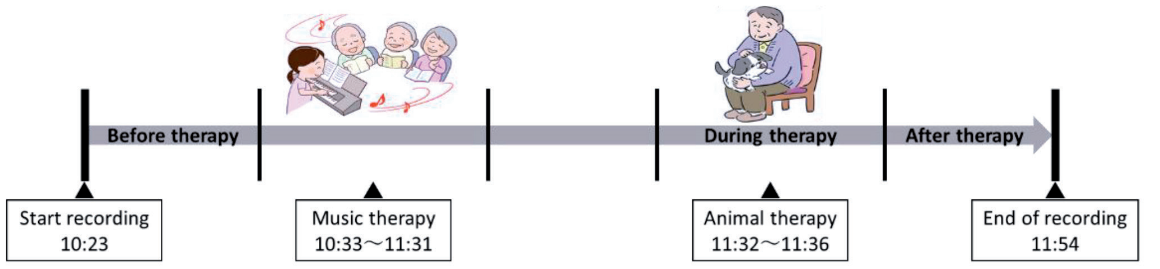

Figure 3.
Animal therapy protocol. Animal therapy data extraction method. Before therapy 10:24:00 ~ 10:28:58 (5 minutes in total); During therapy 11:32:00 ~ 11:36:58 (5 minutes in total); After therapy 11:37:00 ~ 11:41:58 (5 minutes in total). As described above, a total of 5 minutes of data was extracted before, during, and after the therapy.

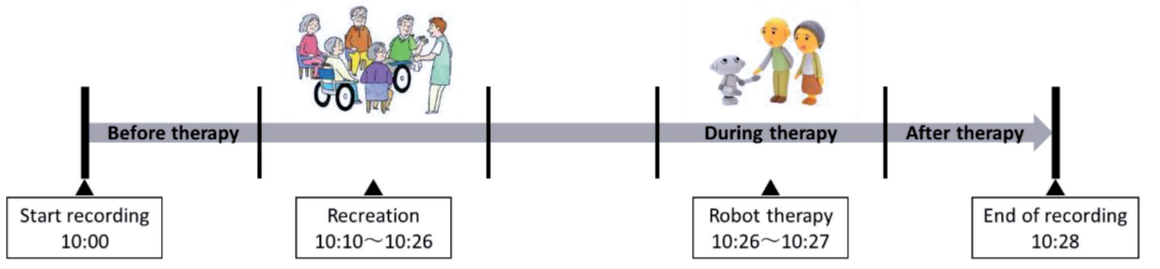

Figure 4.
Robot therapy protocol. Robot therapy data extraction method. Before therapy 10:05:00 ~ 10:09:58 (5 minutes in total); During therapy 10:26:16 ~ 10:27:58 (1 minute 41 seconds in total); After therapy 10:27:58 ~ 10:28:40 (42 seconds in total). As described above, it was set to extract a total of 5 minutes of data before, during, and after the therapy. However, due to data constraints, data during and after the therapy was less than 5 minutes. The measurement time was sometimes short because the measurement was performed according to the procedure of robot therapy in the clinical setting. In addition, an artifact was included in the electrocardiogram due to the subject's movements, so it was not possible to obtain all the data for 5 minutes. This was the limitation of this clinical study.

The low frequency (LF) and high frequency (HF) bands in heart rate variability (HRV) reflect sympathetic and parasympathetic nervous systems which is commonly accepted as the activities of the autonomic nervous system [36, 37]. In a continuously recorded data, inter-beat (R-R) intervals were obtained for a 1-min segment using the maximum entropy method. In this study, the two major spectral components of HRV, the variances of the Low-Frequency (LF: 0.04 - 0.15 Hz) band and High-Frequency (HF: 0.15 - 0.4 Hz) band, were calculated. The HF data can be used as an index of parasympathetic nervous activity, and the LF/HF ratio can be used as an index of sympathetic nervous activity.

An optimal level of variability within an organism's key regulatory systems is critical to the inherent flexibility and adaptability or resilience that epitomizes healthy functioning and well-being [38]. HRV is the change in the time intervals between adjacent heartbeats. It is an emergent property of interdependent regulatory systems that operate on different time scales to adapt to environmental and psychological challenges. The heart's rhythms are characterized as reflecting both physiological and psychological functional status of internal self-regulatory systems. Lowered parasympathetic activity, rather than reduced sympathetic functioning appears to account for the reduced HRV in aging [39]. This can be observed when persons engage in meeting a challenge that requires effort and increased sympathetic activation. Alternatively, it can indicate increased parasympathetic activity as occurs during slow breathing [40]. With psychological regulation, lower HF power is associated with stress, panic, anxiety, or worry [41].

