The Use of Virtual Reality with Children with Cerebral Palsy: A Pilot Randomized Trial

Denise Reid and Kent Campbell

This paper reports on a pilot randomized controlled study on the use of virtual reality (VR) for examining rehabilitation outcomes in children with cerebral palsy. The objectives of the study were to see if changes in the quality of upper-extremity movement and in self-perceived self-efficacy and self concept could be found as a result of VR intervention. There were 19 experimental and 12 control subjects. The main outcome tools for the study were the Harter Self-Perception Profile for Children (SPPC), the Canadian Occupational Performance Measure (COPM), and the Quality of Upper Extremity Test (QUEST). The results were all non-significant with the exception of the Harter's social acceptance subscale (p = .02). These results need to be interpreted with caution, as there was considerable drop out with the control group and variability in the participants. These results do not suggest that VR is more effective than regular OT or PT intervention for children with cerebral palsy. These findings will be discussed to suggest that VR remains a viable rehabilitation tool and further research needs to be done where strategies for control group retention are devised as well as its use in recreation therapy.

KEY WORDS: *Cerebral palsy, virtual reality, rehabilitation, outcomes*

In this pilot study we sought to apply the emerging technology of virtual reality (VR) to the field of pediatric rehabilitation. The primary question that was addressed was:

Dr. Denise Reid is professor in the Department of Occupational Therapy, University of Toronto, 500 University Ave., Toronto, Ontario. M5G 1V7. d.reid@utoronto.ca. Kent Campbell works at the Bloorview MacMillan Rehabilitation Centre, 350 Rumsey Road, Toronto, Ontario M4G 1R8. kcampbell@bloorviewmacmillan.on.ca

"Does the use of virtual reality with children who have cerebral palsy have an effect on their self-competence (self-concept, and self-efficacy perceptions), and quality of upper-extremity movement?"

Background and Theoretical Basis for the Study

Cerebral palsy (CP) refers to a group of posture and movement disorders occurring as a result of a non-progressive lesion of the developing central nervous system (Grether, Nelson 1997; Pellegrino, 1997). Generally, a diagnosis is made before the age of two years, and therapy interventions are provided. The emphasis of therapy programs, especially for younger children with CP, has been on promoting physical growth and development. There have been many popular forms of therapy over the years, however their real value and effectiveness has not been strongly supported by empirical evidence, (Croce & Depaepe, 1989; DeGangi et al., 1983; Ottenbacher et al., 1986). For the older school-age child with CP, the goal of intervention focuses on psychosocial growth and development as well as on motor performance (e.g., Darrah et al., 1999). This is critical given the challenges facing school-age children and adolescents as they grapple with both developmental issues and their motor disorder. However, a steadfast problem is that there is very little research documenting the effects of rehabilitation therapy on motor and psychosocial outcomes.

The potential for use of VR with children with cerebral palsy (CP) holds tremendous promise as a new and effective intervention for improving self-competence and motor performance. Inman et al.'s (1997) study showed that VR was effective in training powered mobility skills in children with CP. Nemire and Crane's (1995) study allowed children with CP to access educational experiences not otherwise provided to them. The results of these two studies suggest that a simulated interactive environment available through VR offers children with CP an opportunity to practice and try out new skills/movements in a safe environment. This in turn can lead to enhanced motor performance, but perhaps even more importantly, a sense of personal control or self- efficacy, and a positive self-concept. Virtual reality (VR) has been described as having the potential to be a powerful tool for use in rehabilitation with people with disabilities (Greenleaf & Tovar, 1994; Kuhlen & Dohle, 1995; Wilson, Foreman, & Stanton, 1997). VR is defined as an immersive and interactive three-dimensional (3D) computer experience occurring in real time (Pimental & Teixeira, 1995). VR applications use 3D computer graphics, which respond to the user's movements, thereby given the user the sense of being immersed in the virtual environment.

