Research Report

The Effects of a Home Exercise Program on Impairment and Health-Related Quality of Life in Persons With Chronic Peripheral Neuropathies

Background and Purpose. The effects of a home exercise program for persons with chronic peripheral neuropathies (CPN) have not been documented. We compared changes in impairment and health-related quality of life (HRQL) between exercise and control groups, investigated the relationship between HRQL and measures of impairment, and contrasted the HRQL of individuals with CPN to that previously described for the general population. **Subjects.** Twenty-eight subjects with CPN, aged 23 to 84 years ($\bar{X}$=56.2, SD=14.9), completed the study. **Methods.** Impairment measures included average muscle score (AMS), handgrip force, walking time, and forced vital capacity. The HRQL instrument measured the eight scales of the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36) and the component scales. The exercise group (n=14) completed a 6-week home exercise program. The control group (n=14) did not participate in a home exercise program. **Results.** There was an increase in the AMS in the exercise group compared with the control group. No other between-group differences were found. The exercise group improved in scores on the role limitation scales of the SF-36. The AMS and walking time were moderately correlated with the physical function scale of the SF-36 (r=.55 and −.62, respectively). The SF-36 scores of individuals with CPN were lower than scores previously described for the general population. **Conclusion and Discussion.** The home exercise program appears to be an important component of the treatment of persons with CPN. Compared with the general population, patients with CPN appear to have a lower HRQL, but some areas appear to improve following a home exercise program. [Ruhland JL, Shields RK. The effects of a home exercise program on impairment and health-related quality of life in persons with chronic peripheral neuropathies. *Phys Ther.* 1997;77:1026–1039.]

Key Words: *Chronic inflammatory demyelinating polyneuropathy; Chronic peripheral neuropathy; Exercise, strengthening and aerobic; Health-related quality of life; Impairments.*

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Persons with chronic peripheral neuropathies often are given home exercise programs that include extremity strengthening and general aerobic conditioning. There is a high correlation between the ability of muscles to generate force and the functional ability of elderly persons and persons with neurological conditions.[1–9] The general adult population benefits from increased activity that decreases the incidence of general health risk factors (eg, body mass, blood pressure, cholesterol, stress).[10,11] We believe that the benefits of exercise may also apply to persons with chronic neurological conditions. Persons with various neuromuscular conditions tolerate strengthening and aerobic conditioning without ill effects and show improved exercise tolerance, strength, and functional ability.[12–18] However, whether a home exercise program for individuals with peripheral neuropathies can improve strength, functional abilities, and health-related quality of life (HRQL) has not been documented.

Chronic peripheral neuropathy encompasses several diagnoses, with chronic inflammatory demyelinating polyneuropathy (CIDP) being the most prevalent.[19–25] Chronic inflammatory demyelinating polyneuropathy is an immune-mediated peripheral nerve root disorder with symmetrical motor or sensory involvement of both proximal and distal muscles.[26] Although CIDP has many similarities to Guillain-Barré syndrome (GBS), the long-term prognosis is far worse for persons with CIDP. Whereas complete reinnervation is generally expected in persons with GBS, studies[20,23,25] have shown that 61% to 74% of persons with CIDP are minimally to moderately disabled and up to 28% are severely disabled (wheelchair bound) 3 to 10 years after diagnosis.

Contemporary medical treatment of CIDP is with plasmapheresis,[27] corticosteroids,[28] or intravenous immunoglobulin (IVIG).[27] These interventions are expensive,[27] may cause adverse side effects,[27,28] and have questionable results.[28–33] For example, in the only published study on the benefits of prednisone for persons with CIDP,[28] the outcome measure was the Neurological Disability Scale (NDS), which relies on the manual muscle test (MMT) as an index of patient change. The authors concluded that short-term (3 months) use of prednisone improved the neurological status of patients with CIDP to a greater degree than no treatment. In a study of the benefits of plasmapheresis for persons with CIDP,[29] 5 of the 15 subjects in the treatment group showed improved neurological status based on the NDS score. The authors concluded that plasma exchange had a beneficial effect on some manifestations of CIDP in

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some patients. Two other studies[30,32] examined the use of IVIG. Van Doorn et al[30] completed a double-blind, crossover study of 7 patients with CIDP and found that all patients responded with improved MMT scores. Vermeulen et al,[32] in a study of 28 subjects, found the average change in total muscle strength scores to be 1.6 for the treatment group compared to 1.3 for the control group (total score range=0–60).

The less-than-compelling results from these studies of medical interventions for persons with CIDP suggest to us that a typical physical therapy home exercise program may be equally effective in improving impairments in patients with chronic peripheral neuropathies. The effect that physical therapy has on individuals with chronic peripheral neuropathies has not been reported. Activity level is not routinely considered to be a confounding factor in the design and analysis of most drug trials in this population.[28–32] Furthermore, none of the studies on chronic peripheral neuropathy have included measures of HRQL. Thus, how HRQL relates to measures of impairment and how HRQL differs between patients with chronic peripheral neuropathies and the general population are not known. By contrasting the HRQL between patients with peripheral neuropathies and the general population, we can obtain an estimate of the disability of these individuals. The extent to which a disease process is disabling has important implications for the medical services being provided.

The purposes of our study were (1) to examine the effects of a home exercise program on impairment and HRQL in persons with chronic peripheral neuropathies, (2) to describe the relationship between various measures of impairment and a measure of HRQL in individuals with chronic peripheral neuropathies, and (3) to contrast the HRQL of individuals with chronic peripheral neuropathies with the HRQL of the general population.

