ABSTRACT

JOHNSON, M. J. Effects of resistance training on adults with Down syndrome. MS in Exercise and Sport Science: Special Physical Education. May 2004, 44pp. (P. DiRocco)

The purpose of the study was to determine the effects of a resistance training protocol on the muscular strength of adults with Down syndrome (DS). Four participants with a mean age of 26.9 years took part in a resistance training program that consisted of performing 1 set of 10 repetitions for 5 exercises. The resistance training program lasted 10 weeks. Muscular strength was measured using 1-RM taken pre- and posttraining on the bench press (upper body) and leg press (lower body). Mean, SD, and effect size (ES) were reported and statistical significance was at $p < .05$. The study revealed that the training protocol produced significant and meaningful increases in lower body muscular strength ($p < .05$, ES = 0.78). It is concluded that a high-intensity resistance training protocol lasting 10 weeks increased lower body muscular strength in the adults with DS.

EFFECTS OF RESISTANCE TRAINING ON ADULTS WITH DOWN SYNDROME

A MANUSCRIPT STYLE THESIS PRESENTED

TO

THE GRADUATE FACULTY

UNIVERSITY OF WISCONSIN-LA CROSSE

IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE

MASTER OF SCIENCE DEGREE

BY

MARQUELL JOHNSON

MAY 2004

COLLEGE OF HEALTH, PHYSICAL EDUCATION, RECREATION, AND TEACHER EDUCATION

UNIVERSITY OF WISCONSIN-LA CROSSE

THESIS FINAL ORAL DEFENSE FORM

Candidate Marquell Johnson

We recommend acceptance of this thesis in partial fulfillment of this candidate's requirements for the degree:

Master of Science in Exercise and Sport Science: Special Physical Education

The candidate has successfully completed the thesis final oral defense.

Signature	Department	Date
Signature of Thesis Chairperson	ESS	9/5/03
Signature of Committee Member	ESS	9-5-03
Signature of Committee Member	Physical Therapy	9-5-03

This thesis is approved by the College of Health, Physical Education, Recreation, and Teacher Education.

Associate Dean, College of HPERTE — Date: 12/15/03

Director of University Graduate Studies — Date: 12/18/03

ACKNOWLEDGEMENTS

I would like to thank Dr. Patrick DiRocco for giving me the opportunity to pursue my Master of Science degree in Adapted Physical Education at UW-L. I would also like to thank him for the knowledge and guidance given to me throughout my time spent here. I would like to thank Dr. Manny Felix for the knowledge and guidance shared with me. I also would like to thank him for allowing me to take full advantage of every aspect of the clinical programs required by graduate students in adapted physical education.

I would like to thank my committee members, Dr. Patrick DiRocco, Dr. Karen McLean, and Dr. Mike McGuigan, for their contributions to this thesis. I would like to thank them for the patience shown as I completed my thesis and oral defense. I would also like to thank them for the time commitment given in the overall process of my thesis.

I would like to thank Erin for her assistance during the training of participants in the study. I would like to thank her for the support she has given to me throughout the duration of the study as well as in the last year. I would also like to thank her for allowing me to experience one of the best years of my life.

I would like to thank my family who have been an inspiration to me throughout my life and will continue to be a driving force in the successes of the future. I would like to thank my undergraduate professor, Dr. Lisa Olenik, for giving me the first opportunities to realize what I wanted to do as my career. I would like to thank all of the individuals who I have had the pleasure to work and learn with in the past two years at UW-L including, faculty, staff, graduate students, and clinic participants.

Lastly and more importantly, I would like to thank God for giving me the strength to overcome the obstacles and adversities that were placed in my path prior to me considering college, in my pursuit of a bachelor's degree, and in my pursuit of master's degree. I would not be the person who I am, and the person I hope to be, without Him watching over me.

TABLE OF CONTENTS

PAGE

ACKNOWLEDGEMENTS iii

LIST OF TABLES vi

LIST OF APPENDICES vii

INTRODUCTION 1

METHOD 6

Participants 6

Protocol 6

Statistical Analysis 8

RESULTS 10

DISCUSSION 12

CONCLUSION 14

REFERENCES 15

APPENDICES 19

LIST OF TABLES

TABLE PAGE

1. Descriptive Statistics 10

2. Mean, Standard Deviation, and Significance of Pre-Post 1-RM Bench Press and Leg Press 11

LIST OF APPENDICES

APPENDIX PAGE

A. Review of Related Literature.. 19

B. Raw Data of Individual Measures... 43

INTRODUCTION

Down syndrome (DS) is the most recognizable genetic condition associated with mental retardation (MR). This condition results from one of three chromosomal abnormalities (Krebs, 2000). Trisomy 21 occurrence accounts for about 95% of the population with DS (Auxter, Pyfer, & Huettig, 2001; Krebs, 2000; National Down Syndrome Society [NDSS], 2003; Sherrill, 1998). Trisomy 21 is a faulty cell division that results in an embryo with three number 21 chromosomes when either the sperm or the egg fails to separate (NDSS, 2003). Over 350,000 people in the U.S. alone have this condition. Individuals with DS are becoming increasingly integrated into society and community organizations, such as schools, healthcare systems, work forces, and social and recreational activities (NDSS, 2003). It is believed that the number of people with DS will double in the next 10 years. More and more people in our society will interact with individuals with this genetic condition, increasing the need for direct attention.

Physical characteristics associated with this population are mild to moderate obesity, poor balance, hypermobility of the joints, underdeveloped respiratory and cardiovascular systems, and hypotonicity (Auxter, Pyfer, & Huettig, 2001; Krebs, 2000; Pitetti, Climstein, Mays, & Barrett, 1992; Sherrill, 1998). Research by Morris et al., as reported by Pitetti, Climstein, Mays, and Barrett (1992) revealed a significant negative correlation between degree of hypotonia and muscle strength. In some individuals with DS, hypotonia never disappears and influences aspects of motor control throughout life.

Individuals with DS have lower aerobic capacity, lower peak heart rates (Fernhall, Pitetti, Rimmer, McCubbin, Rintala, Millar, Kettredge, & Burkett, 1996), and lower levels of isokinetic muscular strength when compared to individuals with non-DS MR.
A high propensity of heart and blood vessel abnormalities together with pulmonary hypoplasia are also associated with DS (Pitetti, Climstein, Campbell, & Jackson, 1992). Congenital heart defects and respiratory infections were the most frequently reported medical disorders on death certificates of people with DS (Yang, Rasmussen, & Friedman, 2002).

