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by

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ISOKINETIC MEASUREMENTS OF SAGITTAL PLANE TRUNK STRENGTH IN OLDER ADULTS

ABSTRACT

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The purpose of this study was to collect normal flexion and extension trunk strength values for a population of individuals between the ages of 50 and 70 years of age. Twelve female and eight male volunteers in generally good health were tested in a seated position using a Biodex isokinetic dynamometer. Each performed five reciprocal maximal efforts of concentric flexion-extension cycles at the three isokinetic speeds of 60, 120 and 180°/s. Raw and body weight adjusted data for peak torque and total work were analyzed. Results suggest strength decreases with age and that extension strength is greater than flexion strength. Due to the paucity of subjects in each of the four elderly age groups tested, no significant results were obtained.

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PREFACE

Definition of Terms

Trunk flexion and extension:
Forward and backward bending.

Torque:
Force multiplied by distance from the axis of rotation.

Work:
Force multiplied by distance produced throughout the entire range of motion.

Peak Torque:
Highest torque value recorded usually at one specific point in the range of motion.

Peak Torque to Body Weight:
A ratio displayed as a percentage of the maximum torque production to the subject's total body weight.

Total Work to Body Weight:
A ratio displayed as a percentage of the maximum repetition work to the subject's body weight.

Total Work:
The sum of work for every repetition performed in the set.

List of Abbreviations

Peak Torque = PT

Peak Torque-to-Body Weight = PTBW

Total Work = TW

Total Work-to-Body Weight = TWBW

Flexion-to-Extension Torque Ration = FETR

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CHAPTER I

INTRODUCTION

Within the United States, the most rapidly growing segment of the population is that of the elderly which includes those who are 65 years old and older. Currently, 11% of the nation is at least 65 years of age. By the year 2020, it is estimated that 30% of the population could be over 65.[1] Along with the elderly, the number of adults who are at least 50 years old is increasing.[2] This aging of our nation is most likely a result of an increase in life expectancy which is undoubtedly related to tremendous scientific advances in health care. However, more research related to the rehabilitative phase of care needs to be completed so that both the quality, and the quantity, of life for older individuals can be improved.

One area of expanding research in rehabilitation of elderly patients involves muscle function. Muscle strength which is a component of muscle function has been reported to peak between 20 and 30 years of age, then remains fairly constant until age 50 when it begins to decline.[3] Many studies involving older persons have only focused on testing muscle strength of the extremities. Some investigations have used an isometric test protocol [3-6] while others have used an isokinetic protocol.[3,4,6-9] However, only a small number of studies reporting isokinetic trunk strength on adults over 50 years of age can be found.[10-12] Additional research needs to be completed so that normative values for isokinetic trunk strength in older adults can be established.[13-18]

Normative trunk strength data may be important in the prevention and rehabilitation of low back pain (LBP). Although a cause-effect relationship between trunk weakness and LBP has not been established, many studies have documented an association between these two factors.[17,19-22] Thus, clinicians and researchers agree that strengthening trunk musculature is an important aspect of treatment for LBP. If this concept is valid, normative trunk strength information can be used to screen people for trunk weakness and prevent potential low back problems through exercise.

In the rehabilitation setting, age specific normative values for isokinetic trunk strength could be crucial. When determining strength goals for extremity muscles, "normal" can often be based on the strength of an individual's uninvolved limb. When looking at the trunk, however, bilateral comparisons cannot be made. Consequently, trunk strength goals have been aimed at functional ability. However, many functional tasks are difficult to quantitate. Therefore, normative trunk strength values for specific age groups need to be established to allow health care professionals to properly evaluate the patient's trunk strength and help determine rehabilitation goals. Furthermore, comparisons of discharge strength data to normal values can be used to measure rehabilitation outcome.

The purpose of this study was to collect normative trunk flexion and extension strength data for older adults between the ages of 50 and 70 years using the Biodex isokinetic dynamometer.

CHAPTER II

LITERATURE REVIEW

Isokinetic measurements of the trunk have proliferated over the last decade. Researchers have reported many different parameters related to trunk testing including range of motion, torque, velocity, fatigability, power, and work, to name a few. There have been an abundance of studies which have examined the relationship between LBP and isokinetics.[10,13,23-25] However, little research has focused on trunk strength in the older individual.

Youdas et al,[26] while testing trunk strength in the three cardinal planes, found that males, aged 20-60, had a decrease in strength of 4% in flexion and 7% in extension. Females in the same age range demonstrated 19% and 18% decreases in flexion and extension strength, respectively. Both males and females demonstrated a significant negative linear correlation between peak torque and age in all three movement planes over the four resistance levels used. Unfortunately, this study did not indicate specific ages where the decreases were noted.

