The Effects of a Downhill Skiing Program on Standing Balance in Adults and Children With Various Disabilities

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THE EFFECTS OF A DOWNHILL SKIING PROGRAM ON STANDING BALANCE IN ADULTS AND CHILDREN WITH VARIOUS DISABILITIES

BY

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THESIS

Submitted to the department of Physical Therapy at Grand Valley State University Allendale, Michigan in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN PHYSICAL THERAPY

1996
THE EFFECTS OF A DOWNHILL SKIING PROGRAM ON STANDING BALANCE IN ADULTS AND CHILDREN WITH VARIOUS DISABILITIES

ABSTRACT

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The purpose of this study was to assess possible improvements in balance following a downhill ski program at Cannonsburg Ski Area. The 15 subjects' ages ranged from 7-67 and were obtained by a convenience sample of participants in the Cannonsburg Challenged Ski Association. Diagnoses of the participants included cerebral palsy, traumatic brain injury, cerebral vascular accident, hearing impaired, visually impaired, and developmentally disabled.

A pre-test, post-test design was used to assess the participants balance using the functional reach test - yardstick method. Data was analyzed by computer using the Statistical Package for the Social Sciences (SPSS). Using the t-test for paired comparisons, a statistically significant increase in mean distance reached was noted ($t=2.46$, $p=0.01$, $df=14$, alpha=0.05) following the ski season. The results of this study indicated that standing balance was improved for children and adults with various disabilities following participation in the Cannonsburg Challenged Ski Program.
ACKNOWLEDGEMENTS

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DEFINITION OF TERMS

1. **Perturbations** - anything that disrupts one's center of gravity outside of his/her base of support

2. **Anticipatory postural adjustments** - preprogrammed motor strategies that assist in preventing displacements of balance

3. **Base of support (BOS)** - the area one's mass must fall between to maintain a stable posture and avoid falls

4. **Center of mass (COM)** - the arbitrary point located anterior to the second sacral vertebral segment where the mass of an object is concentrated, and therefore, is the central point of gravitational pull

5. **Center of pressure excursion (COPE)** - a test where the subject stands on a force platform and the pressure caused by weight shifting is recorded
CHAPTER 1

INTRODUCTION

Based on the latest trends in health care towards cost containment, less of the physical therapist's time is being spent directly with clients. Therefore, the client's time spent outside the clinic must be used more efficiently and to the client's "best interest". Due to managed care changes, the therapeutic responsibility will shift even more from the therapist to the client. The trend in physical therapy seems to be shifting toward a larger consultant role and away from actual hands-on care in the clinic. As a consultant, the physical therapist will be expected to provide more educational advice on how adjunct activities can be beneficial during those times in which traditional therapy will not be available (Selker, 1995). This will be especially important when managing the care of those with chronic physical disabilities.

Regular exercise through recreational activities is a good way to improve or maintain certain conditions. Many non-disabled people and some people with disabilities enjoy the benefits of recreational exercise. Regardless of the motivation behind exercise, there are several proven physical as well as psychological benefits of exercise (Brasile, Kleiber, & Harnisch, 1991; Laskowski, 1991;

Several research studies on exercise programs focus on strength improvements (Fisher, Kame, Rouse & Pendergast, 1994; Lord, Caplan & Ward, 1993; Lord & Castell, 1994; Pavlou, Steffee, Lerman & Burrows, 1985). However, few studies focus on balance changes related to exercise. In one study elderly women participated in a "gentle" aerobic exercise program that increased heart rate while emphasizing balance and flexibility. The results showed the exercise group performed better in tests of strength, reaction time, and sway (Lord, Caplan, & Ward, 1993). A similar study in 1994 by Lord and Castell of elderly men and women also showed improvement in strength, reaction time, and sway following a general physical activity program. These researchers suggest that exercise may play an important role in maintaining fitness and stability.

Balance is a key component in many functional activities of daily living and many recreational activities. Horseback riding, for example, has been shown by some researchers to improve balance (Fox, Lawlor, & Luttges, 1984). Much of the current literature states that balance is a key requirement for downhill skiing (Bilodeau, 1991; Laskowski, 1991; Leonard & Pitzer, 1988; Sodergren, 1991). However, there are no studies which formally test balance changes associated with skiing in either the non-disabled or disabled populations. Based on the apparent agreement that
balance is an important aspect of skiing and the fact that alternative ideas for therapy are becoming more important in the changing health care environment, recreational activities such as skiing may help fill the gap between physical therapy treatments.

This study will attempt to assess balance changes associated with a downhill ski program for people with disabilities. Therefore, the proposed research question is, "Based on pre- and post-season testing of balance as measured by the functional reach test, does a downhill ski program improve standing balance in adults or children with various disabilities?"

The purpose of this study is to assess possible improvements in balance following a downhill ski program at Cannonsburg Ski Area. The ski program is offered through the Cannonsburg Challenged Ski Association annually to people with various physical and developmental disabilities. If improvements are shown this may be an appropriate addition to traditional therapy that could be recommended to clients with balance deficits. We propose that activities such as skiing may be advantageous because they are continually imposing dynamic stressors requiring constant adjustments of the body to maintain balance (Crutchfield and Barnes, 1993). Such supplementary methods to the management of chronic physical disabilities may be necessary due to the changing health care environment and the fact that these
people will not be able to participate in life-long out-patient programs.
CHAPTER 2

LITERATURE REVIEW

Dynamic balance is the continual readjustment of muscular activity to maintain postural orientation (Lewis, Higham, & Cherry, 1985). Balance is influenced by the vestibular, musculoskeletal, and neurological systems in addition to vision, somatosensory inputs, and psychological factors (Duncan & Badke, 1987). All of these systems are called into play as the body attempts to maintain balance and an upright posture. The postural responses to perturbations include fixed patterns of muscle activity, particular characteristics of muscle contractions, and a sequence of muscle activity moving distally to proximally (Duncan & Badke, 1987). To maintain normal postural control or balance, the body must integrate inputs from many systems, the most important of these being somatosensory and visual inputs. The vestibular system is called into play when there is a conflict between those somatosensory and visual inputs. Tinetti refers to a functional definition of balance that involves "the ability to change positions, maneuver through the environment, and withstand perturbations" (Duncan, Shumway-Cook, Tinetti, Whipple, Wolf & Woollacott, 1993). Balance is a dynamic process which requires more than moving the center of mass within the base
of support. It also requires anticipatory postural adjustments before making any movement that may cause balance disturbance (Duncan et al., 1993).