Work capacity may be even more important for persons with MR, because it is also related to vocational productivity in this population (Croce & Horvat, 1992; Fernhall & Pitetti, 2001; Pitetti, Climstein, Campbell, & Jackson, 1992). Individuals with DS have lower work capacities compared to both the population without disability and the population with non-DS MR. Pitetti and Boneh (1995) reported significant associations between isokinetic leg strength and VO2 peak, particularly in individuals with DS, and suggested that leg strength may be a limiting factor to physical work capacity in persons with MR. When considering that employment opportunities in workshops or training centers for individuals with MR demand an appropriate level of muscular strength (e.g., lifting boxes, moving material on an assembly line, and loading supplies on trucks), the possibility exists that many adults with MR may have difficulty performing manual jobs (Pitetti, Climstein, et al., 1992).

A physically active lifestyle is not common in individuals with MR, with or without DS (Fernhall, 1993; Pitetti, Rimmer, & Fernhall, 1993). The effects of physical activity on disease prevention for people with disabilities has been recognized as an underinvestigated, and greatly needed research focus by the American College of Sports Medicine, the American Heart Association, and the Centers for Disease Control and Prevention (Draheim, Williams, & McCubbin, 2003).

Even though recreational programs may seem plentiful for the populations with MR, these programs tend to focus on leisure-type activities rather than on health-related physical fitness activities (Rimmer, 1994). This has left a tremendous gap in the delivery of carefully designed fitness programs for adults with MR including DS. Exercise specialists employed in YMCAs, health clubs, and other types of fitness centers will be exposed to this population in their respective workplaces and will have to meet the responsibility of developing appropriate exercise programs for the population with DS (Pitetti, et al., 1993; Rimmer, 1994). Improved fitness should promote an active lifestyle, decrease health risks, and increase work capacity, which may further decrease the need for premature institutionalization of the population with MR (Fernhall, 1993).

Resistance training has become increasingly popular as a method of developing muscular strength among the population without disabilities (American College of Sports Medicine [ACSM], 2002; Braith et al., 1989; Hass, Garzarella, Hoyos, & Pollock, 2000). Daily participation in exercise programs incorporating resistance training have been shown to reduce the risk of several chronic diseases, including coronary heart disease, hypertension, noninsulin-dependent diabetes mellitus, osteoporosis, colon cancer, anxiety, and depression (Hass, Feigenbaum, & Franklin, 2001; Kell, Bell, & Quinney, 2001; Pate et al., 1995). Research suggests that the use of concurrent resistance (single or multiple sets) training and stretching can have a positive effect on musculoskeletal function and maintain or enhance numerous aspects of independent living (Kell, et al., 2001; Stone, Fleck, Triplett, & Kraemer, 1991).

Participation in a resistance training program has been shown to reduce the rate pressure product when lifting any given load. Thus, strength training may decrease cardiac demands during performances of daily activities such as carrying groceries or lifting heavy objects (Hass, et al., 2001; Pate et al., 1995). Higher levels of strength are accompanied by a greater capacity to perform activities of daily living, improved functional status, maintenance of independence, and the prevention of disability (Galuska, Earle, & Fulton, 2002; Hass, et al., 2001).

There are few studies that have looked at resistance training involving individuals with DS. Pitetti, et al. (1992) examined the differences in isokinetic arm and leg strength between the adults who were mentally retarded with and without DS and sedentary adults without MR. They found no difference in arm strength between groups with and without DS. However, subjects with DS demonstrated inferior leg strength when compared to subjects without DS. In another study, Rimmer and Kelly (1991) determined a 9-week progressive resistance training program could improve muscular strength and endurance in a group of adults with MR. The authors did not specify whether members of the group had DS. They found that a high-intensity resistance training program is capable of inducing dramatic increases in muscular strength and endurance in adults with MR in as little as 9 weeks.

Studies to date (e.g., Pitetti et al., 1992; Rimmer & Kelly, 1991) indicate that people with MR have up to 30% lower levels of strength than their peers without MR, yet they appear to respond normally to training. The possibility that individuals with DS deviate from other persons with MR needs to be investigated (Fernhall, 1993).
Also, more studies are needed to evaluate the effects of exercise on all health-related physical fitness components, particularly body composition, muscular strength, and flexibility in the population with MR. It is particularly important to develop training programs for individuals with DS that will improve their quality of life, overall well-being, and possibly life expectancy (Chanias, Reid, & Hoover, 1998).

Because of the limited research available on resistance training in the population with DS, the purpose of the present study was to determine the effects of a resistance training protocol on the muscular strength of adults with DS. It was hypothesized that individuals with DS will achieve a significant increase in muscular strength after completing a resistance training program.

METHOD

Participants

Four adults with DS participated in this study. The group was comprised of three females and one male ranging in age from 19 to 34 years. All of the members voluntarily participated in the study. They were all recruited from the surrounding area through letters sent out by the primary investigator using a Special Olympics mailing list containing adults with DS. Even though all of the participants were on the Special Olympics mailing list, only two of them had participated in Special Olympics events (soccer and swimming). During the study, none of the participants were active in Special Olympics or any other physical activities. Three of the four participants worked 25 to 30 hours per week in jobs that required vocational-type skills (i.e., lifting, packing boxes, and pushing shopping carts).

All of the participants and their legal guardians were given a description of the training protocol and the rationale for studying individuals with DS. Informed consent forms were obtained from the legal guardians of the participants and a medical clearance form was completed and returned by each participant's physician. All procedures related to this study were approved through the Institutional Review Board for the Protection of Human Subjects.

Protocol

All of the testing and training took place at the local university strength center. All study participants trained in the center during times when university students were also using the center. The primary investigator and an assistant conducted all of the testing and supervised the training program. The Magnum Fitness Systems multi-function and tower-system machines were used for all testing and training. Participants completed the following exercises: bench press, biceps curl, triceps pull-down, leg curl, and the leg press. The maximum amount of weight lifted one time, defined as the one-repetition maximum (1-RM), was used to measure the muscular strength of the participants. The participants had their 1-RM on the bench press (upper body) and leg press (lower body) measured both pre- and posttraining. Height and weight were measured with a standard physicians scale both pre- and posttraining.

Prior to testing, participants completed two 1-hour training sessions to familiarize themselves with the environment, the investigator, the exercises, the equipment, and the testing procedures used in this study. Research has shown that for this particular population, familiarization increases the reliability of the testing protocol (Auxter et al., 2001; Fernhall, 2003; Rimmer, 1994; Rimmer & Kelly, 1991).

After the familiarization phase, participants were pretested for their 1-RM on the bench press and leg press. The 1-RM for the bench press and leg press were normally completed in three to four trials. If the 1-RM was not achieved after the fourth trial, the participants moved to the next exercise and returned later to that machine. All testing sessions lasted for approximately 1 hour. Pretraining 1-RM measures were taken on three different days with 48 hours between each training session with the best results of the three days recorded. Research has shown this procedure to be the most effective for measuring maximum strength outputs in this population (Balic, Mateos, Blasco, &

Fernhall, 2000; Fernhall, 2003; Pitetti, et al., 1992; Rimmer, 1994; Rimmer & Kelly, 1991). Posttesting was completed using the same procedures as the pretest with one exception. The posttest 1-RM measures were taken on two different days instead of three.

