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[Original Research Articles]

Exercise Adherence During Home-Based Functional Electrical Stimulation Cycling by Individuals with Spinal Cord Injury

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Outline

ABSTRACT

Objective: The typically sedentary spinal cord injured population has limited physical activity options because of muscle paralysis, difficulties in transportation, and barriers to access rehabilitation/wellness facilities. It is important to investigate physical activity alternatives to increase physical activity levels and decrease the risk of inactivity-derived diseases. The goal of this study was to determine the effects of a home-based functional electrical stimulation cycling program on exercise adherence of those with spinal cord injury.

Design: Seventeen Veterans with posttraumatic C4-T11 American Spinal Injury Association Impairment Scale A-C spinal cord injury participated in two 8-wk exercise periods of home-based functional electrical stimulation lower extremity cycling. Exercise adherence and the effects of six factors thought to influence exercise adherence were studied during both exercise periods.

: Exercise adherence rates for exercise periods 1 and 2 were 71.7% and 62.9%, respectively. Age, history of exercise, and pain not associated with the exercise activity were determined to have significant impact on exercise adherence rates.

: Exercise adherence rates were well above the reported 35% in the able-bodied population, which provides evidence for the feasibility of a home-based functional electrical stimulation lower extremity cycling program. Younger adults with a history of being physically active have the highest potential for exercise adherence.

On September 19, 2011, the United Nations General Assembly unanimously approved and launched an effort to vigorously promote physical activity in an effort to decrease the prevalence of noncommunicable diseases and enhance the length and quality-of-life of all people. The United Nations action recognized that sedentary lifestyles and the resulting noncommunicable diseases represent a catastrophic threat to global health and that physical activity is of fundamental importance to global health and wellness.1

One group considered at particular risk for inactivity and development of related noncommunicable disease is those with spinal cord injury (SCI). SCI limits the capability to perform regular physical activity because of physical limitations resulting from paralysis and environmental barriers inhibiting access to exercise areas and equipment. It is well accepted among healthcare professionals and now diplomats worldwide that regular physical activity is a cornerstone of physical and psychologic well-being. However, the Centers for Disease Control and Prevention reports that the percentage of able-bodied (AB) adults 18 yrs or older who engage in regular leisure-time physical activity is 35%, whereas 33% engage in no leisure-time physical activity at all.2 More specifically, only 35.6% of AB adults perform 150 mins of physical activity per
week.3,4 Physical activity rates tend to decrease with age, as demonstrated by only 31% of AB older adults reportedly participating in 20 mins of moderate physical activity three or more times per week. Whereas the physical activity rates of AB adults are sorely lacking, the activity levels of those with SCI are reported to be 60% less that those in the AB population, placing them among the world's most sedentary.5

Reflecting the declaration set forth by the United Nations concerning sedentarism leading to noncommunicable diseases (obesity, metabolic syndrome, diabetes, and
osteoporosis) are currently considered epidemic in the SCI population.6 Furthermore, as the life-span of those with SCI's near those without SCI, lifestyle derived cardiovascular diseases have emerged as a leading cause of
death.6,7 While advancing physically active lifestyles is a large undertaking for the AB population, the challenge is dramatically greater for those with SCI.

One method of exercise that has shown success in the advancement of physical rehabilitation of those with SCI is functional electrical stimulation (FES).
Previous reports have shown that FES significantly impacts several health variables after SCI, such as lean mass, percentage body fat, and metabolic
profiles.8,9 Gorgey et al.10 found that 12 wks of electrical stimulation to evoke leg extension resistance training resulted in muscle hypertrophy, reduction in visceral adipose tissue, and improvement in metabolic profile in people with SCI. However, applications of FES cycling had been limited largely to

clinics and research laboratories, which limited its effectiveness as a rehabilitation intervention to promote physical activity and continuity of care after SCI. Considering difficulties in transportation, barriers to access rehabilitation/wellness facilities, and the limited number of sessions covered by health insurances, the goal of this study was to determine the effects of an innovative Internet connected home-based FES cycling program on exercise adherence of those with SCI.