Although, there have been only a limited number of studies exploring the potential of VR in rehabilitation, and fewer still in pediatric rehabilitation, previous applications with children with disabilities have demonstrated the potential of VR to improve life skills, mobility and cognitive abilities, quality of life, and social opportunities (Hirose, Taniguchi, Nakagaki, & Nihei, 1994; Inman, Loge, & Leavens, 1997; Nemire & Crane, 1995; Muscott & Gifford, 1994; Rose, Attree, & Johnson, 1996; Standen & Cromby, 1995; Strickland, Marcus, Mesibov, & Hogan, 1996; Wilson, Foreman, & Tlauka, 1996).

Emerging research in the field of disability studies indicates that individuals with disabilities attach great importance to some technology in their lives. Key attributes identified by participants offered by technology which are key components to their sense of self and wellbeing include such things as: independence, personal autonomy, control, and competence (Lupton & Seymour, 2000). The introduction of new computer technologies such as virtual reality (VR) has incited much interest in examining how psychological and physical bodily experiences are altered via the human/technology interface (e.g., Halberstam & Livingston, 1995; Haraway, 1991), and how meanings associated to technology by people with disabilities influence feelings of self worth (e.g., French, 1993; Roulstone, 1998).

Well-developed theories of behavior change have been proposed in fields beyond rehabilitation, and may be useful for developing hypotheses and specifying mechanisms by which rehabilitation interventions for children with disabilities may work. A combination of theoretical frameworks may be necessary to explain the role and impact of various aspects of an intervention. In this study, self-efficacy theory (Bandura, 1977, 1986) and motor learning theory (Adams, 1971; Schmidt, 1975) are used to explain the impact of a VR intervention with children with cerebral palsy. Self-efficacy theory states that behaviour is cognitively mediated by the strength of a person's self-efficacy beliefs. Self-efficacy is defined as an individual's assessment of his or her ability to perform behaviors in specific situations (Bandura, 1997). Perceptions of self-efficacy are not reflective of a global personality trait; rather, they vary across different behavioral domains, e.g., physical self-efficacy, productivity self-efficacy, etc. A substantial body of research supports this theory and indicates that strong self-efficacy beliefs are related to a variety of positive health outcomes (McAvay, Seeman, & Rodin, 1996). Applied to children with CP, self-efficacy theory, especially the importance of measuring domain-specific perceptions of self-efficacy suggests that the use of VR may enhance motivation in children and provide them with a sense of mastery or self-efficacy. Theoretically, enhanced feelings of self-efficacy will, in turn, result in improved perception of performance and satisfaction with performance. Recent research by Rizzo et al. (1998) underscores the advantage of the enjoyable game-like experience of VR and its relationship to motivation, performance, and satisfaction with performance among children. Thus, as shown in Figure 1, self-efficacy theory offers a testable pathway as to the mechanism by which children with CP may benefit from VR.

Motor learning theory stresses the role of practice and feedback as major influences on motor performance; there are many reports in the rehabilitation literature demonstrating the application of these concepts to interventions with individuals with disabilities (e.g., Croce & Depaepe, 1989; Goodgold-Edwards, 1985; Sabari, 1991). Thus, applied to VR, one mechanism suggested by motor learning theory is that multiple trials of a task where children are continuously informed of their performance, e.g., their accuracy score, may maintain motivation and elicit the desired outcome of improved movement quality (see Figure 2).

There have been problems reported with the use of different VR systems that have important implications for using VR successfully with children with disabilities. Critics of the head-mounted display systems have reported they tend to restrict movement, are heavy to the user, cause motion sickness, have a limited field of view, and are not very comfortable (McGrath & Merickel, 1993; Nemire, Burke, & Jacoby, 1994; Rose et al., 1996). The major limitation with the use of desk-top VR which is accomplished through projecting the virtual environment (VE) onto the computer monitor and the user interacts with the VE with the use of a joystick, mouse, or keyboard is a diminished sense of immersion (McComas, Pivik, & Laflamme, 1998).