After recording the pretest measures, participants completed a 10-week resistance training program. All of the participants completed 27-30 training sessions lasting approximately 30-35 minutes. The participants performed one set of 10 repetitions of each exercise for 3 days per week using 75% of their 1-RM for the bench press and leg press for 5 weeks and 80% of their 1-RM for the bench press and leg press for the second 5 weeks. Resistance used for the biceps curl, triceps pull-down, and leg curl was determined from the final resistance used during the familiarization sessions. Participants were given 2-minute rest periods between each exercise. Prior to and after all training sessions, the participants performed warm-up and cool down exercises lasting approximately 5 minutes. The exercises were as follows: shoulder shrugs, toe-touches, forward and backward arm rotation, and controlled breathing to mimic the proper breathing technique used during resistance training exercise. Posttest 1-RM measures were taken when the participants completed 27-30 training sessions.

Statistical Analysis

Descriptive statistics included the height, age, and pre- and post-weight of each participant. The group mean and standard deviation (SD) were reported on all variables. Pre- and posttest 1-RM bench press and leg press measures were compared using a paired t-test with significance set at $p < .05$. The SPSS 11.5 statistical package was used to analyze the data. Effect size (ES) was calculated using the formula described by Thomas and Nelson (1996). Effect size has been recommended for application in adapted physical activity research as an alternative to relying solely on statistical significance (Sutlive & Ulrich, 1998).

RESULTS

Descriptive statistics for the group are presented in Table 1. The pre- and posttest bench press and leg press 1-RM measures are presented in Table 2. The 1-RM bench press measure had a mean increase of 8.13 lbs, which was a 7% increase. This was not statistically significant. The 1-RM leg press measure had a mean increase of 59.5 lbs, which was a 28% increase. This was statistically significant ($p = .008$). The ES was 0.27 (small) for the bench press and 0.78 (large) for the leg press. The ES indicates the meaningfulness of the difference between pre 1-RM and post 1-RM responses.

Table 1. Descriptive Statistics

Age (Years)		Height (cm)		Pre-Wt (kg)		Post-Wt (kg)	
M	SD	M	SD	M	SD	M	SD
26.89	5.88	150.50	13.00	82.84	11.26	81.80	13.94

Table 2. Mean, Standard Deviation, and Significance of Pre-Post 1-RM Bench Press and Leg Press

1-RM measures	Pretraining		Posttraining		Significance
	M	SD	M	SD	
Bench Press (7%)	119.37	30.09	127.50	35.41	.109
Leg Press (28%)	209	76.41	268.50	64.35	.008*

*Significance at p = .05

DISCUSSION

These findings suggest that the training protocol used in the study was sufficient to produce a training effect in lower body strength, but not sufficient to produce a training effect on the upper body. The reasons for this deficiency are beyond the scope of this project. Possible reasons for this deficiency may be the incidence of hypotonia that is present in individuals with DS. Hypotonia may be distributed more in upper body musculature than in lower body musculature. Another reason could be that the upper-body resistance training protocol volume and/or duration need to be increased to produce a sufficient upper-body training effect. Other possible reasons for minimal improvement in upper body strength could be that the participant's job related duties (i.e., lifting, packing boxes and pushing shopping carts) accounted for upper body strength development prior to training, so a greater training stimulus would be required to produce additional strength gains.

The improvement in lower body strength shown in this study is important because leg strength is related to aerobic capacity, endurance run performance, physical work capacity, and industrial work performance in individuals with MR including DS (Fernhall, 2003; Fernhall & Pitetti, 2001; Nordgren & Backstrom, 1971; Pitetti, et al., 1992). Therefore, the possibility exists that the individuals with DS participating in this study could have experienced an improvement in aerobic capacity, endurance run performance, physical work capacity, and industrial work performance that are associated with the increase in lower body strength.

The study also revealed that the individuals with DS could effectively train in a fitness facility side by side with their nondisabled peers. This setting was interpreted as an enjoyable experience for the participants with DS since their compliance to the training sessions was 89%. These data are in agreement with Rimmer and Kelly (1991) who suggested that a community based weight-training programs may be an excellent age-appropriate recreational activity for adults with MR. Participants enjoyed being able to train together and noticeable positive changes in demeanor and attitude were noted over the course of the study by both the primary investigator and the parents of the participants. Following the completion of the study, one participant was planning to enroll in a weight-training program offered by their local YMCA, and another participant was enrolling in the exercise program for adults with disabilities provided by the local university.

Despite lack of statistical significance in upper body strength, three of four participants improved from pre- to posttraining in the 1-RM bench press. Subject 1 increased 7.50%, subject 2 increased 7.69%, and subject 4 increased by 10.76%. In contrast, subject 3 exhibited no change in upper body strength. It is difficult to generalize the results of this study to the population with DS due to the small number of subjects. Many attempts were made to recruit additional subjects, but some community organizations that deal with populations with disabilities were unwilling to provide lists of individuals with DS. In addition, other individuals who wished to join the study were prevented from doing so due to transportation and scheduling issues, as well as the time constraints of the primary investigator and the university strength center.

CONCLUSION

It is concluded that a high-intensity resistance training protocol lasting 10 weeks increased lower body strength in individuals with DS. The findings warrant further investigation including larger sample size, possible increased volume for upper body exercises, and more exercises included in the overall training protocol. The development of a functional evaluation that is related to work performance and/or activities of daily living for the DS population is needed. This would allow researchers to determine the amount of strength gains needed to improve work productivity, overall well-being, and quality of life. Further studies should also consider the effects of training individuals with DS in group settings compared to individual settings to help address the concerns of motivation and compliance when working with this population.

REFERENCES

American College of Sports Medicine. (2002). Progression models in resistance training for healthy adults. *Medicine and Science in Sports and Exercise, 34*, 364 - 380.

Auxter, D., Pyfer, J., & Huettig, C. (2001). *Principles and methods of adapted physical education and recreation* (9th ed.). New York: McGraw-Hill.

Balic, M.G., Mateos, E.C., Blasco, C.G., & Fernhall, B. (2000). Physical fitness levels of physically active and sedentary adults with Down syndrome. *Adapted Physical Activity Quarterly, 17*, 310 - 321.

Braith, R.W., Graves, J.E., Pollock, M.L., Leggett, S.L., Carpenter, D.M., & Colvin, A.B. (1989). Comparison of 2 vs. 3 days/week of variable resistance training during 10- and 18-week programs. *International Journal of Sports Medicine, 10*, 450 - 454.

Chanias, A.K., Reid, G., & Hoover, M.L. (1998). Exercise effects on health-related physical fitness of individuals with an intellectual disability: A meta-analysis. *Adapted Physical Activity Quarterly, 15*, 119 - 140.

