CHAPTER I
INTRODUCTION

Parkinson's disease (PD) is the most common neurodegenerative movement disorder in many countries including Asian countries (1, 2). Muangpaisan and colleagues reported the prevalence of PD from 35 to 170 per 100000 persons (1). The cause of this disease is a progressive degeneration of the dopaminergic neurons in the substantia nigra pars compacta (3). These patients frequently complain regarding having "clumsy hands" (4) or difficulty in performing manipulative tasks including reach-to-grasp (RTG) task (4-6).

The RTG movement requires the controlling of 2 components:1) transport (reach) component refers to the bringing hand toward the object; 2) grasp component is the part during the fingers and hand are opened and then closed to grasp the object (7). These two components have been repeatedly demonstrated the spatial and temporal coordination (8-10).

PD patients have deficits in planed movement as evidenced by slow reaction time (11), and in movement kinematics of both the transport and grasp components including lower magnitude of peak transport velocity, earlier relative time to maximum deceleration and relative time to maximum elbow velocity, smaller grip aperture, greater variability in the time to maximum aperture, longer closure time (e.g., 4, 12). Moreover, few studies were also found disruption in transport-grasp coordination in these patients (e.g., 4). Although these evidences support that PD patients had deteriorate capability of planning, reaching and grasping execution, and coordination, there have been some studies showed controversial results. Few studies demonstrated non-significant slowing simple reaction time (13), the preserved transporting (14) or grasping performance (12, 14). For coordination, most studies focus only temporal coordination (e.g., 4), while a study revealed decline in both spatial and temporal coordinations during RTG in virtual environment (15). Controversial findings might partly due to the following possible factors; 1) severity or stage of disease, 2) the hand which has more impairment than another hand or “more affected hand”, 3) task condition and difficulty, 4) methods used to measure reach-to-grasp kinematics and coordination.

Considering stage of disease, most of the studies also recruited participants with mild impairment (Hoehn and Yahr stage I) (e.g., 16). The different stage of disease might have differential impact on grasping performance. A study found that mild stage patients demonstrated normal anticipatory hand shaping, while patients in moderate and advanced stage were unable to use anticipatory control for hand shaping (17). Additionally, patients in stage I had difficulty in performing the task in only one side of the limbs, but researchers did not concern to the onset affected side. For instance, some participants showed declined capability of left hand but they were asked to perform the task with right (non-affected) hand. Thus, it might be misinterpreted to conclude that patients have normal movement in some components because some patients perform the task with their unaffected hand.

Moreover, the task difficulty has impact on RTG performance in PD patients. The deficit in movement planning (18) and execution of these patients would be increased when the movement difficulty or cognitive load of task increase such as the task with multi-joint movement (15, 19), with far placement of the object (12) and with small size of the object (0.7 – 3 centimeters) (4, 12, 16). Pieruccini-Faria and co-workers concluded that walking cross over obstacle in PD require more planning than straight line walking (18). Considering the task demand in the studies of RTG movement, the common methods to measure transport-grasp coordination include perturbation of transport or grasp component and then observe the alteration in another components. Instances of these perturbation tasks are the changes in object location, varying object size, and altered hand path (7) e.g., reach over or around barrier (8). Barrier task is an experimental setting that places an obstacle during the hand path and a subject has to reach and grasp a target object by avoiding a collision of the obstacle. This task is able to investigate a coordination between reaching and grasping component as well as the deteriorate of both transport and grasp kinematic reaching is perturbed by a presence of an obstacle (e.g., 8, 20). However, it has not been used in PD population.

Beside task condition, the analysis to quantify the transport-grasp coordination in PD was designed based on hypothesized regarding the temporal constraint, which investigated the interval synchronization some points of arm trajectory (e.g. the time at maximum transport velocity or time of upper arm initiation) and some points of hand trajectory (e.g., the time at maximum aperture or time of index finger initiation) (4, 15). For spatial coordination, there is only one study which analyzed the spatial relationship between the positions of upper arm and index finger, thus it may not represent the coordination of transport and grasp components (15). The cross correlation analysis, a commonly technique to evaluating the degree to which the two interesting trajectories are correlated (21), is calculated from the change of both transport and grasp trajectories at every single point in time. It is a sensitive and appropriate to investigate transport-grasp coordination in previous studies (20, 22, 23).