To overcome these problems, in this study we used the 1996 patented *Mandala ® Gesture Xtreme* IREX VR system developed by Vivid Group Inc., from Toronto. This system uses a video camera as a capturing and tracking device to put the user inside VR experiences. The user sees him/herself on a TV screen and the virtual environment (VE) responds to his/her movements. The user does not have to wear, touch, or hold anything. Through the use of the system's "video gesture" capability, the movements (e.g., reaching, bending) trigger visible or invisible icons to score points and manipulate animations (e.g. playing a virtual drum kit, playing volleyball, or painting a picture). Figures 1 and 2 illustrate painting and volleyball.

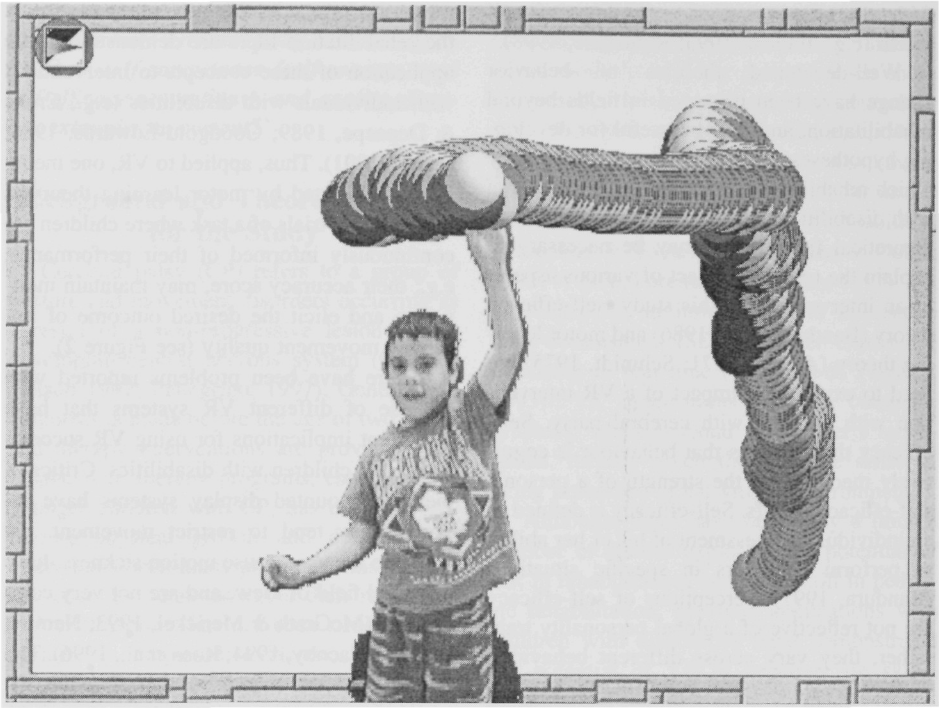

FIGURE 1. BOY PAINTING A PICTURE IN VIRTUAL REALITY

Study Hypothesis

The hypothesis was there will be a significant difference in self-efficacy, self-concept and quality of upper-extremity movement between children with cerebral palsy who receive virtual reality intervention (treatment group) and those receiving standard care (control group).

Method

A two-year randomized controlled trial (RCT) with blinded assessment was conducted. A pilot test phase including three subjects was conducted in year one where protocols were developed and procedures tested and modified. This phase was essential, given the exploratory nature of the study. Once parameters and procedures were confirmed, the RCT began.

Sample

On the basis of available information regarding variability in COPM scores with children with CP (Reid, Rigby, & Ryan, 1999) and assuming at least 80% power, a sample size of 30 children (two groups of 15) was deemed to be adequate to appropriately examine the hypothesis. However, expecting individual variability, which would reduce power, and the possibility of attrition, we determined the sample size to be 40 children (2 groups of 20 children).