Method

Subjects

Inclusion criteria for subjects in this study were as follows. Subjects were included if they had a clinical diagnosis of chronic acquired peripheral neuropathy, including CIDP, chronic idiopathic axonal degeneration (IAD), hereditary sensorimotor neuropathy, and toxic neuropathy if the toxin was no longer detectable through blood samples. Chronic idiopathic axonal degeneration is an acquired peripheral neuropathy that is clinically indistinguishable from CIDP.[22,24,34] Electromyographic (EMG) studies[24] and nerve biopsies[34] show axonal degeneration. Immunosuppressive treatment appears to be helpful, suggesting that this condition may also have an immune pathogenesis. It is treated medically very similarly to CIDP. Hereditary sensorimotor neuropathy is also frequently indistinguishable from CIDP.[29,35] This condition involves chronically progressive demyelinization or axonal degeneration. It is not treated with immune modulating agents. Subjects could be undergoing drug treatment; however, they could not have initiated any new drug or had a change in present regimen within the month preceding entry into the study. Subjects had to have the ability to ambulate at least 4.6 m (15 ft) with or without assistance or an assistive device. This criterion was required because the home program, developed by consensus, differed depending on ambulatory status.

Table 1.
Study Sample

No. of Subjects	Diagnosis
12	CIDP[a]
6	CIDP with monoclonal gammopathy
3	CIDP with central demyelinization or possible toxic neuropathy
4	Idiopathic axonal degeneration
3	Hereditary peripheral neuropathy

[a] CIDP=chronic inflammatory demyelinating polyneuropathy.

A database search of patients seen at the University of Iowa Hospitals and Clinics (Iowa City, Iowa) from 1990 to 1995 was conducted using the International Classification of Diseases[36] (ICD-9) code 3568, "idiopathic peripheral neuropathy." Of 183 patients whose names were produced, 17 patients were deceased, 7 patients were unable to be contacted, 85 patients had a diagnosis that did not fit the inclusion criteria, and 6 patients had CIDP but were unable to ambulate. Sixty-eight persons were contacted to participate in the study. Thirty-one subjects with chronic peripheral neuropathies were recruited and had initial evaluations. Data from these 31 subjects were used to establish the relationship between the various measures of impairment and the measure of HRQL.

Persons declined to participate in the study for various reasons (ie, distance to travel was too great, too busy because of work, unable to participate because of other medical reasons, occupied by caring for a spouse). Twenty-eight subjects completed the preintervention and postintervention phases of the study (Tab. 1). The prednisone level of 2 male subjects in the exercise group was tapered during the trial. For both subjects, the prednisone dosage was reduced 10% because of patient complaints (eg, blurred vision, mood swings). Despite deviation from our original inclusion criteria, we decided to retain these 2 subjects in the study to maintain our balanced sample size and to add to the study's generalizability to what we believe are clinical

conditions faced by physical therapists. The 3 subjects who did not complete the study were similar to the study group in age (23–74 years), gender (2 male, 1 female), and other demographic characteristics.

Study Measurement Tools

Outcome measures of impairments used in this study included the average muscle score (AMS),[37] handgrip force,[38] forced vital capacity (FVC),[39] and a timed 9.1-m (30-ft) walk.[40] The HRQL measure was the Medical Outcomes Study (MOS) 36-Item Short-Form Health Survey (SF-36).[41–44] The Borg Rating of Perceived Exertion (RPE) Scale[45] was used to help guide the exercise prescription.

Muscle force was assessed and individual MMT grades were assigned using a modified Medical Research Council (MRC) grading scale.[37,46] This grading system is often used as a method of measuring muscle force in drug efficacy trials on patients with CIDP (personal involvement with multicenter drug trial [RKS]).[26,32] We adopted this method for our study so that our findings would remain comparable to those of other intervention trials. One investigator (JLR) was trained in using the MRC method during a 1½-day session under the direction of Mendell and King (JR Mendell, W King, unpublished training manual, 1995). Mendell and King are widely published in the area of assessment of individuals with neuromuscular disease.[26,37,47]

In the seated position, force of facial muscle, shoulder abduction, elbow flexion, wrist flexion and extension, thumb abduction, hip flexion, knee extension, and ankle dorsiflexion were assessed bilaterally. In the prone position, neck extension, knee flexion, and ankle plantar flexion were assessed. Elbow extension and neck flexion were assessed in the supine position, and hip abduction was assessed in the side-lying position. Each position was tested according to the MRC definitions, scored, and rescaled as follows: 0=0; 1=1; 2=2; 3−=3; 3=4; 3+=5; 4−, 4, and 4+=7; 5−=9; and 5=10.[37] The nonlinear transformation of the scores indicates a greater weight assigned to muscles in the range of 4 to 5, and the transformed scores do not rely on differentiating among the 4−, 4, and 4+ grades. This rescaling and summing of the scores has been previously described and reported to be reliable.[37] An AMS is derived by summing the individual scores and dividing by the number of muscles tested.[37]

Mendell and King recommend transforming the scores and calculating an AMS (JR Mendell, W King, unpublished training manual, 1995). We adopted this system for several reasons. The AMS showed a linear decline in boys with muscular dystrophy, with an equal amount of force lost each year regardless of age.[9] The AMS is reported to be highly correlated to functions such as mobility.[9] The muscles tested, the position for testing, the transformation of scores, and the calculation of the AMS have been described by Mendell and King (JR Mendell, W King, unpublished training manual, 1995). Mendell is widely published regarding the management of patients with CIDP,[26,47] and previous studies assessing CIDP have adopted this system.[26,32] Given the high reproducibility of the MRC grades[37] and their face validity, we believed the MRC to be an important measure to include along with our HRQL measures (SF-36).