One part of a study by Smith et al[15] looked at strength changes that occurred with age. They suggested that a reduction in trunk strength occurred after age 45, specifically in the extensors of male subjects, whereas no changes in strength were noted between the 18-29 and 30-44 year old age groups. Their older subjects ranged in age from 45 to approximately 65. However, there were only ten in that age range. The authors also suggested that caution be used in calling their data "normative" due to the nature and small size of the sample, and the limited number of subjects over 45.

In another study, Langrana et al,[10] examined trunk muscle strength in 20-

65 year old men who worked in a manufacturing plant. Results from isokinetic testing at five revolutions per minute, indicated that flexion strength decreased in individuals 50-65 years old while extension strength for the same group varied.

Hasue et al[12] tested isometric and isokinetic trunk strength of fifty males and fifty females. They demonstrated a marked strength decrease after 40 years of age. They also noted increased muscle imbalance between abdominals and paraspinals with age, especially in females.

Decreases in trunk strength which come with age may be accompanied by back pain in many elderly individuals. Although there is conflicting information on the prevalence of back pain in the elderly, Hadler[27] believes that it increases linearly through life. He also indicated that 50% of elderly persons experience back pain on any given day. Therefore, maintaining strength in these muscles may be advantageous for older people.

Some studies have demonstrated that appropriate resistance training can reduce or even reverse losses in muscle strength associated with aging. However, none of these studies used isokinetic training. Only isotonic and isometric workouts were employed.[4-6,8]

An extensive review of the literature failed to show any normal data on trunk strength for the elderly. However, a number of studies were found that studied the effects of exercise on the extremities of elderly subjects. These studies are described below.

Aoyagi and Katsuta[4] demonstrated that men can minimize strength declines as they age, especially if they begin training by their mid-fifties. Thirty-nine male subjects, 60-68 years old, were studied. The research did not show to what extent the rate of strength decline could be reduced. They believed it may be due to the type of training activity used.

Brown et al[6] studied 14 healthy 60-70 year old males during a 12 week weight lifting program. Dynamic elbow flexion training of one arm resulted in a 48% mean increase in the maximal load that could be lifted one time (i.e. one repetition maximum or 1 RM). A smaller improvement in isokinetic torque was found (8.8%).

Frontera et al[8] examined 12 healthy 60-72 year old men involved in a 12 week strength training program for knee flexors and extensors. Weekly measurements of 1 RM showed a progressive increase in dynamic strength. By week 12, isotonic extensor and flexor strength had increased 107.4% and 226.7% respectively. Isokinetic peak torques for extension and flexion increased 10% and 18.5% at 60°/s and 16.7% and 14.7% at 240°/s, respectively. The discrepancy between isotonic strength gains and peak torque gains was probably due to the specificity of training.

One study, which included women as well as men, was completed by Fisher et al[5] who studied 14 functionally impaired nursing home residents aged 60-90 years old. In 75% of those tested, there was an improvement in isometric knee extension strength which averaged between 30% and 150%.

The preceding studies support the use of exercise as a means to improve strength in the elderly. Thus, objective isokinetic measures can be used to 1) evaluate trunk strength, endurance, and range of motion 2) obtain baseline strength information and 3) chart progress through rehabilitation.

The number of strength measurement devices has grown in recent years. Most studies to date have used various models of Cybex dynamometers [10,14-16,28-32] or the B-200,[11,17,18,33-42] a device manufactured by Isotechnologies. The Biodex is a relatively new device. Reported research using the Biodex is lacking. Only Grabiner et al[23] has utilized it for trunk testing. One reliability study has been published by Feiring et al.[43] Their study shows a high correlation between peak torque and single repetition work at five speeds tested for knee flexion and extension.

CHAPTER III

METHODOLOGY

Subjects

Twenty volunteer subjects, 8 male and 12 female, between 50 and 70 years of age were tested for trunk strength using the Biodex isokinetic dynamometer. They were selected from the greater Grand Rapids area. Persons with any known history of spinal surgery, low back pain which required treatment within one year prior to the test date, or any cardiopulmonary conditions were not included in this study (Appendix A). Test subjects were required to undergo a pretest screen including a subjective history with a systems review, blood pressure check, and a physical exam (Appendices B, C). The purpose of the screen was to rule out any potential problems that might affect the participant's health. Subjects with systolic blood pressure of 140mm Hg or higher and diastolic pressure of 90mm Hg or higher were not allowed to participate in this study. All eligible subjects signed a consent form prior to testing (Appendix D).

Subjects were recruited through public service announcements on local radio and television stations, flyers posted at local businesses, and memorandums distributed to the faculty at Grand Valley State University. Preliminary screening for spinal and cardiopulmonary conditions were conducted over the telephone in order to streamline selection of eligible subjects (Appendix A).