METHODS

Subjects

Seventeen Veterans (15 men, 2 women) with posttraumatic C4-T11 American Spinal Injury Association Impairment Scale A-C SCI participated in the current study.
Veterans were all nonambulatory and wheelchair reliant and at least 6 mos postinjury. Inclusion criteria included being a Veteran with SCI, 18 to 70 yrs of age, and having the ability to respond with muscular contractions to electrical stimulation of paralyzed muscles. Exclusion criteria included uncontrolled hypertension, uncontrolled coronary artery disease, uncontrolled autonomic dysreflexia, uncontrolled pain, fragility bone fracture, pressure ulcers greater than grade II, deep venous thrombosis within the past 3 mos, pregnancy, and any physical limitation that would preclude the ability to perform the FES low extremity cycling (FES-LEC) activity. The mean age of the participants was 45.8 +/- 13.78 yrs, with a range from 22 to 64 yrs. The average time since injury (TSI) was 12 +/- 13.26 yrs, with a range from 0.5 to 39 yrs (Table 1).

All participants reviewed and signed a written VA Human Subjects Research Consent form. This study was approved by the institutional review board of the McGuire VA Medical Center, and all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed.
Research was conducted in accordance with the Declaration of the World Medical Association.

Functional Electrical Stimulation Low Extremity Cycling

FES-LEC is a rehabilitation activity where electrical current stimulates nerves to evoke muscle contractions in a sequential pattern that enables paralyzed muscles to perform a cycling activity. During this study, an RT300 FES-LE cycle (Restorative Therapies Inc, Baltimore, MD) was placed in each participant's home. Because of the cost of the cycles and the historically low exercise rates of those with SCI, the FES cycles were initially rented with the possibility of the Veterans Affairs Medical System purchasing the FES cycles for long-term use by the Veterans if exercise adherence was near the recommended rate of three times weekly over the initial 8 wks. Exercise adherence rates were then reviewed for an additional 8 wks. Because the exercise adherence during the initial 8 wks of exercise was used to determine whether the FES cycles will be purchased for long-term use, there is the possibility that this would bias the results. Thus, an additional 8 wks was reviewed to see whether there would be a disparity in exercise adherence between the two 8-wk periods since the added incentive of purchase of the cycle was removed for the second 8-wk period.

The RT300 FES-LEC electrically stimulates the quadriceps, hamstrings, and gluteal muscles through wires connected to surface electrodes. The RT300 has Internet connectivity that allows clinicians to follow results and make alterations to the exercise and cycle parameters remotely. Once a session is completed, the performance data including time, distance, power, and energy expenditure and the session parameters such as current amplitude, pulse width, current frequency, cycling speed, and

resistance are displayed and stored. The Internet connectivity allows for the optimization of training and safety. The
RT300 also allows the participant to cycle from his/her own wheelchair, eliminating the need to transfer onto the cycle.

FES-LEC Training

Before starting home-based FES-LEC, participants were screened and cleared for participation by their physicians. The participants also underwent at least one FES-LEC session in the McGuire VA Medical Center SCI exercise laboratory so that heart rate, blood pressure, and possible autonomic dysreflexia symptoms could be monitored. After successful completion of the laboratory trial, they were cleared to begin home-based FES-LEC. All participants were asked to participate in three cycling sessions per week with at least 1 day of noncycling between sessions. Participants were notified that if participation was close to the requested three sessions per week for the first 8 wks, the cycle would be purchased for their continued long-term home use. Sessions were monitored by the research staff via Internet connection. Cycle parameters were individualized depending on the amount of current needed to perform the cycling activity and depending on the comfort of the participants. Cycling parameters ranged among participants as follows: current amplitude, 70 to 140 mA; pulse width, 250 to 400 [micro]sec; and frequency, 33 Hz. Speed was advanced between 30 and 50 rpm, with an initial resistance of 0.5 Nm. The resistance was set on automatic so that the RT300 cycle would vary the resistance to allow the set speed. For example, if the speed was set at 40 rpm and the resistance was at 1.0 Nm, if the participant could not sustain the set speed at that resistance, the cycling system would automatically decrease the resistance to allow the participant to maintain the selected speed. Cycling duration was increased over the 16-wk period until a goal of between 40 and 60 mins of continuous active FES cycling was attained. Participant and participant helpers were provided training concerning the placement of electrodes and the FES-LEC procedures.

