Abdominal and Lower Back Training for People with Disabilities Using a 6 Second Abs Machine: Effect on Core Muscle Stability

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ABSTRACT

Introduction: When people are confined to a wheelchair, central neuropathies such as spinal cord injury and stroke usually reduce strength of core muscles and corresponding functional abilities for standing or reaching. The present investigation describes the effects of an exercise regime on reach and balance, accomplished with a low cost portable device, the 6 Second Abs machine.

Methods and Procedures: Using a modification of the functional reach test (FRT) and assessment of balance through four load cells under a balance platform, 13 control and 14 subjects with spinal cord injury, stroke or multiple sclerosis were evaluated before and after one month of training using three abdominal exercises and one lower back exercise accomplished from a wheelchair.

Results: Improvement in reach and reductions in muscle tremor were associated with a core muscle-strengthening program. Reach, which was less than half that of control subjects, increased in the following directions by 23% (forward), 91% (right), and 50% (left).

Conclusion: This program, which only required twenty minutes of daily exercise, should provide increased functional abilities for people with disabilities.

INTRODUCTION

Numerous studies in the last one hundred years point to the advantage of exercise training in providing positive benefits for general health. Exercise can dramatically increase oxidation of lipids; reduce body weight, low-density lipoprotein (LDL) cholesterol, fasting glucose; and lower resting blood pressure.[1-4] Lifting slowly against loads that fatigue muscle in short periods of time, called anaerobic exercise,[5] causes muscle enzymes to be synthesized to favor glycolysis and reduce oxidation of fatty acids. DNA is transcribed to build actin and myosin in muscle to increase strength.[5-9] This allows muscle to build strength and increase its ability to work without oxygen.[10] In contrast, light repetitive work (aerobic exercise) requires high blood flows for energy and oxygen delivery. This causes the muscle to transcribe genomes on DNA, which increases the concentration of enzymes in the Krebs cycle. It ultimately results in the beta oxidation of fats, which increases the muscle's ability to burn fats.[7,11] Aerobic training also elicits an increase in angiogenesis in capillaries, mitochondrial surface area, and density to allow better oxygen and fuel delivery to tissue for exercise.[12] Aerobic training also lowers triglycerides, inflammatory cytokines, C-reactive protein, and increases collateral circulation in the heart.[13] For people with diabetes, exercise is important because the increased nitric oxide production, from the mitochondria and active skeletal muscle, activates Glut-4 (without insulin as a co-factor) and thereby reduces circulating glucose in the body.[11] This is especially pertinent because there is a high incidence of metabolic disorders, such as diabetes, in people with motor paralysis.[14]

While cardio-respiratory conditioning is important for people with disabilities, the most immediate concern is simply accomplishing the activities of daily living (ADL). The activities of daily living are frequently limited due to weakness in core muscles (ie, the rectus abdominus, transverse abdominus, and the internal and external obliques).[15] This results in an inability to reach anything that is not close to the wheelchair. Moving the trunk more than 5 or 10 degrees from neutral can cause a loss of balance and falls from a wheelchair.[16] Transfers, reach, and general balance are often poor.[17] Because of this poor balance, bone fractures are common and the most common fracture seen is at the head of the femur, which results from falling out of the wheelchair onto the knee.[18] These compression fractures occur in up to 10% of the population of paraplegics and quadriplegics each year.[32]

Studies show that strengthening the core muscles contributes to increased functional abilities.[19,20] Using exercise machines in health clubs or rehabilitation centers strengthens the abdominal and lower back muscles and can increase ADL's and produce more effective bowel and bladder function.[17] This in turn leads to great psychological gains by allowing a person to be more independent.

However, with ever-rising costs in rehabilitation and even health clubs, it is important to develop exercise techniques and devices that allow individuals who are disabled to exercise at home.[21] One existing device is the 6 Second Abs machine. This machine provides a progressive increase in resistance with a built-in timer so that individuals can exercise their abdominal muscles and lower back muscles from a wheelchair.[22] In previous studies, we have shown that these devices offer a unique, more effective way to build abdominal muscle tone and strength when compared to conventional sit ups.[23] The purpose of this investigation was to see if the device would help people with disabilities. This

Table 1. General Characteristics of Subjects

Subjects	Age (years)	Height (cm)	Weight (kg)
Spinal Cord Injury	35.3 ± 12.2	174.9 ± 12.8	75.9 ± 22.1
Stroke	48.1 ± 25.5	169.4 ± 7.7	78.6 ± 19.6
Multiple Sclerosis	49.6 ± 11.6	162.5 ± 9.6	75.1 ± 21.6
Average of all subjects with disabilities	43.3 ± 16.5	170.1 ± 10.1	77.7 ± 17.6
Control	45.8 ± 14.1	171.5 ± 9.7	74.5 ± 17.1

device offers considerable advantage for disabled people because it allows them to exercise in the seated position, as opposed to many of the other abdominal machines, which require people to lay either horizontal or recline outside of a wheelchair.