Croce, R., & Horvat, M. (1992). Effects of reinforcement based exercise on fitness and work productivity in adults with mental retardation. *Adapted Physical Activity Quarterly, 9*, 148 - 178.

Draheim, C.C., Williams, D.P., & McCubbin, J.A. (2003). Cardiovascular disease risk factor differences between special olympians and non-special olympians. *Adapted Physical Activity Quarterly, 20*, 118 - 133.

Fernhall, B. (1993). Physical fitness and exercise training of individuals with mental retardation. *Medicine and Science in Sports and Exercise, 25*, 442 - 450.

Fernhall, B. (2003). Mental retardation. In American College of Sports Medicine (2nd ed.), *Exercise management for persons with chronic diseases and disabilities* (pp. 304 - 310). Champaign, IL: Human Kinetics.

Fernhall, B., & Pitetti, K.H. (2001). Limitations to physical work capacity in individuals with mental retardation. *Clinical Exercise Physiology, 3*, 176 - 185.

Fernhall, B., Pitetti, K.H., Rimmer, J.H., McCubbin, J.A., Rintala, P., Millar, A.L., Kittredge, J., & Burkett, L.E. (1996). Cardiorespiratory capacity of individuals with mental retardation including Down syndrome. *Medicine and Science in Sports and Exercise, 28*, 366 - 371.

Galuska, D.A., Earle, D., & Fulton, J.E. (2002). The epidemiology of U.S. adults who regularly engage in resistance training. *Research Quarterly for Exercise and Sport, 73*, 330 - 334.

Hass, C.J., Feigenbaum, M.S., & Franklin, B.A. (2001). Prescription of resistance training for healthy populations. *Sports Medicine, 31*, 953 – 964.

Hass, C.J., Garzarella, L, Hoyos, D.D., & Pollock, M.L. (2000). Single versus Multiple sets in long-term recreational weightlifters. *Medicine and Science in Sports and Exercise, 32*, 235 - 242.

Kell, R.T., Bell, G., & Quinney, A. (2001). Musculoskeletal fitness, health outcomes and quality of life. *Sports Medicine, 31*, 863 - 873.

Krebs, P. (2000). Mental retardation. In J.P. Winnick (3rd ed.), *Adapted physical education and sport* (pp. 112 - 119). Champaign, IL: Human Kinetics.

National Down Syndrome Society (2003). http://www.ndss.org/content.

Nordgren, B., & Backstrom, L. (1971). Correlations between muscular strength and industrial work performance in mentally retarded persons. *Acta Paediatrica Scandinavica Supplement, 217*, 122 - 126.

Pate, R.R, Pratt, M., Blair, S.N., Haskell, W.L., Macera, C.A., Bouchard, C., et al. (1995). A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *Journal of the American Medical Association, 273*, 402 - 407.

Pitetti, K.H., & Boneh, S. (1995). Cardiovascular fitness as related to leg strength in adults with mental retardation. *Medicine and Science in Sports and Exercise, 27*, 423 - 428.

Pitetti, K.H., Climstein, M., Campbell, K.D., & Jackson, J.A. (1992). The cardio-vascular capacities of adults with Down syndrome: A comparative study. *Medicine and Science in Sports and Exercise, 24*, 13 - 19.

Pitetti, K.H., Climstein, M., Mays, M.J., & Barrett, P.J. (1992). Isokinetic arm and leg strength of adults with Down syndrome: A comparative study. *Archives of Physical Medicine and Rehabilitation, 73*, 847 - 850.

Pitetti, K.H., Rimmer, J.H., & Fernhall, B. (1993). Physical fitness and adults with mental retardation: An overview of current research and future directions. *Sports Medicine, 16*, 23 - 56.

Rimmer, J.H. (1994). *Fitness and rehabilitation programs for special populations.* Dubuque, IA: Wm. C. Brown.

Rimmer, J.H., & Kelly, L.E. (1991). Effects of a resistance training program on adults with mental retardation. *Adapted Physical Activity Quarterly, 8*, 146 -153.

Sherrill, C. (1998). *Adapted physical activity, recreation, and sport: Crossdisciplinary and lifespan* (3rd ed.). Boston: McGraw-Hill.

Stone, M.H., Fleck, S.J., Triplett, T.N., & Kraemer, W.J. (1991). Health and performance-related potential of resistance training. *Sports Medicine, 11*, 210 - 231.

Sutlive, V.H., & Ulrich, D.A. (1998). Interpreting statistical significance and meaningfulness in adapted physical activity research. *Adapted Physical Activity Quarterly, 15*, 103 - 118.

Thomas, J.R., & Nelson, J.K. (1996). *Research methods in physical activity* (3rd ed.). Champaign, IL: Human Kinetics

Yang, Q., Rasmussen, S.A., & Friedman, J.M. (2002). Mortality associated with Down syndrome in the USA from 1983 to 1997: A population-based study. *The LANCET, 359*, 1019 - 1025.

APPENDIX A

REVIEW OF RELATED LITERATURE

REVIEW OF RELATED LITERATURE

This review provides the unique characteristics that distinguish the Down syndrome (DS) population from other populations with mental retardation. Specific areas of focus are: (a) health-related concerns associated with DS; (b) the level of exercise training in this population in comparison to the population with non-DS mental retardation and the population without disability; (c) the need for exercise training (resistance-training) in adults with DS; and (d) benefits that have occurred due to exercise training in this group.

Another purpose of this literature review is to provide information on resistance training and the health-related benefits that have been associated with this particular training intervention. This section will also include the following areas: (a) resistance training impact on function and activities of daily living; (b) recommendations of quantity and frequency of resistance training to produce health-related benefits; and (c) resistance training protocols that have elicited strength gains.

The final purpose of this literature review is to examine the existing research that involves resistance training with persons who have DS. Through this literature review, the lack of studies in the area of resistance training for persons with DS will become apparent.

Down Syndrome

Down syndrome is the most recognizable genetic condition associated with mental retardation. This condition results from one of three chromosomal abnormalities (Krebs, 2000). The three types of abnormalities are trisomy 21 or nondisjunction, translocation, and mosaicism. Trisomy 21 or nondisjunction occurrence accounts for about 95% of the population with DS (Auxter, Pyfer, & Huettig, 2001; Krebs, 2000; National Down Syndrome Society [NDSS], 2003; Sherrill, 1998). Nondisjunction is a faulty cell division that results in an embryo with three number 21 chromosomes instead of two. Prior to or at conception, a pair of number 21 chromosomes in either the sperm or the egg fails to separate. As the embryo develops, the extra chromosome is replicated in every cell of the body.