Equipment

Test equipment included the Biodex Isokinetic Dynamometer with Biodex computer, software, and back station attachment (Biodex Corp., 49 Natcon Drive,

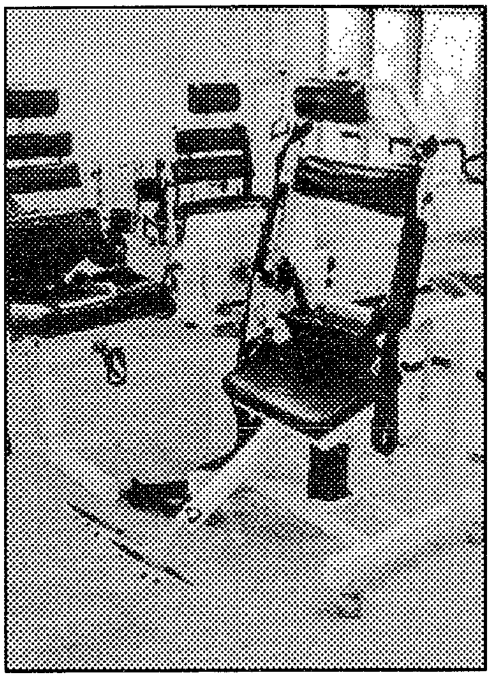

Fig 1.–The Biodex back station.

P.O. Drawer S, Shirley, NY 11967). The back station attachment is a flexion and extension unit which is secured to the powerhead of the dynamometer by three set screws to help prevent artifact in the data recordings (fig. 1). Proper subject stabilization was assured by following established Biodex protocols. Equipment calibration procedures were performed five months prior to testing according to manufacturer's specifications. Six to eight months between calibration is acceptable according Biodex Corporation. There was no correction for gravity. A Schwinn Airdyne was used for a pretest warm up.

Procedure

Prior to testing, each subject performed a five minute warm up on a Schwinn Airdyne to enhance the musculoskeletal and neuromuscular systems. The subjects were tested in a seated position with their anterior superior iliac spines (ASIS) in alignment with the fixed axis of rotation of the Biodex unit. The height of the foot plates was adjusted to provide 15° of knee flexion to avoid hamstring strain.[14,31] The sacral pad was then placed to maintain alignment of the subjects' ASIS. This axis has been determined by Grabiner et al[23] as representing an appropriate positioning method for data collection using the Biodex. Four stabilization straps were placed across each subject. One went over both hips and one went across the proximal thighs. Two were placed diagonally

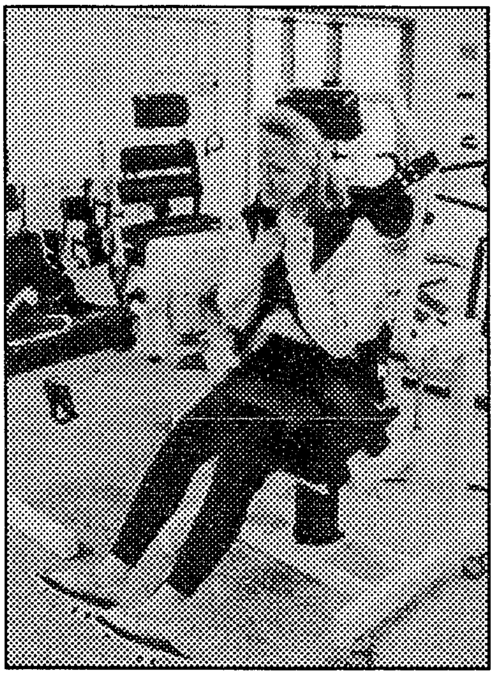

Fig 2.–Proper subject positioning in the Biodex.

across the shoulders and chest (fig. 2). These were used to maintain alignment of the axis of rotation and to prevent torque recording errors. The posterior thoracic roller pad was adjusted to the level of the fourth thoracic vertebra. The head pad was set to the desired comfort of each subject. The range of flexion and extension that each subject moved through was set according to his or her own ability. The subject was instructed to hold onto the shoulder straps during testing.

Once subjects had been properly positioned in the Biodex, they were allowed a warm up of five submaximal and two maximal repetitions (one repetition equals the full range of flexion plus the full range of extension). This was done at each test speed in order to ready the trunk musculature and to familiarize the subject with the device. Participants were given explicit verbal instructions as to what was required prior to testing as well as verbal encouragement to exert maximal effort during each test.

The test protocol consisted of five maximal reciprocal flexion and extension cycles, beginning from full flexion, at each of the following three isokinetic speeds; 60, 120, and 180 degrees per second. Each subject was tested in this order. Grabiner[23] states these speeds represent a broad functional range as well as speeds that patients with LBP can perform. The subjects were given a one minute rest period between each speed tested.

An intratester reliability study was conducted. One researcher performed all the testing activities while the other two researchers alternated in performing the screening exams. Three male and four female subjects were selected for retesting. Data from their first test were compared with their retest data to determine intratester reliability. Retest appointments were scheduled with the seven participants following their first test. Data from their first test was included in the actual study which examines peak torque (PT), peak torque-to-body weight ratio (PTBW), total work (TW), total work-to-body weight ratio (TWBW), and flexion-to-extension torque ratios (FETR).