Conductive adhesive gel electrodes were used to evoke skeletal muscle stimulation.
Electrodes were placed on the skin of the following corresponding skeletal muscle groups. Quadriceps: one electrode was placed on the skin 2 to 3 cm above the superior aspect of the patella over the vastus medialis muscle, and the other lateral to and 30 cm above the patella over the vastus lateralis muscle. Hamstrings: one electrode was placed 2 to 3 cm above the popliteal fossa and the other electrode 30 cm above the popliteal fossa. Gluteus maximus: two electrodes were placed parallel and on the bulk of the muscle belly of each buttock with 3 to 4 cm between electrodes.

Exercise Adherence

The 16 wks of home-based FES-LEC was divided into two 8-wk exercise periods because the exercise rate during the first 8 wks of cycling was used to determine whether the rented cycles would be purchased for long-term use. It was felt that this knowledge may cause the participants to have a greater incentive to exercise during the first 8 wks relative to the second 8 wks. During the second 8 wks of FES-LEC, there were no additional incentives to maintain exercise adherence other than the benefits of the exercise itself. Exercise adherence was measured as the percentage of the recommended sessions (24 total
sessions) completed over the 8 wks of initial cycling. For example, if a participant completed 12 of the recommended 24 sessions over 8 wks, the exercise adherence was considered to be 50%. This same calculation was then repeated for the following 8 wks. Participants were encouraged to maintain cycling three times per week over the entire 16 wks.

Subgroups/Factors

There were six subgroups or factors (age, history of exercise, level of injury, TSI, history of depression, and pain) that the authors identified as possible influences on exercise adherence. Age was divided into younger than 50 yrs and
50 yrs or older, whereas history of exercise was divided into active and inactive categories as determined by participants' self-professed history of exercise using an adapted version of the Brief Physical Activity Tool.11 Participants were asked how many days per week and how many minutes per session they exercised before injury. Exercising 50 mins or more for 3 days or more per week was considered active, whereas less than this was considered inactive.
Level of injury was divided into those with tetraplegia and those with paraplegia; TSI was divided into three categories (10 yrs), and history of depression was determined as those participants who had a diagnosis of depression documented in their medical record. The sixth category, self-professed pain, was determined by using a question from a simple pain questionnaire asking how many days per week the participant feels pain (daily, weekly, monthly). A response of weekly or more frequently was considered as having recurrent pain, and less than weekly was considered not having recurrent pain. Pain was non-FES-LEC related, as pain during FES-LEC was contraindicated for inclusion into the study. Thus, it is important to recognize that no participants experienced pain due to the FES-LEC activity.

Data Analysis

Generalized linear mixed effects models were used to model the adherence rates for each 8-wk exercise period (periods 1 and 2). This model was chosen because the outcome variable was a proportion (number of occasions out of 24) and there were repeated measures because each participant was measured after each period.
The initial model included a fixed effect for each period. Using this model, the adherence rates for each exercise period were determined. Furthermore, the change in adherence between periods was tested and quantified using an odds ratio, expressing how many times greater the odds of adherence were for period 1 vs. period 2. "Odds" was defined as the probability of adherence divided by probability of no adherence.

The subsequent models included fixed effects for period, the covariate of interest, and the period by covariate interaction. Using this model, the effect of the covariate on adherence rates at each period was tested and quantified with odds ratios. This included an expression of how many times greater the odds of adherence were during the given exercise period for one subgroup vs. another subgroup. Furthermore, the effect of time on adherence rates for each subgroup was tested and quantified with odds ratios, expressing how many times greater the odds of adherence were for each subgroup during period 1 vs. period 2.
Finally, the interaction between time and the covariate of interest was examined to see whether the effect of time on adherence differs between the covariate subgroups.