A balance deficit usually involves impairments across several domains. Damage to the vestibular, musculoskeletal, and neurologic systems, as well as changes in vision, somatosensory inputs, and psychological factors, cause a disruption of the mechanisms which maintain balance. If one system or component of balance is impaired, the other systems try to compensate to restore functional abilities (Daleiden, 1990; Geurts & Mulder, 1994). Due to the impairments in one area, the potential of the remaining intact systems must be maximized.

One study found that people with amputations had the same amount of postural sway as controls of the same age, as long as their eyes were open. Once they were blindfolded, however, the sway increased. The authors suggested that loss of somatosensory input from the distal lower extremity after amputation caused the subjects to compensate by relying more on vision (Dornan, Fernie & Holliday, 1978).

To make these compensations effective, the intact systems must be continually stressed with progressively challenging activities (Crutchfield & Barnes, 1993; Shumway-Cook, 1992; DiFabio & Badke, 1991). Such activities that stress the systems used to maintain balance commonly involve weight-shifting activities such as pushing, bouncing,
tipping, rocking, and stepping (Daleiden, 1990). Many experts believe that practicing balance reactions to perturbations in such exercises as those listed above will produce balance improvements by training the person's intact sensory systems to adapt to changing conditions (Brunnstrom, 1992; Daleiden, 1990; Davies, 1993). Skiing for the physically disabled may be one such activity that will produce balance improvements by training the person's intact systems to be more adept at anticipating, monitoring, and adjusting to body position.

Balance can be assessed with a variety of measurement tools. The newest and most functional test is the functional reach test, which was first studied in 1990 by Duncan, Weiner, Chandler & Studenski. Healthy volunteers ranging from 21-87 years old participated in this study. The subjects were contacted by phone and excluded if they were left handed, "carried a major diagnosis", had experienced any unexplained falls within the past 6 months, were unable to stand for 10 minutes without the use of an assistive device, or had pain that would limit their ability to stand or reach. They were excluded by on-site evaluation if they showed painful shoulder abduction, an elbow flexion contracture, asymmetry in the neurological exam, absent proprioception, or abnormal tone.

The subjects went through neurological and musculoskeletal examinations first. Next, their functional
reach was measured using an electronic device. The subjects stood on a force platform and their center of pressure excursion (COPE) was also measured at this time. At another station, their functional reach was measured using a leveled yardstick secured to the wall at right acromion height. The subjects stood on foot tracings on the floor in a normal, relaxed stance and were asked to make a fist and extend their arm forward and the position of the end of the third metacarpal was recorded. Then, they were asked to reach as far forward as they could without taking a step or losing their balance and again a measurement was taken.

The researchers did not control the method the subject used to reach. If the subject touched the wall or took a step, the trial was repeated. The subjects were each given two practice trials and three test trials. During the reach tasks, the subjects were guarded in case of loss of balance. Functional reach was defined as the mean difference between pre-reach and post-reach positions over three trials. The results of this study showed that functional reach measures were correlated with COPE measurements which demonstrated the functional reach test's criterion validity in this study. The functional reach test was also found to have good test-retest and interobserver reliability in this study (Duncan, Weiner, Chandler, & Studenski, 1990). In addition to correlating with functional activities, the functional reach test was found to be simple to perform, inexpensive,
precise, stable, and age-sensitive, therefore making it a practical test to use in the clinic.

In another study performed in 1991, the researchers examined the relationship between functional reach and other physical performance measures. The functional reach test was proven to discriminate levels of physical frailty in community-dwelling elderly persons, thereby demonstrating its concurrent validity in this study. They also stated that "the functional reach test can be performed easily, even by individuals with significant levels of impairment and therefore accommodates a wider range of physical performance" (Weiner, Duncan, Chandler, & Studenski, 1991).

Based on another study done in 1992, the functional reach test was demonstrated to be predictive of recurrent falls in community-dwelling elderly males, when controlled for age, depression, and the Folstein Mental Score, thereby showing its predictive validity in this study. The subjects were elderly male veterans whose common diagnoses included: cerebral vascular accidents, Parkinson's disease, seizure disorders, amputations, arthritis, hip fractures, and joint replacements. The investigators stated that a high reach score may be useful as a screen for low fall risk (Duncan, Studenski, Chandler, & Prescott, 1992).

A recent study done on the functional reach test reviewed the established test characteristics and went on to prove the test's sensitivity to change. In-patient male
volunteers from an extended care and rehabilitation center participated in this study. Their diagnoses included cerebral vascular accidents, hip fractures, multiple osteopenic fractures, spinal cord injury and restorative rehabilitation (Weiner, Bongiorni, Studenski, Duncan & Kochersberger, 1993). Although the subjects did demonstrate some improvement in functional reach scores, this study did not find statistically significant improvements in the distance reached following rehabilitation. However, the authors did prove that the functional reach test is sensitive to change using the responsiveness index. This study also showed that the functional reach test can be easily performed by individuals with a variety of physical disabilities. Therefore, it could be used as a tool to assess balance progress in those persons participating in rehabilitation. The investigators believed, based on their clinical experience, that functional reach is less heavily dependent on strength and endurance, and it therefore represents a more "pure" balance measure. This study also discussed the fact that because of the test's sensitivity to change, only a relatively small sample size is required to detect a meaningful difference in performance in clinical assessments (Weiner et al., 1993).