Intratester reliability using the MRC's AMS was found to be excellent in 102 boys with Duchenne's muscular dystrophy (Cohen's weighted Kappa ranged from .80 to .99).[37] In addition, an intertester reliability study of the AMS and other impairment measures was conducted using a subsample of five subjects from this study. Intertester reliability was established so that a second tester could perform the assessments in the event that the primary tester was not available. The reliability estimates (intraclass correlation coefficients [ICC(2,1)]) from this pilot study were .90, .99, .98, .97, and .80 for the AMS, right handgrip force, left handgrip force, FVC, and walking speed, respectively. Only three measurements were not obtained by the primary tester in this study (JLR).

Handgrip force was assessed using the Jamar handgrip dynamometer,* which was calibrated twice during the study and found to have a measured accuracy of ±2% (range utilized=0–50 kg). We used the Jamar dynamometer because it is commonly used in clinical practice to evaluate handgrip force, to measure progress, and to make clinical decisions and because it has good reliability.[38]

Forced vital capacity was measured using a hand-held Renaissance spirometer,† which was calibrated daily according to specifications of the American Thoracic Society.[39] Measurements are reported as a percentage of the normal value using a reference equation formulated by Knudson that normalizes liters by height and age and adjusts for race.[39] This measure is commonly used to monitor patients with neuromuscular disease, not only in clinical practice but also in therapeutic (drug) trials.[48,49]

A timed 9.1-m walk was measured with a digital stopwatch. This timed test measured the amount of time it took to walk 9.1 m, from the first step to when the last foot crossed a 9.1-m marker. Subjects were instructed to walk as briskly as possible while maintaining safety.

* JA Preston Corp, 2010 E High St, Jackson, MI 49203.
† Puritan Bennett, Boston Division, 265 Ballardvale St, Wilmington, MA 01887.

Subjects were permitted to use assistive devices but not walls, wheelchairs, or the assistance of another person. A close association has been established between walking speed and functions assessed in rehabilitation.[7]

The SF-36 was used to measure HRQL.[41–44] Each of eight health concepts—physical function, role limitation (physical), bodily pain, general health, vitality/energy, role limitation (emotional), social function, and mental health—were measured on a scale of 0 to 100, with a higher score indicating better health. A physical component summary (PCS-36) score and a mental component summary (MCS-36) score were also calculated. Although both component summary scores were calculated from weighted aggregates of all eight individual SF-36 scales, the PCS-36 score was weighted more heavily for the physical function, bodily pain, and role limitation (physical) scale scores. The MCS-36 score was heavily weighted for the mental health, role limitation (emotional), social function, and vitality/energy scale scores.[50] The usefulness, validity, and reliability of scores for the SF-36 have been extensively examined.[41–44] Intraclass correlation coefficients (2,1) varied between .74 and .90 (except for role limitation [emotional], ICC=.57) for test-retest reliability in a group of 27 patients with amyotrophic lateral sclerosis (ALS).[51] Responsiveness to change was also demonstrated in patients with ALS[51] and in older adults in a preventive intervention.[52]

Intervention Protocol Development

The exercise intervention protocol was developed through a modified Delphi technique consensus approach.[53–55] The expert panel consisted of six physical therapists in the neuromuscular division of the physical therapy department at the University of Iowa Hospitals and Clinics. Years of practice ranged from 1½ to 29 years ($\bar{X}$=14). Years of practice treating patients with neurological involvement ranged from 1 to 19 years ($\bar{X}$=9.4). The panel was not informed about the possibility of a study and therefore had no appreciation for the measures of impairment or the measure of HRQL that were ultimately used as outcome variables in this study. This issue is important because we were interested in determining whether the typical home program recommended by physical therapists influences the same outcome measures that are routinely used in medical intervention trials for patients with neurological involvement.

An exercise program of strengthening with Thera-Band®‡ or the resistance of the body, stretching, and aerobic conditioning was used. These broad categories were proposed as appropriate components in a home program for patients with chronic peripheral neuropathies. The therapists showed consensus in believing that 6 weeks was the appropriate time to demonstrate whether the home program was effective.

The exercise program consisted of prone back extensions, prone scapular retraction, abdominal curls, passive prone extension, and active shoulder medial (internal) and lateral (external) rotation. The consensus of the expert panel was that Thera-Band® should be used for strengthening in shoulder flexion, abduction, and lateral rotation and in elbow flexion. The expert panel also believed that the subjects should do heel-cord stretching, supine knee-to-chest stretching, and supine hamstring muscle stretching because they felt that these are primary areas of tightening in patients with neurological disease. The primary mode of lower-extremity exercise recommended by the panel was a progressive walking or cycling program. The expert panel recommended that the walking or cycling should be performed for 10 to 20 minutes. There was agreement that the subjects should strive to work up to the full 20 minutes if that was not possible initially. The expert panel also recommended that the intensity should be such that each subject was working at the "somewhat hard" level of the Borg RPE Scale, or 60% to 70% of his or her estimated maximum heart rate.[45]

Procedure

Subsequent to qualifying for this study according to the inclusion criteria, subjects participated in the following procedure. All subjects provided informed consent. Subjects completed the SF-36 as well as the Activity Level Questionnaire. A brief physical examination was performed. Weight, height, respirations per minute, and pulse rate were measured. Weight and height were needed to use the equation for the spirometer measurement. Heart rate helped guide the exercise prescription. In particular, 60% to 70% of each subject's maximum estimated heart rate was used to establish intensity. Blood pressure also was monitored and noted during the assessments.

Outcome measurements were obtained in the following order: (1) An MMT was completed according to the described methods, (2) handgrip force was determined as the best of three trials with the handgrip dynamometer, (3) FVC was determined as the best of three trials using the hand-held spirometer, and (4) the timed 9.1-m walk was administered one time as described. All variables were measured the same way for the pretest and posttest measurements.