Statistical Analysis

The generated data was separated by gender and grouped into either the 50-59 or 60-69 year old age group. Demographic data included age, height, and weight means. The SAS statistical software package was used to calculate means and standard deviations for peak torque, peak torque-to-body weight ratio, total work, total work-to-body weight ratio, and flexion-to-extension torque ratios.

CHAPTER IV

RESULTS

Results of the intratester reliability study using seven subjects (three males and four females) were analyzed. Pearson's correlation coefficient for PT and TW flexion values ranged from .91 to .98 and extension values for these variables ranged from .86 to .98 across the three speeds tested. This indicated a strong (r=.8-1.0) correlation between test and retest results. PTBW ratios for flexion and extension ranged from .75 to .88. This indicated a moderate (r=.5-.79) to strong (r=.8-1.0) correlation between test and retest. The ratio of TWBW was not calculated due to data reduction errors. The FETR for the intratester reliability ranged from .66 to .77. This reflected a moderate relationship between the initially measured values and those collected during the retest for the seven subjects selected.

A total of 12 female and 8 male subjects were tested. Subjects were separated by sex into two age groups of 50-59 and 60-69 years of age. The four females in the 50-59 year old group ranged in age from 52 to 59 with the average age being 55 years. Their mean height was 64.8 inches and mean weight was 110.8 pounds. The eight females in the 60-69 year old age group ranged in age from 60-67 with the average being 64 years. The mean height and weight of this age group was 64.9 inches and 149.3 pounds, respectively. The five males in the 50-59 year old group ranged in age from 51-58 and had an average age of 54 years. They had a mean height of 72.8 inches and mean weight of 200 pounds. There were only three 60-69 year old males. All were 62 years of age and they had a mean height and weight of 72.0 inches and 229 pounds, respectively.

Data was analyzed separately by sex and age group for each of the three speeds tested before comparisons were made between groups. Tables 1-4 present means and standard deviations for trunk strength variables including peak torque, peak torque-to-body weight ratio, total work, total work-to-body weight ratio, and flexion-to-extension torque ratios. Also, the average percent difference between both age groups across the three speeds tested was calculated for PTBW and TWBW ratios in both gender groups.

Table 1 shows the mean extension results for the two male age groups for all test speeds. The mean values for the 60-69 year old group demonstrated higher values for PT, PTBW, TW, and TWBW than the 50-59 year old group. The mean PTBW of all three speeds demonstrates that the older group had 16.6% greater strength than the younger group. For mean TWBW the older males were 21.9% stronger on the average for the three speeds. However, due to the small sample size these differences were not significant at the .05 level.

Mean trunk flexion test results for the two male groups are reported in Table 2. The mean PTBW for the older males were 14.7% stronger at 60°/s but demonstrated a 1% and 2.3% lower strength than the younger age group at 120°/s and 180°/s, respectively. The TWBW values were equal at the lowest speed for both age groups, younger males were 6.5% stronger at the middle speed, and the older males were 6.4% stronger at the highest speed. The mean FETR for the male groups (Table 2) are percentages based on peak torque values. These values indicate that extension strength was greater than flexion strength. The 50-59 year old group showed less difference in flexion to extension strength values than the 60-69 year old group based on the FETR.

Table 3 shows descriptive statistics for trunk extension in females 50-59 and 60-69 years old. At all three speeds, the 50-59 year old group demonstrated higher mean values for all variables than the 60-69 year old group. The

Speed	PT (ft-lbs) 50-59*	PT (ft-lbs) 60-69†	PTBW (%) 50-59	PTBW (%) 60-69	TW (ft-lbs) 50-59	TW (ft-lbs) 60-69	TWBW (%) 50-59	TWBW (%) 60-69
60°/sec	172.7 ± 54.0	238.7 ± 34.1	87.4 ± 26.4	106.1 ± 13.9	646.1 ± 102.3	809.6 ± 229.1	334.0 ± 90.3	379.7 ± 165.5
120°/sec	189.8 ± 53.9	248.6 ± 58.8	96.1 ± 25.8	112.1 ± 33.8	498.7 ± 87.7	671.7 ± 251.5	254.9 ± 56.0	321.2 ± 173.5
180°/sec	194.9 ± 57.2	281.3 ± 83.9	100.0 ± 33.4	122.0 ± 17.9	424.5 ± 32.2	697.1 ± 314.8	219.9 ± 50.6	327.8 ± 174.7

Table 1.–Extension means and standard deviations for males of both age groups

*n=5. PT=peak torque. TW=total work.
† n=3. PTBW=peak torque-to-body weight. TWBW=total work-to-body weight.