The functional reach test is a dynamic standing balance measure that utilizes a continuous scoring system. This measure simulates a dynamic functional movement used in
activities of everyday living and has been proven to be a valid and reliable test. Duncan, Weiner, Chandler & Studenski (1990) define functional reach as "the maximal distance one can reach forward beyond arm's length, while maintaining a fixed base of support in the standing position." The functional reach test has demonstrated the ability to detect balance deficits, predict potential of recurrent falls, detect levels of physical frailty, and detect changes in balance performance over time in studies performed by Duncan and associates (1992, 1990, 1993, 1991).

A 1994 study by Donahoe, Turner, and Worrell began to look at functional reach scores in normal children ages 5 to 15. This study represents the first attempt to establish age-related normative values in reaching scores for children without disabilities. The results indicated that test-retest, interrater, and intrarater reliability were established for this study. No studies thus far have attempted to use the functional reach test with disabled children.

Although the impaired system altering the overall balance of a person will vary from one to another, balance deficits are common with a wide variety of physical disabilities. For example, cerebral palsy, a disorder caused by developmental abnormalities or an anoxic event either before, during, or after birth, causes a wide range of movement, postural, coordination, and balance problems
(Berkow & Fletcher, 1992). Characteristics of cerebral palsy which also play a role in balance include abnormal muscle tone, abnormal reflexes, and changes in normal development (Pringle, 1994). Balance deficits are also seen in many chronic disabilities including people with amputations, traumatic brain injury, spinal cord injury, developmental disabilities, hemiplegia, spina bifida, multiple sclerosis, and others (Berkow & Fletcher, 1992; Buchanan & Nawoczenski, 1987; Crutchfield & Barnes, 1993; Duncan & Badke, 1987; O'Sullivan & Schmitz, 1988; Sullivan, Markos, & Minor, 1982).

Due to the chronic nature of these disabilities, the potential need for life-long rehabilitation services exists. However, due to changes occurring in health care within the managed care environment, the frequency these clients are seen in traditional out-patient settings is rapidly declining. A major force driving managed care is cost containment. This poses a serious threat to people with long-term disabilities. At the present time, Medicaid pays for about 50% of all long term care (McConnell, 1995). If this program is cut, many people with long-term disabilities will lose the greatly needed medical assistance.

In 1993 a study was done by Fox, Wicks, and Newacheck to see how well Health Maintenance Organizations (HMO's) met the needs of children with chronic disabilities. They found that HMO's commonly made "specialty services", such as
physical therapy, available only when significant improvements were expected in a short period of time. They also put limits on the amount and duration of the services available. Therefore, these HMO's greatly limited the benefits of therapy to children with chronic conditions.

It is important that health care providers understand managed care systems and learn to adapt to them in order to provide adequate care to clients (Hall, 1994). One such adaptation may be to find supplements to traditional therapy. Many recreational activities provide various therapeutic benefits, both physical and psychological which could serve as such supplements to therapy. Some examples of these activities include horseback riding, running, swimming, cycling, soccer, weight lifting, basketball, gymnastics, and skiing.

It was earlier suggested that psychological factors and a person's emotional state can be two of the components that can affect balance (Duncan & Badke, 1987). In addition several researchers have noted that psychological benefits are derived from participation in sports and recreational activities (Fox, Lawlor & Luttges, 1984; Kinney & Coyle, 1992; Laskowski, 1991; Leonard & Pitzer, 1988). Improvements have been observed in the level of self-confidence and independence following participation in several recreational activities. In addition these activities provide a means of meeting and socializing with
others with physical disabilities (Laskowski, 1991; Witchel, 1975). On the other hand, it also allows people with disabilities to participate with other non-disabled friends in the same activity (Leonard & Pitzer, 1988). Another psychological benefit was noted in a study by Kinney and Coyle in 1992 which found a significant correlation between life satisfaction and leisure activities in the disabled population. Based on their research, the authors propose that therapeutic recreation can play a significant role in the rehabilitation process. From this research we suggest that recreational activities can provide the motivational component that several traditional rehabilitation methods cannot elicit from participants.

In addition to the many psychological benefits acquired from recreational activities, many physical benefits have been proposed. For example, one study of children with spastic cerebral palsy following a therapeutic horseback riding program showed improvements in posture and a subjective improvement in balance, weight-bearing activities, and muscle tone (Bertoti, 1988). Another study looking at a horseback riding program for children with cerebral palsy noted improvements in balance, posture, spasticity, self-esteem, strength, flexibility, and range of motion (Wingate, 1982). Literature suggests that these activities may contribute to balance improvements, although few studies have attempted to prove a relationship.
A study completed by Fox, Lawlor, and Luttges in 1984 noted significant improvements in balance by comparing before and after performance scores in participants of a therapeutic horseback riding program. Subjects of this study ranged in age from 7 to 14. Performance scores were obtained by simulating horseback riding on a "small horse figure" to analyze stability and accuracy using visual and auditory feedback. Although these testing procedures have not been proven valid or reliable, this is one of the few studies which attempts to show balance improvements following recreational activities. Participants included people with cerebral palsy, spina bifida, learning disabilities, mild to profound mental retardation, and visual or hearing impairments.