Down syndrome affects people of all ages, races, and economic levels. Over 350,000 people in the U.S alone have this condition. Individuals with DS are becoming increasingly integrated into society and community organizations such as schools, healthcare systems, work forces, and social and recreational activities (NDSS, 2003). Due to advances in medical technology, individuals in this population are living longer than ever before. According to Yang, Rasmussen, and Friedman (2002), the life expectancy of people with DS increased from 25 years in 1983 to 49 years in 1997, an average increase of 1 to 7 years per year studied. It is believed that the number of people with DS will double in the next 10 years. More and more Americans will interact with individuals with this genetic condition, increasing the need for direct attention.

Individuals with DS generally fall into the category of moderate mental retardation with intelligent quotients within a 35 to 55 range. Most of these individuals can acquire self-care skills such as feeding, dressing, bathing and toileting. Self-care and cognitive abilities of adults with DS decline with age to a much greater extent than those of other people (Fernhall & Pitetti, 2001; Rimmer, 1994; Sherrill, 1998). The vast majority will have problems with speech, language, social interactions, facial expressions, and gait (Pitetti, Rimmer, & Fernhall, 1993). Work for individuals with DS is more likely to require physical abilities because most job placements are in the vocational setting (Chanias, Reid, & Hoover, 1998; Rimmer & Kelly, 1991).

The unique physical characteristics that are associated with this population are: short stature, with short broad hands and feet; varied levels of mental retardation; mild to moderate obesity; poor balance; hypermobility of the joints; underdeveloped respiratory and cardiovascular systems; and hypotonicity, a condition that results in muscles that can be stretched far beyond their normal limits (Auxter, et al., 2001; Krebs, 2000; Pitetti, Climstein, Mays, & Barrett, 1992; Sherrill, 1998). A high propensity of heart and blood vessel abnormalities together with pulmonary hypoplasia are also associated with DS (Pitetti, Climstein, Campbell, & Jackson, 1992).

A physically active lifestyle is not common in individuals with mental retardation, with or without DS (Fernhall, 1993; Pitetti, et al., 1993). Physiological differences also exist between individuals who are mentally retarded with and without DS, which might place these individuals at a disadvantage in performing physical activities. One such disorder is hypotonicity that was mentioned previously as a unique characteristic of this group. Research by Morris et al., as reported by Pitetti, Climstein, et al. (1992) revealed a significant negative correlation between degree of hypotonia and muscle strength. In some individuals with DS, hypotonia never disappears and continues to influence motor control throughout life. Individuals with DS generally lack muscle strength due to this poor motor development.

The earlier onset of old age characteristics in individuals with DS suggests that their physical capacities decline faster compared to populations without disability (Chanias, et al., 1998; Pitetti & Campbell, 1991). This is linked with early-onset Alzheimer-type neuropathology, which may be present from about age 40 (Sherrill, 1998). Individuals with DS have lower aerobic capacity and lower peak heart rates (Fernhall et al., 1996), higher rates of obesity, and lower levels of isokinetic muscular strength when compared to individuals with non-DS mental retardation (Pitetti, Climstein, et al., 1992).

Cardiovascular disease is the most prevalent disease among older persons with mental retardation, and this may be the major factor contributing to the shorter life span and higher mortality rate observed in this population (Pitetti & Campbell, 1991). Congenital heart defects and respiratory infections were the most frequently reported medical disorders on death certificates of people with DS. The death rate from all other causes (except cancer) for people with DS is more than 25 times greater than that for the nondisabled population (Yang, et al., 2002).

Work capacity may be even more important for persons with mental retardation because, in this population, it is also related to vocational productivity. Poor levels of physical work capacity may be a major contributing factor to early institutionalization, morbidity, and mortality in individuals with mental retardation, either with or without DS (Croce & Horvat, 1992; Fernhall & Pitetti, 2001; Pitetti, Climstein, Campbell, et al., 1992). Individuals with DS have lower work capacities compared to both populations without disability and populations with non-DS mental retardation.

Pitetti and Boneh (1995) reported significant associations between isokinetic leg strength and VO2 peak, particularly in individuals with DS, and suggested that leg strength may be a limiting factor to physical work capacity in persons with mental retardation. It is suggested that muscular strength must be maintained at some predetermined level for a person to perform moderate to heavy lifting tasks as part of their work (Fernhall, 1993). When considering that employment opportunities in workshops or training centers for persons with mental retardation demand an appropriate level of muscular strength (e.g., lifting boxes, moving material on an assembly line, and loading supplies on trucks), the possibility exists that many adults who are mentally retarded may have difficulty performing manual jobs (Pitetti, Climstein, Campbell, et al., 1992).

Hawkins (1993) analyzed leisure and life satisfaction in a sample of noninstitutionalized aging adults with mental retardation that included individuals with DS and individuals without DS. She found a decreased desire to increase participation and a lower interest in initiating new activities in individuals with DS. The author also noted that the activities these 128 aging adults with mental retardation most commonly engaged in were watching television or listening to the radio, visiting or calling friends, attending parties, eating out, shopping, light walking, and general relaxation.

A clear relationship exists between sedentary lifestyle and higher incidence of cardiovascular diseases in the population without disability. The incidence of cardiovascular disease for individuals with the DS is even higher than in the population without disability. Although recreation programs for adults with mental retardation seem to be plentiful, the part-time staff that usually deliver these programs emphasize leisure-time activities such as bowling and field trips rather than health-related fitness programming (Rimmer, 1994). This has left a tremendous gap in the delivery of carefully designed fitness programs for adults with mental retardation including DS. Exercise specialists employed in YMCAs, health clubs and other types of fitness centers will be exposed to this population in their respective workplaces and will have to meet the responsibility of developing appropriate exercise programs for the population with DS (Pitetti, et al., 1993; Rimmer, 1994).

The benefits of participating in regular moderate to vigorous physical activity program, which include reductions in cardiovascular disease risk and obesity levels, have been well documented in the population without disability. The effects of physical activity on disease prevention for people with disabilities has been recognized as an underinvestigated, and greatly needed research focus by the American College of Sports Medicine, the American Heart Association, and the Centers for Disease Control and Prevention (Draheim, Williams, & McCubbin, 2003). According to the Centers for Disease Control (1997), individuals with disabilities have lower rates of recommended health behaviors, (e.g., cardiovascular, strengthening, and flexibility activities), when compared to individuals without disabilities.

Another study done by the Centers for Disease Control and Prevention (1997), showed that 56% of adults with disability do not engage in any form of leisure-time physical activity. Only 23% of adults with disability are physically active 20 minutes, 3 days per week, and only 11% of this group performs strengthening exercises. Improved fitness should promote an active lifestyle, decrease health risks, and increase work capacity, which may further decrease the need for premature institutionalization of the mental retardation population including DS (Fernhall, 1993).

Eberhard, Eterradossi, and Debu (1997) examined a number of physiological parameters at rest and monitored their variations in relation to metabolic responses induced by a 12-week physical exercise program in young adults with DS. The results showed that regular physical activity programs improve high-density lipoprotein cholesterol levels in individuals with DS, which is advantageous for this population because high-density lipoprotein helps protect against cardiovascular disease.

