

**USE OF COMMERCIAL GAMING CONSOLE  
– WII® FOR REHABILITATION OF HAND  
IMPAIRMENTS IN YOUNG ADULTS WITH  
CEREBRAL PALSY**

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# Keywords

Cerebral palsy, Gross Manual Functioning Classification System, Manual Ability Classification System, Virtual reality.

# Abstract

The purpose of this study examined the feasibility of using a low-cost, commercially available gaming platform, the Wii® on improving the hand dexterity impairments in young adults with cerebral palsy. The study included 5 young adults with spastic cerebral palsy with a score of 1-3 on the GMFCS scale and a score of 1-2 on the MACS scale. The participants underwent an 8-week training intervention using the Wii™ for approximately 30 min/day 2 times a week. Training was performed using the Wii™ sports games software, including boxing, tennis, bowling, and archery. Three outcomes measures for hand impairments were used and tested during the study: such as the Hand dynamometer for the grip strength, Purdue peg board for the fine finger dexterity and the Box and Block test for the manual gross dexterity pre- and post- intervention as well as the family-reported activities of daily living before and after the interventions. A student's t-test was used to analyse the pre- and the post-test results. The feasibility of using the virtual reality (Wii™) in the rehabilitation settings for young adults with CP showed positive outcomes in improving their hand impairments and manual ability. Additional hypotheses were proposed from the study for additional research.

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# List of Abbreviations

ADL	Activities of daily life
CP	Cerebral Palsy
CST	Corticospinal Tract
GMFCS	Gross Motor Function Classification System
MACS	Manual Ability Classification System
VR	Virtual Reality

# Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signature:

A handwritten signature in blue ink, appearing to read 'J. A. B.', written over a horizontal line.

Date:

A handwritten date in blue ink, '30/11/17', written below a horizontal line.

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# Chapter 1: Introduction

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Over the past few decades there has been a significant change in the management of cerebral palsy. This change has posed a big challenge amongst various medical personnel as there has been limited literary resources on the health care needs for adults with CP when these individuals survive the childhood and begin living in their teens. Before bridging the gap in the literature about the various treatment options we need to know about the disease more in detail. This chapter presents an overview of what we know about the disease and the health care needs of adults with CP in the background (section 1.1). The context section (section 1.2) of the study along with its purposes (section 1.3) discusses about the challenge that we are currently facing with the treatment of young adults with CP as the existing paediatric services were not able to support their needs along with the purpose of this study trying to solve the problem. Section 1.4 describes the significance and scope of this research and provides definitions of the terms used. Finally, section 1.5 includes an outline of the remaining chapter of the thesis.

## 1.1 BACKGROUND

Cerebral palsy (CP) is one of the most common major disabling motor disorder affecting children and is still largely perceived as a ‘childhood disease’. However, recent researches have shown that there has been a drastic change in the clinical management of cerebral palsy. Deaths in children with CP have in the recent years has become very rare, with almost 90% of children surviving to live to adulthood unless the child is very severely and multiply disabled (Young, 2007). Approximately 7000 people in New Zealand have some degree of cerebral palsy and of them one third are under the age of 21 (Cerebral Palsy Society New Zealand, 2017). Thus, virtually all children assigned with the diagnosis of CP will survive into adulthood. However, this shift of population is posing a new challenge to many of the health care providers. Attention to the adult with CP has been sparse, and the evolution of the motor disorder as the individual moves through adolescence, young adulthood, middle age, and old age is not well understood.

It is estimated that almost one-quarter of 800,000 individuals living with cerebral palsy are hemiplegic. One of the most disabling aspect of being a hemiplegic is the inability of carrying on with the activities of daily living (ADL) especially the ones that are bimanual (i.e. requires both hands) in nature.

The most commonly used effective treatments for CP included either surgeries with botulinum toxin injections or the traditional rehabilitation methods (e.g. Constraint-induced movement therapy). These treatments were either too expensive for individuals to afford or didn't include clients with severe degree of disability. Hence, an intervention that was more accessible and well tolerated as well as less expensive was needed to help these individuals attain maximum form of independency with their limited hand function. This required an in-depth knowledge about the consequences that adults with cerebral palsy face in their activities of daily life, to be able to develop rehabilitation programmes that are effective in helping young adults with cerebral palsy lead an independent lifestyle in the community.

The introduction of virtual reality in the rehabilitation program for individuals with disabilities have been proven to be advantageous as they provide an interesting and customized at the same time highly motivating environment for individuals especially with hand impairments. Virtual reality requires movements of various parts of the body (e.g. swinging of arms), which is beyond the likes of conventional hand-controlled games. It is also seen that with virtual reality being interactive, enjoyable and at the same time also encourages individuals to participate in repetitive tasks, which further enhances the neuronal plasticity and the functional reorganization of the brain. The visual feedback gained with the use of virtual reality during rehabilitation sessions is an added benefit to individuals.

This thesis aims to address and investigate this aspect of employing virtual reality in improving the hand impairments in young adults with cerebral palsy.

## **1.2 CONTEXT**

The main challenge we are currently facing is the paucity of literature on the rehabilitation measures for young adults with cerebral palsy with the most common source being case studies or reports written by small groups. The next biggest challenge we are also facing amongst most of the rehabilitation team is the lack of motivation from the individual due to the repetitive & invasive nature of many of the traditional exercises performed during rehabilitation, which lacks variety. Hence, this study aims to find out the effectiveness of

rehabilitation protocols/ideas that are repetitive in nature, but at the same time be an enjoyable factor for the CP young adults to motivate them to use them in their treatment.

### **1.3 PURPOSES**

The purpose of this study is to describe the feasibility and outcomes of using a low-cost, commercially available virtual gaming system (Wii®) to augment the hand impairments of young adults with spastic cerebral palsy. The study could lead into further research being undertaken in the rehabilitation medicine amongst adults living with cerebral palsy.

It is the intent that the following questions be answered through this study:

1. Do we need to choose between invasive and less interesting traditional rehabilitative techniques over a less invasive and fun activity – virtual reality therapy to serve the same purpose of enhancing the arm-hand usage among cerebral palsy individual?
2. Should our rehabilitation program focus more on increasing functional independence by improving the coordination among both the upper extremities rather than focusing on unimanual impairments, which does not impact functional independence?

As part of the research study, investigation included the following hypothesis:

1. The more younger adults with cerebral palsy participate regularly in a motivating and fun rehabilitation interventions, the better they will demonstrate improved gripping and hand dexterity skills in their affected arm.
2. Effects of structured rehabilitation interventions in young adults with cerebral palsy will improve the hand impairments and enable to participate more actively and efficiently in the activities of daily life.

### **1.4 SIGNIFICANCE, SCOPE AND DEFINITIONS**

There has been an increase in the life expectancy in cerebral palsy individuals' due to the advancement in medical and surgical care. This increase has led to a big gap in rehabilitation programmes in the adult-centred health care systems when compared to the services offered to children with cerebral palsy. Young adults while growing into adulthood would have to learn a range of skills that would enable them to participate in adult life, such as personal care, vocation, travelling to work and housework – which depends primarily on the use of the upper extremities. Participants with impaired manual ability are more prone to exhibit problems in these activities. It is quite important to consider incorporating the intensive bimanual training in the rehabilitation protocol, which would in turn result in a good

quantity as well quality of bimanual hand use. Hence, this study would aim at service the purpose of exploring the feasibility and outcomes of incorporating the Wii® as an intervention, which incorporates the principles of brain plasticity as well as repetitive bimanual training for improving bimanual dexterity in young adults with cerebral palsy.

*Cerebral Palsy-* Cerebral palsy is considered a neurological disorder caused by non-progressive brain injury or malformation that occurs while the child's brain is under development (Stern, 2017).

*Virtual Reality* – Virtual reality is a term that describes computer-stimulated environment which mimics actual physical presences in locations in the fantasy world (Virtual Reality Guide, n.d.).

## **1.5 THESIS OUTLINE**

The first half of the study below explores a detailed literature review (Chapter 2), which briefly describes the aetiology of hemiplegic CP, as it is one of the most common subtype of CP and the neural basis of the disease. This chapter also discusses how the motor function residual capabilities of the disease improves with movements of repeated nature explaining the concept of neuroplasticity of human brain. This chapter further elaborates the thorough knowledge of various literatures and at the same time critically evaluates the various literature works in the area of treatment comparing the various options available to young adults with CP. This chapter enumerates the key authors and their works done in the area and also addresses the gap in the literature developing a research question from it. The first section of chapter 2 also discusses the various task-oriented approaches used in the treatment of CP that capitalizes on concept of improving the residual function when employed. The second half of chapter 2 describes the potential benefits of employing a task-oriented approach, in this case the most readily available as well as low-cost gaming console, the Wii® as a rehabilitation protocol of young adults with CP, which is will be discussed in detail in the methodology and the research design chapter (Chapter 3). Chapter 3 describes the research design adopted in this study to help achieve the objectives of the study and further will discuss the methodology used in the study, the various instruments used in the study in detail along with justifying its usage and discuss the sample characteristics along with details of the participants of the study (basis of selection, type, size and the reason for the number selected). The next chapter (Chapter 4) – results will be displayed obtained from the study without any interpretation or evaluation being done. The thesis would finally wind up with the discussion of the findings of

the study, the limitations of the study as well as the recommendations from the study. Chapter 4 discusses the practical implications of the results of the study and the questions if applicable for further future research and finishes off with the summary of the entire study in the final chapter (Chapter 5) - Discussion which is followed by a conclusion.



## Chapter 2: Literature Review

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Cerebral palsy (CP) is one of the most common major disabling motor disorder affecting children and is still largely perceived as a ‘childhood disease’. However, recent researches show that there has been a drastic change in the clinical management of cerebral palsy and that deaths in children with CP have in recent years become very rare, with almost 90% of children surviving to live to adulthood unless the child is very severely and multiply disabled. Thus, virtually all children assigned the diagnosis of CP without severe disability would survive into adulthood. However, this shift of population is posing a new challenge to many of the health care providers as the attention to the adults with CP has been sparse, and the evolution of the motor disorder (CP) as the individual moves through adolescence, young adulthood, middle age, and old age is not well understood. It is estimated that almost one-quarter of 800,000 individuals living with cerebral palsy are hemiplegic. One of the most disabling aspects of being a hemiplegic is the inability of carrying on with the activities of daily living (ADL) especially the ones that are bimanual (i.e. requires both hands) in nature. Studies also suggests that there is a natural tendency for individuals with CP to use their affected (hemiplegic) arm in most of the activities of daily life (van Eck, Dallmeijer, van Lith, Voorman, & Becher, 2010).

### 2.1 CEREBRAL PALSY

Bax et al. (as cited in Morris, 2009, p.6) Cerebral Palsy (CP) is defined as "a group of permanent disorders of the development of movement and posture, causing activity limitation, that is attributed to non-progressive disturbances that occurred in the developing foetal or infant brain." The motor disorders of CP are often accompanied by disturbances of sensation, perception, cognition, communication, behaviour, by epilepsy and by secondary musculoskeletal problems. (Ehrman, Gordon, Visich, & Keteyian, 2013). The incidence rates reveal a prevalence of 2.4 per 1000 children in the United States affected with CP (Hirtz, et al., 2007; Ehrman, Gordon, Visich, & Keteyian, 2013) It is approximately 5-10 times more prevalent in developing countries. Amongst the subtypes, the unilateral spastic CP is prevalent in about 22% of the preterm infant and 37% of the term infants (Himpens, Van de Broeck, Oostra, Calders, & Vanhaesebrouck, 2008). Approximately 7000 people in New Zealand have some degree of cerebral palsy and of them, one-third are under the age of 21 (Cerebral Palsy Society New Zealand, 2017) and around 1 in 500 babies are diagnosed with

cerebral palsy. Prevalence rates among gender revealed that both the genders were equally affected of all the subtypes of cerebral palsy except for spastic diplegia was more common in boys (1.3/1000) than in girls (0.71/1000) whereas girls (0.18/1000) had a high prevalence rates when compared to boys (0.05/1000) in ataxic diplegic cases (Westborn, Hagglund, & Nordmark, 2007). A survey of the clinical features reveals an incidence of hand impairments total to almost 50% in most of the CP individuals (van Meeteeren, van Rijn, Selles, Roebroek, & Stam, 2007). At least two-thirds of children with cerebral palsy will have movement difficulties affecting one or both arms (Cerebral Palsy Society New Zealand, 2017). Among the various motor types of CP, the spastic cerebral palsy accounts to around 70-80% of the diagnosed cases. Cerebral palsy can occur from the brain injury occurring before, during or after birth anytime within the first two years before the cerebral development is completed (Kaur, Mehta, & Kumar, 2011) (American College of Sports and Medicine, 2014). It is estimated from the last epidemiological study conducted in the UK that 21 per 1000 people aged in between 16-19 years and 31 per 1000 aged 20-29 years would be physically disabled due to CP (Roebroek, Jahnsen, Carona, Kent, & Chamberlain, 2009).