Speed	PT (ft-lbs) 50-59*	PT (ft-lbs) 60-69†	PTBW (%) 50-59	PTBW (%) 60-69	TW (ft-lbs) 50-59	TW (ft-lbs) 60-69	TWBW (%) 50-59	TWBW (%) 60-69	FETR (%) 50-59	FETR (%) 60-69
60°/sec	117.8 ± 26.0	150.9 ± 22.1	59.1 ± 9.4	69.3 ± 21.8	451.4 ± 55.2	476.4 ± 232.7	229.5 ± 30.1	229.6 ± 136.9	70.8 ± 18.5	64.3 ± 14.2
120°/sec	113.3 ± 23.2	122.6 ± 21.7	56.8 ± 7.7	56.4 ± 18.8	405.5 ± 80.6	401.3 ± 177.3	206.5 ± 41.9	193.1 ± 111.1	62.9 ± 20.5	50.2 ± 9.3
180°/sec	121.1 ± 23.7	130.4 ± 19.4	60.9 ± 8.5	59.5 ± 17.1	379.8 ± 116.8	428.5 ± 184.0	189.9 ± 50.3	202.9 ± 107.4	68.2 ± 29.9	49.5 ± 16.3

Table 2.–Flexion means and standard deviations for males of both age groups

*n=5. PT=peak torque. TW=total work.
† n=3. PTBW=peak torque-to-body weight. TWBW=total work-to-body weight.

Table 3.–Extension means and standard deviations for females of both age groups

Speed	PT (ft-lbs) 50-59*	PT (ft-lbs) 60-69†	PTBW (%) 50-59	PTBW (%) 60-69	TW (ft-lbs) 50-59	TW (ft-lbs) 60-69	TWBW (%) 50-59	TWBW (%) 60-69
60°/sec	138.0 ± 29.5	96.7 ± 31.4	101.2 ± 26.7	64.6 ± 17.5	547.6 ± 127.0	413.7 ± 108.0	406.6 ± 13.5	281.0 ± 88.5
120°/sec	118.9 ± 17.6	97.2 ± 27.4	87.7 ± 22.7	65.6 ± 19.4	396.5 ± 29.5	322.4 ± 97.1	295.0 ± 87.3	221.3 ± 85.1
180°/sec	121.9 ± 15.4	97.8 ± 21.7	91.1 ± 30.2	66.5 ± 18.2	336.0 ± 71.4	247.4 ± 87.5	248.6 ± 86.5	171.3 ± 76.7

*n=4. PT=peak torque. TW=total work.
†n=8. PTBW=peak torque-to-body weight. TWBW=total work-to-body weight.

Table 4.–Flexion means and standard deviations for females of both age groups

Speed	PT (ft-lbs) 50-59*	PT (ft-lbs) 60-69†	PTBW (%) 50-59	PTBW (%) 60-69	TW (ft-lbs) 50-59	TW (ft-lbs) 60-69	TWBW (%) 50-59	TWBW (%) 60-69	FETR (%) 50-59	FETR (%) 60-69
60°/sec	57.9 ± 16.6	55.8 ± 9.2	41.6 ± 9.0	37.8 ± 6.9	303.9 ± 91.6	277.3 ± 55.4	214.9 ± 42.3	188.9 ± 48.4	45.1 ± 23.0	62.0 ± 16.9
120°/sec	63.4 ± 11.3	58.9 ± 9.5	45.6 ± 5.5	40.1 ± 8.2	270.1 ± 86.5	244.6 ± 66.3	189.1 ± 34.9	166.1 ± 50.2	54.6 ± 15.8	64.6 ± 17.5
180°/sec	74.7 ± 20.9	71.6 ± 9.0	52.7 ± 7.1	48.6 ± 8.2	235.6 ± 88.7	211.2 ± 71.5	163.4 ± 37.4	144.3 ± 53.7	63.5 ± 24.7	75.9 ± 14.2

*n=4. PT=peak torque. TW=total work.
†n=8. PTBW=peak torque-to-body weight. TWBW=total work-to-body weight.

mean PTBW average of all three speeds demonstrates that the younger females had 29.5% greater strength than the older females. The mean TWBW average for the younger females was 23.2% stronger when averaged across the three speeds.

Table 4 represents trunk flexion variables for the two female age groups. The mean PTBW for the younger age group was 9.7% stronger over the three speeds. The mean TWBW values were 12.0% stronger in the younger age group than the older group. The 60-69 year old group showed less difference in flexion to extension torque ratio values than the 50-59 year old group as shown in the mean FETR results in Table 4.

When comparing values between the male and female subjects, mean PT and mean TW values were higher for the males in both flexion and extension. However, when adjusted for body weight the mean extension PTBW at 60°/s and mean extension TWBW at all three speeds were greater in the younger females than the younger males. In flexion, the mean PTBW and mean TWBW values were greater in the males.

CHAPTER V

DISCUSSION

The purpose of this study was to collect normative trunk flexion and extension strength data for older adults using the Biodex isokinetic dynamometer. This study represents the beginning of further research which needs to be done so that normative data can be established. This will allow health care professionals to more effectively evaluate a patient's trunk strength and help determine rehabilitation goals. It could also help in assessing discharge rehabilitation outcomes.