Although various people with different types of disabilities have shown improvements in balance following a therapeutic recreational activity, one study on children with Down syndrome did not find improvements in balance after an early intervention program focusing on various gross and fine motor skills (Connolly, Morgan, Russell & Fulliton, 1993). Previous research has suggested that children with Down syndrome have balance deficits because of hypotonia, ligamentous laxity, and decreased strength (Reed, Pueschel, Schnell, et al., 1990). Shumway-Cook and Woollacott also found delayed postural responses to correct loss of balance. In addition they suggest that balance
deficits are not the result of hypotonia, but a disruption of the reflex centers in the higher levels of control in the brain (1985). From this research the authors concluded that balance deficits in children with Down syndrome may be due to "neuropathological" causes (Connolly, Morgan, Russell, & Fulliton, 1993). If balance deficits are primarily due to delayed neurological development associated with Down syndrome, this may limit the extent to which balance may be affected by the 6 week test period of Cannonsburg's ski program.

Several therapeutic benefits, both physical and psychological, have also been noted by those who instruct and participate in downhill skiing (Frank, 1982; Laskowski, 1991; Leonard & Pitzer, 1988). Skiing for people with physical disabilities began in Europe in 1935 (Laskowski, 1991). Following World War II and the Vietnam War, skiing for people with physical disabilities grew in popularity (Leonard & Pitzer, 1988). Today, there are ski programs for the physically disabled in at least 30 states across the United States (Laskowski, 1991).

Various equipment is available to assist skiers in maintaining their balance. One of the most common pieces of equipment for standing skiers is the outrigger. Outriggers are modified poles with ski tips attached for assisting with balance. Most outriggers have "flip skis" which when flipped can be used as crutches or canes for support during
ambulation. Another piece of equipment, the "ski bra," clamps the tips of the skis together to keep an even space between the skis and prevents the skis from crossing. For more advanced skiers, a rubber cord or "bungee cord" can provide similar assistance. For less advanced skiers, a "toe spreader" uses a rigid bar to force the skis into a wedge position (Laskowski, 1991). Although each organization has its own preferences, the above are the most common equipment used to assist the standing skier.

Cannonsburg Challenged Ski Association is one of the many disabled ski programs offered in the United States. It is a chapter of National Handicapped Sports, "promoting life-time sport and recreation" for persons with physical, mental and sensory impairments (Cannonsburg Challenged Ski Association Volunteer Handbook, 1993). Their goal is to "foster a self confidence which will carry over into other aspects of life" (Cannonsburg Challenged Ski Association, 1993). Cannonsburg is located near Grand Rapids, Michigan and runs a program every year with approximately 75-125 participants. The participants include people with developmental disabilities, sensory impairments, amputations, polio, hemiplegia, cerebral palsy, multiple sclerosis, muscular dystrophy, head injuries, & spinal cord injuries. These people are provided with assistance and most of the equipment they may need. Cannonsburg follows the American Teaching System (ATS), which is used by all
Certified ski instructors in the United States. This means that they teach the participants of the program the "three basic skills of skiing, which include pressuring, edging, and rotary movements, all encompassed by the skill of balance" (Cannonsburg Challenged Ski Association Volunteer Handbook, 1995-6). The participants are instructed in the ATS progression by working through the steps at their own pace. (See Appendix A for a detailed description of the ATS progression.)

Many skiing experts state that balance is a necessary component for downhill skiing (Abraham, 1981; Bilodeau, 1991; Laskowski, 1991; Leonard & Pitzer, 1988; O’Donnell, 1980; Sodergren, 1991). However, there are no formal studies showing a correlation between skiing and balance, much less a positive effect. Current literature suggests that other recreational activities which put stresses on the body requiring constant postural adjustments to maintain balance may lead to improvements in balance abilities (Wingait, 1982). Downhill skiing is another recreational activity that constantly forces the body to make anticipatory postural adjustments and adjustments to external stressors to maintain balance (O’Donnell, 1980). Therefore, we hypothesize that a downhill ski program will be beneficial for improving balance in people with various disabilities and balance deficits.
CHAPTER 3

METHODOLOGY

SUBJECTS

The subjects for the study were obtained by a convenience sample of participants in the Cannonsburg Challenged Ski Association. An informational letter regarding this study (See Appendix B) was included in a general information packet (See Appendices C, D, E, & F) mailed to the skiers by the program president, Kathy Fisher. Returning the signed informational letter allowed for the health and registration forms (See Appendices D & E) to be released to the investigators so that inclusion and exclusion criteria could be reviewed. Potential subjects not returning the informational letter were contacted at Cannonsburg Ski Area prior to the first ski session to inquire about possible participation and release of information. Demographic information such as age, sex, and type of disability was determined from registration and health forms.

Participation in the study was determined by a set of inclusion and exclusion criteria. Individuals signed up for the ski program who had a physical or mental impairment and who consented to participation in the study (See Appendix G) were included as potential subjects. If an individual was a
minor or not his or her own legal guardian, the parent or legal guardian also signed the functional reach consent form prior to testing. The Cannonsburg Challenged Ski Association did not require consent from a physician for participation, except in cases of atlanto-occipital instability in people with Down syndrome. Otherwise, a consent form was signed stating that Cannonsburg and those involved with the ski program were not liable for injuries to the skiing participant.

Subjects were excluded from the study if one or more of the following exclusion criteria were present: (1) age less than 5 years, (2) shoulder flexion of dominant arm less than 90 degrees, (3) participation in less than four ski sessions, (4) inability to stand, (5) a progressive disability with the exception of people with multiple sclerosis who do not have an exacerbation of symptoms during the course of the skiing program, and (6) inability to follow testing instructions. We also followed the same screen as that already established by the Cannonsburg Challenged Ski Association (See Appendices C & D).

INSTRUMENTATION

The subject’s balance was evaluated using the functional reach test-yardstick method. Functional reach was measured using a leveled yardstick attached to a perpendicular steel post (See Appendix H) which allowed the leveled yardstick to be positioned at each individual’s
acromion of the dominant arm. Subjects were asked to step onto a piece of paper and foot tracings were made to control for stance width. Pre- and post-tests were conducted on the same floor surface. Participants were asked to wear the same shoes or boots to both pre- and post-test situations. Any prostheses or orthotic devices typically worn were also used during the testing procedure. The placement of the end of the third metacarpal along the yardstick was recorded as individuals were asked to make a fist and to hold their arm out in front of them. They were then asked to reach as far as they could without losing their balance or taking a step, and again a measurement was taken. If the subjects took a step or leaned on the apparatus, the trial was repeated. The method of reach used was not controlled by the investigators. The subject's functional reach was calculated as the mean difference between the two measurements taken over three trials.