Prior to the evaluation, 20 of the 28 subjects were randomly assigned to either an exercise group or a control (no exercise) group. Nonrandomized placement of 8 subjects was required to keep demographics such as

‡ The Hygenic Corp, 1245 Home Ave, Akron, OH 44310.

gender and age as similar as possible between groups. Four of the subjects who were not randomly assigned were placed in the control group, and the other 4 subjects were placed in the exercise group. These placements were done by the research coordinator prior to any investigators meeting the subjects.

Subjects in the exercise group were instructed on individual exercise programs. Subjects were provided with yellow and red Thera-Bands® so that they could progress from no resistance to light and medium resistance for each exercise. A goal of 10 repetitions performed one time each day was established. If the 10 repetitions became easy to perform, the subjects were instructed to progress to the next resistance level. Once the highest resistance level was achieved, the subjects were told to maintain this level for the duration of the 6-week home exercise program. The subjects demonstrated that they could perform each exercise correctly.

To determine the initial aerobic exercise intensity, each subject's baseline resting heart rate was measured. The subjects walked or cycled, attempting to achieve 60% to 70% of their estimated maximum heart rate (220−age), or a "somewhat hard" intensity level on the Borg RPE Scale.[45] Approximately 10 minutes into the aerobic exercise, heart rate was again measured.

Subjects were instructed to exercise initially for the duration that they were able to tolerate, up to 20 minutes each day. Subjects who initially could not accomplish 20 minutes of exercise each day at an aerobic level of 60% to 70% of their maximum heart rate were instructed to attempt to build to that duration and intensity level in equal increments over the first 3 weeks of the exercise program and to continue to exercise at that duration and intensity level during the second 3 weeks of the exercise program. Subjects who could not monitor their pulse were instructed to exercise at the "somewhat hard" intensity level. Only one subject was not able to perform the daily walking and, therefore, used a stationary bicycle. This subject adhered to the same intensity and duration criteria.

Subjects were requested to exercise daily for 6 weeks and to keep a daily log that would be collected at the end of the study. The evaluator telephoned each subject at the end of the first week and during week 5 to monitor progress and encourage adherence. We chose not to contact subjects more frequently because we believed that such follow-up would not be representative of the typical number of contacts made by a therapist after prescribing a 6-week home program. Subjects in the control group were requested to maintain their levels of activity without modification. Subjects in the control group were also contacted by telephone at the same frequency as the exercise group and asked whether they had experienced any problems associated with the initial evaluation.

At the end of the 6-week exercise period, all subjects were reevaluated according to the preexercise procedure and completed a second SF-36 form. All subjects in the control group were offered and instructed in an exercise program, according to the previously described procedure. The adherence of the exercise group was tabulated from the exercise logs. Thirteen of the 14 subjects (93%) returned completed log sheets. The subjects' log sheets indicated that they exercised at least 5 days a week throughout the 6 weeks. Ninety-one percent of the total exercise days possible were logged in as completed. The subject who did not return the log claimed to have exercised daily over the 6-week period.

Data Analysis

All statistical analysis was performed using the general linear model of the Statistical Analysis System (SAS)[§] procedures. Descriptive statistics of the demographic data, the impairment measures, and the SF-36 were computed. The exercise group and the control group were statistically compared at baseline to determine the need for using an analysis of covariance. A split-plot repeated-measures analysis of variance was used to determine whether the way the control group responded to the intervention was similar to the way the exercise group responded. Covariates such as age and differences in the baseline measures were used to adjust for differences in the overall model.

In the event of an interaction, indicating that the control group responded differently than the exercise group did, a simple-effects analysis was carried out using the complete model's error term as the best estimate of the population variance.[53] Age and baseline differences were used as covariates when assessing differences between the control and exercise groups. If there was no interaction, within-group comparisons were analyzed using a repeated-measures analysis of variance. Between-group comparisons of the change were analyzed with *t* tests while controlling for age and the different baseline covariates. An alpha level of .05 was selected as the level of significance for all tests.

Regression analysis was used to establish the relationships among the various measurements of impairment and HRQL for the entire sample of 31 subjects initially enrolled in the study. The strength of the correlation was tested under the null hypothesis that the correlation is equal to zero. A power analysis was also carried out to explore whether the sample size with respect to each

[§] SAS Institute Inc, Box 8000, Cary NC 27511-8000.

Table 2.
Baseline Characteristics of Subjects

Characteristic	Control Group (n=14)			Exercise Group (n=14)			P
	$\bar{X}$	SD	Range	$\bar{X}$	SD	Range	
Age (y)	52.9	16.2	23–74[a]	63.6	10.5	43–84	.0484
No. of female subjects[b]	4 (29)			5 (36)			.6989
Height (cm)	175.4	7.8		171.8	9.8		.2961
Weight (kg)	79.6	13.1		87.4	14.3		.1462
Education (yr)	13.2	2.9		13.1	3.4		.9053
Highest activity level (MET[c])	5.4	1.0		5.4	0.6		1.0
No. of left-handed subjects[b]	1 (7)			3 (21)			.1053
No. of subjects receiving CIDP[d] medication[b]	5 (36)			4 (29)			.6989

[a] Different from the exercise group ($P \leq .05$).
[b] Percentage shown in parentheses.
[c] MET=metabolic equivalent (1 MET=3.5 mL $O_2 kg^{-1} \cdot min^{-1}$).
[d] CIDP=chronic inflammatory demyelinating polyneuropathy.