SUBJECTS

Fourteen people with disabilities and 13 control subjects participated in the study. Seven of the participants with disabilities had paraplegia, three had multiple sclerosis, and four had strokes. The general characteristics of all of the subjects are shown in Table 1. The control subjects were free of any physical disabilities, but were selected to create baseline data for reach and motor control, which would later be compared with the data for people with disabilities. Control subjects performed all the exercises in wheelchairs except for the balance platform exercise. All subjects were free of cardiovascular disease or orthopedic injuries that would limit participation in an exercise program. Subjects with stroke were limited to hemiplegia and had no cognitive loss. All protocols and procedures were approved by the committee on human experimentation at Loma Linda University and all subjects signed a statement of informed consent.

METHODS

6 Second Abs Machine

The 6 Second Abs machine was a commercial exercise device manufactured by Savvier LP in Carlsbad, Calif. The device consisted of a rectangular plastic frame with rubber bands on the inside to adjust resistance. Resistance could be increased in a number of different stages so that it became increasingly more difficult to compress the rectangle (Figure 1).

As the machine was compressed to the first, second, and third click positions, there was a linear increase in load. Muscles work concentrically, isometrically, and eccentrically. With 3 different pairs of resistance bands, a total of 9 different band settings could be selected. Both the upper and lower rectangles were padded (Figure 1).

Measurement of Muscle Strength

Muscle strength was measured in the abdominal and back muscles. The subject was in the seated position with their back at 90 degrees in reference to the hips. A strap was placed around their chest just below the axilla and connected to a strain gauge force sensor (Figure 2). Strength was then assessed for flexion and extension as the highest of 3 maximal efforts in each muscle group; 1 minute separated the contractions. A complete description is given below.[22]

Assessing Balance

Balance was assessed using a computerized dynamic posturography device that was built to accommodate wheelchair bound subjects. The basic frame of the platform was constructed from two sheets of plywood and a ramp. The 1-inch plywood plates were separated by four metal bars connected to strain

Figure 1. A subject exercising the rectus abdominus muscles using the 6 Second Abs machine.

Figure 2. Strength is measured in a wheelchair bound subject during extension of the back muscles. In practice, the subject would bend 30 degrees forward and then try to straighten up. An isometric strain gage transducer was used to measure the strength.

gages. Each bar was positioned at a 90° angle with reference to the other bars. Strain gauges were placed at 0°, 90°, 180°, and 270° angles. With the wheelchair placed in the center of the platform, leaning in any direction was then transduced through strain gauges mounted on the metal bars to an electrical output so that the deviation and center of gravity could be assessed (Figure 3). The output of the strain gages was connected to four strain gauge amplifiers (Biopac Incorporated, Santa Barbara, Calif) and digitized with a sixteen-bit A/D converter (Biopac Incorporated, Santa Barbara, Calif). The digitized data was then sorted on an IBM computer for later analysis. A full description of the device is given later.[24]

Figure 3. A subject in a wheelchair on the balance platform with eyes closed to measure seating stability.

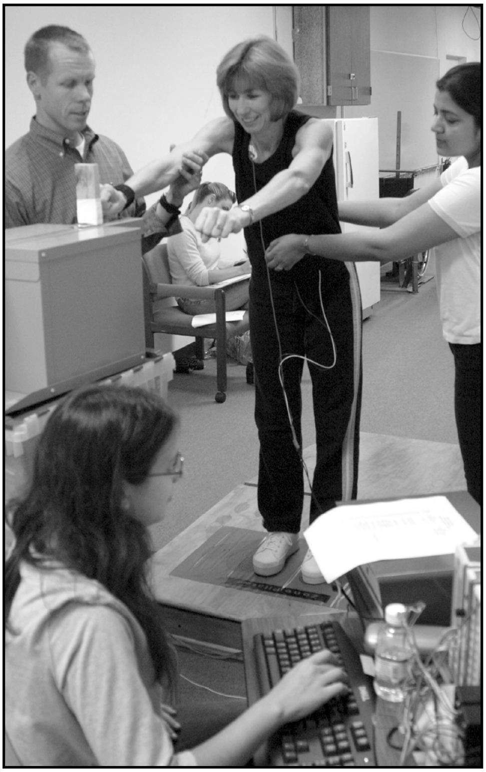

Figure 4. A subject with MS standing on the balance platform reaching forward to measure the limits of stability in a forward direction.

Figure 5. A subject with a spinal cord injury in a wheelchair leaning to the right side at minimal reach to measure stability.