Since the females and males were 40 pounds and 30 pounds heavier, respectively than the males and females in the younger groups. The mean torque and mean work values were adjusted to account for body weight. The authors believe that PTBW and TWBW ratios are more accurate indicators of normalized strength values as body weight differences can be a source of data variability.

The results of the intratester reliability study indicate strong correlation between first and second tests across the speeds tested with the exception of PTBW in flexion and the FETR. This discrepancy in correlation may be the result of the small number of subjects in the pilot study. Random assignment of the first and second tests for analysis could have minimized variations in the correlation results.

Several authors indicated an expected decrease in strength with age.[1, 5, 10, 12, 15, 26] However, for the male subjects, this study found an increase in strength values as age increased for mean extension PTBW and TWBW which was not anticipated. This was probably a result of the small sample size and the fact that one of the three subjects in the 60-69 age group was a very active person. However, recalculation of PT, PTBW, and TW means without this possible outlier indicated that his increased activity level did not alter the trends significantly. Thus, the small sample size was the probable cause of the unexpected findings.

This study did not control for the individual activity levels of each participant. Several authors have found that strength can increase in the elderly with training.[5, 6, 8] Therefore, another plausible explanation for the increase in mean extension PTBW and TWBW with increased age may be that our older male subjects are more active and thus stronger than those who are less active. A large sample size would tend to minimize the effects of activity level. Further investigation is needed to determine the effects of activity level in relation to strength values.

Langrana[10] found that male flexion strength decreased in 50-65 year olds. McNeil[20] found the mean isometric strength for younger subjects (30 years or less) tended to be 10%-30% greater than the mean isometric strength for older subjects (greater than 30 years old). This study found that the difference between the mean flexion PTBW and TWBW values for the two male age groups were varied across the speeds tested. There was a tendency for the values to drop slightly at 120°/s and to increase at 180°/s. Again, these results are not statistically significant due to the small sample size, the different activity levels of the participants, and the variation in range of motion settings between subjects. The mean FETR of the younger male age group indicates less of a muscle imbalance than the older males. This could be related to the small sample size as well as to the fact that two subjects in the older group had relatively high extension values but low flexion values which would cause the data to reveal this trend.

As found in other studies,[12, 15, 26] females demonstrated decreases in flexion and extension strength for all speeds as age increased. This may be a result of neurologic and muscular changes such as loss of fast twitch fibers and decreased motor unit recruitment that can occur with increased age.[3] There is also a tendency to be more sedentary with age. The mean FETR of the older female group indicated less of a muscle imbalance between the flexor and extensor trunk muscle strength than what was found in the younger age group. This may be due to the small sample size or it may indicate that extensor strength decreases faster with age while flexor strength decreases more slowly or stays relatively stable between the ages of 50-70 years. Further investigation is needed to determine the reason.

This study found that mean PT values tended to increase across the three speeds tested in both gender groups. These findings are not consistent with Grabiner,[23] Youdas,[26] and Davies[31] who found PT decreased with increased test speeds. Smith[15] found the difference across speeds to be negligible. A possible explanation for the opposite findings in this study was that a learning effect may have lead to increased effort as participants become more familiar with the device. Also, the overshoot which occurred when subjects reached end range of motion was included in the data and could contribute to these findings. Lastly, the elderly may have been more reluctant to maximize their effort at lower versus higher speeds for fear of injury since the greatest resistance was experienced at the lowest speed.

Based on a previous study[26] the authors expected male strength values would be greater than female values. This was not the case in the extension PTBW at 60°/s and extension TWBW at all three speeds in the younger age group. This could result from greater flexibility of the female subjects in that they were able to begin the extension movement in a more flexed position thus providing a greater range of motion. Since total work is a product of force times distance, this would allow for an increased total work value. However, the trend of strength being greater in older males than older females was consistent with the previously mentioned study.

As found in other studies,[12, 15] extensor strength was found to be greater than flexor strength in both male and female groups. It is believed that this may be a result of the extensor muscles having a greater cross-sectional area than that of the flexor musculature.

Limitations

The original intent of this study was to test 100 subjects so that the data collected would be reflective of normative values. This goal was limited by time constraints from delays with the Human Subjects Review Committee and deadlines for completion of this study. Other factors limiting the sample size include narrow inclusion criteria such as a potentially low blood pressure limit for this age group and difficulty in coordinating subject and researchers schedules for testing.

The age range of 50-70 years was chosen for two main reasons. First, there is little data currently available for this age range. Secondly, a population older than 70 years will tend to have a greater probability of having health problems. This would further limit the number of eligible subjects in the over 70 years age group and the sample would not be representative of the overall population. Furthermore, this type of testing may be too strenuous for individuals over 70 years of age..