### Aetiology of Cerebral Palsy

The majority of the cases of cerebral palsy have an unknown aetiology. It is also postulated that low birth weight accounts for 13-20% and 30-40% of cases in low-income and the high-income families respectively (Gladstone, 2010). The injury to the developing brain can be prenatal, perinatal or postnatal. A history of prenatal cause is found in about majority (75-80%) of the cases and only a small number (10-15%) of cases are associated with hypoxia or other perinatal causes (Bialik & Givon, 2009).

#### Prenatal causes:

Alcohol, drug abuse along with maternal infections, epilepsy, hyperthyroidism and severe toxemia are other prenatal risk factors associated with the development of Cerebral Palsy (Bialik & Givon, 2009).

#### Perinatal causes:

Perinatal risk factors are multiple pregnancies along with brain haemorrhage during delivery, birth traumas, kernicterus, hypoxia and anoxia (Bialik & Givon, 2009).

### Postnatal causes:

Postnatal causes of CP include head trauma, meningitis, encephalitis and brain infarcts (Bialik & Givon, 2009).

### Classification of Cerebral Palsy

The major subtypes of CP based on the nature of motor impairment revealed by neurological examination were: hypertonia, hypotonia, dystonia, dyskinesia, paresis and ataxia (Aisen, et al., 2011). It can also be classified based on the area of presumed cerebral dysfunction into two types: pyramidal, extrapyramidal and based on the body parts involved either both legs and both arms or one-half of the body or all the four limbs (Aisen, et al., 2011, Himpens, Van de Broeck, Oostra, Calders, & Vanhaesebrouck, 2008). The unilateral spastic type is the most common subtype of CP resulting due to either a middle cerebral artery infarct, hemi-brain atrophy, periventricular lesions, or a post-haemorrhagic porencephaly, where there is weakness localized to one side of the body. Often a neuroimage in hemiplegic CP shows an image of combined grey and white matter abnormalities (Aisen, et al., 2011).

The clinical features that a CP individuals often exhibits are not always proportional to the nature or type of CP and hence a functional classification is also essential during the diagnosis. There are variety of classifications used, but the Gross Motor Functional Classification System (GMFCS) and the Manual Ability Classification System (MACS) are the most widely used scale and discussed much in detail as they are quite significant with the research topic. The GMFCS score usually classifies the individuals during gross motor functions with an emphasis more on sitting, transfers and mobility, whereas the MACS score helps us to classify the individual's hand dexterity.

The GMFCS scale includes 5 levels (level I-V) and four age bands: 0 to <2 years, 2 to <4 years, 4 to <6 years and 6 to 12 year (Palisano, Rosenbaum, Bartlett, & Livingston, 2008; McCormick, et al., 2007). The GMFCS scale also helps to classify the individuals in the various levels and set up functional rehabilitation goals. The differences in the levels represent the differences in the individual's ability to perform activities of daily living represented through the gross motor abilities. A higher score on the GMFCS scale (level 5) corresponds to a lower level of gross motor functioning (Nieuwenhuijsen, et al., 2009). The different age bands found on the scale represents the age-related differences based on the gross motor function (Palisano, Rosenbaum, Bartlett, & Livingston, 2008). A study done by Palisano, Rosenbaum, Bartlett, & Livingston, in 2008 as well as in the following year by

Rosenbaum, Paneth, Leviton, Goldstein, & Bax in 2009 suggest the Gross Motor Function Classification System (GMFCS) is a most reliable and valid objective functional scale used for classification of CP and has a high interrater reliability and stability, which helps us to group an individual with CP into one of the five levels (I-V level) (see Appendix A). The GMFCS score has shown to be relatively stable through the childhood of an individual and has a score of 0.79 test-retest reliability (McCormick, et al., 2007). However, this scale can be used to classify individuals with cerebral palsy between the ages of 6 to 12-year-old and would not be applicable for the young adult age group of individuals with cerebral palsy. Studies are being done now to try and revise this scale to increase its suitability among the young adult population as it is now seen that cases of CP in the older population is recorded and it is no longer common only in the paediatric population (Palisano, Rosenbaum, Bartlett, & Livingston, 2008).

The same study along with another study conducted by Gunel, Mutlu, Tarsuslu, & Livanelioglu in the same year also suggested a good inter-rater reliability for the Manual Ability Classification System (MACS) (see Appendix B), which is another scale used to measure the hand-arm function (Eliasson, & Burtner, 2008). MACS is a five-level classification tool used to determine the way objects of daily activities are being handled by a CP individual between the age of 4 to 18 years of age. A higher level suggests a lower level of manual ability (Nieuwenhuijsen, et al., 2009). A study done by Imms, Reilly, Carlin, & Dodd, in the year 2008 on CP individuals between 10-12 years of age used MACS score for classification of the participants as there was evidence of high validity and interrater reliability as well high correlation between the individuals' scores rated both by the parents and therapist when compared varying from 0.91 to 0.98. A study done by McConnell, Johnston, & Kerr, in 2011 recommended MACS to be a suitable tool for classifying upper limb function as it has good interrater reliability and content validity. The intraclass correlation coefficient was high for this scale at around 0.92 (Öhrvall, Krumlinde-Sundholm, & Eliasson, 2013). This study also found that an individual's MACS score remains the same over long periods of time and this could be attributed to the broadness of the each of the five categories and also the reference of the scale was always done to the objects handled relevant to the individual's age. In addition a study done by McConnell, Johnston, & Kerr, in 2011 recommended the usage of MACS scale in terms of assessing the upper limb function in CP individuals as it was the most psychometrically robust and demonstrated evidence of reliability and validity and excellent clinical utility. These studies advocated the usage of both

the GMFCS and MACS both in practice and in research areas as these scales had a good correlation with each other and were practically applicable and easy to use and provides us a simple classification of the functional status among CP children. Hence, this study used both the GMFCS and MACS scale to include participants for the research. The study included participants on a score of 1-3 on the GMFCS scale and 1-3 on the MACS scale.

### Clinical presentation in CP individuals

Impairment of voluntary motor control is the hallmark sign exhibited by CP individuals (Rauworth & Rimmer, 2013). Although the underlying neuropathology is non-progressive in nature it could not be extended to the clinical manifestations of the disease, which is believed to change through the lifespan of the affected individual (Hanna, et al., 2008). The child with cerebral palsy also exhibits primary difficulties in swallowing and other poor oromotor skills along with dental issues such as malocclusion resulting in an acute angle in the mandible initially during the neonatal period followed by delays in developmental milestones such as crawling, sitting, rolling over, walking, etc. along with the various neurological issues that accompany the other impairments such as seizures, cognitive disturbances and pain (Aisen, et al., 2011; Ehrman, Gordon, Visich, & Keteyian, 2013). Besides neuromuscular impairments, these individuals also exhibit associated conditions such as cognitive deficits, impaired sensation, seizure disorders, behavioural dysfunction and emotional problems. Speech impairments such as aphasia and dysarthria are also seen in some of the subtypes (dyskinetic) of CP (Ehrman, Gordon, Visich, & Keteyian, 2013). Musculoskeletal problems such as scoliosis (more prevalent in the spastic CP) is seen mostly in teens and young adults with CP. The motor deficits observed in CP individuals are quite complex ranging from primary deficits such as abnormal muscle tone, decreased strength, balance impairments, coordination problems and selective motor deficits especially the gross motor skills such as the grasping and the fine skills involving the finger tips to secondary deficits which develops from the primary deficits such as muscle contractures and bony deformities (Papavasiliou, 2009). The next paragraphs elaborate more on just the hand impairments seen in CP individuals as it pertains to the research topic.

## **2.2 IMPAIRED HAND FUNCTION IN CP INDIVIDUALS**

The imbalance between the antagonistic muscles influences the position of the arm in a CP individual, wherein the arm is adducted and internally rotated at the shoulder, flexed at the elbow, pronated at the forearm, flexed at the wrist and fingers and opposed at the thumb

(Eliasson, Ekholm, & Carlstedt, 2008). The severity of hand impairments depends upon the extent of damage to the Corticospinal tract (CST). The damage to the CST and other motor pathways causes impairments in the skilled independent finger movements, hand dexterity and movement execution pattern in the upper extremity, which exhibits abnormal muscle tone, decreased strength and there is loss of finger movements such as the precision grip, which results in movements that are often clumsy, slow, and uncoordinated. Studies have found out that half the CP individuals have impaired tactile sensation in their hands, which further reduces their grasping ability (Eliasson, Ekholm, & Carlstedt, 2008). Around 45% of individuals with hemiplegic CP have found to have moderate to severely impaired hand grip in their paretic arm (Eck, Dallmeijer, Lith, Voorman, & Becher, 2010). Gordon, Bleyenheuft, and Steenbergen (2013) found in their research that the fingertip coordination in the CP child at the age of 6-8 years, resembles that of a very young child compared to a typically developing child whose coordination resembles that of an adult. The finger-tip coordination is impaired during the object release as well in a CP individual as well. In addition to movement execution pattern, they also exhibit disturbances in motor planning as well as is seen in the decreased ability to scale the amplitude of force development while handling objects in the affected arm.

It is also being reported in few of the cases that due to the damage to the parietal cortex and the supplementary motor areas (Eliasson & Burtner, 2008), the spastic unilateral CP individuals along with unimanual dexterity defects also exhibit impairments in bimanual coordination among the paretic and the normal limb. These individuals are seen to compensate movements with their non-involved hand to coordinate bimanual reaching task and they rarely use their involved hand spontaneously during the activities of daily life (Eck, Dallmeijer, Lith, Voorman, & Becher, 2010). This is often due to the ‘developmental disuse’ that a CP individual experiences. As seen with earlier research conducted on hand functions in CP individuals, an emphasis was laid more on the unimanual coordination with not much on the bimanual coordination. However, it should be taken into consideration that most of the activities of daily life require coordination of both the arms (bimanual). Therefore, the main purpose of this study is to compare the effectiveness of the commercially available video games, which incorporates the bimanual coordination over the traditional intervention such as the modified constraint-induced movement therapy incorporating the unimanual coordination. Also, the study conceptualizes on the fact that hand impairments in spastic unilateral CP children improve with extensive practices, emphasizing more on the intensity of the

treatment, which is the basis of both interventions employed in the study whereby the mode of treatment is emphasized by its repetitive nature.

### Measures of Hand Impairments:

According to the WHO's International Classification of Functioning, Disability and Health (ICF) impairments is defined as "significant deviations or loss of body function or body structure" (Wichers, Hilberink, Roebroek, van Nieuwenhuizen, & Stam, 2009, p.367). More often the difficulties in performing the daily activities (manual ability) are generally attributed to the sensorimotor impairments (hand impairments) experienced by the CP individuals, however this is not the case as it is clearly stated by the International Classification of Functioning, Disability and Health (ICF) that hand impairments and manual ability are two different concepts of functioning. They also state that these two concepts are not necessarily related in a linear fashion (Arnould, Penta, & Thonard, 2007; Kaur, Mehta, & Kumar, 2011). Hence in this study we examine both the extent of manual ability of a child using the ABILHAND-individuals score as well as the severity of the motor impairments such as the grip strength measured by the hand dynamometer, the gross manual dexterity measured by the box and block test and the fine finger dexterity measured by the Purdue Peg board test.