RESULTS

There were 17 participants in this study; 59% were 50 yrs or older, 58% had a history of active exercise, 65% had tetraplegia, 24% had a history of depression, and 71% reported recurrent pain. Furthermore, 35% had a TSI of less than 3 yrs; 18%, 3 to 10 yrs; and 47%, more than 10 yrs.

Adherence

The adherence rates for exercise periods 1 and 2 were determined to be 71.7% and 62.9%, respectively, without adjusting for any of the predictor variables. There was a nonsignificant decline in adherence rates from period 1 to period 2
($F_{1,3.4}$ = 1.91, P = 0.25). The adherence odds for the first exercise period were
1.46 times greater than the odds of adhering to the exercise program for the second period.

The effect of each of the subgroups was examined not controlling for any of the other predictor variables with the results as follows (Table 2).

Age

There was a significant age effect on adherence rates for exercise period 1 (t = 2.65, df = 14.97, P = 0.02) but not for exercise period 2 (t = 1.32, df = 9.24, P = 0.22). The odds of adhering to the exercise program were 4.86 and 2.04 times greater for younger participants vs. older participants for exercise period 1 and exercise period 2, respectively. There was not a significant time effect on adherence rates for younger (t = 2.19, df = 5.71, P = 0.07) or older (t = 0.14, df = 10.47, P = 0.89) participants. The odds of adhering to the exercise program were 2.56 and 1.07 times greater for exercise period 1 vs. exercise period 2 for younger and older participates, respectively. Finally, there was not a significant time-by-age interaction effect (t = 1.32, df = 8.40, P = 0.22). That is, the effect of age on adherence rates did not differ significantly between the periods (i.e., 4.86 [almost equal to] 2.04) and the effect of time on adherence rates did not differ significantly between younger and older participants (i.e., 2.56 [almost equal to] 1.07).

History of Exercise

There was a significant exercise history effect on adherence rates for exercise period 1 (t = 2.52, df = 14.93, P = 0.02) but not for exercise period 2 (t = 1.31, df = 6.18, P = 0.24). The odds of adhering to the exercise program were
4.59 and 2.23 times greater for those with an active history vs. inactive history for period 1 and period 2, respectively. There was not a significant time effect on adherence rates for those with an active history (t = 1.65, df = 4.02, P = 0.17) or those with an inactive history (t df = 6.78, P = 0.10), although there was a decrease seen for the active history group. The odds of adhering to the exercise program were 2.06 and 0.99 times greater for exercise period 1 vs. exercise period 2 for those with active and inactive exercise histories, respectively. Finally, there was not a significant time-by-exercise history interaction effect (t = 0.98, df = 5.65, P = 0.37); thus, the effect of exercise history on adherence rates did not differ significantly between the periods (i.e., 4.59 [almost equal to] 2.23) and the effect of time on adherence rates did not differ significantly between participants with active and inactive exercise histories (i.e., 2.06 [almost equal to] 1.00).

Level of Injury

There was not a significant injury level effect on adherence rates for exercise period 1 (t = 0.92, df= 14.96, P = 0.37) or for exercise period 2 (t = -0.07, df = 4.44, P = 0.95). The odds of adhering to the exercise program were nominally
1.77 and 0.95 times greater for tetraplegia vs. paraplegia at sessions 1 and 2, respectively. There was not a significant time effect on adherence rates for those with tetraplegia (t = 1.98, df = 2.74, P = 0.15) or

those with paraplegia (t = 0.02, df = 5.20, P = 0.99), although there was a nominal decrease seen for the tetraplegia group. The odds of adhering to the exercise program were 1.88 and 1.01 times greater for exercise period 1 vs. exercise period 2 for those with tetraplegia and paraplegia, respectively. Finally, there was not a significant time-by-injury level interaction effect (t = 0.93, df = 4.36, P = 0.40); that is, the effect of injury level on adherence rates did not differ significantly between the exercise periods (i.e., 1.77 [almost equal to] 0.95) and the effect of time on adherence rates did not differ significantly between participants with tetraplegia and paraplegia (i.e., 1.88 [almost equal to] 1.01).