In this study, the use of HRV was critical in measuring the psychological functional status and emotional experience of older persons particularly those

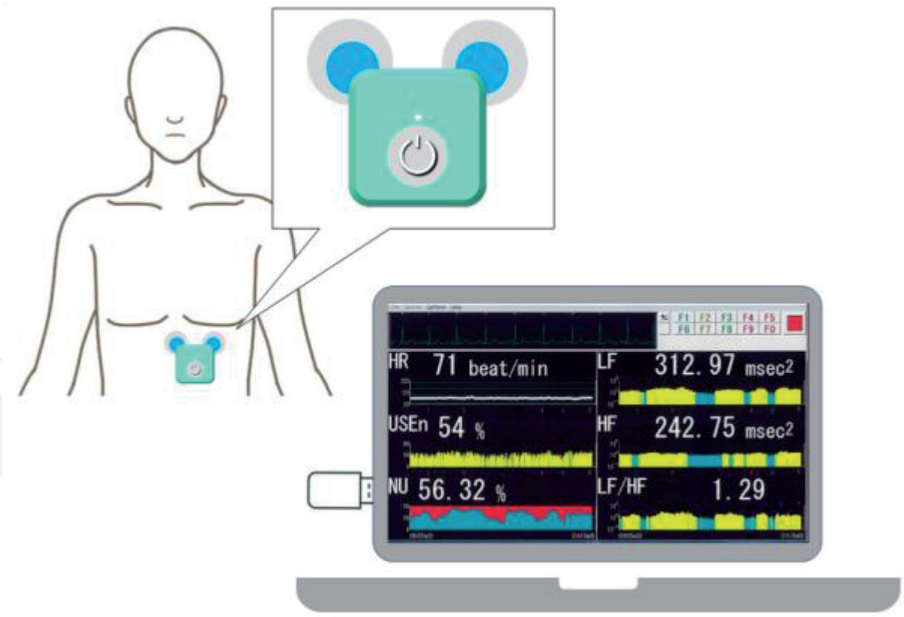

Figure 5.
Heart Rate Variability (HRV) data were assessed at various frequency bands using an HRV software tool (MemCalc/Bonaly Light: GMS, Tokyo, Japan).

with dementia. Changes in autonomic nervous activity were determined using HRV. Heart Rate (HR) -mean, HF, LF/HF, NU % (ratio of sympathetic nerve components), and body movement (acceleration) are shown in the graph, it shows the relationship between subjects' interaction with dog or robot doll during intervention. The results were recorded graphically, enabling visual assessments and measurements (**Figure 5**).

5. Typical examples and discussions

5.1 Comparison of animal therapy and robot therapy using the HRV and accelerometer as biological responses of older persons with dementia

5.1.1 Animal therapy

5.1.1.1 The experimental data before the animal therapy

The data were visually recorded enabling graphic visual assessments and measurements. The analysis of the HRV allowed the evaluation of autonomic nervous function.

After the movement of the dog (animal) trunk, the sympathetic nerve recordings became predominant. Afterwards, it was the parasympathetic nerve that became predominant. Changes in autonomic nervous activity can be confirmed from the data recorded in the accelerometer and the results of heart rate variability analysis as the body moves (**Figure 6**).

5.1.1.2 The experimental data during the animal therapy

Subject A's HRV data showed sympathetic nerve predominance after touching the dog, after which it showed a sympathetic nerve predominance. Before touching the dog for the second time, the pulse rate decreased, and the parasympathetic nerve became predominant. By interacting with the dog, fluctuations in heart rate were observed,