Procedures

The subjects exercised 3 days per week for 4 weeks. On any exercise day, a total of 20 minutes of exercise was accomplished. For each muscle group that was exercised, 4 different exercises were used; the load in the abdominal exerciser was adjusted to fatigue the muscles in 5 minutes. Exercise was accomplished with 3 seconds of flexion and 3 seconds of slow relaxation. If, on any one day, 5 minutes of exercise was accomplished in any one exercise position, the workload was increased by 5 pounds, so that on the next day, they fatigued within the 5-minute period. In this manner, then, over 30 days, the workload was progressively increased. Four different 5-minute bouts of exercise were accomplished each day. In the first bout, the subject sat in the wheelchair facing forward to exercise the rectus abdominus muscles. To exercise the external and internal oblique muscles, two other bouts of exercise were accomplished with the subject facing 45° to the left and 45° to the right. Muscle use was verified by electromyogram studies as described previously.[22,23] Finally, an additional 5 minutes of work was done extending the back muscles. The 6 Second Abs machine was placed under the arms and the torso was positioned at 30 degrees of flexion. By extending the back, the torso was brought to the neutral position against the load of the 6 Second Abs machine.

Pre and Post Testing

Before and after the 4-week exercise period, functional reach, tremor, and muscle strength was recorded. As stated above, muscle strength was measured for the lower back and abdominal muscles. After strength was measured, a modified FRT was used.[25] Each subject either sat in their wheelchair or stood in the middle of the balance platform. Subjects remained as motionless as they could with their eyes closed and the direction and angle of any movements from the center of gravity was determined. Next, the subjects reached forward (Figure 4), left and right (Figure 5) as far as possible without losing their

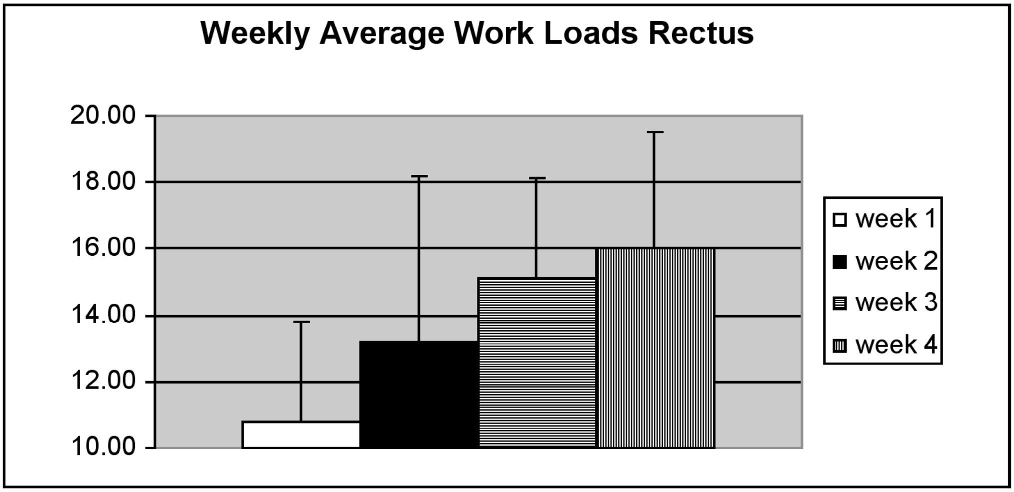

Figure 6. The increase in load in the AB machine each week for exercise of the rectus abdominus muscles. Each bar is the mean of the group (± the appropriate standard deviations).

balance. Subjects held this position for approximately 10 seconds and the movement at the center of gravity (COG) off of the base of support (BOS) was determined. Subjects then repeated this movement, at minimal reach (that is the arm extended but the back unbent), at maximum reach without losing balance, and at half the distance between the minimal and maximum reach. Tremor was assessed by acceleration at the wrist. The ability to displace the COG of their body away from their BOS was determined in the forward, left, and right directions to see if they improved after the one-month core strengthening program.

RESULTS

In a one-month period, the average increase in workload was similar for the rectus abdominus, right and left oblique, and back extensor muscle exercises. For example, Figure 6 shows the average increase in the workload for exercises of the rectus abdominus muscles. The initial workload started at less than 9 kg on the first day of the first week. However, it gradually increased and the weekly average for the first week was 10.8 ± 4.11 kg. For the fourth week, the average load was 16.0 ± 7.6 kg. The range of workload was large. In some subjects the final workload was 9 kg, while in other subjects the workload increased to over 31 kg. For example, in one subject with MS, the work in the first week was 9 kg, and in the third week was 15.1 kg, whereas the average workload in the last week was 31.19 kg. Thus, individuals had either a smaller or a larger increase in workload depending on their motivational level and the ability of muscles to train due to their paralysis. The same pattern was seen for the oblique muscles. For the right oblique, the average workload increased from 11.9 ± 4.3 kg to 15.72 ± 7.1 kg in the last week. The left oblique muscle exercises workloads increased from 11.9 ± 4.4 kg to 15.7 ± 7 kg in the last week. For the back extension exercise, workloads generally started higher at the beginning of the one-month exercise period with loads set at 18.0 ± 15 kg and increased to 23.0 ± 13 kg in the final week.