Time Since Injury

There was not a significant TSI effect on adherence rates for exercise period 1 ($F_{2,13.76}$ = 0.54, P = 0.60) or for exercise period 2 ($F_{2,3.99}$ = 1.13, P = 0.41).
For exercise period 1, the odds of adhering to the exercise program were 2.45 times greater for less than 3 yrs since injury vs. 3 to 10 yrs since injury,
1.22 times greater for less than 3 yrs since injury vs. more than 10 yrs since injury, and 0.50 times greater for 3 to 10 yrs since injury vs. more than 10 yrs since injury. For exercise period 2, the odds of adhering to the exercise program were nominally 1.59 times greater for less than 3 yrs since injury vs. 3 to 10 yrs since injury, 0.46 times greater for less than 3 yrs since injury vs.
more than 10 yrs since injury, and 0.29 times greater for 3 to 10 yrs since injury vs. more than 10 yrs since injury. There was not a significant time effect on adherence rates for those less than 3 yrs since injury (t = 0.98, df = 2.72, P = 0.41), those 3 to 10 yrs since injury (t = 0.11, df = 4.12, P = 0.92), or those more than 10 yrs since injury (t = -0.66, df = 3.42, P = 0.55). The odds of adhering to the exercise program were 1.71, 1.11, and 0.65 times greater for exercise period 1 vs. exercise period 2 for those less than 3 yrs, 3 to 10 yrs, and more than 10 yrs since injury, respectively. Finally, there was not a significant time-by-TSI interaction effect ($F_{2,3.43}$ = 0.64, P = 0.58); that is, the effect of TSI on adherence rates did not differ significantly between the exercise periods (i.e., 2.45 [almost equal to] 1.59, 1.22 [almost equal to] 0.46, and 0.50 [almost equal to] 0.29) and the effect of time on adherence rates did not differ significantly between the TSI groups (i.e., 1.71 [almost equal to] 1.11 [almost equal to] 0.65).

History of Depression

There was not a significant depression history effect on adherence rates for exercise period 1 (t = 1.19, df = 14.98, P = 0.25) or for exercise period 2 (t = 0.43, df = 3.73, P = 0.69). The odds of adhering to the exercise program were nominally 2.21 and 1.34 times greater for participants with no depression history vs. those with a history of depression for exercise periods 1 and 2, respectively. There was not a significant time effect on adherence rates for those with no history of depression (t = 1.57, df = 3.27, P = 0.21) or those with a history of depression (t = 0.05, df = 3.83, P = 0.96), although there was a nominal decrease seen for the no depression history group. The odds of adhering to the exercise program were 1.70 and 1.03 times greater for period 1 vs. period 2 for those with no history of depression and those with a history of depression, respectively. Finally, there was not a significant time-by-depression history interaction effect (t = 0.75, df = 3.68, P = 0.50); that is, the effect of no depression history on adherence rates did not differ significantly between the exercise periods (i.e., 2.22 [almost equal to] 1.14) and the effect of time on adherence rates did not differ significantly between participants with no depression history and with a depression history (i.e., 1.70 [almost equal to] 1.03).

Pain

There was only one subject with a report of no pain who completed both exercise periods. Thus, the effect of pain on adherence rates for the second exercise period or on changes in adherence rates could not be examined. However, the effect of pain on adherence during the first exercise period could be examined.
There was a significant effect of pain on adherence rates for the first exercise period ($t = 3.22$, $df = 14$, $P = 0.01$). The odds of adhering to the program for the first exercise period were 2.22 times greater for those with reports of pain than those without.

Thus, according to the results of this study, age, exercise history, and non-FES-LEC-related pain significantly affected exercise adherence, whereas TSI, level of injury, and history of depression did not.