PROCEDURES

Prior to conducting this study, a proposal was sent to the Human Subjects Research Review Committee of Grand Valley State University. The proposal was reviewed and approved. From this point, we proceeded with our investigation.

Reliability of the investigator who collected the data was established using the measuring apparatus prior to testing. The investigator assessed two practice and three test trial reaches of 12 nondisabled adult subjects to
establish an intrarater reliability of 0.8821. Test-retest reliability (0.8434) for this investigator was established by repeating the same subjects and the same procedure on separate days.

Data collection was conducted at the Cannonsburg Ski Area on two occasions to gather pre- and post-ski season information. The pre-test was conducted immediately preceding the first ski session during the second week in January, 1996. The post-test was conducted preceding the skiers final ski session. Each skier participated in at least four of the six scheduled ski sessions with each session consisting of two hours of skiing. Each ski session consisted of such activities as the sidestep, the gliding wedge, the breaking wedge, and the wedge turn. (See Appendix A for an entire outline of the ATS progression and individual descriptions of each step.)

Upon arrival to the testing site, subjects were thanked for being in the study and given a brief description of the events to follow. Consent forms were signed at this time, if not previously done so (See Appendix G). Prior to testing, a screen was conducted by the investigators to ensure none of the exclusion criterion had been violated. More demographic information was gathered at this time such as years of participation in the ski program, onset of disability, and other physical or recreational activities they have participated in within the past year (See Appendix
Any questions or concerns regarding the study were addressed prior to the data collection. The testing procedure began by an investigator stating a consistent set of instructions to the participants (See Appendix J). Data collection consisted of two practice trials and three actual trials. One investigator gave the participant instructions and provided spotting to prevent falling due to unexpected loss of balance. Another investigator collected the data by observing each of the actual trials. The final investigator recorded the data on the data collection sheet (See Appendix J) and assisted in spotting during the reach.
CHAPTER 4

RESULTS/DATA ANALYSIS

The original hypothesis was that a downhill skiing program would be beneficial for improving balance in people with various disabilities. The null hypothesis was that there would be no change in the mean scores, and the alternative hypothesis was that there would be a significant improvement in the mean scores. The data were analyzed using a one-group pre-test, post-test design. The effects of skiing on balance were determined by comparing data taken before and after the 6 week ski season. Pre- and post-season scores of the mean distance reached in three trials using the functional reach test were compared to determine if balance improvement had occurred (See Appendix K).

Data were analyzed by computer using the Statistical Package for the Social Sciences (SPSS). A t-test for paired comparisons was used to test the hypothesis. Using alpha=0.05, the increase in mean distance reached after the ski season was significant, \( t(14)=2.46, p=0.01 \) (See Graph 1 for pre- & post-test averages). The Wilcoxon signed rank test was used to validate the results of the t-test, because the normality of the data was questionable. The mean difference in the distance reached was determined to be 0.95 with a standard deviation of 1.55 (See Appendix L).
BOXPLOT OF PRE-TEST & POST-TEST AVERAGES

Key:

a = The average reach of the subject who reached the furthest distance
b = The average distance reached of the middle half of the data
c = The average reach of the subject who reached the shortest distance
d = The averages of the subjects who were in the middle 50%

N = 15

PRETEST

POSTTEST
Several subjects were excluded based on the criteria mentioned in the preceding chapter, primarily because they were unable to follow the instructions or unable to stand. Twenty-two subjects who met the criteria performed the pre-test. From these 22, several were excluded because they did not attend enough ski sessions or were absent for the post-test. This left 15 remaining subjects for post-testing who met all of the criteria and were included in the study. Ages of the participants ranged from 7-67. Diagnoses included traumatic brain injury, cerebral palsy, cerebral vascular accident, hearing impaired, visually impaired and developmentally disabled. Nine of the subjects were males and 6 were females. See Table 1 for subject demographics.

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<tr>
<td>NUMBER</td>
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**KEY:**
- *SD=STANDARD DEVIATION
- *P.T.=PHYSICAL THERAPY
- *YEARS=YEARS OF PARTICIPATION INCLUDING THIS YEAR
Descriptive research regarding the subjects' demographic information was assessed (See Appendix K for data collected, means, and demographic information). Data were analyzed in an exploratory fashion in an attempt to identify trends and generate hypotheses for future studies. Due to the small sample size, few trends were found in relation to our demographic information. No major differences were noted based on subjects' ages, gender, or whether or not they were receiving physical therapy services.

Two trends were noted by examining the data that may possibly lead themselves to future research. It did appear that those skiers who have skied 4 or more years in the Cannonsburg Challenged Ski Association were least likely to show an improvement in balance as measured by the functional reach test. The other trend noted was that the only 2 subjects who had cerebral vascular accidents significantly improved their mean distance reached.
CHAPTER 5
DISCUSSION AND IMPLICATIONS

DISCUSSION OF FINDINGS

The results of our study indicate that standing balance was improved for children and adults with various disabilities following the Cannonsburg Challenged Ski Program. Although there is no existing literature regarding balance changes as a result of a ski program, the results of our study suggest that downhill skiing may be one such activity which improves balance. Skiing requires anticipatory postural adjustments and ongoing postural adaptations to maintain balance (O’Donnell, 1980). We propose that balance may have improved in skiers by maximizing and progressively challenging the intact systems which influence balance (Crutchfield & Barnes, 1993; Shumway-Cook, 1992; DiFabio & Badke, 1991). Skiing involves activities that stress intact systems such as weight shifting, stepping activities, and wedging, much like those outlined in the ATS guidelines which make up each ski session. Another aspect of skiing which requires continual postural adjustments is the skiing surface, snow. This surface may have changed during each ski run and varied from ski session to ski session, challenging the skier to continually make adjustments to maintain an upright posture.
and keep from falling.