Thus, the first part of this study aimed to measure RTG planning, RTG execution by measured the transport and grasp kinematics, and transport-grasp coordination by controlling for 1) the characteristics of patients, including selecting the patients who have moderate bilateral limb impairments (Hoehn and Yahr stage II-III) and have the more affected hand on right side, 2) nature of task including the use of the barrier task, small object to be grasped and placed at relatively far position and 3) using cross correlation analysis between transport velocity and grasp aperture size for analyzing the transport-grasp coordination.

The second part of the present study emphasized on the training which could minimize the deficits in the manipulative task in PD. In rehabilitation sessions, PD learned the practiced task with slower rate for acquiring the skill, poorer retained performance and inability to transfer their skill to other tasks or environment when compare to controls without neurological problems (see review 24-26). Various practice conditions or techniques applied to PD patients to improve their motor learning for upper extremity training (26-28). A recently technique, so called “action observation (AO)” when combined with motor training could enhanced prehensile motor learning of non-disabled adults (29, 30), individuals with stroke (31, 32) and PD (33, 34). Additionally, the AO was able to promote transferring the performance to untrained task in non-disabled people (35). Observation could activate observation-execution system, so called “mirror neurons” that are activated motor cortex during observing hand action similar to during executed action (36). The activations in these neurons could enhance motor memory formation and then facilitate retained performance (37). Additional benefits of action observation were explored in previous studies. For instance, the studies either in healthy people (29) and stroke patients (38) postulated that observation is able to remind the correct movement sequence, error detection and correction process of model. The utilizing of these advance visual information might promote the process of movement preparation and execution. Action observation might also increase practitioners' motivation and allowed the practitioners to direct their attention to observing the sequence and rehearsing it at the same time (29).

Castiello and co-workers revealed that PD participants' movements were facilitated following the observation of Parkinsonian model combined with physical training by reduced the reaction and movement time of the actions (39). However, they mentioned only the effect of action observation on the temporal domains of reaching action, while PD patients express great deficits of grasping action both spatial and temporal domains (4, 40, 41) and transport-grasp coordination (4, 15). Thus, it's still questionable if action observation could promote movement execution of reaching and grasping in both spatial and temporal domains and coordination between these two components.

Moreover, there is no evidence support that AO could enhance transferred learning to untrained tasks when apply to PD population. In the present study, training protocol with AO concept was adopted from protocols in Pelosin (34) and Castiello studies (39). Additionally, the AO protocols were also adjusted by following influential factors for maximizing the learning effect; 1) the observed duration (34, 42), 2) AO alternate with the physical training for the similar actions as the model do (32, 43, 44), 3) training duration for 45 minutes (e.g., 45, 46), 4) parkinsonian models (39), 5) observed perspective as seeing their own movements (47) and 6) heard the sound from model's actions (48, 49). In addition, we chose the barrier avoidance task, which is one of the activities in daily living, to be assessed as an untrained task. This task was also used to investigate a coordination between reaching and grasping component during performing RTG (e.g., 8, 23, 50). Therefore, we hypothesized that this training protocol might be able to facilitate learning in trained task and also transfer to barrier avoidance task.

Therefore, the specific aim of second study was to examine the learning effects of action observation on movements planning, execution of reaching and grasping movement and transport-grasp coordination. The learning effects were determined in acquisition and retention phase of both trained- and untrained-tasks.

1.1 Purposes of the study

1.1.1 General objectives

To examine RTG planning as measured by reaction time (RT), kinematics of reaching and grasping, and transport-grasp coordination during performing reach-to-grasp under barrier avoidance condition in Parkinson's disease patients.

To examine the effect of action observation combined with physical training on speed of trained-task in Parkinson's disease patients.

To examine the effect of action observation combined with physical training on RTG planning, execution and coordination during reaching and grasping of untrained-task or transferred capability in Parkinson's disease patients.

1.1.2 Specific objectives

<u>First experiment</u>

1.1.2.1 To compare averaged RT, kinematic data in transport and grasp components, and transport-grasp coordination between Parkinson's disease group and age-matched control group.