Millar, Fernhall, and Burkett (1993) wanted to determine if individuals with DS could improve their cardiovascular fitness following a 10-week walk/jog training program. The results showed that there was no increase in peak VO2; however, improvements that would be clinically important such as gains in endurance and physical work capacity could still be obtained.

Balic, Mateos, Blasco, and Fernhall (2000) evaluated how involvement in a sports training program can affect adults with DS. All subjects in the study were either

Special Olympians with DS or sedentary individuals with DS. The results showed that a group of individuals with DS who are highly physically active exhibit significantly higher aerobic capacity, muscular strength, and power than a group of sedentary individuals with DS.

Resistance Training

It has been recognized in the scientific and medical communities that muscular strength is a fundamental physical trait necessary for health, functional ability, and an enhanced quality of life (American College of Sports Medicine, 2002). Resistance training has become increasingly popular among the population with disability as a method of developing muscular strength (American College of Sports Medicine, 2002; Braith et al., 1989; Haas, Garzarella, Hoyos, & Pollock, 2000). It has become a primary component of athletic conditioning, rehabilitation, and general fitness programs (Feigenbaum & Pollock, 1999; Starkey et al., 1996). Resistance training is defined as a specialized method of conditioning that involves the progressive use of resistance to increase one's ability to exert or resist force (Baechle & Earle, 2000).

Daily participation in exercise programs incorporating resistance training have been shown to reduce the risk of several chronic diseases, including coronary heart disease, hypertension, noninsulin-dependent diabetes mellitus, osteoporosis, colon cancer, and anxiety and depression (Hass, Feigenbaum, & Franklin, 2001; Kell, Bell, & Quinney, 2001; Pate et al., 1995). Other health benefits associated with the intervention of resistance training are: a reduced resting heart rate; increased stroke volume at rest and exercise; maintenance of cardiac output at rest; a decline in resting systolic and diastolic blood pressure; improved resting lipid levels; improved glucose sensitivity; and improved insulin response and sensitivity (Kell, et al., 2001)

Besides increasing maximum skeletal muscle force output, resistance training may also increase the maximum strength of tissue including tendons and ligaments.

Stronger muscles protect the joints they cross, and these strengthening effects may reduce the possibility of strains, sprains, and other injuries that often accompany physical activity (Stone, Fleck, Triplett, & Kraemer, 1991). Galuska, Earle, and Fulton (2002) analyzed the proportion of adults in the U.S. who engage in any resistance training and regular resistance training, as defined by weight lifting at least twice a week, and the characteristics of these individuals. They found that 71% of those who ever lifted weights and 82% of those who regularly lifted weights also engaged in other physical activities at least five times per week.

Research suggests that the use of concurrent resistance training (single or multiple sets) and stretching can have a positive effect on musculoskeletal function and maintain or enhance numerous aspects of independent living (Kell, et al., 2001; Stone, et al., 1991). Independent living requires the ability to complete most activities of daily living. Participation in a resistance training program has been shown to reduce the rate pressure product when lifting any given load. Thus, strength training may decrease cardiac demands during performances of daily activities such as carrying groceries or lifting heavy objects (Hass, et al., 2001; Pate et al., 1995). Higher levels of strength are accompanied by a greater capacity to perform activities of daily living by improving functional status, the maintenance of independence, and the prevention of disability (Galuska, et al., 2002; Hass, et al., 2001). Physical activity and promotional efforts targeted to people with disabilities or chronic disease, or to older adults should emphasize the importance of being physically active by routinely carrying out their daily activities with a minimum of assistance (Pate et al., 1995).

The literature supports the recommendation of prescribing single set programs performed to fatigue and indicates that quality, not the quantity, of resistance training may be the most important factor for developing muscular strength in sedentary persons (Feigenbaum & Pollock, 1999). Considering the similarities in strength gains for single- and multiple-set programs during the initial training period, single-set programs are recommended for healthy nonathletes and clinical populations because they are less time consuming, more cost efficient and appear to produce comparable health and fitness benefits (American College of Sports Medicine, 1998; Feigenbaum & Pollock, 1999; Haas, et al., 2001;).

A minimum of 8-10 exercises involving the major muscle groups should be performed with a minimum of 1 set of 8-12 repetition maximum (American College of Sports Medicine, 1998). Loads greater than 50% of one-repetition maximum (1-RM) have been shown to increase muscular strength in previously untrained individuals (Hass, et al., 2001). A 48-hour rest period between concurrent training sessions is generally recommended, which corresponds to a 3-day/week frequency of training guideline for individual muscle groups. The ability to complete a comprehensive exercise program within 45 to 60 minutes, 2 to 3 days/week, should facilitate increased program compliance while inducing favorable adaptation and improvement in multiple organ systems (i.e., cardiorespiratory, musculoskeletal, endocrine, and immune)(American College of Sports Medicine, 1998; Hass, et al., 2001).

These recommendations for resistance training are based on three factors. First, the time it takes to complete a comprehensive, well-rounded exercise program is important. Second, although greater frequencies of training, and additional sets or combinations of sets and repetitions may elicit larger strength gains, the difference in improvement is usually small in the adult fitness setting. Third, although greater gains in strength and fat-free mass can be attained when using heavy weights, few repetitions and multiple set regimens, this approach may not be suitable for adults who have different goals than the athlete (American College of Sports Medicine, 1998).

McLester, Bishop, and Guilliams (2000) determined whether low-frequency (1 day per week) training could have a comparable effect to higher frequency (3 days per week) training when the total volume is held constant. Twenty-five healthy subjects, recreationally experienced in free-weight training, were randomly assigned to one of two groups: one day per week of three sets to failure or three days per week of one to failure. Beginning intensities for resistance training were set at 80% of the subject's 1-RM for the following exercises: supine bench press, elbow extension, standing lateral arm raise, seated arm pull-down, elbow flexion, hip extension, seated knee extension, prone knee flexion, and standing heel raise. The study revealed that all upper body and lower body 1-RM increased significantly over the 12-week training period. Because the 3-day group experienced greater gains in strength than the 1-day group, it was suggested that frequency is probably the more important factor.

Hass, et al. (2000) determined whether increasing training volume (one to three sets) would elicit greater improvements in muscular strength, muscular endurance, and body composition in recreational weight lifters. The training subjects for this study were divided into two groups. The training groups completed either one set or three sets of the following exercises: leg extension, leg curl, pullover, arm cross, chest press, lateral raise, overhead press, biceps curl, and triceps extension on a variable resistance exercise training machine. They trained for 13 weeks and each set of exercises required performing 8-12 repetitions to volitional fatigue. The initial load was set at 75% of 1-RM. The results indicated that the 1-RM for both groups improved significantly across time. The data also indicated that additional sets do not significantly improve the physiological adaptations to resistance training within the first 13 weeks of training in recreational weight lifters participating in a well-rounded exercise program compared with 1-set training.