Table 3.
Baseline Outcome Variable Values

Variable	Control Group (n=14)		Exercise Group (n=14)		P
	$\bar{X}$	SD	$\bar{X}$	SD	
Average muscle score	8.8	1.1	8.8	0.7	.8963
Right handgrip force (kg)	28.6	10.5	28.6	11.5	.9865
Left handgrip force (kg)	28.1	11.9	28.3	11.1	.9611
Forced vital capacity (%)	91.0	14.0	83.9	15.8	.2181
1.9-m (30-ft) walking time (s)	5.6	2.6	7.2	5.4	.3518
SF-36[a]					
Physical component summary	39.9	8.7	37.0	9.7	.2829
Mental component summary	55.6	7.3	49.1	11.8	.0877
Physical function	70.7	19.7	53.2	33.1	.1016
Role limitation (physical)	55.4	36.9	28.6	36.5	.0645
Bodily pain	67.1	22.7	56.4	23.6	.2343
General health	51.1	21.2	54.9	22.9	.6472
Vitality/energy	58.6	19.6	49.3	20.2	.2273
Social function	89.3	15.4[b]	70.5	29.3	.0435
Role limitation (emotional)	92.9	26.7[b]	47.6	46.6	.0041
Mental health	78.0	16.7	76.3	19.9	.8069

[a] SF-36=Medical Outcomes Study 36-Item Short-Form Health Survey.[41–44]
[b] Different from the exercise group ($P \leq .05$).

dependent variable was adequate to detect between-group differences.

Results

Twenty-eight subjects (14 subjects in the exercise group and 14 subjects in the control group) completed the 6-week trial. Tables 2 and 3 present the demographic information and baseline outcome variable measurements by group. The mean age, role limitation (emotional) scale score, and social function scale score were different between the two groups at the baseline measurement, and these variables were therefore included as covariates in the data analyses.

Analysis of Interactions Between Groups

The split-plot repeated-measures analysis demonstrated an interaction for the control group and the AMS, indicating that the control group responded to the intervention differently than the exercise group did. The simple-effects analysis showed that conditions before intervention were not different between the control and exercise groups (AMS=8.8) but that the AMS was

Table 4.
Comparison of the Change in Strength Impairment Measurement From Pretest to Posttest in the Control and Exercise Groups

Variable	Control Group (n=14)				Exercise Group (n=14)			
	Pretest	Posttest	Change	P[a]	Pretest	Posttest	Change	P[a]
Average muscle score	8.8	8.6	−0.2	.1126	8.8	9.2	0.4	.0025
Right handgrip force (kg)	28.6	29.1	0.5	.5000	28.6	30.8	2.2	.0334
Left handgrip force (kg)	28.1	28.9	0.8	.3356	28.3	29.4	1.1	.2327
Forced vital capacity (%)	91.0	90.2	−0.8	.7916	83.9	86.9	3.0	.1397
9.1-m (30-ft) walking time (s)	5.8	5.6	−0.2	.0899	5.9	5.5	−0.4	.0625

[a] Within-group analysis.

greater for the exercise group (AMS=9.2) than for the control group (AMS=8.6) after intervention. The simple-effects analysis also indicated that the AMS increased within the exercise group (from 8.8 to 9.2) but not within the control group (from 8.8 to 8.6). The AMS was the only dependent variable to show an interaction. That is, the variability between groups was high enough that no other impairment measurement or HRQL score responded differently to the intervention across the control and exercise groups. Lower within-group variability, however, did not preclude changes within groups.

Differences in Measurements of Impairment

Within-group analysis of measurements of right and left handgrip force, FVC, and 9.1-m walking time (Tab. 4) showed that right handgrip force was the only impairment variable that increased after the exercise intervention. The control group did not show a change over the 6 weeks. Despite within-group differences in handgrip force in the exercise group and the lack of change in handgrip force in the control group, the between-group variability was high, which could have precluded an interaction in the overall model.

One subject had a fall during his 6-week intervention period and exhibited an increased fear of falling during retesting. His walking time increased dramatically from the preintervention measurement (24.16 seconds) to the postintervention measurement (39.40 seconds). His score was considered an outlier, and analysis of the time to walk 9.1 m was completed both with and