Therefore, a total of 40 children between the ages of 8 and 10 years who have a diagnosis of CP and are receiving occupational therapy and/or physical therapy intervention were to comprise the sample. A final number of 19 experimental and 12 control children were recruited. Participants were recruited from a variety of sources including rehabilita-

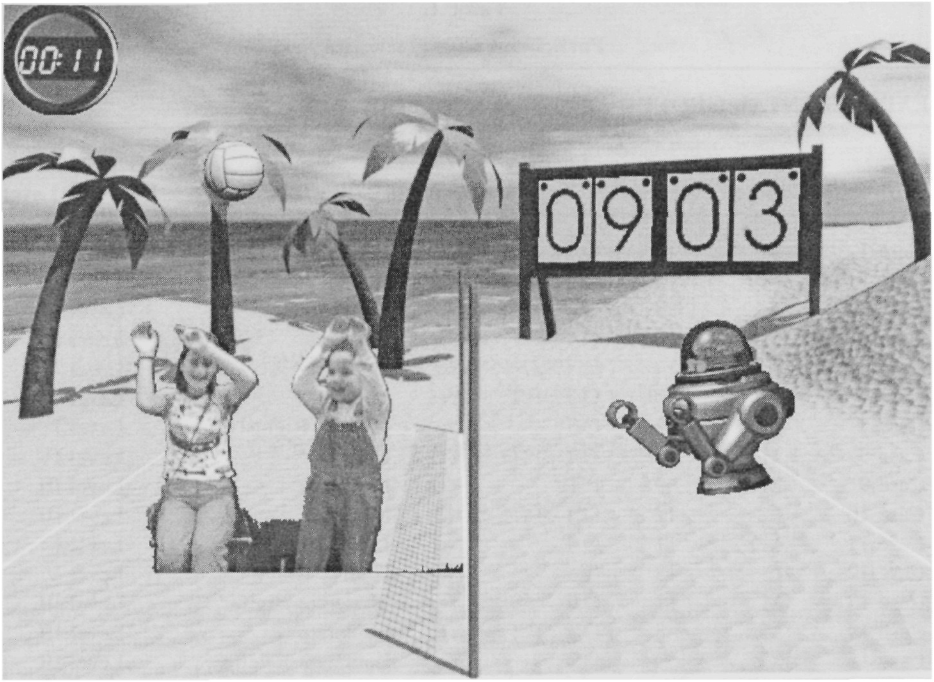

FIGURE 2. GIRLS PLAYING VOLLEYBALL IN VIRTUAL REALITY

tion centers, hospitals, private pediatric therapy organizations, and community organizations in the Greater Toronto Area. Children were classified on the basis of their mobility function for entry into the study using Palisano et al.'s (1997) Gross Motor Function Classification System for children with CP (GMFCS). This 5-level classification system is based on current concepts of disability and functional limitations consistent with the ICIDH model of the World Health Organization (1980) and models of disablement advanced by Nagi (1965) and the National Institutes of Health. The inter-rater reliability of the system for children 2 to 12 years is reported to be (κ) = 0.75. Table 1 describes the participants. Participants were included if they could see and reach with at least one hand. They were randomly assigned to one of two groups by means of a computer generated table of random numbers. Exclusion criteria included: severe cognitive disability preventing participants from understanding and cooperating with study procedures; spoken language other than English; presence of any other medical diagnosis, e.g., Attention Deficit Hyperactivity Disorder.