The ABILHAND-individuals is a functional scale developed to measure the child's capacity or how easily the child manages to complete tasks of daily activities involving the use of hands and upper limbs (Arnould, Penta, & Thonard, 2007; Eck, Dallmeijer, Lith, Voorman, & Becher, 2010). The scale consists of twenty-one bimanual tasks which are usually rated by a child's parent or caregivers on a 3 level scale (0: impossible, 1: difficult, 2: easy) (appendix 3). Both the reliability and reproducibility over time of the scale was reported high and was around 0.94 and 0.91 respectively (Winkels, Kottink, Temmink, Juliëtte, & Burrke, 2012). There were few issues that many have come across when using this scale such as the difficulty in converting the ordinal scores into interval scores. This was resolved with the scores were recalculated to a percentage of maximum score in between the range of 0-100 for easier interpretation as shown in the study done by Eck, Dallmeijer, Lith, Voorman, & Becher in 2010. Also, this scale was more applicable to the elder children (6 years and above) and not for the younger ones (Arnould, Penta, & Thonard, 2007; Eck, Dallmeijer, Lith, Voorman, & Becher, 2010; Gilmore, Sakzewski, & Boyd, 2010).

In a study undertaken by Arnould, Penta and Thonard (2007) the types of hand impairments which were common in CP individuals in the order of decreasing prevalence were as follows: Fine finger dexterity, gross manual dexterity, grip strength, tactile pressure

detection, stereognosis and finally proprioception. It was seen that unilateral CP individual showed motor impairments especially the fine finger dexterity even in their non-paretic arm. This study also found the fact that CP individual develop their handedness on the less affected side as it could be seen that motor impairments were less on the dominant side when compared to the nondominant side (Arnould, Penta and Thonard, 2007). Although, it is to be noted that bilateral hand impairments were observed in all CP types including the unilateral individuals, this further confirms prior studies done which also report that motor impairments were noticed in the non-paretic arm as well although not to a greater extent as the paretic arm. This concept aligns well with the research question for this study, 'Should the rehabilitation program focus more on increasing functional independence by improving coordination among both upper extremities rather than focussing on unimanual impairments – by employing constraint-induced movement therapy, which does not improve functional independence?'

As mentioned earlier and according to the prevalence of hand impairments, the study mainly focuses on the fine finger and gross manual dexterity as well as the grip strength. The grip strength is measured using the Jamar hydraulic hand dynamometer (refer appendix 4 for normative data), while the box and block test was used for measuring the gross manual dexterity and the Purdue peg board test for the fine finger dexterity.

The grip strength score was determined as an average maximal force across 3 trials using the Jamar hand dynamometer, which is considered to be the gold standard reference for other dynamometer being evaluated. The dynamometer is a small and quite portable piece of equipment, which reads force both in kilograms as well as pounds (Roberts, et al., 2011). The position of the arm (pronated, neutral or supinated) did influence the reading on the dynamometer. However for this study, the upper arm was adducted with the elbow flexed at 90° and the forearm was in a neutral position without support, as recommended by the American Society of Hand Therapists (van Meeteeren, van Rijn, Selles, Roebroek, & Stam, 2007). The grip strength measured using the hand dynamometer has a good test-retest reproducibility and inter-rater reliability (Roberts, et al., 2011).

The gross manual dexterity was measured by the 'Box and Block Test (BBT)' that requires moving 1-inch blocks repeatedly from one side of the box to the other side in one minute passing a 2cm high partition. This is done for 3 trials and an average is taken. The interrater and test-retest reliability were quite high for the box and block test. This test consists of a box with 2 compartments and 150 blocks. The test would be repeated for both the paretic arm and the healthy arm. The interrater and test-retest reliability and validity

measure were excellent for the box and block test (Yancosek & Howell, A Narrative Review of Dexterity Assessments, 2009).

Fine finger dexterity was measured by the Purdue Pegboard (PP). This test has been the first choice for many of the clinical and research settings to measure the fine finger dexterity. The test consists of four subtests that average the number of pegs picked up from the container and placed into the holes of the board in 30s (Yancosek & Howell, 2009; Arnould, Bleyenheuft, & Thonnard, 2014).

### **2.3 REHABILITATION METHODS IN UPPER EXTREMITY MANAGEMENT IN INDIVIDUALS WITH CEREBRAL PALSY**

During recent times, with the advancements in treatment choices as well as the consistent efforts put forth by bodies such as the International Classification of Functioning, Disability and Health (ICF) an intervention's success is changed from being seen as a measure to reduce impairments, but rather seen as a measure to being able to produce a better quality of life of the person receiving the treatment (Damiano, 2009). The rehabilitation therapies are mostly directly based on evidence from the advancement of the neuroscience of the growing brain plasticity and its ability to reorganize throughout the lifetime of an individual. Experimental evidence found on works done in the early 2000s found that intensive training involving the acquisition of a new motor skill is associated with long-term brain plasticity (Adamovich, et al., 2005). Reflecting back on the work done by Eliasson, and Burtner in the year 2008 after a series of experiments found two important concepts on the plasticity of the brain – firstly that the development of the CNS is based on the external factors' interactions during the lifetime rather than being a predetermined concept and secondly, this development further depends on the activity of the neural circuits, which implies the fact that those circuits that are frequently used are strengthened whereas those not so often used becomes weakened. This concept led to the development of several interventions capitalizing on the fact of the potential plasticity of the brain and thus improve motor recovery (Aisen, et al., 2011). This is a clear and highly important statement, which merges well with the recent trends in the rehabilitative medicine carried on in individuals with CP. A critical variable which was highly repetitive, intensive as well as motivating was a must to be included in the rehabilitative regime for inducing the brain plasticity. There were studies, which also pointed that participating in exercises that are repetitive in nature, these clients with motor disabilities overcome limitations that they experience (Jen Chang, Fang Chen, & Da Huang, 2011). Bimanual performance in the form of intensive upper extremity training is one of the four

approaches that was seen to demonstrate positive effects on the impairments exhibited by CP individuals. As we can see from the studies conducted on the upper extremities interventions were to improve the usage of the affected upper limb in the ADLs, especially the ones that requires bimanual dexterity. There has been a recent shift in the treatment approach for hand functions in CP individuals due to recent neurorehabilitation topics on what the children can do in a controlled environment rather than what they actually do. This shift has led to greater promotion, exploration, and outcomes targeting related to activity promotion. Hence the purpose of the study is to evaluate and compare in further depth for the best choices available with today's treatment choices in one of the approaches – intensive upper extremity training.

### **2.3.1 Effects of commercially available video gaming technology as a rehabilitation tool for individuals with Unilateral Spastic Cerebral Palsy**

Virtual reality (VR) is defined as “an immense, interactive, 3-dimensional computer experience occurring in real time” (Deutsch, Borbely, Filler, Huhn, & Guarrera-Bowlby, 2008). There are several classifications used to classify virtual reality. One of the classification named the ‘Specific patient population classification’ classifies VR into either musculoskeletal VR, post-stroke VR or cognitive VR. It could also be classified based on the ‘rehabilitation protocol’ into – VR augmented and VR-based therapy. Finally, VR could also be classified based on ‘the proximity the therapist is to the patient’ into therapy done locally in an outpatient environment and as a Virtual telerehabilitation approach in remote situations (Burdea, 2002). Virtual reality has been one of the advanced technological approach, which not only increases the motivational level of an individual but also conceptualizes the neuroplasticity (Aisen, et al., 2011). Several research studies have explored the efficacy and the feasibility of using VR systems in rehabilitation of individuals with CP especially from the age of 8 to 15 years. Jannink, *et al.*, in their study done in the year 2008 stated that by employing virtual reality gaming technology into the rehabilitation protocol we also have the potential to provide augmented feedback and motivate patients further to involve in repetitive tasks, all of which were important to improve cortical changes in the cerebrospinal tract in CP individuals. The virtual reality technology also capitalizes on the fact of the recent approaches, which does not support the fact that the motor impairments in CP individuals are static and that residual motor capabilities and the neuroplastic changes in the nervous system improves with tasks which are repetitive in nature (Gordon & Okita, 2010). This study also pointed out that video gaming technologies helps to motivate individuals engaging in

repetitive tasks by directing their attention towards specific movements that are goal-oriented and diversifying. They also found out that activities done in virtual environment allows the individuals to produce movements that were not produced by the individuals in the actual world due to their impairments. This study also pointed out the essential points to be taken into consideration while choosing the gaming platforms such as 1) initial ability of the learner, 2) motor impairments targeted and last but not the least 3) the interest of the individual. Studies also shows (Hurkmans, van den Berg-Emons, & Stam, 2010) playing active video games especially the Wii® Sports also helps the individuals to improve the energy expenditure as well as the increase their physical fitness. Another study done by Taylor, McCormick, Shawis, Impson, & Griffin, in 2011 found that adding virtual games to the rehabilitation program also distracts the individuals making them concentrate more on the game rather than their impairment, which in turn results in more fun and enjoyable exercise leading to improved adherence to the rehabilitation protocol. Thus all these studies done by early researchers point out the advantages of employing virtual reality technology in the rehabilitation protocol of young adults with CP.

There were many studies done on the benefits of employing virtual reality in improving the impaired hand functions in hemiplegic CP individuals. One of the study done by Huber, et al., in 2010 conducted a pilot study with 3 CP individuals treated with 6-10 months of home hand telerehabilitation. The results suggested that this form of telerehabilitation was feasible and acceptable to clients and does improve their hand function as well, despite the technical difficulties encountered during the rehabilitation course. After the rehabilitation, the researchers found out that there has been an improvement in the range of motion in the hand and wrist of the participants and thereby improved their ability to perform their ADLs without any issues. During this study, they also found out that the participants were able to lift large heavier objects, which they were unable to do so before the study. This study however lacked in its ability to be applied in a clinical settings as there was no control participants included in this study, which further questions whether the results obtained through using virtual reality would be any different from the control participants if they had practised the same opening and closing of their hands for a similar duration.

### **2.3.2 Advantage of the virtual reality over video games:**

In comparison with the various buttons on a game controller, the motion control of the virtual reality gaming consoles is more user-friendly amongst the users with impaired dexterity to benefit from the gameplay. Also, these virtual reality gaming consoles are

inexpensive and are easy to store and does not consume more space. Studies done by Taylor, McCormick, Shawis, Impson, & Griffin, in 2011 also found that the games available on these commercially available ones were quite entertaining and distracted the individuals and makes them focus on the game rather than their own impairments. This leads to greater adherence to the rehabilitation training.

### **2.3.3 Limitations of virtual reality technology**

Although these virtual reality technologies have demonstrated a great potential in motivating individuals with impairments to participate in regular physical activities, it also has limitations. Although providing an enjoyable environment, these games were designed for the general population and were not designed keeping the rehabilitation purpose in the mind. Hence adaptations to the games were necessary to make it more suitable for CP individuals. Also one of the drawbacks seen with these motion sensors is that the clients need to wear them as either strap fastened on limbs or hold them in their hands or even wear them, which can cause discomfort in certain cases.

## **2.4 SUMMARY AND IMPLICATIONS**

Based on the above premise, we developed a fun and motivating bimanual intervention using a commercially available gaming console (Wii®), to help address and improve the hand impairments of young adults with cerebral palsy. This intervention would employ the principles of motor learning and neuroplasticity to address the bimanual impairments, which were found lacking in traditional rehabilitation protocol. This study would also evaluate the course of treatment options available for young adults with CP as there is found to be a great paucity from the previous literatures.

This study would aim at answering the following hypothesis

1. The more younger adults with cerebral palsy participate regularly in a motivating and fun rehabilitation interventions, the better they will demonstrate improved gripping and hand dexterity skills in their effected arm.
2. Effects of structured rehabilitation interventions in young adults with cerebral palsy will improve the hand impairments and enable to participate more actively and efficiently in the activities of daily life.

# Chapter 3: Research Design

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## 3.1 METHODOLOGY AND RESEARCH DESIGN

### 3.1.1 Methodology

This was an experimental study which employed a mixed research method involving both qualitative and quantitative research with an independent and a dependent variable.

### 3.1.2 Research Design

A pilot study research design was used in the study to examine the training effects of the commercially available gaming console, in this case the Wii® in improving the hand impairments in young adults with cerebral palsy. The testing procedure consisted of an initial baseline testing for a week for various outcome measures followed by an 8-week intervention protocol. Each individual received two 30-minute sessions of the Wii® per week and was tested again at the end of the 8-week intervention.