DISCUSSION

While regular physical exercise is essential for the health and wellness of all persons, it is even more crucial for those with SCI because of the accelerated atrophy of body tissues such as muscle and bone caused by paralysis. When you consider the constraints concerning available physical activities caused by physical limitations and environmental barriers, the importance of developing innovative barrier-free exercise options is recognized. The advent of FES cycles with Internet connectivity to allow healthcare professionals to monitor exercise sessions from a distance is one innovative approach. However, the risk of poor exercise adherence among those with SCI after the acquisition of expensive specialized equipment remains a pediment to the decision to purchase an FES cycle for home use. This study provides evidence concerning the feasibility of a home-based FES-LEC program and also provides information concerning a number of characteristics that may show predisposition of successful adherence to a home-based FES-LEC program. The exercise adherence for the first 8-wk exercise period may be considered biased because there was the extra incentive of having the FES cycle purchased for long-term use. Even so, it is important to determine whether those who are severely limited in exercise options because of physical limitations and external barriers and are typically sedentary populations would participate in regular physical activity if the means were provided to them. The answer was yes, as their combined exercise adherence rate was 71.7%. The second
8 wks of FES-LEC was perhaps even more important because all incentive to participate was removed other than the benefits derived from the exercise. The exercise adherence rate did drop to 62.9%; however, this was statistically insignificant.

The exercise adherence rate of both 8-wk exercise periods (71.7% and 62.9%) was greater than the reported 35% rate of exercise in the AB population. This may well have been influenced by the availability of home-based exercise, the elimination of the need to transfer onto the cycle, and the monitoring of exercise sessions by research staff via the Internet. The three factors or subgroups that significantly influenced exercise adherence rates were age, exercise history, and recurrent pain not involving FES-LEC. Reasons given by the participants for missing exercise sessions or lack of participation were a decrease in interest in the exercise program, setup involving placement and removal of electrodes was too time-consuming, not enough time because of employment or other responsibilities, illness (urinary tract infection, infected cat bite, development of pressure ulcers unrelated to cycling, burns to bottom of feet unrelated to cycling), lack of support ("spouse not helping as much as they said they would"), muscle spasms, and vacation away from home without access to an FES cycle.

However, contradictory to the generally lower exercise rate of the older group, two participants in particular from the older group had the best overall rates of exercise adherence during the first 8-wk exercise period (108% and 100%).

Both decreased in exercise adherence during the second 8 wks of exercise to 63% and 71%, respectively, but still remained well above that reported for the AB population.

History of exercise was also a prime indicator of a successful exercise adherence rate, with four of the seven with self-professed sedentary lifestyles dropping out of the program or leaving the program because of lack of participation.
Self-professed descriptors of the active group were minor league baseball player, soccer player, runner, body builder, wheelchair athlete, and active working on the farm and around the house. Self-professed descriptors of the inactive group were tired, "cocoon personality"(wanting to stay in bed all day under the covers), not an athlete, and not able to do a lot because of physical limitations.

Surprisingly, those who reported recurrent pain had significantly higher exercise adherence than did those who reported no recurrent pain. Most (12/17) of the participants described themselves as having recurrent pain; however, pain was not an occurrence during FES-LEC exercise. It is also interesting to note that three of the five participants who did not continue the exercise after the first 8-wk exercise period were categorized as having no pain. Although it is reasonable to theorize that if pain during FES-LEC exercise had not been part of the exclusion criterion and participants who perceived pain during FES-LEC were included in the study, the results may have been different because, generally, pain during any activity is expected to depress the performance of the activity.
However, the results of this study indicate that the perception of recurrent pain apart from the exercise activity does not decrease the level of exercise adherence but may provide incentive to continue with the activity perceived as not causing pain.

Pain is a subjective experience, and although there are physiologic factors at play, how a particular person reacts to pain is largely dependent on his/her past experiences with pain.12 Linton and Shaw 12 described fear of pain as one of the most influential psychologic factors involving chronic pain. The fear of pain often manifests itself through what is known as the "fear avoidance model,"
which would typically cause individuals to avoid activities that they perceive as painful.12 However, the increased exercise adherence rate in this study using an activity not perceived as painful by those with recurrent pain suggests the possibility of a "pain-free affinity model" whereby persons with chronic pain are more likely to participate in an activity that they perceive as pain free when compared with persons who do not have recurrent pain. In this case, FES-LEC provided participants with an activity that allows them to follow the advice of McCracken and associates,13 who espouse that persons with chronic pain should divert their attention away from avoiding pain and concentrate on living life to the fullest. The use of FES-LEC activity in this study was essentially pain free and thus, apparently, was not subject to the powerful effects of the fear avoidance model, allowing participants to concentrate on the activity in a positive manner. Further research is needed to corroborate the existence of a pain-free affinity model for those with chronic pain.