VR Intervention

In a lab environment, children in the VR group sat on a bench or in their wheelchair in a demarcated area viewing a large TV screen with a video camera mounted on the top. A pretest of outcome measures was done followed by one session a week for 8 weeks of VR intervention. Each intervention session was approximately 1.5 hours. A random number of VR applications were given to the participants. Each VR application required them to reach with their arms to the targets. There were a number of sports applications, like soccer and volleyball; music

Table 1.
Participant Characteristics

EXPERIMENTAL GROUP

Subjects	Gender	Age (years)	Therapy Type	W/C User	Tone	Gross Motor Function Level
Case 1	M	10	O.T., P.T.	Yes	High	Level V
Case 2	M	8	O.T., P.T.	No	Low	Level I
Case 3	F	9	O.T., P.T.	No	Low-Moderate	Level I
Case 4	M	10	O.T., P.T.	No	Moderate	Level I
Case 5	F	10	O.T.	Yes	High	Level V
Case 6	M	10	O.T., P.T.	Yes	Moderate	Level V
Case 7	F	12	O.T.	No	High in Right U/E	Level I
Case 8	M	10	O.T., P.T.	Yes	High	Level IV
Case 9	M	9	P.T.	Yes	Moderate	Level III
Case 10	F	12	O.T., P.T.	No	Moderate	Level III
Case 11	M	11	O.T.	No	Low	Level I
Case 12	F	13	O.T.	No	High	Level V
Case 13	M	11	O.T.	Yes	Moderate-High	Level III
Case 14	M	8	O.T., P.T.	Yes	Moderate	Level III
Case 15	M	9	O.T.	Yes	Low	Level III
Case 16	F	8	O.T.	No	Low	Level I
Case 17	F	8		Yes	Moderate	Level III
Case 18	M	8	P.T.	No	Moderate (left only)	Level III
Case 19	M	8	O.T., P.T.	No	Low	Level I

CONTROL GROUP

Subject	Gender	Age (years)	Therapy Type	W/C USER	Tone	Gross Motor Function Level
Case 1	F	11	O.T., P.T.	Yes	High	Level V
Case 2	F	10	P.T.	Yes	Moderate Left Side	Level III
Case 3	M	11	O.T.	No	Moderate	Level I
Case 4	M	9	O.T.	No	Low (mild)	Level I
Case 5	F	10	O.T., P.T.	Yes	High	Level III
Case 6	M	9	P.T.	No	Moderate	Level I
Case 7	F	10	O.T., P.T.	Yes	High	Level III
Case 8	M	8	O.T	Yes	Low	Level V
Case 9	M	8	O.T.	Yes	Low-High	Level III
Case 10	M	9	O.T., P.T.	Yes	High	Level III
Case 11	M	9	O.T., P.T.	Yes	High	Level V
Case 12	M	8	O.T.	No	Low	Level I

Application of Self-Efficacy Theory to VR Effect on

Self-Competence in Children with Cerebral Palsy

Child's interactions with virtual environment are enjoyable and non-threatening

⇓

Child motivated to maintain engagement and control

⇓

Child practices new movements/actions

⇓

Child feels sense of mastery, self-efficacy

FIGURE 3.

programs, like drums; and game-like programs, like sharks or juggler. In all the programs the participant could see himself as part of the application. To motivate the participant they could choose the applications to be played. In a given session at least 6 or 7 applications were played. A random number of trials that lasted approximately 1–2 minutes were given for each application. Accuracy scores were recorded by the computer, and these were shown to the participants at the end of each session. Figures 3 and 4 shows examples of VR applications.

Standard of Care

Participants in the control group received "standard of care"; in this case, this was the

Application of Motor Learning Theory to VR Effect on

Motor Performance in Children with Cerebral Palsy

Child repeats same movements/actions due to multiple trials of task

⇓

Child receives visual and auditory feedback

⇓

Child adapts/modifies movements/actions

FIGURE 4.

therapy services (occupational therapy and or physical therapy) they typically received. There was no single "standard" for occupational therapy and physical therapy services for children with cerebral palsy, and considerable variety existed in the types of services available. There were direct "hands on" services provided through private therapy clinics and hospital and rehabilitation programs, and indirect "consultative" services provided through school health support programs or community agencies. The time spent receiving services, and the type and frequency of services for all subjects, was on average once a week. The types of goals varied but all included a focus on the upper extremity for movement control and productivity issues.