Overall compliance for accomplishing the exercise for the group was 97.8% ± 5.4%. Compliance was calculated by dividing the actual number of days subjects exercised in the month by the total number of days that participants were

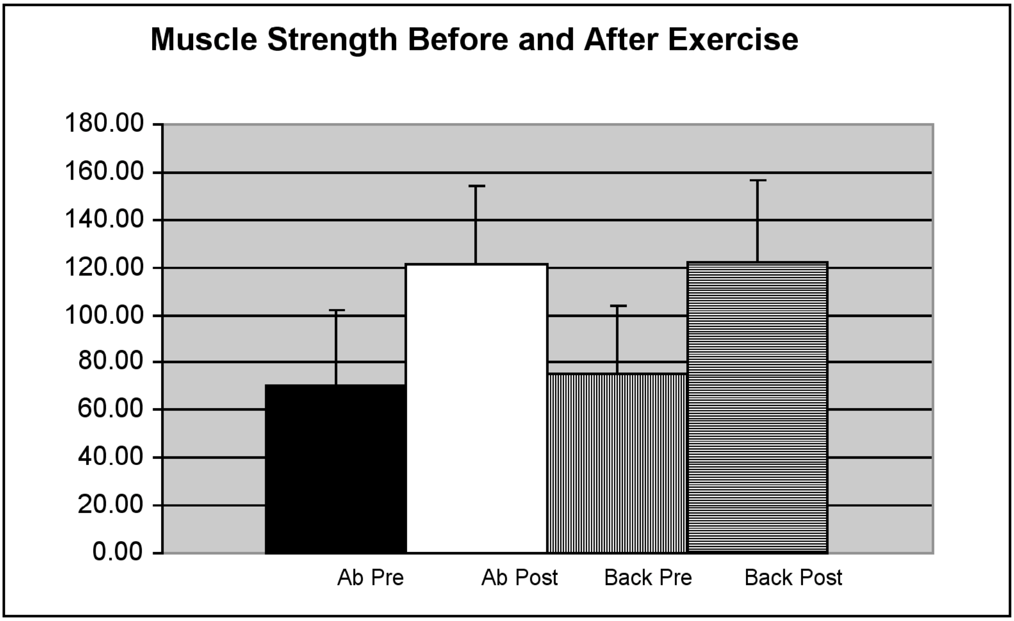

Figure 7. The strength of the abdominal and back extensor muscles during testing before (pre) and after (post) of a one-month exercise program using the 6 Second Abs machine. The mean response of the entire group (± the appropriate standard deviation) is shown.

told to exercise. However, since subjects had severe disabilities and limited muscle function, workloads for many subjects could only be increased marginally throughout the exercise period, but all subjects did increase their workload. More importantly, the large standard deviation seen in these experiments is simply due to the fact that subjects with greater paralysis simply could not exercise at a greater workload.

The results of the measurements of muscle strength for the abdominal and paraspinal muscles are shown in Figure 6. The average strength of the abdominal muscles increased from 70.46 ± 32.54 lbs (31.96 ± 14.76 kg) before the exercise program to an average of 121.08 ± 33.62 lbs (54.92 ± 15.25 kg) after the one-month program. This corresponded to a 72% increase in muscle strength. The increase was significant ($P < 0.01$). In the back muscles, strength increased from 75.62 ± 28.42 lbs (34.32 ± 12.89 kg) to 122.54 ± 34.90 lbs (55.58 ± 15.83 kg) after the exercise program, an increase of 62%. This increase was also significant ($P < 0.01$).

A corresponding increase in the FRT was associated with this increase in muscle strength, as shown in Figure 7. Figure 8 shows the results of the FRT before and after the one-month training program in the forward, right side, and left side directions. Functional reach in the forward direction increased from 22.3 inches (56.6 cm) to 28.4 inches (72.1 cm), an increase of 23.9%. Reach to the right increased from 15.5 inches (38.2 cm) to 29.4 inches (74.8cm), an increase of 91% and, reach in the left direction increased from 15.4 inches (39.1 cm) to 23.2 inches (58.8 cm) and increase of 50.4%. These increases in reach were all statistically significant ($P < 0.01$) when comparing pre- to post-conditioning data. There was no consistent difference in the gain in reach or strength in any of the three subgroups of people with disabilities examined here ($P > 0.05$).