Level of injury, TSI, and level of depression had no statistically significant bearing on exercise adherence in this study.

The average exercise adherence rate during the second 8 wks decreased by 8.8%, from 71.7% to 62.9%; however, this rate of decrease fell short of statistical significance. Nevertheless, both rates of exercise were well above the reported rate of exercise (35%) in the AB population. This drop may be because of the fact that the FES cycles were, at this point, guaranteed for future use and the need to ardently adhere to a high exercise rate may have seemed less important to participants. All subgroups experienced a decrease in rate of exercise after the first 8-wk period with the exception of the 50 yrs or older group. However, this result was undoubtedly influenced by the five older persons who dropped out, were dropped from the program because of lack of exercise, or were not able to participate in the second 8 wks of exercise because of injury.

The average of 82.5% exercise adherence rate found by Hicks and colleagues 14 while studying persons with SCI during two sessions per week of progressive resistive volitional exercise over a 9-mo period is slightly higher than the 71.7% found during the first 8-wk exercise period in this study. However, the participants in this study were asked to exercise three times per week as opposed to just two times per week in the study by Hicks et al.14 Hicks and associates 14 reported a 46.7% dropout rate over the 9-mo program, with a 38% dropout rate at the 6-mo mark, which is higher than the 29% dropout rate in this 4-mo study.

The exercise adherence rates of participants in this study provide encouragement for the successful use of home-based FES-LEC as a method of providing long-term physical activity for those with SCI. However, further innovation may provide increased exercise adherence and maintenance over the long-term. Interventions to decrease problems such a pressure ulcers, muscle spasms, and injuries as well as to provide increased motivation would likely be beneficial to those with SCI, particularly older persons and those with a history of sedentary lifestyle.

As indicated by the results of this study, a program of home-based FES-LEC with Internet monitoring by healthcare professionals can provide regular physical activity for those with SCI. Other technologic innovations such as telehealth programming, which is the use of telecommunications technologies including two-way visual and audio connection to support long-distance clinical health care and monitoring of the exercise sessions, may be a way of further increasing motivation and optimization of program safety.15 Several researchers have demonstrated improved functional and cognitive status and improved exercise adherence with utilization of telehealth technology.15-19

Limitations

A primary limitation of this study is the lack of female participants (two), which eliminated the ability to test for sex influences on exercise adherence.
The lack of female participants reflects the fact that it is harder to recruit female participants because there are fewer women with SCI and fewer female Veterans. Another limitation of the study is that age was divided only into two groups (=50 yrs). The limited number of study participants (N = 17) did not allow for the division into multiple age groups.

CONCLUSIONS

The high exercise adherence rates indicate that when provided the means, those with SCI can participate in a regular exercise program. This provides evidence for the feasibility of a home-based FES-LEC program. The overall participation was at a much higher rate than the reported 35% in the AB population. The results also indicate that adults with SCI younger than 50 yrs who consider themselves as having lived an active lifestyle have the highest probability of adhering to a home-based FES-LEC exercise program. It is important to investigate ways to further increase exercise adherence, especially for older adults with SCI and with a history of a sedentary lifestyle. It is also important to investigate the long-term effects of FES on body composition, particularly percentage body fat, fat mass, and lean mass, because of their association with obesity, metabolic syndrome, diabetes, and cardiovascular diseases. Perhaps even more important because of the lack of research evidence and understanding of bone reformation after SCI is the investigation of methods to induce positive changes in bone mass. Loss of bone mass is directly associated with osteoporosis and fractures. The ultimate goal of any rehabilitation or wellness program is to increase the quality-of-life of the participants 20; thus, it is important to investigate the degree to which these changes affect quality-of-life. As the life expectancy of those with SCI continues to grow, it is important to develop methods of helping to maintain or increase quality-of-life as well.

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