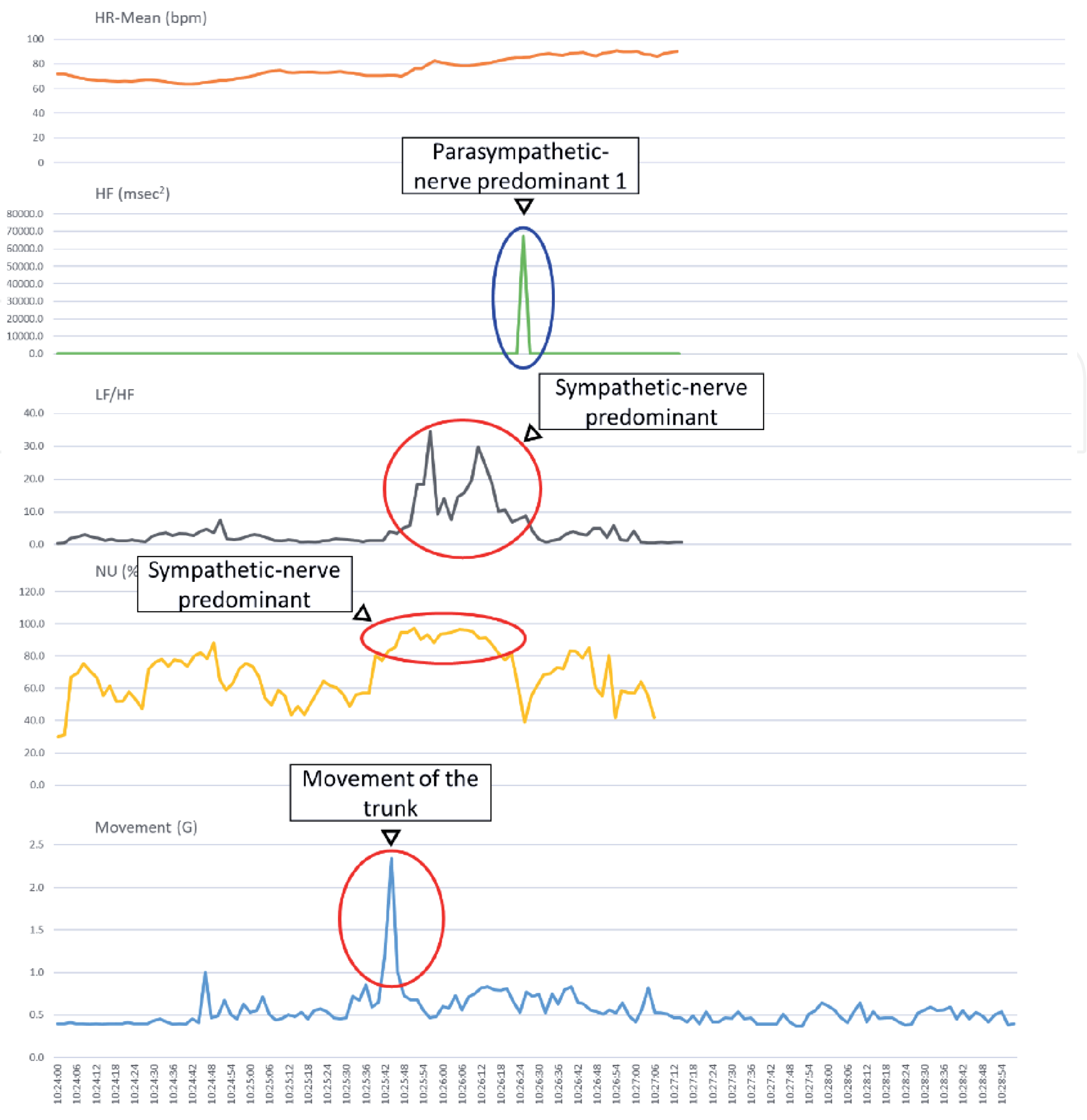

Figure 6.
The experimental data before the animal therapy (Subject A). Note: HR-mean; Heart Rate mean, HF; High Frequency, LF/HF; Low Frequency / High Frequency, NU; Normalized Unit, Movement; the body movement. The unit of vertical axis. HR-Mean; Beat/min, HF; msec2, LF/HF; Nothing, NU (%), Movement; G. The unit of horizontal axis; hour: min: second.

and a balance between sympathetic and parasympathetic nerve activities was observed. Therefore, it was considered that effective stimulation could be provided by contact between the subject and subject A through interaction with the dog (**Figure 7**).

5.1.2 Robot therapy Data

5.1.2.1 The experimental data before robot therapy

Figure 8 shows the alternating sympathetic and parasympathetic activities before the robot therapy.

5.1.2.2 The experimental data during the robot therapy

After holding the robot, it was observed that the parasympathetic nerve activity became predominant, and then subsequently, the sympathetic nerve became predominant. In addition, after holding the robot for the second time, the parasympathetic nerve became predominant.