Starkey et al. (1996) determined the effects of training volume (1 set vs. 3 sets) on the development of full range of motion, strength of both knee extension flexion, and associated muscle thickness in healthy adults. Forty-eight healthy untrained volunteer subjects completed the study. Subjects were randomly assigned to one of two training groups or to a nonexercising control group. The training groups completed three bilateral training sessions per week for 14 weeks using either one or three sets of exercise that required performing 8-12 repetitions of dynamic variable resistance exercise to volitional fatigue for both knee extension and knee flexion. The data shows that one set of knee extension and knee flexion exercises performed to volitional fatigue three times per week was as effective as three sets three times per week for improving torque output and increasing muscle thickness.

Braith et al., (1989) wanted to determine the effectiveness of a single set, high-intensity variable resistance training regimen performed to volitional fatigue, and conducted it for either 2 days/week or 3 day/week for the duration of 10 or 18 weeks. One hundred and seventeen healthy sedentary individuals who had not participated in a regular exercise program for at least 1 year took part in the study. The first study was conducted for the duration of 10 weeks where 19 subjects trained 3 days/week, 25 subjects trained 2 days/week, and 15 subjects served as control. The second study was conducted for the duration of 18 weeks where 22 subjects trained 3 days/week, 25 subjects trained 2 days/week and 11 subjects served as controls. Each training session consisted of a single set of bilateral knee extensions performed to volitional fatigue with a weight load that allowed 7–10 repetitions. The authors found significantly greater improvements in variable resistance training weight for the 3-day/week groups relative to the 2-day/week groups in both the 10- and 18-week studies. They also found that resistance training 3 days per week is more productive than the 2 days per week for up to 18 weeks in previously untrained adult subjects.

Resistance Training and Down Syndrome

Pitetti, Climstein, et al. (1992) examined the differences in both isokinetic arm and leg strength in adults who are mentally retarded with and without DS and sedentary adults without mental retardation. Eighteen individuals with DS and 18 individuals with mental retardation (11 men and 7 women) with similar intelligent quotients and ages participated in the study. All subjects with mental retardation were recruited from sheltered workshops or vocational training centers. Elbow and knee extension and flexion strength were measured from the dominant side. Subjects with mental retardation tested on two different days with 48 to 96 hrs between test days. The best results were then recorded. The study found no differences in arm strength between groups with and without DS. Subjects with DS demonstrated inferior leg strength when compared to subjects without DS.

Rimmer and Kelly (1991) wanted to determine if a 9-week progressive resistance training program could improve the muscular strength and endurance in a group of adults with mental retardation (not specifying with or without DS). They also wanted to determine whether adults with mental retardation could adhere to a resistance program for 9 weeks and could learn to use the Nautilus weight-training system with minimal assistance. Twenty-four adults (13 women and 11 men) ranging in age from 23 to 49 years were randomly assigned to a control or experimental group. The experimental group received a progressive resistance training program at a local university 2 days per week, while the control group participated in a university-based clinic consisting of dance, aquatics, and lifetime sports.

All subjects participated for two sessions in the weight-training program before any baseline strength/muscular endurance measurements were taken.

Following the two initial weight-training sessions, muscular strength and endurance measures were recorded. The 1-RM tests on all machines were usually accomplished in two to three trials. If 1-RM was not achieved after the third trial, the subject was asked to move to another machine in order to avoid fatigue, and to return to the initial machine later. The subjects in the experimental group participated in the weight-training program for 9 weeks. They performed three sets of exercises on each machine and completed 8-10 repetitions in each set. Set one was performed at 30% 1-RM, set two was performed at 60% 1-RM, and set three was performed at 70% 1-RM. The following exercises were completed on Nautilus equipment: leg extension, leg curl, pectoral deck, shoulder abduction, pull over, biceps curl, and triceps extension. Each subject completed 15-18 one-hour training sessions during this period. The findings of the study revealed that a high-intensity resistance-training program is capable of inducing dramatic increases in muscular strength and endurance in adults with mental retardation in as little as 9 weeks.

Weber and French (1988) compared the effects of weight training and a strength exercise treatment program upon strength development of adolescents with DS. Fourteen adolescents (11 males and 3 females) who had been medically diagnosed with trisomy DS and were between 13 to 18 years of age participated in the study. Subjects were given a week to become familiar with the equipment to be used, as well as to learn proper lifting techniques so that muscular strength was truly measured. Both the weight training and strength exercise group utilized warm-up exercises, which included the hamstring stretch, quadriceps stretch, low back twister, and arm and shoulder circles. Both groups trained 3 days per week for 6 weeks. The weight training exercises consisted of the latissimus dorsi pull-downs, leg press, upright rowing, leg extension, shoulder press, calf raises, arm curls, leg curls, chest press, and dead lift. The strength exercise program consisted of the following exercises: latissimus dorsi isometric, chair squat, upright isometric pull, bench step, knee push ups, toe stand, low bar pull-ups, flutter kick, shoulder pull, and back extension. The findings revealed that both male and female adolescents with DS could achieve significant improvement in muscular strength using a weight-training exercise program.

Fernhall (1993) reported that there is little data available on muscular strength of individuals with mental retardation (including DS). The studies to date indicate that people with mental retardation have up to 30% lower levels than their peers without mental retardation, yet they appear to respond normally to training. The possibility that individuals with DS deviate from other persons with mental retardation needs to be investigated.

The studies above are in agreement that muscular strength can be accurately and reliably measured in individuals with mental retardation. Chanias, et al. (1998) add that exercise prescription components, such as exact type of exercise program, duration of exercise session, and intensity of exercise program should be clearly outlined.

Also, more studies are needed to evaluate the effects of exercise on all health-related physical fitness components, but particularly on body composition, muscular strength, and flexibility in the mental retardation population.

REFERENCES

American College of Sports Medicine. (1998). The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. *Medicine and Science in Sports and Exercise*, *30*, 975 - 991.

American College of Sports Medicine. (2002). Progression models in resistance training for healthy adults. *Medicine and Science in Sports and Exercise*, *34*, 364 -380.

Auxter, D., Pyfer, J., & Huettig, C. (2001). Principles and methods of adapted physical education and recreation (9th ed.). New York: McGraw-Hill.

Baechle, T.R., & Earle, R.W. (2000). Essentials of strength training and conditioning (2nd ed.). Champaign, IL: Human Kinetics.

Balic, M.G., Mateos, E.C., Blasco, C.G., & Fernhall, B. (2000). Physical fitness levels of physically active and sedentary adults with Down syndrome. *Adapted Physical Activity Quarterly*, *17*, 310 - 321.

Braith, R.W., Graves, J.E., Pollock, M.L., Leggett, S.L., Carpenter, D.M., & Colvin, A.B. (1989). Comparison of 2 vs. 3 days/week of variable resistance training during 10- and 18-week programs. *International Journal of Sports Medicine*, *10*, 450 - 454.