Instrumentation

Outcome measures used in this study included: the Canadian Occupational Performance Measure (COPM) (Law et al., 1998), the Self-Perception Profile for Children-SPPC (Harter, 1985), and the Quality of Upper-Extremity Skills Test (QUEST) (DeMatteo et al., 1992).

Canadian Occupational Performance Measure

The COPM (Law et al., 1998) was used in this study as a measure of functional self-efficacy. The COPM was designed as an outcome measure with a semi-structured interview format and structured scoring method to: (1) identify and prioritize problem areas in occupational performance among clients with a variety of disabilities and across developmental levels, (2) evaluate self-perception of performance and satisfaction relative to problem areas, and (3) measure changes in a client's perception of his/her functional performance over time. Results of a number of validation studies (reported in the test Manual) show that the COPM demonstrates good test-retest reliability, validity, and responsiveness. Sanford, Law, Swanson, and Gyatt (1994) showed test-retest reliability to be .63 for performance scores and .84 for satisfaction scores. In another study with children with disabilities the test-retest reliability was .79 for performance scores and .75 for satisfaction (Law & Stewart, 1996). The validity was established for content validity by developing the test against a theoretical model of OT and having experts evaluate whether the construct was measured. A study by McColl, Paterson, and Law (2000) showed that 53% of individuals were able to correctly name problems that were also identified on the COPM, showing criterion validity. A recent study conducted by the principal investigator, which examined the effects of a rigid pelvic stabilizer device on perceived functional performance in children with CP who were wheelchair users, showed the COPM to be a responsive instrument (Reid et al., 1999). In this study, the same approach to administering the COPM that was used in the Reid et al. (1999) study was used. That is, the context for framing the interview was related to problems with performing functional activities involving the upper extremities.

Self-Perception Profile for Children

The SPPC (Harter, 1985) was used in this study as a measure of self-concept. It is a widely used assessment tool in research and in clinical practice to document children's self-concept and to evaluate changes on this construct over time. It has been used in studies with children with cerebral palsy (see Darrah et al., 1999; King et al., 1997). The instrument contains six separate subscales tapping five specific domains (Scholastic Competence, Social Acceptance, Athletic Competence, Physical Appearance, Behavioural Conduct), as well as Global Self-Worth. Reliability is acceptable with Cronbach alphas ranging from 0.71 to 0.86. Results of factor analysis reveals that there are no cross-loadings greater than .18 therefore defining distinct domains. Physical Appearance is the subscale, which is consistently related to Self-Worth (most *r*'s falling with the range of .62 and .73).

Quality of Upper-Extremity Skills Test

The QUEST (DeMatteo et al., 1992) was used in this study as a measure of motor performance. The QUEST is a criterion-referenced test designed to look at patterns of movement, which form the basis of upper-extremity function. The QUEST measures performance in four domains: dissociated movements, grasp, weight bearing, and protective extension. Only the dissociated movement domain will be used. Studies of the QUEST with children with CP demonstrates that the QUEST has excellent inter-rater reliability (.90–.96) and test-retest reliability (.75–.95), and strong correlations with the Peabody Developmental Motor Scales (.78). The QUEST has also been shown to be responsive to evaluating the qualitative aspects of upper-extremity movements in a study of children with CP (Law et al., 1991; Loewen et al., 1998). Scoring of the QUEST is reported in percentage scores.

Procedures

Informed consent and assent was required from each participant (guardians/children) prior to involvement in the study. Two to three children with CP meeting the same eligibility criteria (but not part of the study sample) were recruited to participate in the pilot phase. This phase established the software applications parameters (e.g.. speed, number and direction of virtual balls), and standard set-up protocol for positioning of child and VR equipment. The results of the pilot test phase informed us as to whether changes were needed to the design of the RCT, e.g., increasing number of treatment sessions or changing parameters (Reid, 2002a; Reid, 2002b). The Gross Motor Function Classification System for Children with CP-GMFCS (Palisano et al., 1997) was used for classifying participants. The different levels reflect the degree of independent gross motor function. All eligible participants following the classifying process underwent a blinded assessment (baseline). Using a randomized table of numbers, children were randomly assigned either to the VR or control group (Intervention Phase). A second blinded assessment was conducted for each child by the same evaluator after the 8-week treatment period. The COPM, SPPC, and QUEST were administered on both occasions (Baseline and Post Test) according to the protocols outlined in the Test Manuals.