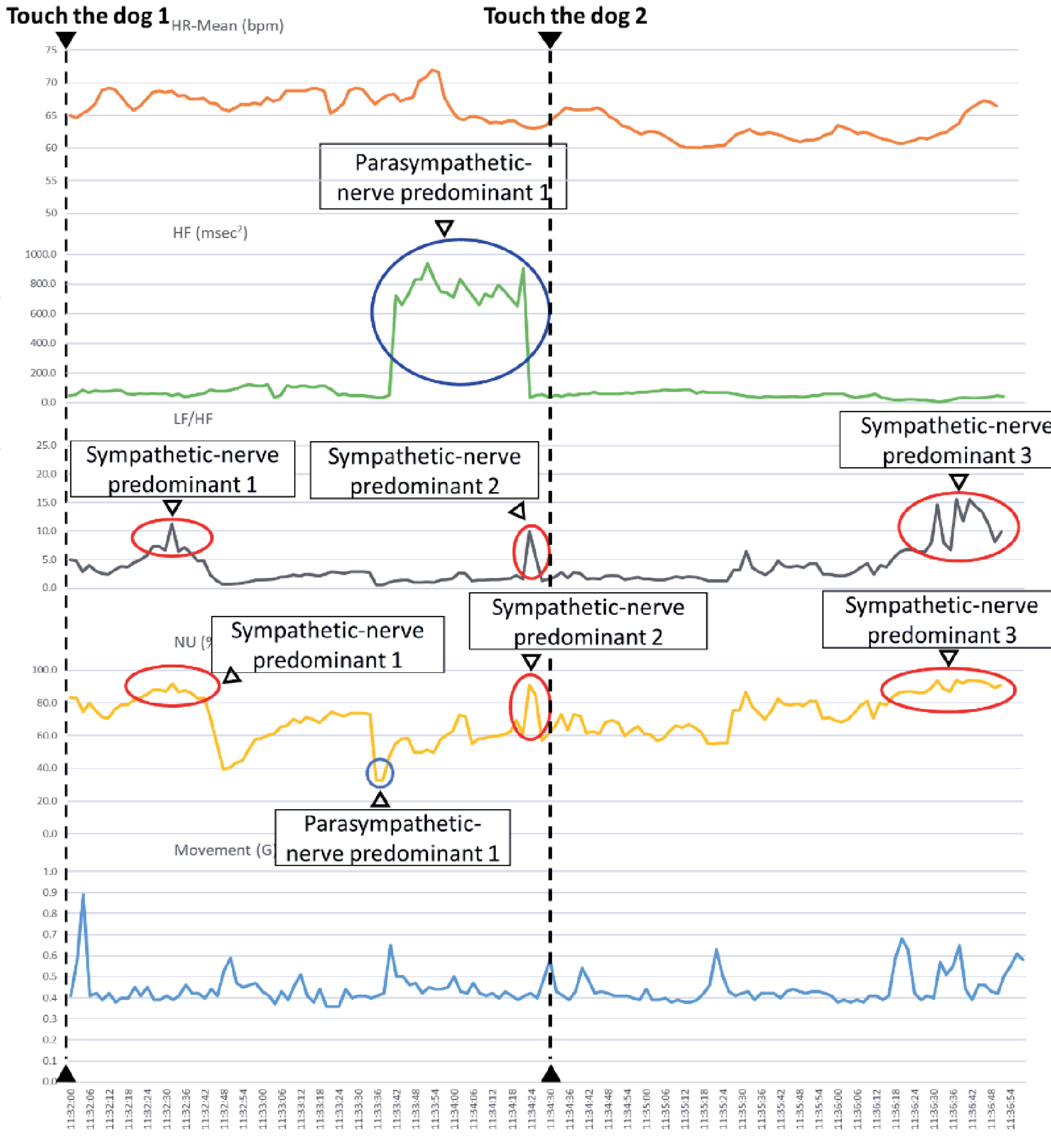

Figure 7.
The experimental data during animal therapy (Subject A).

Sympathetic nerve activity was predominant before the start of the therapy. However, during the therapy, the sympathetic nerve activity predominance continued immediately after holding the robot was observed. Autonomic nervous activity was stable at the end of the therapy (**Figure 9**).

5.1.2.3 Comparison of the interactions between older people with dementia and their caregivers during animal therapy and during robot therapy

In both animal therapy and robot therapy, stable heart rate and body movements were confirmed in all processes before, during, and after therapy. These were during the awake state, and the awakening could be confirmed visually by participant observation and recorded video data.

In the animal therapy, the LF/HF value was high even before the start of therapy, and the predominance of sympathetic nerve activity was confirmed. During the therapy, the LF/HF value increased immediately after the first touch of the dog, immediately before the second touch of the dog, and immediately after the touch. These activities confirmed that the sympathetic nerve activities were dominant.

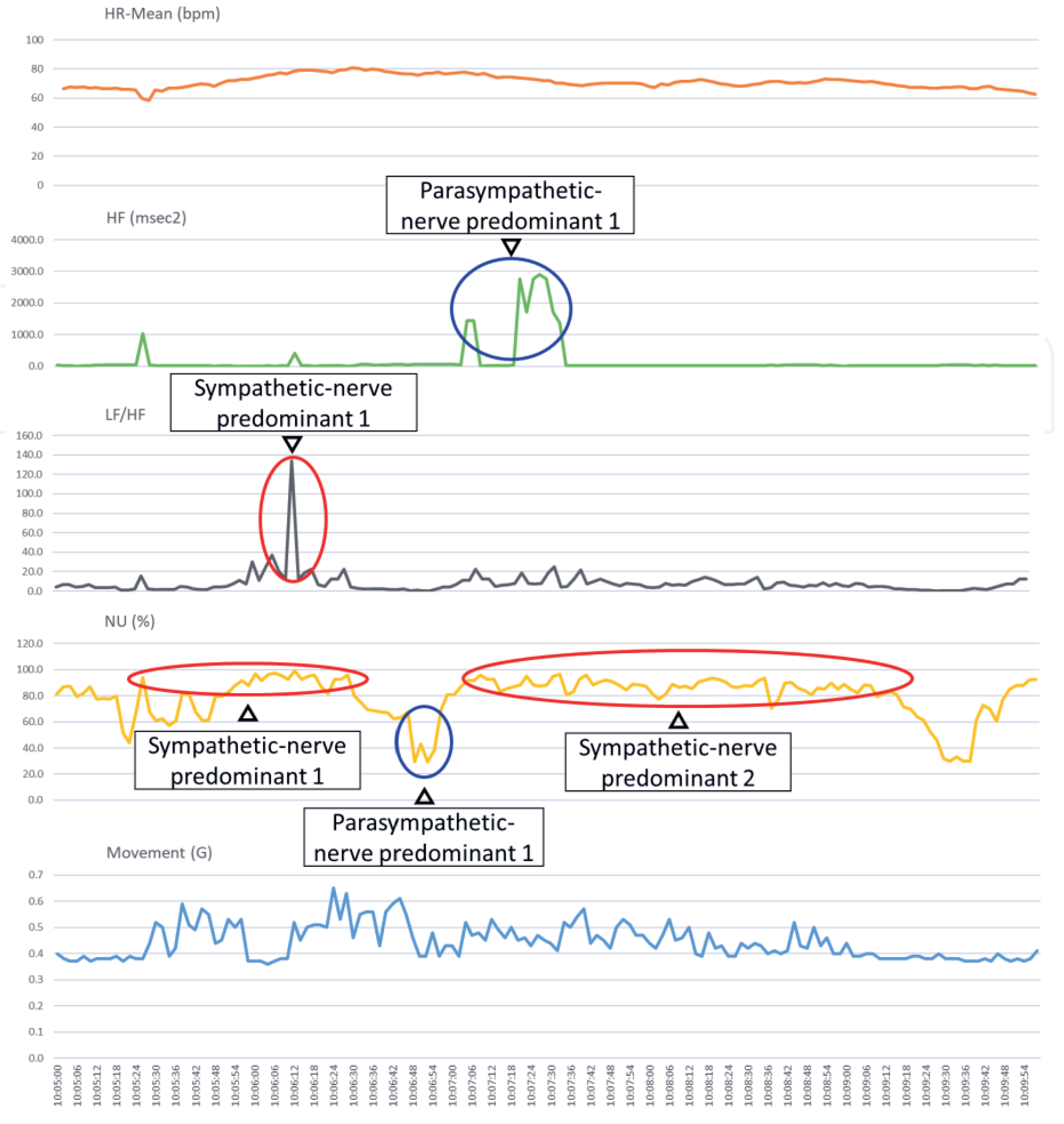

Figure 8.
The experimental data before robot therapy (Subject B).