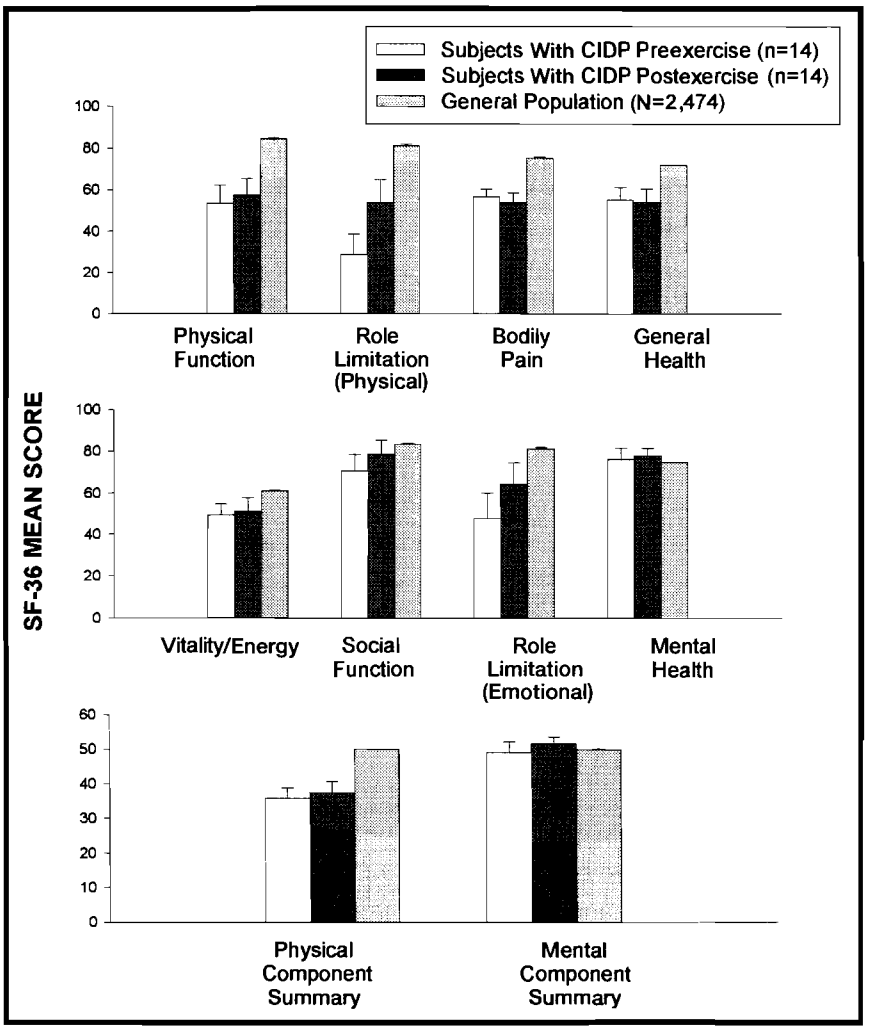

Figure.
Medical Outcomes Study 36-Item Short-Form Health Survey[41-44] (SF-36) mean scores, with standard error bars, for subjects with chronic inflammatory demyelinating polyneuropathy (CIDP) before and after 6 weeks of a home exercise program and for the general population. The upper panel displays the results for the physical health scales, and the middle panel displays the results for the mental health scales. The bottom panel displays the results for the component summary scales.

Table 5.
Comparison of the Change in Quality-of-Life Measurement From Pretest to Posttest in the Control and Exercise Groups

	Control Group (n=14)				Exercise Group (n=14)			
SF-36[a] Scale	Pretest	Posttest	Change	P[b]	Pretest	Posttest	Change	P[b]
Physical component summary	39.9	41.9	2.0	.1852	35.7	37.3	1.6	.1779
Mental component summary	55.6	54.3	−1.3	.3326	49.1	51.7	2.6	.2518
Physical function	70.7	71.1	0.4	.9107	53.2	57.1	3.9	.1956
Role limitation (physical)	55.4	62.5	7.1	.4533	28.6	53.6	25.0	.0072
Bodily pain	67.1	69.6	2.5	.4952	56.4	53.6	−2.8	.5516
General health	51.1	57.3	6.2	.0882	54.9	53.8	−1.1	.7137
Vitality/energy	58.6	57.9	−0.7	.8303	49.3	51.1	1.8	.6917
Social function	89.3	85.7	−3.6	.6170	70.5	78.6	8.1	.0868
Role limitation (emotional)	92.9	88.1	−4.8	.1648	47.6	64.3	16.7	.2208
Mental health	78.0	79.1	1.1	.6714	76.3	78.0	1.7	.6484

[a] SF-36=Medical Outcomes Study 36-Item Short-Form Health Survey.[41–44]
[b] Within-group analysis.

Table 6.
Univariate Relationships Between Health-Related Quality-of-Life Measures and Measures of Impairment (N=31)

	Average Muscle Score		Right Handgrip Force		Left Handgrip Score		Forced Vital Capacity		9.1-m (30-ft) Walking Time	
SF-36[a] Scale	r[b]	P	r	P	r	P	r	P	r	P
Physical function	.55	.001*	.07	.72	.14	.44	.23	.21	−.62	.0002*
Role limitation (physical)	.36	.04*	.18	.32	.21	.25	.25	.18	−.35	.05*
Bodily pain	.31	.09	.29	.12	.33	.17	.13	.48	.09	.62
General health	.31	.09	.13	.48	.22	.23	.12	.53	−.12	.50
Vitality/energy	.38	.04*	.21	.26	.28	.12	.14	.46	−.21	.26
Social function	.27	.14	.14	.46	.14	.44	.19	.30	−.39	.03*
Mental health	−.18	.33	.16	.39	.14	.45	.005	.98	.006	.97
Role limitation (emotional)	.29	.11	.32	.08	.32	.07	.31	.09	−.33	.67
Physical component summary	.57	.0009*	.12	.53	.21	.26	.21	.27	−.43	.02*
Mental component summary	.009	.96	.27	.14	.25	.17	.15	.43	−.12	.52

[a] Asterisk (*) indicates significant at $P \leq .05$.
[b] SF-36=Medical Outcomes Study 36-Item Short-Form Health Survey.[41–44]

without this measurement included. Despite removing the outlier, there was still no change in either the control group or the exercise group.

Differences in Measurements of Health-Related Quality of Life

The Figure illustrates the HRQL measurements for each scale of the SF-36 before and after exercise for the subjects with chronic peripheral neuropathies. As shown in the Figure, the subjects' performance on the role limitation (physical), role limitation (emotional), and social function scales of the SF-36 appears to have improved following the exercise intervention. Table 5 shows that the scores of the subjects in the exercise group increased 25 points on the role limitation (physical) scale, 8.1 points on the social function scale, and 16.7 points on the role limitation (emotional) scale. No other scales of the SF-36, including the component summary scales, showed a change with exercise.

The Figure also plots the general population norms for the SF-36 measurements so that the extent of perceived health in the subjects with chronic peripheral neuropathies can be depicted. Scores on the physical function, role limitation (physical), role limitation (emotional), bodily pain, and general health scales of the SF-36 were lower for the subjects with chronic peripheral neuropathies relative to the general population. Performance on the mental health, social function, and vitality/energy scales appeared to be less involved. The differences between the PCS-36 scores and the MCS-36 scores indicate that most of the perceived loss in health status, relative to the normative values, is within the scales related to physical health in patients with chronic peripheral neuropathies (Figure).