#### Operational Definitions:

- *Cerebral Palsy* - “a group of permanent disorders of the development of movement and posture, causing activity limitation that are attributed to non-progressive disturbances that occurred in the developing foetal or infant brain. The motor disorders of CP are often accompanied by disturbances of sensation, perception, cognition, communication, behaviour, by epilepsy and by secondary musculoskeletal problems” (as cited in Morris, 2009, p.6).
- *Hand Impairments*- Hand impairments in CP individuals refers to the “inability to grasp or pick objects with the paretic hand and struggling with the completion of the activities of daily living, which requires either one or both the hands. The hand impairments would also include the inability to release objects as well (Wichers, Hilberink, Roebroek, van Nieuwenhuizen, & Stam, 2009, p.367).
- *Virtual Reality*: Virtual reality (VR) is defined as “an immense, interactive, 3-dimensional computer experience occurring in real time” (Deutsch, Borbely, Filler, Huhn, & Guarrera-Bowlby, 2008).

#### Independent variable:

- Structured physically interactive games played using the Nintendo Wii®

Dependent variables:

- Grip strength.
- Gross manual dexterity.
- Fine finger dexterity.

Outcome measures:

- Grip strength is used to assess the grip strength in the hands of the participants.
- Gross manual and fine finger dexterity is used to assess the grasping, releasing and object manipulation ability in the hands of the participants.
- ABILHAND adult questionnaire to assess the manual ability in performing the activities of daily living completed either by the parent or the caregiver.

### **3.2 PARTICIPANTS**

Based on the inclusion and exclusion criteria, the study recruited 5 young adults of age range 15-25 years of age, with spastic cerebral palsy. During the course of the study one of the participant exited the study. The recruitment was done with flyers (Appendix C) sent out to both the special schools for individuals with special education programme adapted to the needs of the children and some of the normal schools, which were satellites for the special schools catering to cerebral palsy individuals in mainstream education. Flyers were also sent to the organization Parent2parent which, deals with parents of children with disability for the recruitment. The definition adopted in this study for selecting cerebral palsy individuals would be “all non-progressive but often changing motor impairment syndromes secondary to lesions or anomalies of the brain arising in the early stages of development”.

Inclusion Criteria:

- Young adults between the age of 15-25 years of age.
- Spastic type of Cerebral Palsy.
- Score of 1-3 on the Gross Manual Functional Scale (GMFCS) and a score of 1-3 on the Manual Ability Classification System (MACS) with difficulty opening and closing their hemiplegic hand and struggling to pick up objects with that hand.
- A good cognitive function and a high motivation to participate in the study.
- Both males and females.

Exclusion Criteria:

- Severe learning disabilities (IQ <50).
- Visual or auditory impairment
- Epilepsy.

Before the participation, the participants and the parents (if the participants were under 21 years of age) were required to sign their individual informed consent, attached in the Appendix D.

Table 1

*Participants' Characteristics (n=4)*

Characteristics	n
Age	20 ± 5(15-25)
<b>Sex</b>	
Girls	2
Boys	2
<b>GMFCS</b>	
Level 1	2
Level 2	2
<b>MACS scale</b>	
Level 1	0
Level 2	3
Level 3	1

MACS – Manual Ability Classification System,  
GMFCS – Gross Manual Function Classification Scale

### 3.3 INSTRUMENTS

Hand impairments assessment:

**Instrument #1**

Grip strength: The grip strength in the participants was measured using a Jamar hydraulic hand dynamometer. The grip strength score would be determined as an average maximal force across 3 trials using the Jamar hand dynamometer, which is considered to be the gold standard reference for other dynamometer being evaluated. The dynamometer is a small and portable piece of equipment, which reads force both in kilograms as well as pounds (Roberts, et al., 2011). The upper arm of the individuals would be adducted with the elbow flexed at 90°

and the forearm was in neutral position without support, as recommended by the American Society of Hand Therapists (van Meeteeren, van Rijn, Selles, Roebroek, & Stam, 2007). The grip strength measured using the hand dynamometer has a good test-retest reproducibility and inter-rater reliability (Roberts, et al., 2011).

### **Instrument #2**

Gross manual dexterity: The gross manual dexterity in the participants was measured using the 'box and block test'. This test consists of a box with 2 compartments and 150 blocks. The test required the subject to move 1-inch blocks repeatedly from one side of the box to the other side in one minute passing a 2cm high partition for 3 trials and the average of the them would be considered. The test was repeated for both the paretic arm and the healthy arm. The interrater and test-retest reliability and validity measure were excellent for the box and block test (Yancosek & Howell, 2009).

### **Instrument #3**

Fine finger dexterity: The fine finger dexterity in the participants was measured using the Purdue Pegboard, which required the subject to pick up pegs from a container and place it in the holes of the pegboard in 30s. The number of pegs picked up over an average of 3 trials was noted down. The Purdue Pegboard test has been one of the most commonly used instrument to quantify fine finger dexterity.

### Assessment of the hand impairments:

The participants were tested individually in a quiet room and instructed on how to perform each test. The motor impairments were assessed on both hands, starting with the dominant hand and then on their non-dominant hand. Each subject's handedness was determined by the individual's writing hand preference.

### Manual ability assessment:

### **Instrument #4**

The manual ability of the subject was assessed with the ABILHAND – Individual questionnaire (Appendix E). This questionnaire measured the child's capacity to manage activities of daily life requiring the use of both the upper limbs. The questionnaire consisted

of twenty-one mostly bimanual activities that was rated mostly either by the child's parent or caregiver on a 3-point Likert scale (0 – impossible, 1 – difficult or 2 – easy).

### **3.4 PROCEDURE AND TIMELINE**

The baseline tests were performed on each subject individually in a quiet room and instructions were given to each of them on how to perform the tests. Three motor tests were assessed on both hands starting from the dominant hand, which was determined by writing hand preference for fine finger dexterity, then the gross manual dexterity and the grip strength respectively.

#### **Intervention**

The feasibility of introducing virtual reality games into the rehabilitation protocol of a young adult with spastic CP was the main goal of the study. The games that were used in the intervention was a publicly available one (Wii® Sports & Resort Sport) based on a client-centred approach. After the baseline tests were assessed, the participants were allowed to familiarize themselves with the games for a maximum of 3-5 minutes before playing. The choice of gaming platforms considered 1) initial ability of the learner, 2) the ability to create increasingly challenging movements rather than compensations 3) the interest of the subject as well as 4) the handheld interface to the virtual world should read acceleration changes to map the movements of the person into the gaming environment. This would encourage movements that could be performed both in standing as well as sitting. For games played in a standing position, the researcher was either guarding from behind or on the side of the participant and for games in sitting position the researcher was guarding from behind, stabilizing the chair if necessary. Instructions to the participants about the game was kept as simple as possible. Each participant was made to play each game on the beginner level holding the console in their most-affected arm with a rest period of 3-5 minutes in between each game, which progressed and got more challenging when they reached the pro level consecutively for 3 times in a row. The remote was held both in the dominant as well as non-dominant hand alternatively during the session in games like bowling, and most of the racquet sports games; and with one hand (mostly dominant) holding the remote and the other hand (non-dominant) holding the nunchuck in games such as boxing, archery, cycling.

The demands for the motor controls and the visual-spatial demands were different for each game however it was made sure that the games stimulated more of the upper limb control. Activities were monitored closely during the session and were either stopped for

recovery or modified when the deterioration in the performance was observed. The recovery period was quite brief and would only the participants to reposition the remote before carrying on with the game.

The 16 sessions were scheduled in a flexible manner with the condition that the sessions were separated by  $\geq 12$  hours. The treatment intensity aimed at 30 minutes per session, two times a week for 8 weeks. To reduce the risk of photosensitive-induced seizures, the lights were kept on during the gaming session and the participants were instructed to be seated  $\geq 6$  feet away from the television and the researcher remained with the participants in the room during the sessions.

Table 2

*Outline of Wii-Fit Exercise Program*

Parameter	Description
Wii Sport - Tennis & other racquet sports	This game elicits an upper body motor control along with good eye hand coordination either serving the ball or hitting the ball from the opponent.
Boxing	This game is played holding the console on the dominant hand and nunchuck on the other hand and knocking off the opponent at the same time defending the blows. Good for improve movements of the trunk and upper extremities in various positions eliciting balance perturbations.
Wii Sports Resort	Wii Sports Resort with its dozens of activities such as the Archery, Basketball, Canoeing, Cycling, and Air sports, Wakeboarding, where the players use the precision controls of the console with their fingers.

**3.5 ANALYSIS**

As mentioned earlier, the study employed a mixed method research analysis. A quantitative analysis for the pre-intervention and post-intervention measurement of grip strength, gross manual and fine finger motor test and a qualitative analysis for the pre-intervention and post-intervention measurement of the manual ability. The statistical

comparison of the grip strength, gross manual and fine finger dexterity parameters between both the hand of the participants' pre-test and post-test was done using the student's t-test. A p-value greater than 0.05 was considered statistically significant. A 3 point Likert Scale (0-2) was used to convert the qualitative data obtained from the manual ability scale.

An excel worksheet and an online statistical calculator (MathPortal.org) was used to analyse the pre- and post-intervention scores for statistical difference.

### **3.6 ETHICS AND LIMITATIONS**

The study was approved by the Ethics Committee of Waikato Institute of Technology (Wintec) and conducted in accordance of the Treaty of Waitangi (Appendix F).

The study findings may be limited in their generalizability to other subtypes of CP populations other than the spastic type. The study was also based on the inclusion criteria of well-functioning (GMFCS & MACS score of 1-3) young adults also focused on young adults with CP without learning disabilities, which limits the generalizability as well. The size of the population being studied also further limited its generalizability as the statistics were not of a large significance and were less descriptive in nature.



## Chapter 4: Results

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The study aimed at interpreting one of the main challenge we are currently facing in the rehabilitation field due to the paucity of literature on the rehabilitation measures for young adults with cerebral palsy. The most common source being a case study or reports written by small groups. It also aimed at the next biggest challenge we are facing amongst most of the rehabilitation team due to lack of motivation from the individual due to the repetitive and invasive nature of many of the traditional exercises performed during rehabilitation, which lack variety. Hence this study was aimed at finding out the effectiveness of rehabilitation protocols/ideas that are repetitive in nature, but at the same time be an enjoyable factor for the CP young adults to use them in their treatment.

Between July and October 2017, four participants were recruited for the pilot study to determine the feasibility and outcomes of using a commercially available gaming system (Wii®) in improving the hand impairments in young adults with cerebral palsy. The mean age was 19.7 years (range 15-25 years, two males and two females). The characteristics of the participants are presented in Table 1. The patient population comprised of only spastic type of cerebral palsy. All four participants completed an intervention with the different Wii® games as presented in Table 2 for about 2 sessions per week for eight weeks.

The scores of the outcome measures- hand grip strength, gross manual dexterity, fine finger dexterity along with the manual ability assessment before and after the Wii® intervention are shown in Table 3.