At the end of the therapy, the LF/HF value was high for about one minute, confirming the predominance of sympathetic nerve activity.

In the robot therapy, the subjects had high LF/HF values and predominant sympathetic nerve activity before the start of the therapy. In addition, during the therapy, high LF/HF values that continued immediately after the robot was first held were observed, confirming the predominance of sympathetic nerve activity. After the therapy, the autonomic nervous activity became stable.

5.2 Comparison intermediary interactions during animal therapy and robotic therapy using participant observations with older adults

Animal therapy was conducted by the therapist and pianist in the healthcare institution. After music therapy, the therapist brought a dog to the older person (Subject A). Her expression can be seen from **Figure 10**. From the observation, it was evident that the older person spontaneously touched and stroked the dog. Subject A seemed happy touching the dog and intermediary bring the dog near her.

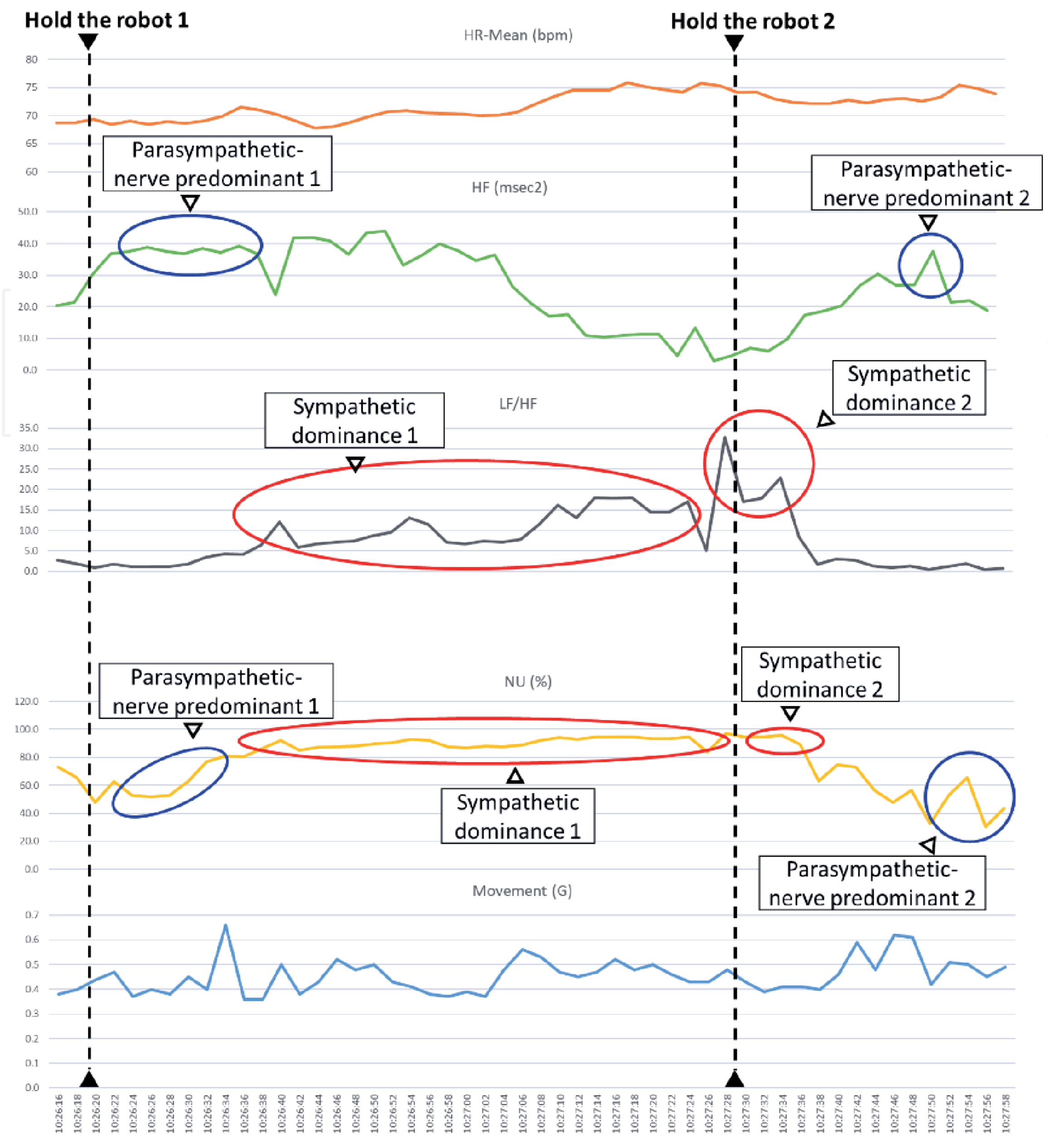

Figure 9.
The experimental data during robot therapy (Subject B).