Treatment Fidelity

In clinical trials, treatment fidelity refers to a confirmation that the manipulation of the independent variable occurred as planned (Moncher & Prinz, 1991). In this study, to ensure procedural reliability with respect to treatment delivery, a standardized script including a detailed task analysis of interventions and instructions was developed. In addition, a random number of sessions were monitored by videotaping them. To ensure adherence to protocols, worksheets/logs were developed to record treatment delivery and these will also be monitored periodically.

Data Analysis

Measures of the dependent variables include: (1) total COPM Performance, and Satisfaction scores, and (2) SPPC domain scores, (3) total QUEST - dissociated movements Percentage score. Higher scores on the COPM and SPPC reflect more positive perceptions. A higher score on the QUEST represents better quality of movement.

All data were analyzed first using descriptive statistics followed by inferential statistics. COPM, SPPC, and QUEST scores were analyzed using t-tests due to the high variability in the data.

Results

Table 1 describes the participant characteristics. Table 2 displays the means and standard deviations of the outcome measures. Results from t-tests revealed no statistically significant result except for the social acceptance subscale

Table 2.
Means and standard deviations of outcome measures

Outcome Pretest	Group Treatment	Mean	SD	Group Control	Mean	SD
COPM - P		3.35	.84		3.80	1.3
COPM - S		3.89	1.1		4.20	1.5
Harter - SC		2.84	.77		2.70	.59
Harter - SA		3.01	.80		3.35	.71
Harter - AC		2.38	.76		2.48	.52
Harter - PA		3.45	.59		3.16	.51
Harter - BC		3.44	.48		3.05	.61
Harter - GSW		3.38	.70		3.29	.52
QUEST		67.68	28.87		42.71	35.31
Posttest						
COPM - P		5.83	1.7		5.07	1.9
COPM - S		6.58	1.5		6.02	2.33
Harter - SC		2.92	.79		2.88	.74
Harter - SA		3.2	.65		2.90	.75
Harter - AC		2.65	.67		2.51	.99
Harter - PA		3.71	.45		3.22	.63
Harter - BC		3.53	.51		3.28	.56
Harter - GSW		3.65	.50		3.42	.57
QUEST		71.19	28.83		54.51	35.59

Key: COPM - P = Canadian Occupational Performance Measure - Performance Scale, COPM - S = Canadian Occupational Performance Measure Satisfaction Scale, Harter SC = Scholastic Competence, SA = Social Acceptance, AC = Athletic Competence, PA = Physical Appearance, BC = Behavioral Conduct, GSW = Global Self Worth, QUEST = Quality of Upper Extremity Test

of the Harter SPPC. Table 3 shows the results of t-tests.

Discussion

This study was conducted to examine the effectiveness of using VR with children with cerebral palsy. We compared VR against standard O.T. or P.T. interventions. All participants' mean scores changed at post-test. The trend was toward improvement. The only significant change was for the social acceptance subscale of the Harter showing a significant improvement for the treatment group. Participants receiving VR may have felt more accepted by their non-disabled peers and felt more competent as a result of experiencing VR. The items on the social acceptance subscale were: perceiving that they were making lots more friends, that they were liked more, and perceiving that they did more things with other kids. Results from other pilot research showed that children with cerebral palsy showed similar results and that their self-efficacy skills in areas of social play were enhanced (Reid, 2002b).