APPLICATIONS FOR CLINICAL PRACTICE

Due to changes in the managed care environment, the role of the physical therapist as a consultant is growing. Physical therapists will be expected to provide education and recommendations as to adjunct activities which can enhance physical performance in times when traditional physical therapy is not available (Selker, 1995). Most of the subjects in our study did not receive traditional physical therapy services, yet several did appear to benefit from the downhill skiing program. Therefore, we propose that downhill skiing may be an additional activity that physical therapists could recommend to clients with chronic or long-term disabilities to improve balance.

As another application to clinical practice, we recommend the use of the functional reach test to assess balance. We chose the functional reach test because it was simple to use, a function-related test, and inexpensive, all of which had been reported by Duncan et al. as advantages to this test (1990). In addition Weiner et al. reported success using the functional reach test in people with various disabilities (1993). During this study, the only subjects we found to have difficulty performing the functional reach test were those unable to comprehend the directions of the test or those unable to stand.
LIMITATIONS

The investigators noted several limitations to this study. Ideally, we would have liked to have had the skiers ski more frequently and for a longer duration. However, due to the constraint of the previously established ski program and time and financial restraints of the investigators, the participants were only able to ski a maximum of 12 hours over a 6 week period. Due to variable conditions such as lack of snowfall and particularly cold temperatures, low attendance was a problem. In addition the convenience sample, small sample size, and the limited demographics of the participants did not allow us to generalize to a larger population. Our experimental design did not provide a control group and also possessed several threats to internal validity such as participants increasing familiarity with the test and researchers becoming more skilled in the testing procedure. The functional reach test was limited by the fact that it measures only feedforward mechanisms and not feedback mechanisms. In addition, we were not able to control or monitor all other activities that may have contributed to changes in balance, including the current physical therapy services that 4 of the participants were receiving or other variables such as motivational factors. Due to the fact that we made some changes from the original studies performed by Duncan & associates, some limitations to validity were introduced to this study. For example, we
did not exclude left-handed people and did not require participants to be barefoot due to the fact that some participants wore orthotic devices. Also, we did provide cuing to subjects in an attempt to control for scapular and wrist positions.

SUGGESTIONS FOR FURTHER RESEARCH

Due to the limitations and small sample size of this study, replication is needed in order to allow generalizability to a larger population and to further validate our results. If this study were to be replicated, the investigators recommend that a balance test that measures feedback mechanisms be used along with the feedforward measurement of the functional reach test.

Further research could also focus on the effects of skiing on people with particular disabilities. Since we noted that both skiers with a diagnosis of cerebral vascular accident (CVA) showed significant improvements in balance as measured by the functional reach test, this may be an appropriate focus for further research. This is supported by a study performed by Weiner et al. which noted greater improvements in functional reach in clients following CVAs when compared with other diagnostic groups after participation in a rehabilitation program.

CONCLUSION

In conclusion, this study suggests that a downhill skiing program may be beneficial for improving standing
balance in children and adults with various disabilities. These findings have implications for people with chronic or long-term disabilities. Physical therapists may recommend downhill skiing to clients with balance deficits as an adjunct to more traditional therapy.
BIBLIOGRAPHY


Appendix A

ATS - The American Teaching System

Progression:
1. Walk on the flats: in a straight line, in circles, with one ski on, with both on.
2. Correct body position: Feet under hips, knees bent, hands slightly below and in front of hips. Chin up, look ahead. Physically mold student if necessary.
3. Side Step: up the hill a short ways. Skis across fall line, take small steps, roll knees into hill.
4. Straight run: Assume proper body position. Slide forward, let terrain stop skier. If terrain is too steep to head down the fall line, orient your straight run across the fall line.
5. Gliding wedge: In proper body position, press tails of skis apart, and hold this position while sliding. Let terrain stop skier.
6. Wedge change-ups: From straight run, brush skis out into gliding wedge, rise slightly and bring skis back to straight run. Repeat.
7. Gliding wedge turns: In a slight wedge, utilize steering (rotary) to create a turn. Instruct student to turn both feet and knees, look in direction of turn, follow you...
8. Braking wedge: Brush tails of skis out to create slowing of gliding wedge.
9. Braking wedge to a stop: Using the braking wedge, increase the width of the wedge until you come to a stop.
10. Wedge turns: Using a medium width wedge, with a fairly high stance, steer feet and knees in and out of the fall line, equalizing the arc in both directions.
11. Wedge christies: Beginning with a wedge turn, emphasize active steering of the inside leg to cause skis to gradually match after the turn. Gradually begin matching skis earlier in the turn, until the match comes before the fall line. The distinction between wedge christie 1 and 2 in no longer made.
12. Wedge christie with pole touch: When skiing with good wedge christies, touch the pole to the snow (forward and to the side) just after rising, and prior to the fall line. The turn has a skidded finish.
13. Open stance parallel: Using much foot steering, release pressure on uphill ski just prior to fall line, causing matching to occur at initiation of turn, and continuing throughout the turn.
14. Dynamic parallel: Turn becomes more carved and less skidded.
APPENDIX B

ATTENTION SKIERS

THREE GVSU PHYSICAL THERAPY STUDENTS NEED YOUR HELP!!

We are doing a study to see if balance is affected by participation in the Cannonsburg Ski Program. We need participants who are willing to spend 30 minutes with us before the first and last ski sessions. We will be measuring your balance by asking you to do a reaching task.