The nurse intermediary was in charge of connecting Subject A with the dog. The intermediary asked Subject A some questions: "Do you like dogs and animals" and "Have you ever owned a dog?" Subsequently, the intermediary asked, "May I bring the dog closer to you?" Since Subject A's mobility requires a cane when walking, and her daily activities is slow due to old age, the intermediary held on to the small dog, and brought it near to subject A's chest (**Figure 10**) to make it easier for her to touch the dog. Subject A replied that she had a dog, and that she liked dogs and had many dogs, and that one of her dogs was as small as the size of dog used for animal therapy. Then the intermediary picked a conversational topic, and the dog waved its tail seemingly to mean that "This dog seems happy."

Subject B was in the robot therapy section. It was observed that older persons seemed happier during their interactions with robots. Subject B touched and held the robots. She stroked their legs and arms, and head as if the robots were her grandchildren. When the older person saw the pictures displayed in the television screen, they turned the robot to see the TV screen and she exclaimed to the robot "Look at the TV!" After that, she asked the robot some questions like "Do you like animals?" And she stroked the robot's head. When the robot said, "Thank you", she

Figure 10.
Subject A's scene during the animal-assisted therapy. During animal therapy: she spontaneously stretched her arms, stroked dog's body, and smiled from beginning to end.

laughed. When the robot sang, she clapped her hands and said, "You're so good!" (**Figure 11**).

The intermediary asked subject B about her impression of robots and if she was interested in the robot. Subject B was interested in the robot and listened to what the robot had to say. She replied, "around 80 years old" to the robot question, "How old are you?" However, there were some occasions when she could not hear what the robot said. Therefore, the intermediary had to repeat what the robot said. Since the inexpensive robot used had limited conversational word content, the intermediary supplemented the conversation content and enhanced the interval in the conversation. Also, since the robot can sing songs, the intermediary tried to sing thereby illustrating that it was the robot that was singing. Subject B listened intently while the robot was singing, and she enjoyed singing to the tune along with the robot. On one occasion, the intermediary informed subject B that she could touch the robot. She asked. "Would you like to pick up robot Mi chan?"

Figure 11.
Subject B' scene during robot therapy. During robot therapy: she hugged robot, smile and talked to the robot.

Conversations with the robots illustrated that nurses as intermediaries can show that emotional conversations establish effective transactive engagements between subjects and robots.

The comparison of AAI and Robot therapy showed that each method has its benefits and shortcomings indicating that the two methods could potentially complement each other. Both therapies were shown to have a possibility of beneficial effects on the emotional wellbeing of patients with dementia. There is a possibility that if robot therapy using an inexpensive robot such as used in this study might be obtain the same effect as AAI, barriers peculiar to AAI such as zoonotic diseases, animal bites, and allergies can be avoided. In addition, it will be possible to use AAI and robot therapy properly while taking advantage of their respective characteristics and advantages.

6. Conclusion

This chapter explained the robot therapy program for patients with dementia from the viewpoint of its framework and effectiveness.

The electrographic data provided neurophysiological evidence of the influence of robot utilization on the autonomic nervous system activity of older adults with dementia. The examples described were demonstrations of studies, which captured how data were collected through different devices and specific procedures to describe, explain, predict, and prescribe phenomena, as evidenced from a rigorous analysis of data regarding human-robot interaction with nurses as intermediaries.

The typical examples show that animal therapy has almost the same effectiveness as robot therapy among older people. It is clarified that robot therapy can be expected to have a healing effect on patients, improve motivation for activity, and increase the amount of activity, similar to animal therapy. Furthermore, it was essential to consider the intermediary role of nurses for connecting the robot and older adults and their role, even if the robot is not sophisticated enough to be useful as a humanoid nurse robot for rehabilitation and dialogue with older adults.

Thus, robot therapy could be considered another important intervention in the challenging health and innovative care practices needed in the care of older persons. Nevertheless, two issues were realized regarding living with a human-type communication robot as a strategy for rehabilitation care and to improve cognitive functions and prevent cognitive decline in the older adults. In this regard, robot therapy has not been generalized, and more analysis, descriptions and discussions about its practical utility are required.

Acknowledgements

This work was supported by JSPS KAKENHI Grant Numbers JP17K17504. We would like to express our sincere appreciation to all the patients and participants who contributed to this article. With many thanks to Dr. Savina Schoenhofer for reviewing this chapter prior to its publication.

DOI: http://dx.doi.org/10.5772/intechopen.96410

Author details

Kyoko Osaka[1*], Ryuichi Tanioka[2], Feni Betriana[2], Tetsuya Tanioka[3], Yoshihiro Kai[4] and Rozzano C. Locsin[3]

1 Department of Clinical Nursing, Kochi Medical School, Kochi University, Kochi, Japan

2 Graduate School of Health Sciences, Tokushima University, Tokushima, Japan

3 Department of Nursing, Institute of Biomedical Sciences, Tokushima University Graduate School, Tokushima, Japan

4 Department of Mechanical Engineering, Tokai University, Kanagawa, Japan

*Address all correspondence to: osaka@kochi-u.ac.jp

References

[1] Muramatsu N, Akiyama H: Super-aging society preparing for the future. The Gerontologist. 2011;51(4):425-432. DOI: 10.1093/geront/gnr067