FRT data in the disabled group is compared to that of the control subjects

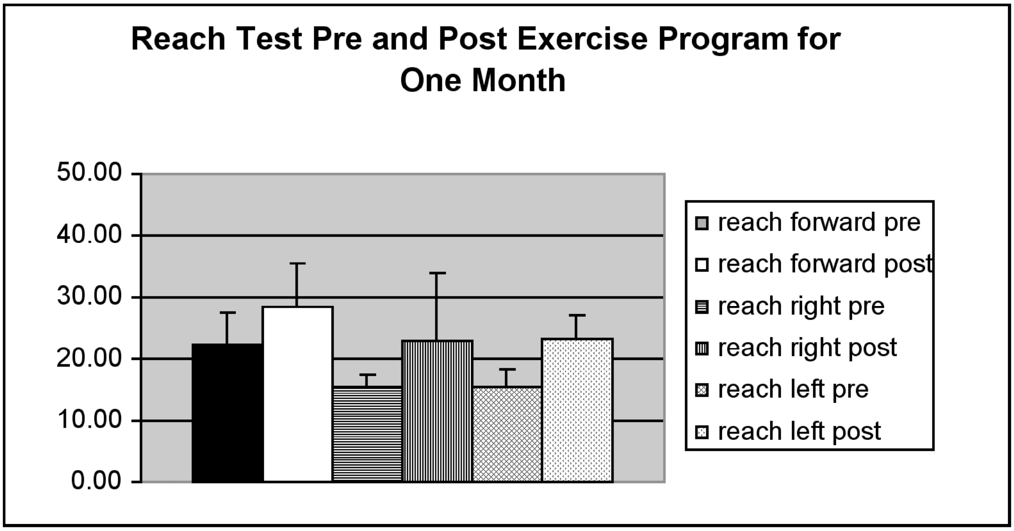

Figure 8. The reach distance from the neutral position to the furthest reach in inches for reaching in the forward direction and to the right and left before (pre) and after (post) of one-month exercise program. Each point is shown with the appropriate standard deviation representing the mean for the entire group.

in Figure 8. The forward reach for the subjects with disabilities averaged 22.3 inches (56.6 cm) compared to the controls in a seated position who had an average forward reach of 37.9 inches (96.1 cm). For the right reach, subjects with disabilities had a reach of 15.5 inches (39.4 cm), whereas control subjects had a reach of 37.9 inches (96.1 cm). The differences for the right and left reach, and forward reach between control subjects and subjects with disabilities were significant ($P < 0.01$).

After the one-month exercise program, the functional reach had increased to 28.4 (forward), 22.9 (right), and 23.2 inches (left). In subjects with disabilities, there was still a statistical difference in the forward reach and left reach, when compared to control subjects ($P < 0.05$) (Figure 9).

The results of the determination of balance and movement of the COG and limits of stability (LOS) are shown in Tables 2, 3, and 4. Table 2 shows the data for control subjects. Table 3 shows data for the subjects before the one-month exercise program and Table 4 shows the data after the one-month exercise program. The data for reaching in the forward direction, to the right, and to the left and includes the magnitude of the shift in the COG while lifting the arm in that direction (minimal reach, maximum reach, and a point halfway between the two) is shown in Tables 1, 2, and 3. The standard deviations are for the change in COG. Whereas the standard deviation shows a measure of variation within the group, the average peak-to-peak variation in the COG during that maneuver is also shown. Peak-to-peak is useful in that it shows tremor or wobble during sitting or extension of the arms. If the arm is held steady, then there is very little variation in the COG on the platform, on the other hand if the subject moves a great deal, there would be a large peak-to-peak variation in the COG. These tables also show the direction of the angle of movement and the standard deviation of the angle of movement of the subject on the platform. Finally, the LOS in degrees was also calculated for the movement of the body away from neutral.

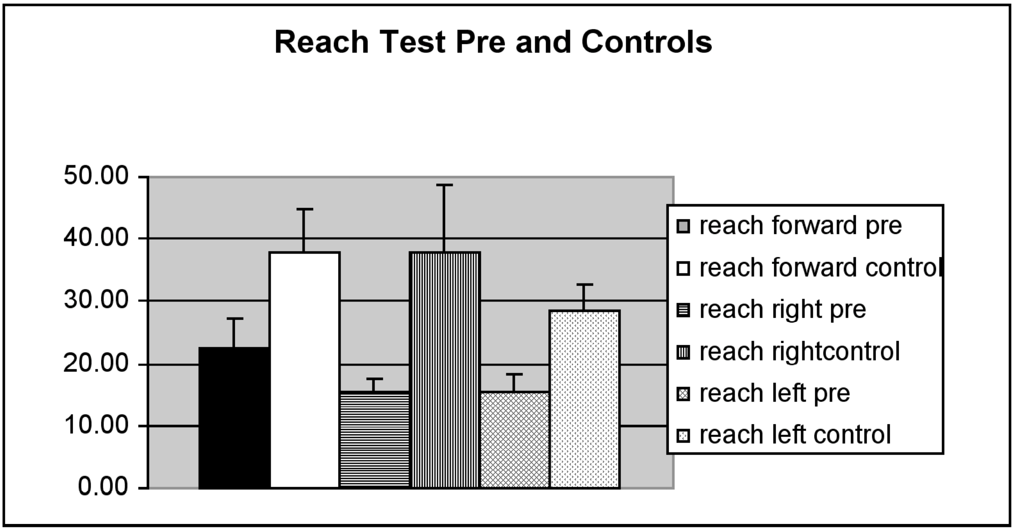

Figure 9. Results of the functional reach testing the forward direction and to the right and left side while sitting in a wheelchair in the subjects with disabilities before engaging in the one month exercise program (PRE) compared to control subjects doing a similar test. Each bar represents the mean response of the appropriate group (± the standard deviating of the group).