Table 3

### *The Changes in the Outcome Measures*

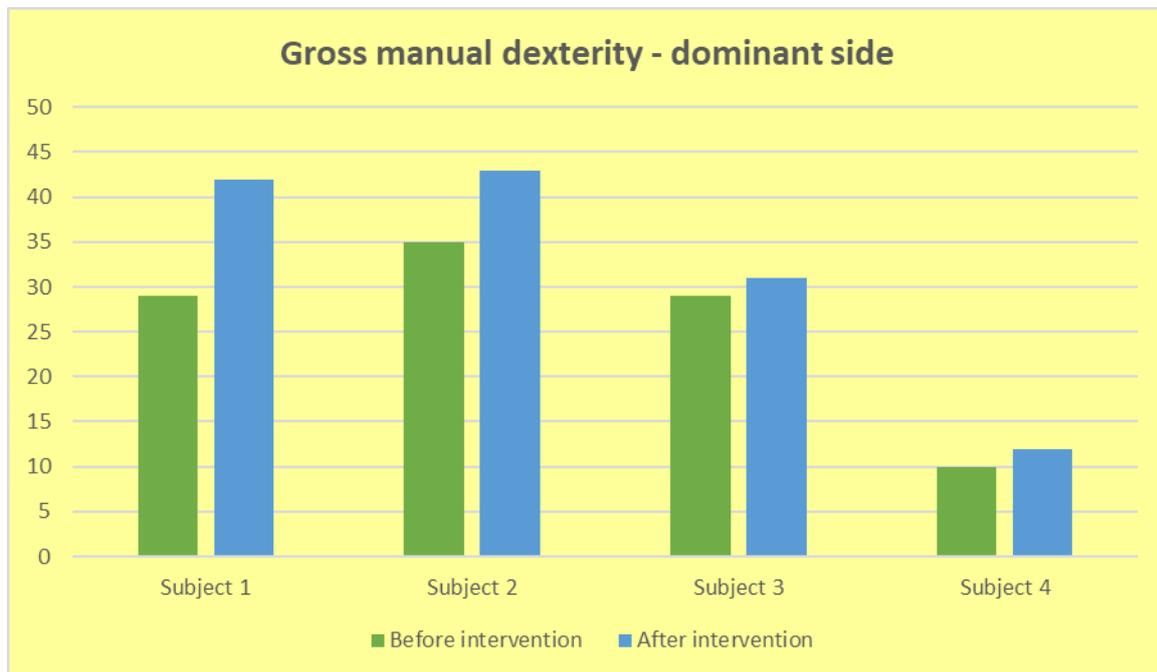
Outcome measures	Pre-treatment mean		Post-treatment mean	
	Dominant	Non-dominant	Dominant	Non-dominant
Grip strength	7	6.4	6.5	6.02
Gross manual dexterity	10.9	8.2	14.3	9.6
Fine finger dexterity	2.95	2.8	3.3	3.4

Table 4

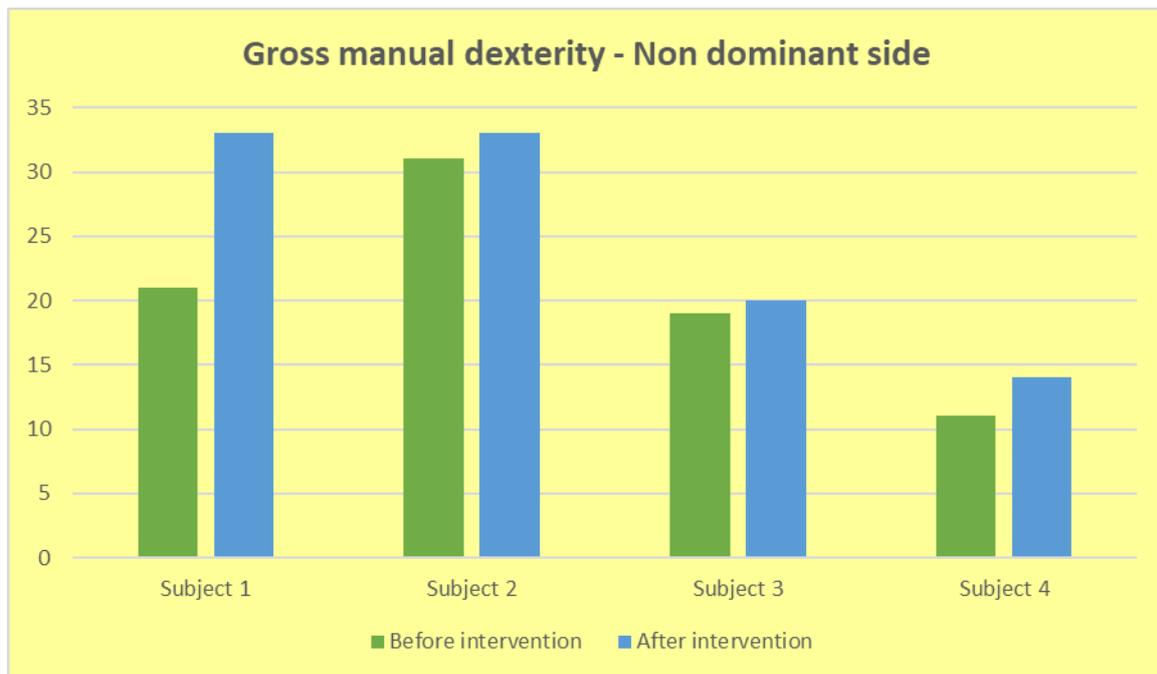
*The Changes in the Outcome Measures*

Outcome measures	Pre-intervention	Post-intervention
Manual ability	2.75	5.19

The outcome measures for each individual are presented in the figures 1-7 as well.



*Figure 1* Gross manual dexterity of participants' dominant side before and after intervention.



*Figure 2* Gross manual dexterity of participants' non-dominant side before and after intervention

The Figures 1& 2 depicts the before and after intervention measurement of the client's gross manual dexterity on both their dominant as well as non-dominant hand. As explained in the earlier chapter (Chapter 3 - Research design), the gross manual dexterity of the individual is measured as the average measurement of 3 trials taken from the 'Box Block test'. The average mean scores across the participants from the test before the 8-week intervention on their dominant and non-dominant hand were 10.87 and 8.22 respectively. These scores have improved after the intervention to about 14.39 and 9.55 on their dominant and non-dominant hand respectively. Although, there was an increase on the mean scores from the test before and after intervention, there was not significant differences observed when analysing the scores using the t-test. This result could be due to small sample size of the study.

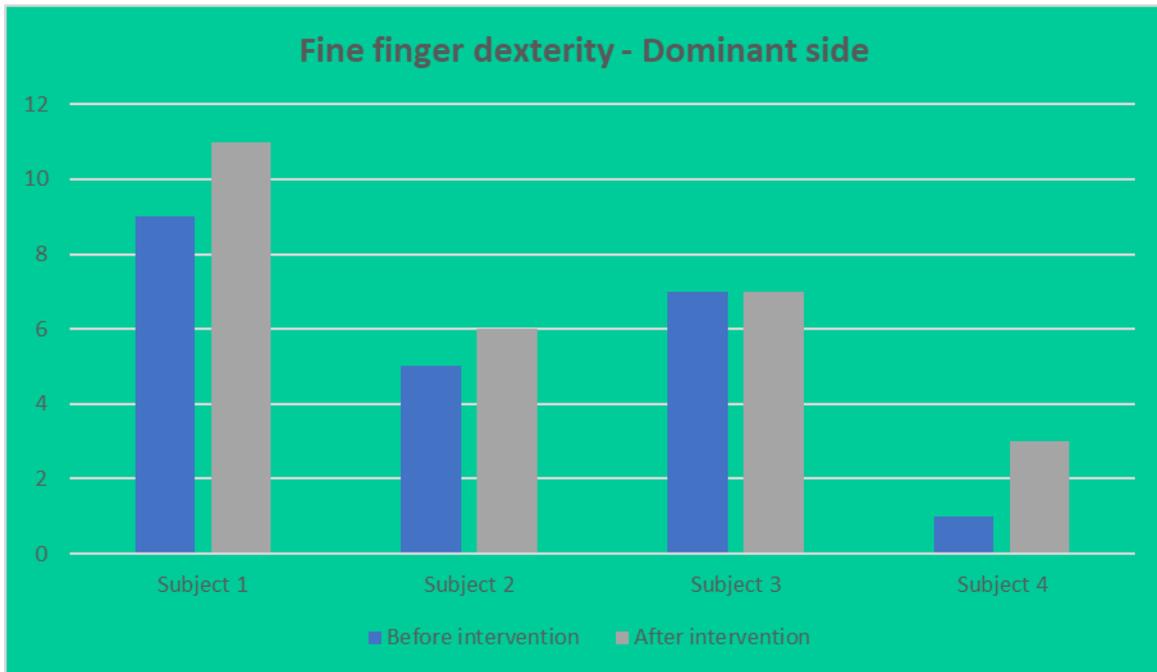


Figure 3 Fine finger dexterity of participants' dominant side – before and after intervention

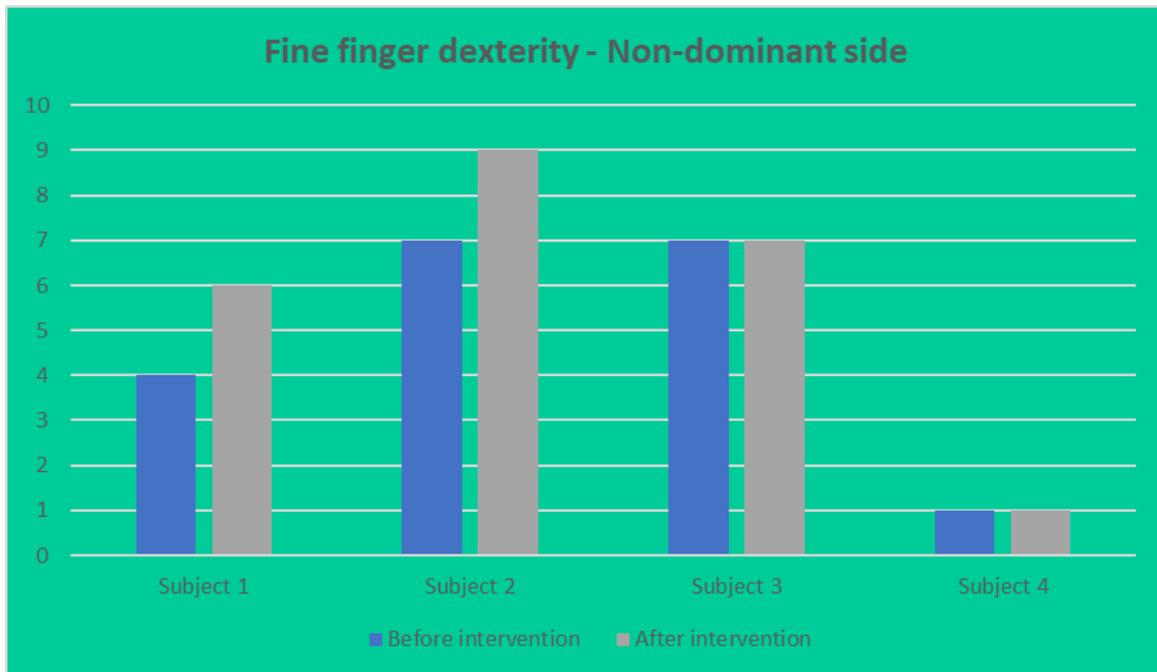
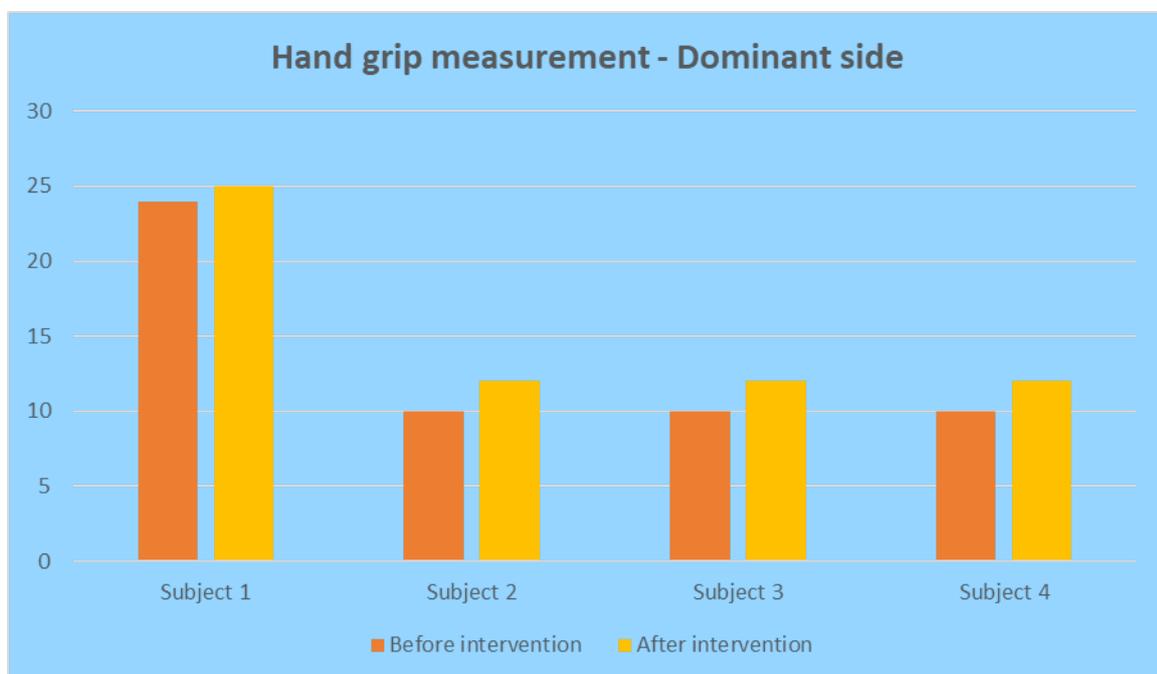


Figure 4 Fine finger dexterity of participants' non-dominant side – before and after intervention

The Figure 3 & 4 above represent next most common hand impairments seen in CP individuals, the fine finger dexterity. This was measured with the 'Purdue pegboard test' from the subjects before and after the 8-week intervention on both their dominant and non-

dominant hand. The average mean score was 2.95 and 2.87 on the dominant and non-dominant side respectively before intervention. The score increased after the intervention to about 3.30 and 3.40 respectively in the dominant and the non-dominant side respectively. This increase showed a significant difference in the mean score value and they were significantly improved after the intervention.