[2] Ministry of Health, Labour, and Welfare. 2015 Edition, Annual Health, Labour and Welfare Report-Consideration of a depopulating society- Towards a society where people can live in peace and realize of their hope. 2015. https://www.mhlw.go.jp/english/wp/wp-hw9/dl/summary.pdf [Accessed: 2020-12-25]

[3] Department of International Affairs Japanese Nursing Association: Nursing in Japan 2016. https://www.nurse.or.jp/jna/english/pdf/nursing-in-japan2016.pdf

[4] Buchan J, Aiken L: Solving nursing shortages: A common priority. J Clin Nurs. 2008;17(24): 3262-3268. DOI: 10.1111/j.1365-2702.2008.02636.x [Accessed: 2020-12-25]

[5] Amjad H, Carmichael D, Austin AM, Chang C, Bynum JPW: Continuity of care and health care utilization in older adults with dementia in Fee-for-Service Medicare. JAMA Intern Med. 2016;176(9):1371-1378. DOI: 10.1001/jamainternmed.2016.3553

[6] Mangalavite AM: Animal-Assisted Therapy: Benefits and Implications for Professionals in the Field of Rehabilitation. 2014;1-26. Research Papers. Paper 547. http://opensiuc.lib.siu.edu/gs_rp/547

[7] Paula Calvo, Joan R. Fortuny, Sergio Guzmán, Cristina Macías, Jonathan Bowen, María L. García, Olivia Orejas, Ferran Molins, Asta Tvarijonaviciute, José J. Cerón, Antoni Bulbena, Jaume Fatjó: Animal Assisted Therapy (AAT) Program As a Useful Adjunct to Conventional Psychosocial Rehabilitation for Patients with Schizophrenia: Results of a Small-scale Randomized Controlled Trial. Frontiers in Psychology. 2016;7:1-13. DOI: 10.3389/fpsyg.2016.00631

[8] Thodberg K, Sørensen L.U, Christensen J.W, Poulsen P.H, Houbak B, Damgaard V, Keseler I, Edwards D, Videbech P.B: Therapeutic effects of dog visits in nursing homes for the elderly. Psychogeriatrics. 2016;16(5):289-297. DOI: 10.1111/psyg.12159

[9] Richeson NE: Effects of animal-assisted therapy on agitated behaviors and social interactions of older adults with dementia. Am J Alzheim Dis Other Dement. 2003;18(6):353-358. DOI: 10.1177/153331750301800610

[10] Park S, Bak A, Kim S, Nam Y, Kim H, Yoo DH., Moon M: Animal-assisted and pet-robot interventions for ameliorating behavioral and psychological symptoms of dementia: a systematic review and meta-analysis. Biomedicines. 2020;8(6):150. DOI: 10.3390/biomedicines8060150

[11] Minmin L, Peng L, Ping Z, Mingyue H, Haiyan Z, Guichen L, Huiru Y, Li C: Pet robot intervention for people with dementia: a systematic review and meta-analysis of randomized controlled trials. Psychiatric Research. 2019;271:516-525. DOI: 10.1016/j.psychres.2018.12.032

[12] Feast AR, White N, Candy B, Kupeli N, Sampson EL: The effectiveness of interventions to improve the care and management of people with dementia in general hospitals: a systematic review. Int J Geriatr Psychiatry. 2020;35(5):463-488. DOI: 10.1002/gps.5280

[13] Yokoyama A: Challenges for the future of robot assisted therapy from the viewpoint of psychiatry: with the knowledge of animal assisted therapy.

Journal of The Society of Instrument and Control Engineers. 2012 July 10; 51(7): 598-602.

[14] Osaka K, Sugimoto H, Tanioka T, Yasuhara Y, Locsin R, Zhao YR, Okuda K, Saito K: Characteristics of a transactive phenomenon in relationships among older adults with dementia, nurses as intermediaries, and communication robot. Intelligent Control and Automation. 2017; 8: 111-125. DOI: 10.4236/ica.2017.82009

[15] Osaka K, Tanioka T, Tanioka R, Kai Y, Locsin RC. Effectiveness of care robots, and the intermediaries' role between and among care robots and older adults. In: Proceedings of the IEEE/SICE International Symposium on System Integration (SII '20), 12-15 January 2020; January 2019; Honolulu, Hawaii: IEEE; 2020. p.611-616 DOI: 10.1109/SII46433.2020.9026262

[16] Tanioka R, Yasuhara Y, Osaka K, et al: Autonomic nervous activity of patient with schizophrenia during Pepper CPGE-led upper limb range of motion exercises. Enferm Clin. 2020;1:48-53. DOI: 10.1016/j.enfcli.2019.09.023

[17] American Veterinary Medical Association. Animal-assisted interventions: Definitions. (n.d.). Retrieved from https://www.avma.org/resources-tools/avma-policies/animal-assisted-interventions-definitions [Accessed: 2020-12-25]

[18] Nimer J, Lundahl B: Animal-assisted therapy: a meta-analysis. Anthrozoos. 2007;20(3): 225-238. DOI: 10.2752/089279307X224773.

[19] S H Hosseini, K M Goher: Personal Care Robots for Older Adults: An Overview. 2017;13:11-19. DOI: 10.5539/ass.v13n1p11

[20] Fiske A, Henningsen P, Buyx A: Your robot therapist will see you now: ethical implications of embodied artificial intelligence in psychiatry, psychology, and psychotherapy. J Med Internet Res. 2019;21(5). DOI: 10.2196/13216.