For the control subjects, the average shift in the COG for maximum reach was approximately 30 kg. For example, movement in the front direction for minimal reach, which required simply extending the arm forward without bending the trunk, the shift in the COG averaged 8.9 kg. There was an increase of 18.3 kg for mid reach, and 29.7 kg for the furthest extended reach. During either minimal or maximal reach, the standard deviation of the COG was small, averaging only 4.7 kg for minimal reach and 7.5 kg for maximal reach. This is reflected in peak-to-peak movement. The average tremor or variation in the COG was 0.9 kg peak-to-peak for minimal reach and 2.2 kg for maximal reach. The calculated angular LOS showed that the furthest extent that the subjects could reach without losing their balance was a 23.5° shift in the angle of the body in the front reach direction compared to 22.1° for the right reach and 19.5° for the left reach. The angular LOS in the three positions was statistically different from each other ($P > 0.05$).

The average data for the subjects with disabilities is shown in Table 3. There was a significant difference between this group and the control group of subjects. For example, looking at the shift in the COG during minimal, mid, and maximal reaches, subjects with disabilities could not reach as far as shown above for control subjects and they could not shift their COG as well as the control subjects. For example, looking at maximum reach, the shift in the COG was 16.8 ± 7.5 (front reach), 14.4 ± 4.9 (right reach), and 15.0 ± 10.2 kg (left reach) in the subjects with disabilities (Table 3); whereas the shift in the COG was 29.7 ± 7.5 (front reach), 33.6 ± 9.1 (right reach), and 33.3 ± 8.9 kg (left reach) in the control subjects (Table 2). The differences for each direction were statistically significant ($P < 0.01$). Even at less reach, the peak-to-peak variation in the COG was much higher in subjects with disabilities. For the control subjects, the front reach at maximal excursion peak-to-peak variation was 2.2 kg compared to 4.2 kg for subjects with disabilities. For control subjects, this amounted to a variation of

Table 2. Data for Control Subjects*

		Center of Gravity (kg)	SD Center` of Gravity	Peak-to-peak	Angle of Movement (degrees)	SD angle of Movement	Limits of Stability (degrees)
Front							
	min	8.9	4.7	0.9	15.3	33.4	7.2
	mid	18.3	7.2	1.4	-37.2	23.6	13.6
	max	29.7	7.5	2.2	18	21.6	23.5
Right							
	min	6.6	3.6	0.7	-42	18.4	3.8
	mid	18.6	5.4	1.3	-11.7	21.8	13.2
	max	33.6	9.1	1.9	4.9	9.9	22.1
Left							
	min	6.1	3.2	0.7	15.2	14.9	4.2
	mid	16.7	5.5	1.3	-10.4	17.2	14.1
	max	33.3	8.9	1.8	3.9	21.3	19.5

*Displacement of the center of gravity (vector and angle), variation of the force vector over a 4 second period (SD vector and peak-to-peak excursion) and the variance in vector angle (SD of the angle), and Limits of Stability (LOS) during reach in the group of control subjects. Min indicates minimal reach; Max, maximum reach; Mid, a point halfway between the two; and SD, standard deviation.

Table 3. Data for Subjects with Disabilities Before the One-month Exercise Program*

		Center of Gravity (kg)	SD Center of Gravity	Peak-to-Peak	Angle of Movement (degrees)	SD angle of Movement	Limits of Stability (degrees)
Front							
	min	4.8	2.3	2.6	33.0	24.5	3.8
	mid	9.8	5.7	3.1	14.0	57.2	7.4
	max	16.8	7.5	4.2	17.7	53.7	12.9
Right							
	min	4.5	1.7	2.8	33.9	28.4	3.5
	mid	12.0	7.9	3.6	-0.5	38.9	8.6
	max	14.4	4.9	4.1	-2.5	56.8	10.3
Left							
	min	3.9	1.4	2.1	28.6	46.1	3.1
	mid	9.3	5.0	3.0	17.1	43.3	7.1
	max	15.0	10.2	4.0	8.1	52.8	11.2

*Displacement of the center of gravity (vector and angle), variation of the force vector over a 4 second period (SD vector and peak-to-peak excursion) and the variance in vector angle (SD of the angle), displacement of the center of gravity and Limits of Stability (LOS) during reach in the group of disabled subjects before 1 month of exercise. Min indicates minimal reach; Max, maximum reach; and Mid, a point halfway between the two.

plus or minus 7.74% at maximum reach. However, since their maximum reach was twice the distance of the control subjects, the more correct comparison would be to compare the mid reach data where the reach distances are the same. The mid reach data, peak-to-peak variation was 1.4 kg against a movement of