Looking at the scores for the next most common hand impairment, the hand grip in young adults with CP. The outcome measure was an average of three trials taken using the hand dynamometer, which was the gold-standard measurement for assessing handgrip measurement in both the dominant and non-dominant side. The average mean score of the individuals before the intervention were 6.5 and 6.02 on the dominant and non-dominant side respectively. After the 8-week intervention the average mean scores improved to 7 and 6.40 on the dominant and non-dominant side respectively. Statistical analysis of the scores before and after the intervention showed a significant difference in the scores on the dominant hand and no significant difference on the non-dominant hand.



*Figure 5* Hand grip measurement of participants' dominant side – before and after intervention

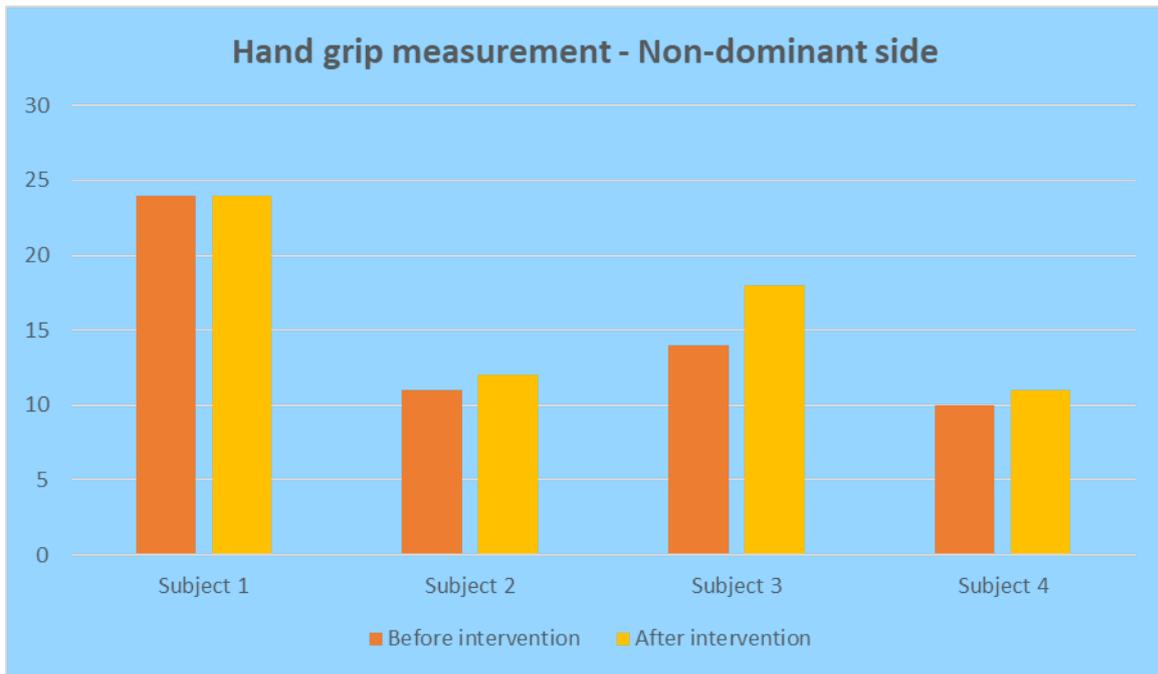


Figure 6 Hand grip measurement of participants' non-dominant side – before and after intervention

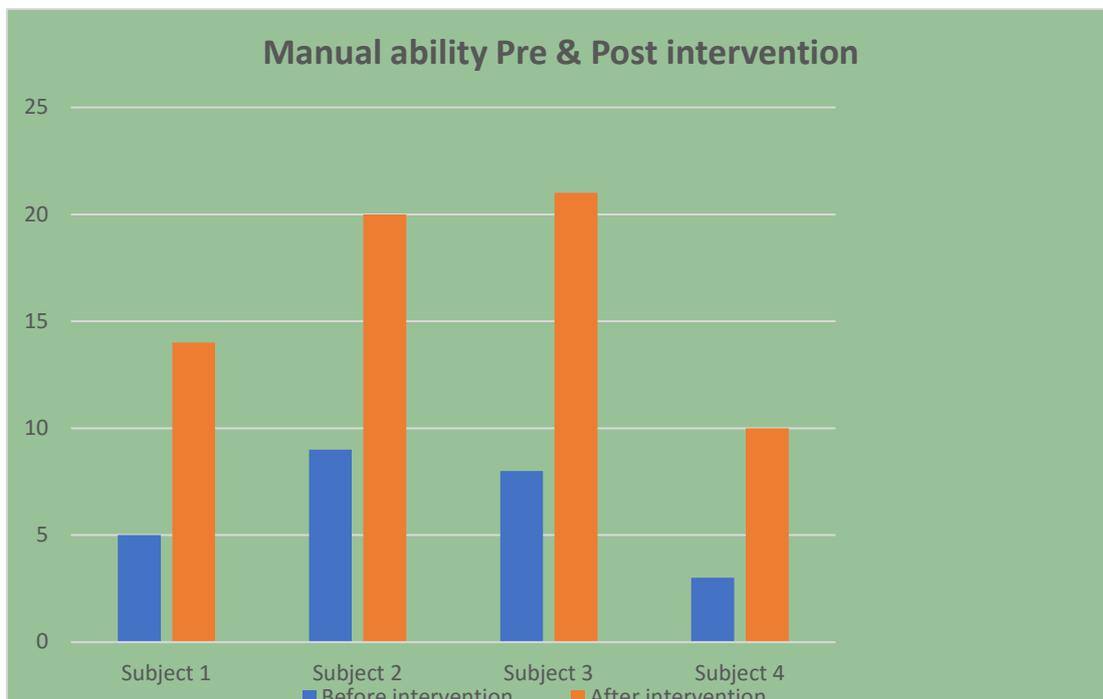


Figure 7 Manual ability measurement of participants before and after intervention

As discussed earlier, the hand impairments of an individual don't determine the manual ability of the individuals at any time. So, it was also one of the outcome measure

which was measured in the study. The average mean score before the intervention was 2.75 and it improved to 5.18 after the 8-week intervention and the analysis showed that the improvement was of significant difference.

Hence it showed from the above study that incorporating virtual reality (Wi®) in the rehabilitation program of young adults with CP helped in improving most of the domains of the hand impairments (fine finger grip dexterity, gross manual dexterity and manual ability) except for the hand grip measurement.

Table 5

*Outcome Score Measures – Gross Manual Dexterity Before and After Intervention*

Outcome measures	Participants	Dominant side		Non-dominant side	
		Before	After	Before	After
Gross manual dexterity	1	29	42	21	33
	2	35	43	31	33
	3	29	31	19	20
	4	10	12	11	14
Average scores	mean	10.87	14.39	8.22	9.55

Table 6

*Outcome Score Measures – Fine Finger Dexterity Before and After Intervention*

Outcome measures	Participants	Dominant side		Non-dominant side	
		Before	After	Before	After
Fine finger dexterity	1	9	11	4	6
	2	5	6	7	9
	3	7	7	7	7
	4	1	3	1	1
Average scores	mean	2.95	3.30	2.87	3.40

Table 7

*Outcome Score Measures – Hand Grip Dynamometer Before and After Intervention*

Outcome measures	Participants	Dominant side		Non-dominant side	
		Before	After	Before	After
Hand grip dynamometer	1	24	25	24	24
	2	10	12	11	12
	3	10	12	18	14
	4	10	12	10	11
Average mean score		6.5	7	6.02	6.39

Table 8

*Outcome Score Measures - Manual Ability Before and After Intervention*

Outcome measures	Participants	Before	After
Manual ability	1	5	14
	2	9	20
	3	8	21
	4	3	10
Average mean scores		2.75	5.18

# Chapter 5: Conclusions

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## DISCUSSION

The study aimed at assessing and reporting the effectiveness of incorporating a more fun and motivating intervention, in this case the Wii® into the rehabilitation programme of young adults with CP. Previous research showed the challenges associated with the transition of treatment for young adults with CP when compared to the paediatric cases. Apparently, there are only a few recommendations from recent researchers ranging from case studies to consensus statements on the health care needs of adults with CP. All these studies point out to the conspicuous fact that about 20-30% of the population faces health issues such as relating to the lower body as in mobility impairments as well as issues with upper body as in dexterity impairments originating from the childhood that lingers on into the adulthood as well. These impairments were commonly reported as problems for example walking for long distances or cutting food into bite size pieces. It is often seen that young adults with CP with normal intelligence experiences several problems in daily life carrying out their day to day activities. Although frequently addressed during paediatric rehabilitation, these problems still prevail in the young adults, which are not often discussed due to the paucity in the resources. Despite the known fact as many of the earlier researches over the decade have pointed out, decreased physical activity in individuals with disabilities persists due to various factors such as cost of the exercise program, transportation of the individuals to and from the rehabilitation centres and the lack of knowledge on the type of exercise that they would benefit from when done individually. Task-oriented training is seen to improve the motor performance in individuals with CP by improving the neuro plasticity and residual capacities. Commercially available virtual reality gaming consoles could be seen as a possible solution to the afore mentioned questions and could be used in the rehabilitation program for practice of repetitive movements as video-gaming today is an activity, which many of us enjoy and are willing to engage in.

The introduction of virtual reality in this case, the Nintendo Wii® in between class schedules of four young adults at special schools as well as volunteering work allowed us to have a minimum of a 30-minute session twice a week for an 8-week time duration, totalling to about 16 sessions altogether. The participants were highly motivated to participate in the intervention due to the gaming challenges. The intervention was conducted both at the school campus for some of the participants (n=2) during school term and at the Wintec Biokinetic clinic for other participants (n=2) and during school holidays for the remaining participants. In both situations, the participants arrived independently for their sessions. The sessions were carried out individually for each of the participants and were supervised by the researcher themselves. The school and the clinic at which the intervention was conducted had both the Wii® along with the consoles and a television set and hence there was not a need for any purchase.

The intervention used in the study allowed the participants to be involved in tasks of a repeated nature such as the hand gripping and grasping during various games and sports played with the hand-held controller and the nunchuck. The gaming control of the Wii® has evolved from the previous video gaming controller (joysticks) to a wireless handheld Wii® remote (Wiimote) mimicking natural gestures. The Wii® received much attention in the field of rehabilitation when compared to the other gaming systems due to its cost and the finger movement systems which are important for activities of daily living. This intervention aimed at improving 4 outcome measures: gross motor control, fine finger dexterity, handgrip and the manual ability of an individual.

The repetitive tasks of handling the control of the game improved the quality of the participants' gripping and grasping skills which was measured with the various hand dexterity tests namely the gross motor dexterity, fine finger dexterity, hand grip strength and manual ability before and after the intervention. The VR systems used in the study alongside with improving the hand impairments in the young adults with CP also displayed a motivating reinforced visual feedback to the individuals during the performance. Recent evidences suggest addition of task-oriented training approaches as seen in this intervention to improve the motor capacities of an individual through improved neural plasticity.