Relationship Between Health-Related Quality of Life and Impairments

Table 6 lists the correlations between the various mea-

sures of impairment and the eight scales of the SF-36. Only the AMS and 9.1-m walking time were correlated to the SF-36 scales. The AMS was correlated to scores on the physical function scale ($r=.55$), the role limitation (physical) scale ($r=.36$), the vitality/energy scale ($r=.38$), and the PCS-36 ($r=.57$). There were extremely low correlations between the impairment measures and the MCS-36. The 9.1-m walking time was inversely correlated to scores on the physical function scale ($r=-.62$), the role limitation (physical) scale ($r=-.35$), the social function scale ($r=-.39$), and the PCS-36 ($r=-.43$). The inverse correlations reflect that the 9.1-m walking time decreased (subjects walked faster), whereas the score on the associated scale of the SF-36 increased (improved).

Discussion

The major finding of this study was that a home exercise program resulted in the improvement of muscle testing scores of patients with chronic peripheral neuropathies as compared with the scores of a group of subjects who did not exercise. The changes were measured using an impairment measure (AMS) that is routinely used in medical intervention studies of chronic peripheral neuropathy.[26] Despite the differences in AMS scores between the exercise and control groups, no difference was found between the groups with respect to the measure of HRQL and other functional measures (9.1-m walking time and FVC). Several of the scores of the SF-36 related to physical health were depressed in individuals with chronic peripheral neuropathies when compared with the general population normative values. This finding suggests that persons with chronic peripheral neuropathies have an extremely poor perception of their HRQL. The AMS and the 9.1-m walk showed the highest correlations to scores on the physical function scale of the SF-36 and the PCS-36, which suggests that these impairment measures reflect some component of the patient's perception of health status.

The effects of a home exercise program on impairment and HRQL of persons with chronic peripheral neuropathies have not previously been documented. The results of our study and the results obtained in drug intervention studies of persons with CIDP provide for an interesting comparison.

Muscle Force and Mobility Outcomes

In our study, the exercise group had an increase in the AMS of 0.4 points, whereas the control group had a decrease of 0.2 points (range of the AMS=0–10). Each of the 28 muscles can receive a score of 0 to 10, for a maximum possible total of 280. An evaluator can potentially detect one grade change in one muscle. If one muscle declined in strength 1 point, the total score would be 279. The score of 279 is then divided by 28 to obtain an average score of 9.96. The average score of 9.96 is subtracted from 10 to yield .04. Therefore, the resolution of this MMT measure is .04. Data from our reliability study produced a standard error of the measurement of 0.12. Therefore, a 95% confidence interval for individual scores would be equivalent to a score of ±0.24. Hence, our change of 0.4 represented a 5% improvement in muscle force for the exercise group. The −0.2 represented a −2.26% decline in muscle force in the control group.

In a study of the effects of IVIG (0.4 g/kg/body weight/d for 5 days) in previously untreated persons with CIDP,[32] subjects who received treatment improved 0.27 points and control (untreated) subjects improved 0.22 points on the AMS. The researchers reported they could not demonstrate an effect of IVIG treatment. Intravenous immunoglobulin treatment, however, continues to be a very common therapy for patients with CIDP. No other published drug studies used the AMS, although several studies[28,29,57] used the NDS, a scale that measures bulbar, respiratory, and extremity strength (using MMT) as well as extremity reflexes and sensation. In a study of the effects of a decreasing dosage of prednisone (120 mg to 0 mg over 13 weeks) in patients with CIDP,[28] there was a decline in NDS scores of 1.5 in the control group and an improvement in NDS scores of 10 in the treatment group (range of the NDS=0–280). On a scale of 0 to 10, the improvement in NDS scores of 10 would equate to an improvement of 0.36, similar to the effect that we measured with the AMS. Based on these changes, the authors concluded that prednisone improved the neurological status of patients with CIDP to a greater degree than no treatment.

The results of drug intervention studies[28–33,57] have generally shown modest improvements in impairment measures, improvements that are comparable to those seen in our exercise intervention study. Nonetheless, we believe that these drug treatments (prednisone, IVIG, and plasma exchange) are beneficial, necessary, and often lifesaving. All of the subjects in our study were receiving one or a combination of these treatments at one time during the course of their disease. Nine of the subjects (five in the control group and four in the exercise group) who were receiving drug treatment at the time of enrollment in the study, according to our inclusion criteria, continued drug treatment throughout the study. Hence, the notion that a home exercise program may affect the very outcome measures used to assess the efficacy of medical treatments warrants closer attention. We do not know whether a more dramatic effect or a less dramatic effect would have been seen if the subjects had not been receiving medication. Our exercise and control groups were similar with respect to

medication regimens, so drug treatment would not appear to be a factor influencing our results.

Health-Related Quality-of-Life Outcomes

There were no between-group differences in the change in either the PCS-36 scores or the MCS-36 scores during the 6-week exercise program. Substantial within-group changes in scores on the SF-36 role limitation (physical) scale (Figure) were evident in the exercise group but not in the control group. The exercise group had a 25-point increase in scores on the role limitation (physical) scale (compared with the control group's 7.1-point increase), a 16.7-point improvement in scores on the role limitation (emotional) scale (compared with the control group's decrease of 4.8 points), and an 8.1-point increase in scores on the social function scale (compared with the control group's decrease of 3.6 points). The direction of change of these self-perceived functions may have clinical relevance. Recently, similar improvements in scores on these scales of the SF-36 during strengthening regimens have been observed (KB Schechtman, personal communication, 1996). In particular, scores on the role limitation (emotional) and social function scales of the SF-36 were improved in exercise groups compared with control groups in a study of older individuals.