Free snacks will be provided to thank you for your participation. If you are interested in participating or would like more information, please print and sign your name below and return this form with your other forms.

If you are willing to participate, would you be willing to release your registration and health forms to us for use in our study? YES NO

All information will be kept confidential.

__________________________  ____________________________
participant's name          participant's signature

__________________________
guardian's signature

Thank You,

Colleen Kavanaugh
Tara McNabb
& Tami Revett

40
Fall 1994

Greetings Skiers!

It's snowing in Montana, so our ski season can't be far away! It's time to get your registration in for the 94/95 season, so that we have the right equipment and volunteers reserved for you! To be a skier, you must be at least 4 years old (no upper age limit) and want to have fun!

Cannonsburg Challenged Ski Association (CCSA) teaches downhill skiing to persons with disabilities. We have taught lessons to people who are blind, or deaf, who have CP, MD, MS, spina bifida, spinal cord injury, Lou Gerrigs disease, arthrogryposis, strokes, brain injuries, amputations (arm and leg), polio, and who are mentally impaired. We teach 6 different ski techniques: sensory impaired, developmentally disabled, 3 track, 4 track, sit/bi ski, and mono ski.

Sensory impaired: For individuals who are deaf or hearing impaired, blind or visually impaired. An instructor with special communication skills will guide you through the hill and learning process.

Developmentally disabled: For individuals with mental impairments (our instructors are equipped to handle only TMI, EMI, and LD students, thanks), or learning disabilities.

3 track: This choice is for people who have the use of only 1 leg - amputees are obvious, but it also includes those with a bad leg due to polio, surgery, fusions, or accidents.

4 track: This choice is for people who can stand and walk at least 50% of their day - using any type of assistive device, braces, canes, crutches, or walkers, or nothing at all! 4 Track is for people with poor leg strength, poor control, or poor balance. Some four trackers may become 2 trackers (using no adaptive equipment) with time.

Sit/bi-ski: Is for individuals who use a wheelchair and have poor balance, poor trunk control, and/or poor arm strength. The bi-ski resembles the mono-ski, but, having 2 skis is more forgiving for those with poor balance and trunk control. We only have a few so far, so if you really want to use this (it's more fun than the sit ski), you will need to be flexible with scheduling.

Mono ski: For paraplegics and high level amputees, nothing beats the mono-ski! You must have good trunk and arm control and decent balance for the mono (SCI injuries up to T3 have successfully used the mono).
APPENDIX D

CANNONSBURG CHALLENGED SKI ASSOCIATION SKIER HEALTH FORM

Skier's Name: ___________________________ Parent/Guardian Name: ___________________________

Birthdate: ___________________________ Phone No. H_________ W_________

Address: _____________________________________________________________________________

City/State/Zip ___________________________________________________________________________

School: ______________________________ Worksite: ______________________________

EMERGENCY CONTACT: Name: ___________________________

Phone: H_________ W_________

Health Insurance Company: ___________________________ Policy #: ___________________________

Doctor's Name: ___________________________ Phone No. ___________________________

DIAGNOSIS: ____________________________________________________________________________

DESCRIPTION OF IMPAIRMENT: ____________________________________________________________________________

Are there any limitations on the skier's activities? Please describe: ____________________________________________________________________________

Medical Precautions (Please Describe): ____________________________________________________________________________

Seizures: Yes____ No____ If yes, is it controlled by medication? _____________________________

Type: ___________________________ Last Seizure: ___________________________

Allergies: ____________________________________________________________________________

Is skier a HEPATITIS B Carrier? ______ Yes ____ No

Is skier a CYTOMEGALOVIRUS Carrier? ______ Yes ____ No

Does skier have DOWN'S SYNDROME? ______ Yes ____ No

If skier has Down's Syndrome, verification of atlantoaxial dislocation is needed. X-rays/Doctor's Signature is required.

Diet: ______ Regular Please Describe if on a special diet: _____________________________

Special ____________________________________________________________________________

Does skier need assistance with:

Using Bathroom ______ Yes ______ No If yes, please describe: _____________________________

Eating ______ Yes ______ No

Cathing ______ Yes ______ No

Does skier have any behavior characteristics that staff should be aware of: Yes No If yes, please describe: ____________________________________________________________________________

Is there any other information the staff should be aware of? ____________________________________________________________________________
APPENDIX E

CANNONSBURG CHALLENGED SKI ASSOCIATION
10831 GRANGE NE
SPARTA MI 49345-9451
(615) 887-4905

SKIER REGISTRATION: Complete this application, health form, and liability waiver, and mail them with your check (made payable to CCSA) by December 18, 94. Confirmation of your lesson time and day will be sent by Jan 2, 95.

Skier's name: ____________________________________________________

Address: _________________________________________________________

City, State, and Zip: ____________________________________________

Phone: __________________ Skier's Age: _______ Shoe size:___________

Height:___________ Weight:_________

Skier's disability: _________________________________________________

Is skier a disabled veteran, or the child of a veteran? yes no
State skier's functional abilities (can skier walk, transfer, eat, toilet, do they have trunk control, strength, hand function?): ______________________________________

Please indicate your choice of lesson day, by ranking them 1, 2, 3, etc.:

( ) Sunday ( ) Monday ( ) Tuesday ( ) Wednesday ( ) Thursday

Please indicate your choice of series or single lesson, by checking your choice.

( ) series ( ) single lesson ( ) Ski Buddy pass

Please indicate your choice of lesson time, ranking them 1, 2, 3, etc. Lessons may be scheduled 1/2 hour on either side of selected times.

Sunday ( ) 1-3 PM ( ) 2-4 PM ( ) 3-5 PM
Monday - Thursday: ( ) 4-6 PM ( ) 5-7 PM ( ) 6-8 PM

Please indicate your discipline: ( ) Sensory impaired ( ) Developmentally disabled ( ) 3 track

( ) 4 track ( ) Sit ski ( ) Bi-aki ( ) Mono ski

Payment: Sunday series - $85

Sunday single - $20/lesson

Weekday series - $80

Weekday single - $12

Special events: Indicate if you will attend by checking beside the event.