The feasibility of using virtual reality in the rehabilitation program of young adults with CP appeared beneficial in improving their hand impairments. The results of the study demonstrated that all the 4 young adults with spastic unilateral CP showed improved results in most of the outcomes measures during the 8-week VR intervention. As seen in the results chapter, there was an overall as well as individual improvement in the outcome measures, although, as discussed before as the study involved a small sample size there was not much of a significant difference seen in the scores.

There were three individual components of the outcome measures which showed a significant difference after the 8-week intervention period. These movements included the fine finger dexterity, hand grip strength and the manual ability, whereas the gross motor dexterity did not show much of a significant difference. Interestingly, it was also noted that there were significant differences only on the dominant side when compared to the non-dominant side in the participants. Overall the trends appear similar between genders.

Hence, we could conclude from this study that employing a low-cost commercially available gaming console does improve the hand impairments such as the gross manual as well as the fine finger dexterity in young adults with spastic CP. This study also suggests that there is an improvement in the manual ability of young adults with CP with the use of commercially available gaming console. We could also conclude that incorporating the Wii™ in the rehabilitation program of young adults results in increase in confidence level of the individuals by allowing them to mimic the natural grip gestures similar to the real-world using the upper extremities to control the game as found in accordance to a previous study done by Gordon and Okita (2010).

The design of this investigation has several limitations. The first limitation was the smaller size of the sample population of individuals. The subtype of cerebral palsy individuals involved in the study is another limitation of this study. Spastic CP individuals with normal intelligence were included in the study, which limited the generalizability of the results on the other subtypes of the same population and on individuals with lesser IQ.

## **5.2 RECOMMENDATIONS**

Although the virtual reality is likely to have many positive benefits for adults with CP, further research is needed to understand what type of program and intensity duration is safe and most beneficial for these individuals. Also, consideration of incorporating educational measures to manage CP during adulthood must be incorporated in most of the

rehabilitation team. Future research is also needed to examine the barriers to regular exercise that these individuals would experience along with adherence to exercise amongst young adults with CP. In addition, it would be interesting to compare the outcomes of the low-cost commercially available gaming system used in this study (Wii®) with the other motion sensing input gaming devices systems such as the PlayStation and Microsoft Kinect.

### **5.3 CONCLUSION**

When growing into adulthood, young adults will have to learn a range of activities of daily life that would increase their independency to participate in adult life. Most of these activities would depend on the individual's bimanual ability and dexterity. The current study shows that young adults with CP showed improvement in their hand impairments by incorporating a commercially available gaming console into their rehabilitation protocol. Based on these findings it is recommended that virtual reality (Wii™) should be incorporated in the rehabilitation protocol of young adults with CP in their daily practice.

# References

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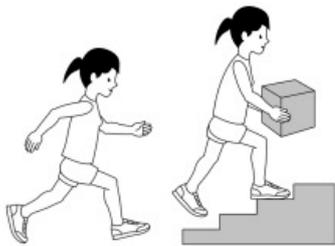
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# Appendices

## Appendix A Gross Motor Function Classification System



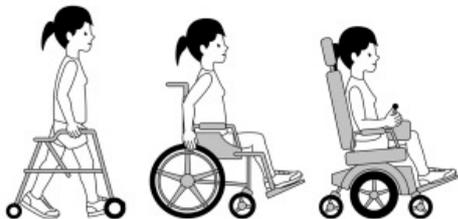
### GMFCS Level I

Youth walk at home, school, outdoors and in the community. Youth are able to climb curbs and stairs without physical assistance or a railing. They perform gross motor skills such as running and jumping but speed, balance and coordination are limited.



### GMFCS Level II

Youth walk in most settings but environmental factors and personal choice influence mobility choices. At school or work they may require a hand held mobility device for safety and climb stairs holding onto a railing. Outdoors and in the community youth may use wheeled mobility when traveling long distances.



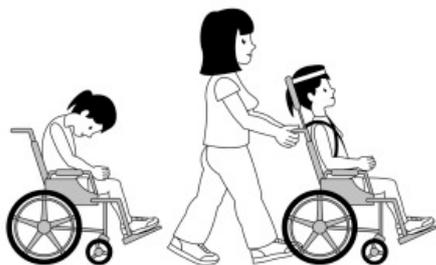
### GMFCS Level III

Youth are capable of walking using a hand-held mobility device. Youth may climb stairs holding onto a railing with supervision or assistance. At school they may self-propel a manual wheelchair or use powered mobility. Outdoors and in the community youth are transported in a wheelchair or use powered mobility.



### GMFCS Level IV

Youth use wheeled mobility in most settings. Physical assistance of 1-2 people is required for transfers. Indoors, youth may walk short distances with physical assistance, use wheeled mobility or a body support walker when positioned. They may operate a powered chair, otherwise are transported in a manual wheelchair.



### GMFCS Level V

Youth are transported in a manual wheelchair in all settings. Youth are limited in their ability to maintain antigravity head and trunk postures and control leg and arm movements. Self-mobility is severely limited, even with the use of assistive technology.

## Appendix B

### Manual Classification Ability Scale

Level 1	Handles objects easily and successfully.
Level 2	Handles objects, but with somewhat reduced quality and/or speed of achievement.
Level 3	Handles objects with difficulty; needs help to prepare and/or modify activities.
Level 4	Handles a limited selection of easily managed objects in adapted situations.
Level 5	Does not handle objects and has severely limited ability to perform even simple actions.

## Appendix C

### Recruitment flyers



# Participate in Research

## Wintec

WAIKATO INSTITUTE OF TECHNOLOGY  
Te Kōwhiri o Waikato



#### Who?

Young adults with Cerebral Palsy of 15-25 years of age

#### What?

Participates in fun studies like playing the Nintendo™ Wii (virtual reality)

#### Where?

At their respective school & Wintec Sport & Exercise Science Department, Hamilton

#### Why?

To understand how the fun element could be used for rehabilitation protocols

#### Contact me for more information:

**Farah**  
**Phone:** 021 293 4656  
**Email:**  
[farah.mohammed@wintec.ac.nz](mailto:farah.mohammed@wintec.ac.nz)

## Appendix D

### Informed consent form

### Parents form



**Wintec**  
WAIKATO INSTITUTE OF TECHNOLOGY  
Te Kuratini o Waikato

**This informed consent form is for parents of children between the ages of 15 and 25 years of age who would be attending the Biokinetic Clinic and who we are asking to participate in research \_\_\_\_\_**

**Farah Banu Noor Mohammed  
Wintec Sport and Human Performance Department**

**This Informed Consent Form has two parts:**

- **Information Sheet (to share information about the study with you)**
- **Certificate of Consent (for signatures if you agree that your child may participate)**

**You will be given a copy of the full Informed Consent Form**

### **PART I: Information Sheet Introduction**

I am Farah, studying my Masters of Science at the Wintec Sport and Human Performance Department. We are doing research on young adults with cerebral palsy.

I am going to give you information and invite you to have your child participate in this research. You do not have to decide today whether you agree that your child may participate in the research. Before you decide you can talk to anyone you feel comfortable with.

There may be some words that you do not understand. Please ask me to stop as we go through the information and I will take time to explain. If you have questions later, you can also ask them of me or my supervisor.

## **Purpose**

Cerebral Palsy is one of the most common physical disability that affects movement and posture in children caused by the defect or lesion to one or more specific areas of the brain usually occurring during foetal development before, during or shortly following birth or during infancy.

Approximately 7,000 people in New Zealand have some degree of cerebral palsy (one third are under 21 years of age). Individuals can have problems such as weakness, stiffness, awkwardness, slowness, shakiness and difficulty with balance. At least two-thirds of the individuals with cerebral palsy will have movement difficulties affecting one or both arms and the child may be exhibiting difficulties in carrying out their activities of daily living (ADLs).

The rehabilitation exercises that is currently being used is not as motivating and enjoyable to the individuals as we would like it to be but there are some new protocols, which may work better. The main purpose of this research is to test the rehabilitation protocol of the new commercially available video gaming (Wii™) to see if it motivates and helps the cerebral palsy young adults better than the regular school exercise programme.

## **Type of Research Intervention**

Your child will be taken in a one on one session through an eight – week exercise protocol in the Wii™ group. The child will also be tested before and after the eight-week exercise protocol for their manual grip strength along with the gross and fine motor dexterity strength.

## **Participant selection**

Virtual reality use in physical therapy is suggested to have several strengths including the capability of adapting to the virtual environment and allow the children to play in a safe environment, preventing injury and at the same time facilitates children to get real time performance feedback and independent motivational training.

We are inviting you to take part in this research because it is important that we research a new rehabilitation protocol on cerebral palsy children to enable them to stick to them more than the regular traditional rehabilitation protocol, which they often find less interesting and motivating.

## **Voluntary Participation**

Your decision to have your child participate in this study is entirely voluntary. It is your choice whether to have your child participate or not. You may also choose to change your mind later and stop participating, even if you agreed earlier.

## **Procedures and Protocol**

- Your child will be taken through an eight-week interventions using the Wii™ (virtual reality).
- The main aim of the study is to describe the feasibility and outcomes of using a low-cost, commercially available gaming system (Wii) to augment the hand impairments of young adults with spastic cerebral palsy.
- Your child will be tested for his/her current hand and finger dexterity skills before beginning the intervention and then would be tested again in the same order after the intervention to see if the interventions have helped them improve their dexterity skills.
- You could choose to stay with the child during these procedures.
- It is also essential that we have access to the child's medical records as this is quite important for the study.

### **A. Unfamiliar Procedures**

There would be no unfamiliar procedures other than the ones described in the process.

### **B. Description of the Process**

You may stay with your child during each of the rehabilitation session. In the first visit, your child will be tested for his/her grip strength, gross motor and fine finger dexterity respectively. This will be tested for his/her current overall hand and finger strengths. There are no invasive procedures during this period and your child will not feel any discomfort other than just plain fatigue in the arm muscles due to the test.

In the next visit, your child will be started on the Wii™ protocol, wherein he/she would be using the Wii and play some physically interactive video games. The whole session would take no longer than 30-45 minutes. The child's comfort and physical fatigue levels would be tested throughout the session. Adequate breaks for rest and hydration will also be provided for the child.

We would ask you/ your child's physician to give us the details of your child's health and illness related information. If you do not wish us to do that, please let us know. However, your child's health records are very important for the study.

### **Duration**

The research will take place over 8-10 weeks in total. During that time, it will be necessary that your child comes to either the school or the Biokinetic clinic for that time-period for about an hour each day for 3 alternate days of the week. Altogether we will see your child at least 30 times over a 3-month period.

## **Side Effects**

There are no known side effects from this rehabilitation program. We will give you a telephone number to call if you notice anything out of the ordinary, or if you have any concerns or questions.

## **Risks**

By participating in this research, there are no known possible risks that your child would be subjected to. While the possibility of this happening is very low, you should still be aware of the possibility. If something unexpected happens and harm does occur, we will provide your child with immediate first aid care by the researcher as they hold a first aid certificate.

## **Discomforts**

By participating in this research, it is possible that your child may experience some discomfort such as the mild generalized fatigue that can accompany after an hour session with the Wii. These should get better after a couple of sessions as they get used to the exercises. But if you are concerned, please call me at my number or email me.

## **Benefits**

If your child participates in this research, he/she will not have any benefits such as paid medical charges or transportation reimbursements other than helping us to find the answer to the research question. There may not be any benefit to the society at this stage of the research, but future generations are likely to benefit.

## **Reimbursements**

You will not be provided any incentive/ reimbursements to take part in this research.

## **Confidentiality**

The information that we collect from this research project will be kept confidential. Information about your child that will be collected from the research will be put away and no-one but the researcher will be able to see it. Any information about your child will have a number on it instead of his/her name. Only the researcher will know what his/her number is and we will lock that information up in a locker with a lock and key. It will not be shared with anyone except the supervisor [Dr. Glynis Longhurst].

## **Sharing of the results**

The knowledge that we get from this study will be shared with you if you choose for it. Confidentiality will be maintained throughout the study. Afterwards, we will publish the results in order that other interested people may learn from our research.

## **Right to Refuse or Withdraw**

You do not have to agree to your child taking part in this research. You may stop your child from participating in the research at any time that you wish.