Centers for Disease Control and Prevention. (1997). http://www.cdc.gov/ncbddd/dh

Chanias, A.K., Reid, G., & Hoover, M.L. (1998). Exercise effects on health-related physical fitness of individuals with an intellectual disability: A meta-analysis. *Adapted Physical Activity Quarterly, 15*, 119 - 140.

Croce, R., & Horvat, M. (1992). Effects of reinforcement based exercise on fitness and work productivity in adults with mental retardation. *Adapted Physical Activity Quarterly, 9*, 148 - 178.

Draheim, C.C., Williams, D.P., & McCubbin, J.A. (2003). Cardiovascular disease risk factor differences between special olympians and non-special olympians. *Adapted Physical Activity Quarterly, 20*, 118 - 133.

Eberhard, Y., Eterradossi, J., & Debu, B. (1997). Biological changes induced by physical activity in individuals with Down syndrome. *Adapted Physical Activity Quarterly, 14*, 166 - 175.

Feigenbaum, M.S., & Pollock, M. (1999). Prescription of resistance training for health and disease. *Medicine and Science in Sports and Exercise, 31*, 38 - 45.

Fernhall, B. (1993). Physical fitness and exercise training of individuals with mental retardation. *Medicine and Science in Sports and Exercise, 25*, 442 - 450.

Fernhall, B. (2003). Mental retardation. In American College of Sports Medicine (2nd ed.), Exercise management for persons with chronic diseases and disabilities (pp. 304 - 310). Champaign, IL: Human Kinetics.

Fernhall, B., & Pitetti, K.H. (2001). Limitations to physical work capacity in individuals with mental retardation. *Clinical Exercise Physiology, 3*, 176 - 185.

Fernhall, B., Pitetti, K.H., Rimmer, J.H., McCubbin, J.A., Rintala, P., Millar, A.L., Kittredge, J., & Burkett, L.E. (1996). Cardiorespiratory capacity of individuals with mental retardation including Down syndrome. *Medicine and Science in Sports and Exercise, 28*, 366 - 371.

Galuska, D.A., Earle, D., & Fulton, J.E. (2002). The epidemiology of U.S. adults who regularly engage in resistance training. *Research Quarterly for Exercise and Sport, 73*, 330 - 334.

Hass, C.J., Feigenbaum, M.S., & Franklin, B.A. (2001). Prescription of resistance training for healthy populations. *Sports Medicine, 31*, 953 - 964.

Hass, C.J., Garzarella, L, Hoyos, D.D., & Pollock, M.L. (2000). Single versus multiple sets in long-term recreational weightlifters. *Medicine and Science in Sports and Exercise, 32*, 235 - 242.

Hawkins, B.A. (1993). An exploratory analysis of leisure and life satisfaction of aging adults with mental retardation. *Therapeutic Recreation Journal, 2*, 98 - 109.

Kell, R.T., Bell, G., & Quinney, A. (2001). Musculoskeletal fitness, health outcomes and quality of life. *Sports Medicine, 31*, 863 - 87

Krebs, P. (2000). Mental retardation. In J.P. Winnick (3rd ed.), Adapted physical education and sport (pp. 112 - 119). Champaign, IL: Human Kinetics.

McLester, J.R., Bishop, P., & Guilliams, M.E. (2000). Comparison of 1 day and 3 days per week of equal-volume resistance training in experienced subjects. *Journal of Strength and Conditioning Research, 14*, 273 - 281.

Millar, L.A., Fernhall, B., & Burkett, L.N. (1993). Effects of aerobic training in adolescents with Down syndrome. *Medicine and Science in Sports and Exercise, 25*, 270 - 274.

National Down Syndrome Society (NDSS). http://www.ndss.org/content.

Pate, R.R, Pratt, M., Blair, S.N., Haskell, W.L., Macera, C.A., Bouchard, C., et al. (1995). A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *Journal of the American Medical Association, 273*, 402 - 407.

Pitetti, K.H., & Boneh, S. (1995). Cardiovascular fitness as related to leg strength in adults with mental retardation. *Medicine and Science in Sports and Exercise, 27*, 423 - 428.

Pitetti, K.H., & Campbell, K.D. (1991). Mentally retarded individuals: A population at risk. *Medicine and Science in Sports and Exercise, 23*, 586 - 593.

Pitetti, K.H., Climstein, M., Campbell, K.D., & Jackson, J.A. (1992). The cardiovascular capacities of adults with Down syndrome: A comparative study. *Medicine and Science in Sports and Exercise, 24*, 13 - 19.

Pitetti, K.H., Climstein, M., Mays, M.J., & Barrett, P.J. (1992). Isokinetic arm and leg strength of adults with Down syndrome: A comparative study. *Archives of Physical Medicine and Rehabilitation, 73*, 847 - 850

Pitetti, K.H., Rimmer, J.H., & Fernhall, B. (1993). Physical fitness and adults with mental retardation: An overview of current research and future directions. *Sports Medicine, 16*, 23 - 56.

Rimmer, J.H. (1994). Fitness and rehabilitation programs for special populations. Dubuque, IA: Wm. C. Brown.

Rimmer, J.H., & Kelly, L.E. (1991). Effects of a resistance training program on adults with mental retardation. *Adapted Physical Activity Quarterly, 8,* 146 - 153.

Sherrill, C. (1998). Adapted physical activity, recreation, and sport: Crossdisciplinary and lifespan (3rd ed.). Boston: McGraw-Hill.

Starkey, D.B., Pollock, M.L., Ishida, Y., Welsch, M.A., Brechue, W.F., Graves, J.E., & Feigenbaum, M.S. (1996). Effect of resistance training volume on strength and muscle thickness. *Medicine and Science in Sports and Exercise, 28,* 1311 - 1320.

Stone, M.H., Fleck, S.J., Triplett, T.N., & Kraemer, W.J. (1991). Health and performance-related potential of resistance training. *Sports Medicine, 11,* 210 - 231.

Weber, R., & French, R. (1988). Down syndrome adolescents and strength training. *Clinical Kinesiology, 42,* 13 - 21.

Yang, Q., Rasmussen, S.A., & Friedman, J.M. (2002). Mortality associated with Down syndrome in the USA from 1983 to 1997: A population-based study. *The LANCET, 359,* 1019 - 1025.

APPENDIX B

RAW DATA OF INDIVIDUAL MEASURES

RAW DATA

Participants	Pre-Bench press	Post-Bench press	Pre-Leg press	Post-Leg press
Participant 1	100	107.5 (7.5%)	207	248 (17%)
Participant 2	97.5	105 (7.5%)	119	204 (71%)
Participant 3	117.5	117.5 (0%)	204	265 (30%)
Participant 4	162.5	180 (11%)	306	357 (19%)