( ) Skiestal Feb 19, 3-6 PM ($10)

( ) Take the Challenge Race, Feb 18 - must be able to ski the Quad, no charge

( ) Crystal Mountain trip, Feb 25, fees range between $19-30

( ) School Field trip ($5/person, we will send further info and schedule date)
APPENDIX F

CANNONSBURG CHALLENGED SKI ASSOCIATION
NATIONAL HANDICAPPED SPORTS
INSURANCE WAIVER AND RELEASE OF LIABILITY

In consideration of being allowed to participate in any way in Cannonsburg Challenged Ski Association's (hereafter known as CCSA) programs, related events and activities, I and/or the minor participant, the undersigned:

1. Agree that prior to participating, I will inspect, or if a parent and/or legal guardian, I will instruct the minor participant to inspect, the facilities and equipment to be used, and if I believe anything is unsafe, I and/or the minor participant will immediately advise CCSA of such conditions and refuse to participate.

2. Acknowledge and fully understand that I and/or the minor participant will be engaging in activities that involve risk of serious injury, including permanent disability and death, and severe social and economic losses which might result only from my own actions, inactions, or negligence of others, the rules of play, or the condition of the premises, or any equipment used. Further, that there may be other risks not known to me or not reasonably foreseeable at this time.

3. Assume all the foregoing risks and accept personal responsibility for the damages following such injury, permanent disability, or death.

4. Release, waive, discharge and covenant not to sue CCSA, NHS, their representative administrators, directors, agents, coaches, and other employees, other participants, sponsoring agencies, sponsors, advertisers, and if applicable, owners and lesasers of premises used to conduct the event, all of which are hereinafter referred to as "releasees", from demands, losses, or damages on account of injury, including death or damage to property, caused or alleged to be caused in whole or in part by the negligence of the releasee or otherwise.

I/WE HAVE READ THE ABOVE WAIVER AND RELEASE, UNDERSTAND THAT I/WE HAVE GIVEN UP SUBSTANTIAL RIGHTS BY SIGNING IT AND SIGN IT VOLUNTARILY.

____________________________  __________________________  __________________________
PARTICIPANT'S NAME             SIGNATURE                  DATE

If the participant is a minor and/or has a legal guardian:

____________________________  __________________________  __________________________
PARENT/GUARDIAN'S NAME         SIGNATURE                   DATE

General liability insurance policy Transamerica SSP2719075
APPENDIX G

INFORMED CONSENT FORM

I, ____________________, understand that I will be involved in a study that is looking at the effects on balance following a 6 week downhill ski program through the Cannonsburg Challenged Ski Association. I further understand that Tara McNabb, Colleen Kavanaugh, and Tami Revett will be administering the Functional Reach Test to assess my balance before and after the ski program. They will be using these test results for a Master's thesis at Grand Valley State University (GVSU). They hope to be able to recommend programs similar to Cannonsburg Challenged Ski Program to people with balance deficits.

I recognize that my voluntary participation in this ski program has made me a candidate for this study. I realize that this study involves my active participation in a 6 week ski program and two-30 minute assessments of my balance. I further understand that GVSU or the administrators of these tests are in no way liable for any repercussions evolving from my participation in the Cannonsburg Challenged Ski Program. I understand that the Functional Reach Test poses minimal physical risks and will be stopped if I experience any discomfort or if I verbally express my desire to discontinue the test.

I authorize the results of this study to be used in
scientific literature and I understand that my name will be kept confidential. I understand that at any time during this study if I have any questions regarding this project I may feel free to contact Colleen at 669-3968, or Tami at 662-0620. I understand that at any time I may discontinue my participation in this study.

I have read and understand this consent form and I agree to participate in this study under these terms.

Participant's signature  ___________________________ Date

Parent's/Guardian's signature  ___________________________ Date

Witness  ___________________________ Date
APPENDIX H

MEASUREMENT DEVICE
APPENDIX I

ADDITIONAL INFORMATION AND CONSENT

1. Years of participation in Cannonsburg's ski program

2. Onset of disability

3. Additional recreational or physical activities within the past year

I agree to allow Grand Valley State University student investigators Tami, Tara and Colleen to videotape me while participating in balance testing and downhill skiing at Cannonsburg Ski Area.

print participant's name

participant's signature

guardian's signature
APPENDIX J
DATA COLLECTION SHEET

The following will be read prior to data collection: "Make a fist with your dominant hand and hold your arm out straight in front of you. Reach forward as far as you can without taking a step or losing your balance."

NAME: DOMINANT ARM: R L

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Mean Distance Reached = ____ inches
## APPENDIX K

### SUMMARY OF PARTICIPANTS INFORMATION

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**KEY:**
- M = MALE
- F = FEMALE
- C = CONGENITAL
- A = ACQUIRED
- Y = YES
- N = NO
- DD = DEVELOPMENTAL DELAY
- CP = CEREBRAL PALSY
- PW = PRADER WILLI SYNDROME
- CVA = CEREBRAL VASCULAR ACCIDENT
- ADD = ATTENTION DEFICIT DISORDER
- DD/CP = DEVELOPMENTAL DELAY/CEREBRAL PALSY
- ADD/DD = ATTENTION DEFICIT DISORDER/DEVELOPMENTAL DELAY
- TBI = TRAUMATIC BRAIN INJURY
- HI = HEARING IMPAIRED
- VI = VISUALLY IMPAIRED

*YEARS OF PARTICIPATION INCLUDES THIS YEAR.*
APPENDIX L

Participants' Change in Reach Distribution

Std. Dev = 1.54
Mean = .98
N = 15.00