## **Alternatives to participating**

If you do not wish your child to take part in the research, your child will be provided with the regular ongoing established sessions at the school.

## **Who to Contact**

If you have any question you may ask them now or later, even after the study has started. If you wish to ask questions later, you may contact any one of the following: [Farah, 51 Akoranga Road, Q block, Wintec/ 021 293 4656/ [farah.mohammed@wintec.ac.nz](mailto:farah.mohammed@wintec.ac.nz). Dr. Glynis Longhurst, 51 Akoranga Road, Q block, Wintec/ 07 834 8800 ext. 8157/ [glynis.longhurst@wintec.ac.nz](mailto:glynis.longhurst@wintec.ac.nz)]. This proposal has been reviewed and approved by the Wintec Ethics committee, which is a committee whose task is to make sure that the research participants are protected from harm.

## **PART II: Certificate of Consent**

### **Certificate of Consent**

**I have been invited to have my child participate in research of the Wii program. I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction. I consent voluntarily for my child to participate as a participant in this study.**

**Print Name of Participant** \_\_\_\_\_

**Print Name of Parent or Guardian** \_\_\_\_\_

**Signature of Parent or Guardian** \_\_\_\_\_

**Date** \_\_\_\_\_  
**Day/month/year**

***If illiterate***

*A literate witness must sign (if possible, this person should be selected by the participant and should have no connection to the research team). Participants who are illiterate should include their thumb print as well.*

**I have witnessed the accurate reading of the consent form to the parent of the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.**

***Print name of witness*** \_\_\_\_\_ ***AND*** ***Thumb print of***  
***parent***

***Signature of witness*** \_\_\_\_\_

**Date** \_\_\_\_\_  
**Day/month/year**

**Statement by the researcher/person taking consent**

**I have accurately read out the information sheet to the parent of the potential participant, and to the best of my ability made sure that the person understands that the following will be done:**

- 1.
- 2.
- 3.

**I confirm that the parent was given an opportunity to ask questions about the study, and all the questions asked by the parent have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.**

**A copy of this ICF has been provided to the participant.**

**Print Name of Researcher/person taking the**  
**consent** \_\_\_\_\_

**Signature of Researcher /person taking the**  
**consent** \_\_\_\_\_

**Date** \_\_\_\_\_  
**Day/month/year**

# Participant Information Sheet

Study title: **Use of commercially available gaming system – Wii for rehabilitation of hand impairments in young adults with cerebral palsy**

Locality: **Hamilton**

Lead investigator: **Farah** Contact phone number: 021 293 4656

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## Individual Consent form

You are invited to take part in a study on the 'Use of commercially available gaming console – Wii for rehabilitation of hand impairments in young adults with cerebral palsy. Whether you take part is your choice. If you don't want to take part, you don't have to give a reason, and it won't affect the care you receive. If you do want to take part now, but change your mind later, you can pull out of the study at any time.

This Participant Information Sheet will help you decide if you'd like to take part. It sets out why we are doing the study, what your participation would involve, what the benefits and risks to you might be, and what would happen after the study ends. We will go through this information with you and answer any questions you may have. You do not have to decide today whether or not you will participate in this study. Before you decide you may want to talk about the study with other people, such as family, whānau, friends, or healthcare providers. Feel free to do this.

If you agree to take part in this study, you will be asked to sign the Consent Form on the last page of this document. You will be given a copy of both the Participant Information Sheet and the Consent Form to keep.

This document is 5 pages long, including the Consent Form. Please make sure you have read and understood all the pages.

### WHAT IS THE PURPOSE OF THE STUDY?

- *The main purpose of this study is to describe the feasibility and outcomes using a low-cost, commercially available gaming system (Wii) to improve the hand impairments of young adults with cerebral palsy.*
- *You would be attending an eight-week interventions, before and after which you would be tested through various physical fitness (non-invasive) tests for hand and finger dexterity skills.*
- *The study has been through, reviewed and agreed upon by the Wintec Ethic Committee.*

- *Your confidentiality would be maintained throughout the study.*

### **WHAT WILL MY PARTICIPATION IN THE STUDY INVOLVE?**

- *You have been chosen to participate in this study as it would involve young adults with cerebral palsy.*
- *You would be going through an eight-week interventional study with the Wii™ gaming systems to see if it would improve your hand and finger dexterity skills.*
- *You would be expected to attend a 30-45-minute session, at least 3 sessions a week for about 8 weeks. The study would mostly be based at your school/ the Wintec Biokinetic Clinic at the Rotokauri Campus. At this stage, there would be no follow up for this study.*
- *You would be tested for the following skills*
  - *Grip strength – 3 trials using the hand dynamometer.*
  - *Gross Manual strength – 3 trials using the box and block test.*
  - *Fine finger dexterity strength – 3 trials using the Purdue Peg board test.*
  - *Manual ability skills – a questionnaire consisting of 21 questions rating your bimanual skills filled by either one of your parent or the caregiver.*
- *Your medical records would also be accessed for the study.*

### **WHAT ARE THE POSSIBLE BENEFITS AND RISKS OF THIS STUDY?**

- *By participating in this research, there are no known possible risks that you would be subjected to. While the possibility of this happening is very low, you should still be aware of the possibility.*
- *If something unexpected happens and harm does occur, we will provide your child with immediate first aid care by the researcher as they hold a first aid certificate.*

### **WHO PAYS FOR THE STUDY?**

- *There would be no cost incurred on you for participating in this study.*
- *There would be no reimbursements/ incentives paid to you during the study.*

### **WHAT IF SOMETHING GOES WRONG?**

- *If you have private health or life insurance, you may wish to check with your insurer that taking part in this study won't affect your cover.*
- *If you were injured in this study, which is unlikely, you would be eligible for compensation from ACC just as you would be if you were injured in an accident at work or at home. You must lodge a claim with ACC, which may take some time to assess. If your claim is accepted, you will receive funding to assist in your recovery.*

## WHAT ARE MY RIGHTS?

- *You do not have to agree to take part in this research.*
- *You may stop from participating in the research at any time that you wish without experiencing any disadvantage.*
- *You will have the right to access information about your results collected as part of the study.*
- *You will be informed of any new information, either adverse or beneficial effects related if that becomes available during the study that may have an impact on your health.*
- *Your confidentiality will be maintained throughout the study as the records would only be assessed by the lead researcher and their supervisor and no one else.*

## WHAT HAPPENS AFTER THE STUDY OR IF I CHANGE MY MIND?

- *There would be no study intervention available to you after the study.*
- *The data collected for the study would remain 7 years*
- *The study results will be shared with you if you choose for it at the end of the research the earliest by the end of November. Afterwards, we will publish the results in order that other interested people may learn from our research*

## WHO DO I CONTACT FOR MORE INFORMATION OR IF I HAVE CONCERNS?

If you have any questions, concerns or complaints about the study at any stage, you can contact:

Farah, Lead researcher  
021 293 4656  
[farah.mohammed@wintec.ac.nz](mailto:farah.mohammed@wintec.ac.nz)

If you want to talk to someone who isn't involved with the study, you can contact an independent health and disability advocate on:

Phone: 0800 555 050  
Fax: 0800 2 SUPPORT (0800 2787 7678)  
Email: [advocacy@hdc.org.nz](mailto:advocacy@hdc.org.nz)

# Consent Form

**If you need an INTERPRETER, please tell us.**

*If you are unable to provide interpreters for the study, please clearly state this in the Participant Information Sheet*

**Please tick to indicate you consent to the following** (*Add or delete as appropriate*)

I have read, or have had read to me in my first language, and I understand the Participant Information Sheet.	Yes <input type="checkbox"/>	No <input type="checkbox"/>
I have been given sufficient time to consider whether or not to participate in this study.	Yes <input type="checkbox"/>	No <input type="checkbox"/>
I have had the opportunity to use a legal representative, whanau/ family support or a friend to help me ask questions and understand the study.	Yes <input type="checkbox"/>	No <input type="checkbox"/>
I am satisfied with the answers I have been given regarding the study and I have a copy of this consent form and information sheet.	Yes <input type="checkbox"/>	No <input type="checkbox"/>
I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without this affecting my medical care.	Yes <input type="checkbox"/>	No <input type="checkbox"/>
I consent to the research staff collecting and processing my information, including information about my health.	Yes <input type="checkbox"/>	No <input type="checkbox"/>
If I decide to withdraw from the study, I agree that the information collected about me up to the point when I withdraw may continue to be processed.	Yes <input type="checkbox"/>	No <input type="checkbox"/>
I consent to my GP or current provider being informed about my participation in the study and of any significant abnormal results obtained during the study.	Yes <input type="checkbox"/>	No <input type="checkbox"/>
I understand that there may be risks associated with the treatment in the event of myself or my partner becoming pregnant. I undertake to inform my partner of the risks and to take responsibility for the prevention of pregnancy.	Yes <input type="checkbox"/>	No <input type="checkbox"/>
I agree to my (type of tissue) samples being sent overseas and I am aware that these samples will be disposed of using established guidelines for discarding biohazard waste.	Yes <input type="checkbox"/>	No <input type="checkbox"/>
I agree to an approved auditor appointed by the New Zealand Health and Disability Ethic Committees, or any relevant regulatory authority or their approved representative reviewing my relevant medical records for the sole purpose of checking the accuracy of the information recorded for the study.	Yes <input type="checkbox"/>	No <input type="checkbox"/>
I understand that my participation in this study is confidential and	Yes <input type="checkbox"/>	No <input type="checkbox"/>

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that no material, which could identify me personally, will be used in any reports on this study.

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I understand the compensation provisions in case of injury during the study. Yes  No

---

I know who to contact if I have any questions about the study in general. Yes  No

---

I understand my responsibilities as a study participant. Yes  No

---

I wish to receive a summary of the results from the study. Yes  No

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**Declaration by participant:**

I hereby consent to take part in this study.

Participant's name: \_\_\_\_\_

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

**Declaration by member of research team:**

I have given a verbal explanation of the research project to the participant, and have answered the participant's questions about it.

I believe that the participant understands the study and has given informed consent to participate.

Researcher's name: \_\_\_\_\_

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

## Appendix E

### ABILHAND – ADULTS FORM

#### ABILHAND - individuals – Manual Ability Measure (Pre-intervention measure)

Patient:

Date

	How difficult are the following activities?	Impossible (0)	Difficult (1)	Easy (20)
1	Pulling up the zip of trousers			
2	Holding a tea cup			
3	Sharpening a pencil			
4	Taking a cap off a bottle			
5	Filing one's nail			
6	Peeling potatoes with a knife			
7	Buttoning up shirt			
8	Opening a screw-topped jar			
9	Cutting one's nails			
10	Tearing open a bag of chips			
11	Unwrapping a chocolate bar			
12	Hammering a nail			
13	Spreading butter on a slice of bread			
14	Washing one's hands			
15	Buttoning up the trousers			
16	Threading a needle			
17	Cutting meat			
18	Wrapping up gifts			
19	Fastening a snap			
20	Zippering up a jacket			
21	Taking a coin out of a pocket			
Total score				
Grand total				

## Appendix F

### Ethics form



Waikato Institute of Technology  
Research and Postgraduate Office  
D Block, Tristram Street / Private Bag 3036  
Hamilton 3240  
e-mail [research@wintec.ac.nz](mailto:research@wintec.ac.nz)  
Telephone 07 834 8800 Extn 8339

19 June 2017

Centre for Sport Science and Human Performance  
Farah Mohammed

Dear Farah,

#### **HUMAN ETHICS RESEARCH APPLICATION**

**Title:** Use of a commercially available gaming console – Wii for rehabilitation of hand impairments in young adults with cerebral palsy

Thank you for your application which was considered by the Human Ethics in Research Group on 15 June 2017. It is with pleasure I advise ethics approval for your project is granted.

Ethical approval is granted until 31 December 2017 or until the project has been completed, whichever comes first.

Please note that should there be any changes to the approved research project then it will need to be referred back to the committee for further consideration.

The Human Ethics in Research Group wishes you every success with this project.

Kind regards

Megan Allardice  
pp Elizabeth Bang  
Chairperson  
Wintec Human Ethics in Research Group

Cc. Glynis Longhurst, Supervisor