We conducted informal interviews with the participants who received VR following a random number of sessions and the results of the interviews suggested that the participants felt they could do more things like their peers and

Table 3.
T-tests results for outcome measures

Outcome	T	P value
Pretest		
COPM - P	−1.63	0.12
COPM - S	−0.84	0.41
Harter - SC	0.39	0.70
Harter - SA	−2.63	0.02*
Harter - AC	−0.64	0.53
Harter - PA	−0.95	0.35
Harter - BC	0.97	0.34
Harter - GSW	−0.67	0.51
QUEST	0.82	0.43

Key: COPM - P = Canadian Occupational Performance Measure - Performance Scale, COPM - S = Canadian Occupational Performance Measure - Satisfaction Scale, Harter SC = Scholastic Competence, SA = Social Acceptance, AC = Athletic Competence, PA = Physical Appearance, BC = Behavioral Conduct, GSW = Global Self Worth, QUEST = Quality of Upper Extremity Test

that their peers would be envious of them if they saw them doing the VR. These findings were seen in pilot work (Miller & Reid, 2003; Reid, 2002b). Unfortunately, many participants in the control group were not motivated to return for the post-test session, resulting in incomplete data. This may have been a combination of parental and child lack of interest. We offered an honorarium to all participants upon completion of the study for their time commitment, but this did not seem to be a good enough incentive to retain members in the control group. Further investigations need to develop strategies, possibly introducing a computer type of alternative treatment to the VR to equalize the motivation in both groups. We have preliminary data on children's motivation during VR, however we need to study this further (Harris & Reid, 2005; Miller & Reid, 2003). Other researchers found that youngsters with disabilities showed a high level of enthusiasm and a sense of empowerment during similar VR experiences to those that we worked with (Weiss, Bialik, & Kizony, 2003). The lack of findings for the quality of upper extremity movement outcome could be due to the fact that the intensity of the VR intervention was not great enough. To modify quality of movement in children with cerebral palsy much time and effort is usually necessary. Interestingly in a pilot study we found improvements in upper extremity skills (Reid, 2002a). The participants in this study all had cerebral palsy but were quite heterogeneous (Table 1). Their physical function and variability in performance may have greatly influenced the results. Furthermore, if sensitive measures were taken such as fMRI, it is possible that cortical changes underlying motor performance could have been seen (You, Jang, Kin, Kwon, Barrow, & Hallett, 2005).

However the limited findings do suggest that as a tool VR demonstrates promise. Implications for recreation therapist (RT) and occupational therapists are that VR seems to be useful as a tool that can increase the enjoyment and feelings of acceptance by others among disabled children. Recreation therapists may consider using VR in health care settings to engage children who are disabled and who are at risk for low self-esteem and isolation. Yang and Poff (2001) encourage RTs to consider using VR as an innovative treatment modality within the context of recreation and leisure. VR provides a barrier free alternative to engaging children with disabilities in play situations. Flow theory (Csikszentmihalyi, 1990) offers support for our findings where our participants by engaging in VR play activities their skill level matched the challenges imposed by virtual play. This is relevant to RTs and OTs who are concerned with providing flow like experiences through engagement in activities. Our participant's anecdotal comments were that they were lost in the moment and that time went by fast during VR sessions.

Our findings indicate that children enjoyed the VR experience. By increasing the opportunity to play a virtual game such as volleyball with others the enjoyment was enhanced as well as the opportunity for social contact. Research has shown that the use of virtual reality has been shown to modify emotions and feelings in individuals with disabilities (Yang & Poff, 2001) and provide social experiences (Broida, Germann, Houck, & Broida, 2000). This study showed that children with cerebral palsy perceived a greater acceptance and recognition by their peers because they likely saw themselves like them doing things like them. Through VR they could engage in playing volleyball or snowboarding with their non-disabled peer thus equalizing the situation. The consideration of VR as an equalizer is exciting. This study provides preliminary evidence that VR provides opportunities for social engagement between individuals disabled and non-disabled. It also shows that VR fosters feelings of competence and social acceptance by others. Future research is needed before we can conclude that VR is an effective treatment for children with cerebral palsy.

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