Although volunteer subjects were sought from a large geographic area, the majority of those who responded and were included in this study were professors affiliated with Grand Valley State University. In general, teaching is considered more of a sedentary job and thus, values taken from among this group may not be indicative of the general population. Another potential limitation resulting from this occupational factor relates to each subject's activity level. A majority of the participants indicated having a low activity level. As mentioned earlier, future research can take into account the effects of activity level.

The investigators found that problems with the dynamometer created potential for limitations in this study. As Grabiner[23] noted, the unstable nature of the sacral pad allowed significant anteroposterior translation of the pelvis during testing. Thus, these changes in the axis of rotation can influence the data. There was also difficulty in achieving 15 degrees of knee flexion on smaller subjects. Knee flexion values for this study ranged from 15 to 18 degrees. The adjustability of the foot rest on the Biodex was limited by its rigid frame. Thus, shorter participants were less stable in the device because their feet were not in full contact with the foot plates. This may have affected the torque and work variables and decreased reliability of the test data. This knee flexion angle may need to be adjusted to accommodate shorter persons and those with less hamstring flexibility. The set screw which fastens the back station attachment to the powerhead occasionally would loosen and required tightening. This, along with the fact that the device was not secured to the floor and would move slightly when larger subjects reached end range of motion, could also have produced inaccuracies in the data collected.

The data included torque spikes which occurred when subjects reached end range. This may cause the appearance of increased strength in subjects of this study as compared to similar subjects in other studies.

Since work is a product of force times distance, range of motion settings should have been consistent between all subjects tested. The varied distances each person moved through in the arc of motion could have effected the TW values.

In future studies, a more rigid time frame should be implemented for test retest reliability measures. Due to subjects' time constraints, retests were conducted anywhere from one to three weeks following their original test. This may lead to inconsistent learning effects between subjects.

Conclusions

This study represents an attempt to gather normative strength data for male and female adults between the ages of 50-59 and 60-69. Due to the paucity of subjects in each of the four elderly age groups tested, no significant results were obtained. The results of this study are not entirely consistent with those of other published studies. This is due in large part to the small sample size and numerous limitations. Further data collection will be needed before this information can be considered normative. Once a large data base has been collected, however, these data can be used to help patients and rehabilitation professionals establish appropriate strength goals.

Further research is needed to compile a normative trunk flexion and extension strength data base for older individuals. Other studies could seek to determine if variables such as weight, height, body type, activity level, and random speed assignment influence values collected when using isokinetic testing methods. In addition, regression analysis of these factors could be performed to determine their effects on the data collected.

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APPENDIX A:

PRELIMINARY QUESTIONS

Are you willing to come to NOI to be tested?

Have you ever had any neck or back surgeries? (If so, exclude.)

Have you experienced back pain in the last year which required medical treatment? (If yes, exclude.)

Have you been hospitalized in the last year? (Major or Minor?) For what reason? Are there any residual medical or musculoskeletal effects? (If yes, exclude.)

Have you seen a physician in the last year? For what reason?

Do you have or have you ever had any known heart conditions?

Do you know if you have high blood pressure? (> 140/90 = borderline HTN) If they don't know, it will be measured at screening. If yes, is it controlled by medications? If yes, ask following question.

Would you mind if we contact your physician to get his/her approval for you to participate in this study? (Yes, No) Name: Phone:

APPENDIX B:

SCREEN EXAM CONTENTS

Questions for patient history:

Subject name: ____________________DOB: ______Age: ______Sex: ______

Ht: _____Wt: _____Occupation: ____________Exercise level: low / med / high

1. **Race:**

2. **Smoking history:** (yes or no)
   a. If "yes", for how many years? __________Age when started? __________
      How many per day? _________________
   b. If you quit, when?_____How much did you smoke before quitting?_____
3. **Medical Conditions:** If "yes" to <u>any</u>, indicate: When diagnosed? What was prescribed? If given medications, what they were? If condition limited activity, how?
   a. Osteoporosis?
   b. Arthritis?
   c. High blood pressure?
   d. High cholesterol?
   e. Diabetes?
   f. Gout?
   g. Liver disease?
   h. Stroke?
   i. Fractures?
   j. Cancer?

4. **Chest pain** (shoulder pain?) If "yes", when? ______________

   If limits activity, how?

   a. **Heart Attack?** (yes or no) If "yes", when? ______________

      If taking meds, what kind?

      If limits activity, how?

   b. **Pacemaker?** (yes or no) If "yes", why ________how long? __________

      If had it removed, why and when?

5. **Short of breath?** If "yes", when?______________

   If limits activity, how?

6. **Artificial joints?** Where? ______________For how long? ______________

   If limits activity, how?

7. **Weight changes?** (loss/gain) How much? ______________

   Why?

8. **Visits to physician or a hospital for health care reasons?** (Include nurse, nurse practitioner, physicians assistant, chiropractor, dietician, psychologist, etc.)