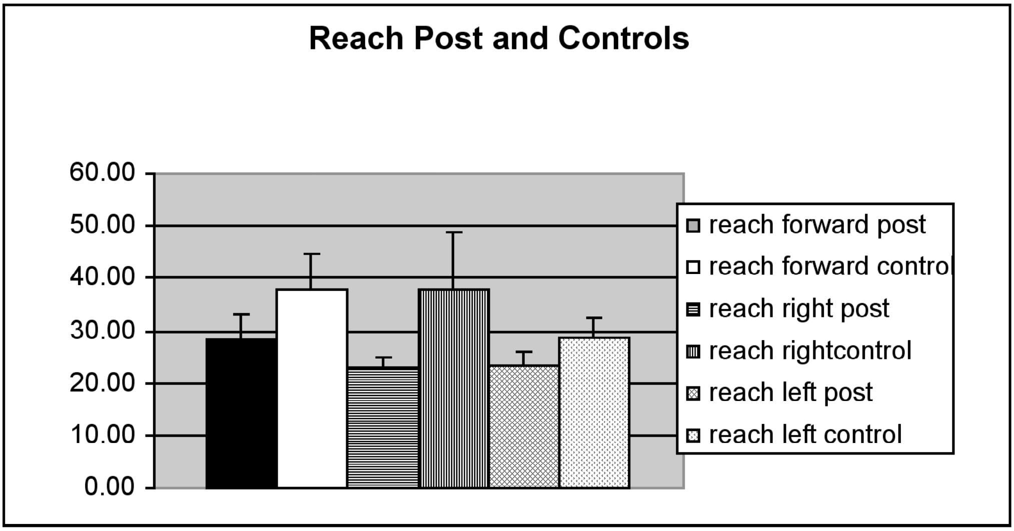

Figure 10. The results of the functional reach test in the forward right and left directions while sitting in a wheelchair in subjects with disability after a one month exercise program (post) compared to control subjects. Each point is the mean response of the appropriate group (± the standard deviation).

18.3 kg or 7.6%. For the subjects with disabilities, as shown in Table 3, a maximum reach (the same reach distance as mid reach on the control subjects), the variation was 4.2 kg during peak-to-peak movement or against the total shift of 16.8 kg, 25% of the shift in weight. In other words, the subjects with disabilities had approximately four times the tremor in holding their hand at maximum reach or even at mid reach than was seen for the control subjects.

Not only were the tremor, reach, and shift in COG less in subjects with disabilities, the LOS angle was also less. The control subjects were able to shift their COG by an angle of 23.5°, 22.1°, and 19.5° for front, right, and left reaches, respectively. In contrast, for maximum reaches for the subjects with disabilities, the average change in body angle was 12.9° (front), 10.3° (right), and 11.2° (left).

However, after the one-month exercise program, as cited above, functional reach increased significantly (Figure 10). Associated with this increase in functional reach was an increase in the abilities of their bodies to shift their COG without losing balance. For example, for the following reaches the shift in the COG was 26.4 ± 6.3 kg (front), 26.6 ± 9.6 kg (right), and 25.3 ± 8.6 kg (left) (Table 4). These shifts in the COG were statistically greater than seen in the same subjects (related *t* test) before the one-month of exercise ($P < 0.01$). Tremor was also reduced. For example, looking at the furthest extent of the reach for front reach, the peak-to-peak variation was 3.1 kg. With the shift of 26.4 kg of body weight, this amounted to an 11.7% variation in COG during the reach. Thus, tremor was reduced by 50%. However, the furthest reach was substantially longer, away from the central core of the body, after training than before training. The correct comparison would be comparing mid reach where the variation was only 2.1 kg in a forward direction. Here, the variation was only 12%. Thus, tremor was reduced by over half, even though reach increased by almost double after core training. These differences were significant ($P < 0.01$).

Table 4. Data for Subjects with Disabilities After the One-month Exercise Program*

		Center of Gravity (kg)	SD Center of Gravity	Peak-to-Peak	Angle of Movement (degrees)	SD angle of Movement	Limits of Stability (degrees)
Front							
	min	8.3	6.1	1.6	19.6	71.2	6.3
	mid	16.3	6.4	2.1	-29.1	78.5	10.2
	max	26.4	6.3	3.1	15.9	80.9	20.4
Right							
	min	7.1	4.2	1.3	-36.5	65.1	4.3
	mid	15.1	6.2	2.9	-8.5	21.6	10.5
	max	26.6	9.6	3.2	3.1	11.3	19.7
Left							
	min	4.2	4.0	1.3	19.3	61.7	3.2
	mid	14.3	6.2	2.1	-12.3	14.6	9.8
	max	25.3	8.6	3.0	-2.0	14.7	18.3

*Displacement of the center of gravity (vector and angle), variation of the force vector over a 4 second period (SD vector and peak-to-peak excursion) and the variance in vector angle (angle of the SD), and Limits of Stability (LOS) during reach in the group of disabled subjects after 1 month of exercise. Min indicates minimal reach; Max, maximum reach; Mid, a point halfway between the two; and SD, standard deviation.