No published studies of exercise interventions using the SF-36 for persons with disabilities are available for direct comparison with our study. According to Ware et al,[50] the health phenomenon measured by the role limitation (physical) scale is self-perception of physical disability, that measured by the role limitation (emotional) scale is self-perception of mental disability, and that measured by the social function scale is a combination of self-perception of physical disability and self-perception of mental disability. Ware et al[50] state that the role limitation (physical) scale pertains to problems with work or other regular daily activities as a result of physical health, the role limitation (emotional) scale pertains to problems associated with emotional well-being (specifically depression or anxiousness), and the social function scale pertains to perceived interference with normal social activities because of physical health or emotional problems.

Some researchers[58–61] have attempted to measure the effect of exercise on depression, anxiety, self-concept or self-esteem, and "mastery," or the extent to which an individual perceives life as something that he or she can manage or control. Although they do not measure the same aspects as the role limitation (physical), role limitation (emotional), and social function scales of the SF-36, these measures provide some overlap for comparison.

Blumenthal et al[58] reported that subjects in exercise groups perceived themselves as changing in psychological, social, and physical dimensions (as measured by a Perceived Change Questionnaire). Subjects reported that they felt in better health, that they believed they looked better, that they slept better, and that they had more energy, endurance, and flexibility. They reported improved family relations, better sex lives, less loneliness, and a better social life. Subjects reported improved mood, self-confidence, and life satisfaction and better memory and concentration. The authors suggested that people's self-perceptions may be more sensitive to change than the standard psychometric instruments.

The results of our study support the notion that our exercise intervention may have improved the perceptions of participants regarding how they function in their work and social roles. Disability has been defined as a behavioral response to continued impairment that limits the performance of normal functioning.[62] A home exercise program for persons with chronic conditions not only may be an intervention that helps modify impairments (increase in strength) but may also affect the way people feel about and deal with those impairments (behavioral response) and, over time, help to modify the path from impairment to disability positively.

An important finding of our study was that patients with chronic inflammatory neuropathy who were referred for rehabilitation had lower SF-36 scores compared with the general population.[50] As shown in Table 3, the SF-36 scores of the subjects in the exercise group were very similar to the SF-36 scores of the subjects in the control group. This finding supports the notion that individuals matching the case mix (Tab. 1) evaluated in our study have a very poor perception of their physical health-related quality of life. Conversely, the mental health-related quality of life is minimally affected by this disease process.

Relationship Between Health-Related Quality of Life and Impairments

Virtually no data are available that describe the relationships among the various scales of the SF-36 and the measures of impairment used in our study. The poor correlation between handgrip force and physical function, however, is not surprising because most of the physical function questions pertain to activities involving the lower extremities.[50] Support for this observation comes from the higher inverse correlation ($r = -.62$) found for the time to walk 9.1 m and scores on the physical function scale of the SF-36. Accordingly, the AMS, which sums the scores of various upper- and lower-extremity muscles, was correlated to scores on the physical function scale ($r = .55$). Closer scrutiny of the AMS indicated that the sum of the lower-extremity

scores caused a higher correlation to scores on the physical function scale (r=.66). If the difference between the correlation coefficients .55 and .66 is meaningful, then the summed total of the Medical Research Council's MMT,[37] by virtue of its upper-extremity component, may provide additional information regarding the physical status of a patient that is not detected by the eight questions comprising the physical function scale of the SF-36.

Exercise Intensity

The group that participated in the modified Delphi process recommended that the intensity of this exercise program should not be high. They recommended doing 3 to 5 repetitions of stretching and 10 repetitions of strengthening, taking precautions to progress gradually and avoid fatigue. Heart rate guidelines given were 60% to 70% of the estimated maximum heart rate. This attitude reflects the caution that is commonly held by many physicians and physical therapists when dealing with persons with neuromuscular diseases such as multiple sclerosis, ALS, muscular dystrophy, and chronic peripheral neuropathy. This cautious view is not supported by research. Studies of aerobic exercise in persons with multiple sclerosis[17] and slowly progressing neuromuscular disease[15,16] and a recent case study of a patient with GBS[18] indicate that aerobic exercise is beneficial in improving exercise capacity and decreasing other impairments and that it is not harmful to a person's neurological or functional condition. Strengthening exercises have been given to persons with muscular dystrophy,[14] myotonic dystrophy,[63] and hereditary sensorimotor neuropathy[63] with purported positive results and no ill effects.

A possible limitation of our study was that the final sample size was smaller than originally anticipated. Based on the variability of preliminary data from a pilot study, we needed only 15 subjects to detect a change between subject groups, assuming an alpha level of .05 and power of .80. A power analysis at the completion of the study, however, indicated that our power fell below .80 when attempting to find a difference on several variables between groups.

Conclusion

Following a home exercise program designed by physical therapists, an improvement in muscle force and an improvement on the role limitation (physical) scale of the SF-36 in individuals with CIDP were found. Our study illustrates that individuals with CIDP have a very poor perception of their physical health when compared with the general population. Moreover, the individuals' perception of their physical health is associated with muscle force and walking speed impairments. These findings suggest that exercise is an important factor to consider when assessing any medical intervention on individuals with CIDP. Future drug intervention studies may need to consider exercise and activity levels as viable contributors to changes in measured health status as well as muscle force impairments. Future studies are needed to further elucidate the relationships between impairments and HRQL and to clearly define the role that exercise plays in contributing to overall well-being in individuals disabled from neurological disease.

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