   - Where?
   - Why?
   - When?
   - For how long?
   - Results?

9. **Medications** (prescription or non-prescription)

   - Type?
   - Dosage and frequency?
   - For what condition are you taking them?
   - Do you take vitamins? If "yes", what kind?; In what dosage?

APPENDIX C:

RESEARCH STUDY SCREENING FORM

Blood Pressure:___________

Screen:____

____

____

Posture:____

____

Cervical Range of Motion:

F/E:___________________

SB:___________________

ROT:___________________

Trunk Range of Motion:

F/E:___________________

SB:___________________

ROT:___________________

Straight Leg Raise:

Right:___________________

Left:___________________

General Spinal Evaluation

Blood Pressure

Posture
- a. Symmetry of related parts?
- b. Head in midline?
- c. Presence of normal spinal curves?

Trunk Range of Motion (Standing)
- a. Flexion
- b. Extension
- c. Sidebending (right/left)
- d. Rotation (right/left)

Neck Range of Motion (Seated)
- a. Flexion
- b. Extension
- c. Sidebending (right/left)
- d. Rotation (right/left)

Straight Leg Raise
- a. Within normal range? (approximately 45°)
- b. Any associated pain?

APPENDIX D:

CONSENT FORM

The Biodex is a device used in rehabilitation that measures strength. The screening and test will take approximately one hour. Each subject will be secured to the Biodex back attachment in a seated position using velcro straps across the chest, hips, and thighs. Three different speeds will be tested in order to provide comparative data for rehabilitation applications.

I, ________________, freely and voluntarily agree to participate in this research project under the direction of Jill Thauvette, Pat Townshend, and Ralph Bidwell to be conducted at NOI (Neurologic Orthopedic Institute).

I understand that:

1. this study is being done in order to help determine normal strength values for back and abdominal muscles and that this knowledge will help to provide an improved standard of treatment by physical rehabilitation professionals.

2. prior to the actual testing I will be given a physical examination to screen for any orthopedic condition which might exclude me from further testing. I understand that the risks involved with this testing are minimal but may include some delayed muscle soreness.

3. in the unlikely event of minor injury, financial compensation is not available. However, I understand that medical care should continue under the direction of my physician, in accordance with my own particular financial arrangement.

4. I have been selected for this study because I am relatively healthy, have not had back pain for at least twelve months, and have never had any back surgery.

5. the information I provide will be kept strictly confidential.

6. my participation in this study is voluntary and that I may withdraw at any time without any prejudice from the research team.

<u>Participant Statement</u>

This study has been explained to me and I voluntarily consent to participate in this study. I have had the opportunity to ask questions.

______________________________ Participant Signature ______________ Date

______________________________ Investigator Signature ______________ Date

AUTOBIOGRAPHICAL INFORMATION

Ralph Bidwell: I have been in college for 12 years during which I have extensively studied computer programming and the field of psychology. My first experience with physical therapy was the result of a running injury. A year later, with encouragement and support of my wife, I began taking prerequisites for entry physical therapy program. I received my Associate degree in Arts and Science from Grand Rapids Junior College in 1988. I was accepted into the Masters program in Physical Therapy at Grand Valley State University in 1990. Shortly thereafter in 1991, I received my Bachelors degree in Health Science with honors. Currently, I am working as a Student Physical Therapist for Professional Physical Therapy Services Inc. in Grand Rapids, Michigan. My Master of Science in Physical Therapy degree will be completed in May 1993. My wife and I will be moving to Denver, Colorado where I have accepted a position in a neurologic rehabilitation center.

Jill Thauvette: I received my Bachelor of Science degree in Biology from Michigan Technological University. The activities I enjoyed the most during my four years in the great north were organizing winter carnival as a member of Blue Key National Honors Fraternity, playing broomball, copper country cruising, and meeting my future husband.

I now attend Grand Valley State University in Michigan and cannot wait to receive my Master of Science in Physical Therapy on May 1, 1993. After graduation I look forward to finally marrying the love of my life and being a practicing Physical Therapist. However, I will miss the summers on the beaches of Lake Michigan and dancing with my friends.

Pat Townshend: The youngest in a family of eleven, I have been inspired and supported thorough my college career by my parents and siblings who have all obtained their Bachelor or Masters degrees. I received my Bachelor of Science degree from Michigan State University in 1988 with the original intention of pursuing a career in medicine. However, after a volunteer experience in physical therapy I was drawn to the rehabilitation aspect of patient care and the rewards of assisting patients in their recovery from illness and injury. In 1988, I began program coursework for a degree in physical therapy and gained entry in to the masters program in physical therapy at Grand Valley State University in 1990. I am currently working as a Student Physical Therapist for Professional Physical Therapy Services Inc. in Grand Rapids, Michigan. I am looking forward to obtaining my Master of Science degree in physical therapy in May of 1993 and beginning a bright future as a physical therapist.