Finally, with regard to the angle at the LOS, the maximum angular movement before the subjects lost their balance also significantly improved ($P < 0.01$) after training. For example, looking at the maximum reach in the forward direction, the maximum angle that the subjects could lean before losing their balance went from 12.9° to 17.9°. Whereas the LOS angle for either front, right, or left reach was still significantly less than control subjects ($P < 0.05$), this was still a significant improvement in the reach of the subjects.

DISCUSSION

There are many benefits of daily exercise. These include reducing LDL cholesterol, increasing oxidation of lipids, and increasing overall aerobic capacity.[1-3,5] Further, the overall benefit of exercise on building strength and endurance is well established.[10] But for people with disabilities there may be the added advantage of strengthening core muscles. Theoretically at least, this should increase functional ability by allowing individuals to move the COG away from their BOS without falling[19,20] The core muscles (the erector spinae, transverse abdominus, and rectus abdominus muscles) stabilize the upper body. Increased reach (movement of the COG away from the BOS) translates into more functional independence.[17] Therefore, the practical role of rehabilitation, increasing functional independence, could be accomplished with a good strengthening program for the core muscles. However, because of the inaccessibility of most health clubs, individuals who are disabled generally prefer to exercise at home.[21] One recent option, a device called the 6 Second Abs machine, provides a progressive increase in resistance to exercise the abdominal muscles and could be used quite practically from a wheelchair.[22] These devices are commonly marketed in most sports stores in the United States, but up until this point, have not been tested on people with disabilities. While it is easy to establish a training program using a machine such as the 6 Second Abs machine, it is more difficult to evaluate changes in the ability to reach. In a recent publication, Nichols[26] divided balance into three aspects, steadiness, symmetry, and dynamic stability. The neurological mechanism causing the loss of balance can be complex involving the vestibular system, visual cues, and loss of sensory and motor pathways.[27,28] For motor disabilities, the usual deficit is the strength of the core muscles. Evaluating the ability to balance, especially while sitting in a wheelchair is conventionally accomplished with a test called the FRT. Duncan and colleagues[25] published the FRT for people in wheelchairs. Duncan presented evidence that the FRT was a highly reliable tool for measuring dynamic balance. But while the FRT showed a good correlation to forward-back movement, it did not correlate as well for assessing side-to-side movement.[29] This is a problem especially because individuals usually fall when reaching to the side.[29] Newton[29] modified the FRT into two different planes and found a high correlation to multidirectional experience with falls. But Jonsson[30] found a low correlation between reach distance and the actual displacement to the COG of the body. And therefore, Jonsson[30] suggested measuring the actual displacement of the COG and not just the actual reach, since reach can be accomplished by a number of different strategies involving shifting of the body frame. In the present investigation, therefore, the FRT was modified to measure not only the reach, but also the actual displacement of the COG of the body, measuring the angle, magnitude, and error in maintaining stability on the balance platform. In the present investigation, there was a significant improvement after 30 days of exercise in the ability to reach. Both the distance that could be reached in the forward and side-to-side directions and the ability to move the COG away from the BOS improved. Further, the tremor or error in controlling movement even at the furthest reach was dramatically improved after core strengthening with the 6 Second Abs machine.

It is important to distinguish the use of the LOS test and the LOS. Often, the LOS test has been used to assess balance. However, functional reach measures performance irrespective of angle. A recent paper has stated that the LOS test in some cases does not correlate well with the FRT.[31] In this study, there was a good correlation. This may be due to the fact that sitting in a wheelchair limits the strategy that can be used to reach. While standing, movement can be achieved at the hips, knees, ankles or shoulders to achieve a strategy for a given reach. Therefore, good reach can be achieved with or without the same shift in LOS angle depending on how the reach was achieved. Sitting in a wheelchair, the strategies are much more limited and therefore, the two tests correlated well. Further, from the perspective of a therapist, the FRT dictates how independent someone can be. How they get there (eg, shifting their body weight) is inconsequential. Therapy is therefore outcome driven and not driven by academic measurements of how someone is able to move. As such, the FRT becomes more important than the balance analysis.

For individuals with disabilities, there was better reach with less tremor and less motor error after strengthening the core muscles. Often, in rehabilitation, the cost outweighs the benefits. Here, however, with the low cost of a machine such as the 6 Second Abs machine (less than $75 US), exercise was performed safely and efficiently at home to increase independence in activities of daily living with nominal expense.

Anecdotally, patients have remarked that they have “never felt so stable in a wheelchair” and they “are able to accomplish more at home" than before exercising with the 6 Second Abs machine. The improvement in reach after only 30 days of exercise to near the reach of the control subjects, and the reduction in tremor seen here is highly significant for any type of exercise. Perhaps there is no type of exercise that can bring the group with disabilities to the performance level of the control group sitting in wheelchairs, but the present exercise regime was remarkably effective toward the benchmark reach and tremor of the controls.

In the present investigation, our goals were realized in that subjects increased their activities of daily living and functional independence with a simple home-exercise strengthening program.

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