[21] Shibata T, Wada K: Robot therapy: a new approach for mental healthcare of the elderly - a mini review. Gerontology. 2011;57: 378-386. DOI: 10.1159/000319015

[22] Huei-Chuan Sung, Shu-Min Chang, Mau-Yu Chin, Wen-Li Lee: Robot-assisted therapy for improving social interactions and activity participation among institutionalized older adults: a pilot study. Asia Pac Psychiatry. 2015;7:1-6. DOI: 10.1111/appy.12131

[23] Birks M, Bodak M, Barlas J, Harwood J, Pether M: Robotic seals as therapeutic tools in an aged care facility: a qualitative study. J Aging Res. 2016;article ID 8569602:7 pages. DOI: 10.1155/2016/8569602

[24] Osaka K: Development of the model for the Intermediary role of nurses in transactive relationships with healthcare robots. Int J Hum Caring. 2020;24(4):265-274. DOI: 10.20467/HumanCaring-D-20-00014

[25] Yasuhara Y, Tanioka R, Tanioka T, Ito H, Tsujigami Y: Ethico-legal issues with humanoid caring robots and older adults in Japan. Int J Hum Caring. 2019;23(2):141-148. DOI: 10.20467/1091-5710.23.2.141

[26] Locsin R: Technological competency as caring in nursing. Sigma Theta Tau International Press. 2005. 229 p.

[27] Boykin A, Schoenhofer S: Nursing as caring: A model for transforming practice. 2nd ed. Jones and Bartlett. 2001. 71 p.

[28] Cherniack EP, Cherniack AR: The benefit of pets and animal-assisted therapy to the health of older individuals. Curr Gerontol

Geriatr Res. 2014;2014:623203. DOI: 10.1155/2014/623203

[29] Lundqvist M, Carlsson P, Sjödahl R, Theodorsson E, Levin LÅ: Patient benefit of dog-assisted interventions in health care: a systematic review. BMC Complement Altern Med. 2017;17(1):358. DOI:10.1186/s12906-017-1844-7

[30] K. Wada, T. Shibata, T. Saito, K. Tanie. Effects of robot-assisted activity for elderly people and nurses at a day service center. In: Proceedings of the IEEE, 2004;92(11):1780-1788, DOI: 10.1109/JPROC.2004.835378

[31] Fasola J, Mataric MJ: Using socially assistive human–robot interaction to motivate physical exercise for older adults. In: Proceedings of the IEEE, 2012;100(8):2512-2526, Aug. 2012, DOI: 10.1109/JPROC.2012.2200539

[32] Tanaka M, Ishii A, Yamano E, Ogikubo H, Okazaki M, Kamimura K, Konishi Y, Emoto S, Watanabe Y: Effect of a human-type communication robot on cognitive function in elderly women living alone. Med Sci Monit. 2012;18(9):CR550-557. DOI: 10.12659/msm.883350

[33] Tanioka T, Smith CM, Osaka K, Zhao Y: Framing the development of humanoid healthcare robots in caring science. Int J Hum Caring. 2019;23(2):112-120, 2019. DOI: 10.20467/1091-5710.23.2.112

[34] Ferreira FMRM, Chaves MEA, Oliveira VC, Van Petten AMVN, Vimieiro CBS: Effectiveness of robot therapy on body function and structure in people with limited upper limb function: a systematic review and meta-analysis. PLoS One. 2018;13(7):e0200330. DOI: 10.1371/journal.pone.0200330.

[35] Imai Y, Hasegawa K: The revised Hasegawa's Dementia Scale (HDS-R)-Evaluation of its usefulness as a screening test for dementia. Hong Kong Journal of Psychiatry. 1994;4(SP2):20-24.

[36] von Rosenberg W, Chanwimalueang T, Adjei T, Jaffer U, Goverdovsky V, Mandic DP: Resolving ambiguities in the LF/HF ratio: LF-HF scatter plots for the categorization of mental and physical stress from HRV. Front in Physiol. 2017;.8:360. DOI: 10.3389/fphys.2017.00360

[37] Takahashi N, Kuriyama A, et.al: Validity of spectral analysis based on heart rate variability from 1-minute or less ECG recordings. Electrophysiology. 2017;40:1004-1009. DOI: 10.1111/pace.13138

[38] Fred Shaffer, Rollin McCraty, Christopher L. Zerr: A healthy heart is not a metronome: an integrative review of the heart's anatomy and heart rate variability. frontiers in psychology. 2014;5:1-19. DOI: 10.3389/fpsyg.2014.01040

[39] Umetani K, Singer DH, McCraty R, Atkinson M. Twenty-four hour time domain heart rate variability and heart rate: relations to age and gender over nine decades. J Am Coll Cardiol. 1998;31(3):593-601. DOI: 10.1016/s0735-1097(97)00554-8

[40] Marc A. Russo, Danielle M. Santarelli, Dean O'Rourke: The physiological effects of slow breathing in the healthy human. Breathe. 2017;13(4): 298-309. DOI: 10.1183/20734735.009817

[41] Rollin McCraty, Fred Shaffer. Heart Rate Variability: New Perspectives on Physiological Mechanisms, Assessment of Self-regulatory Capacity, and Health risk: Glob Adv Health Med. 2015;4(1): 46-61. DOI: 10.7453/gahmj.2014.073