<u>Second experiment</u>

1.1.2.2 To compare average value of each variable of both trained- and untrained-tasks between action observation (AO), Placebo (P), and control (C) groups at each time of testing (Pretest, Posttest, and Retention test)

1.1.2.3 To investigate training effect in each training group (AO, P, and C groups) by comparing variable in trained-task between Pretest, and Posttest

1.1.2.4 To investigate retained capability in each training group (AO, P, and C groups) by comparing variable in trained-task between Posttest and Retention test.

1.1.2.5 To investigate saving capability in each training group by comparing variable in trained-task between Pretest and Retention test.

1.1.2.6 To investigate training effect in each training group (AO, P, and C groups) by comparing average value of each variable in untrained-task between Pretest, and Posttest

1.1.2.7 To investigate retained capability in each training group (AO, P, and C groups) by comparing average value of each variable in untrained-task between Posttest and Retention test.

1.1.2.8 To investigate saving capability in each training group by comparing average value of each variable in untrained-task between Pretest and Retention test.

1.2 Parameters of the study

First experiment

1.2.1 Variables in RTG under barrier avoidance task which was untrained-task

1.2.1.1 Reaction time (RT)

1.2.1.2 Kinematics

1) Total movement time (MT)

2) Transport component

- Maximum velocity (V_{max})
- Time to maximum velocity (TV_{max})
- Deceleration time (DT)

3) Grasp component

- Maximum aperture (A_{max})
- Time to maximum aperture (TA_{max})
- Aperture closure distance (ACD)
- Aperture closure time (ACT)

1.2.1.3 Reach and grasp coordination: Cross correlation analysis

1) Maximal correlation coefficient (r_{max})

2) Associated time lag (T_{max})

Second experiment

1.2.2 Primary outcome

1.2.2.1 Total time of dexterity items in Wolf motor function test (WMFT) which was the trained-task.

1.2.2.2 Variables in RTG under barrier avoidance task which was untrained-task. All variables were similar to first experiment.

1.2.3 Secondary outcome: Agreement level of each question in questionnaire regarding the advantage of training.

1.3 Scope of the study

The present study aimed to investigate the effect of Parkinson's disease on motor planning, execution and coordination of RTG movement. Thus, all variables from reaching and grasping task were compared between PD and age-matched group.

Moreover, this study also aimed to examine the effect of action observation combined with physical training on speed of trained-task and on motor planning and execution during perform reaching and grasping of untrained-task in PD patients. All variables were compared between the AO group which received both observing upper extremities actions and physical training, P group which received both observing natural perspectives and physical training and C group which received only physical training. The P group is the placebo group that was controlled the level of attention similar to the experimental group but will not be observed the hand actions, observer only observe the unseen natural perspectives which could not activate mirror neurons.

1.4 Hypotheses of the study

First experiment

1.4.1 There were significant differences in averaged kinematic data in transport and grasp components, and transport-grasp coordination between Parkinson's disease group and age-matched control group.

Second experiment

1.4.2 There were significant differences in average value of each variable of both trained- and untrained-tasks between action observation (AO), Placebo (P), and control (C) groups at Posttest, and Retention test

1.4.3 There were significant differences in a variable of trained-task between Pretest, and Posttest in each training group (AO, P, and P groups)

1.4.4 There were not significant differences in a variable of trained-task between Posttest and Retention test in each training group (AO, P, and P groups)

1.4.5 There were significant differences in a variable of trained-task between Pretest and Retention test in each training group (AO, P, and P groups)

1.4.6 There were significant differences in average value of each variable in untrained-task between Pretest, and Posttest in each training group (AO, P, and P groups)

1.4.7 There were not significant differences in average value of each variable in untrained-task between Posttest and Retention test in each training group (AO, P, and P groups)

1.4.8 There were significant differences in average value of each variable in untrained-task between Pretest and Retention test in each training group (AO, P, and P groups)

1.5 Advantages of the study

The present study investigated the effect of Parkinson's disease on motor planning, execution and coordination of RTG movement. Thus, the result might be able to thoroughly represent the deficiency in manipulation including kinematics of both reaching and grasping component, and coordinative deficit in PD patients.

Moreover, this study also determined the effect of training with AO on performance of trained- and untrained-task in PD patients. This information could be guideline for applying AO to clinical intervention or treatment in PD patients, because this training was able to maximize training effectiveness. Moreover, patients could self-practice, then might increase cost effectiveness.

1.6 Conceptual framework