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Claudia Eliza Patrocinio de Oliveira[1,2], Osvaldo Costa Moreira[1,2], Zoila Marilú Carrión-Yagual[1], Carlos Medina-Pérez[3], José Antonio de Paz[1]

[1] Institute of Biomedicine, University of Leon, Leon, Spain.

[2] Department of Physical Education, Federal University of Viçosa, Viçosa, Brazil.

[3] University Isabel I, Burgos, Spain.

* **Corresponding author:**

Claudia Eliza Patrocinio de Oliveira

Institute of Biomedicine, University of Leon, Campus Vegazana, 24008, Leon, Spain;
Phone number: +34629959278

Email: cpatrocinio@ufv.br

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Conflicts of interest

The authors declare that there is no conflict of interest.

Effects of classic progressive resistance training *versus* eccentric-enhanced resistance training in people with multiple sclerosis

Abstract

Objective: To compare the effects of classic progressive resistance training (PRT) *versus* eccentric strength-enhanced training (EST) on the performance of functional tests and different strength manifestations in the lower limb of patients with multiple sclerosis (PwMS).

Design: Experimental trial.

Participants: Fifty-Two PwMS (19 men and 33 women) belonging to MS associations from the Castilla y León/Spain.

Intervention: Participants were assigned to one of two groups: a control group that performed PRT or an experimental group that performed EST. In both groups, the knee extensor muscles were trained for 12 weeks.

Main Outcome Measures: Before and after 12 weeks of training, maximal voluntary isometric contraction (MVIC) and one repetition maximum (1RM) of the knee extensors were evaluated, as were the chair stand test (CST) and timed 8-foot up and go (TUG) functional tests.

Results: No differences were found between the groups in the initial values for different tests. For intragroup comparisons found significant differences in CST (F= 69.4; p= 0.000), TUG (F=40.0; p=0.000) and 1RM (F=57.8; p=0.000). For intergroup comparisons, EST presented better results than PRT in CST (EST: 4.7±2.8% *vs* PRT: 1.9±2.8%; F=13.1; p=0.001) and TUG (EST: -2.9±4.7 *vs* PRT: -0.41±5.6; F=5.6; p=0.022).

Conclusion: EST produces similar effects as PRT on the improvement of 1RM, TUG, and CST for PwMS. However, for patients who participated in this study the EST seems to promote a better transfer of strength adaptations to the functional tests, which are closer to daily-living activities.

Keywords: Multiple sclerosis, strength training, activities of daily living, muscle weakness.

List of abbreviations in alphabetical order

1RM: One Repetition Maximum

BMI: Body Mass Index

CST: Chair Stand Test

EDSS: Expanded Disability Status Scale.

EST: Eccentric Strength-Enhanced Training

MS: Multiple Sclerosis

MVIC: Maximal Voluntary Isometric Contraction

OMNI-RES: Resistance Exercise Scale

PRT: Progressive Resistance Training

PwMS: Patient with Multiple Sclerosis

TUG: Timed 8-Foot Up and Go Test

Introduction

Multiple sclerosis (MS) is an autoimmune disease of unknown etiology that has inflammatory components and chronic degenerative effects on the central nervous system.[1] This disease is more prevalent in women[2] and is the main cause of non-traumatic neurological disability in the young population (25-40 years old). Those who are affected often present a progressive reduction in functional capacity and a consequent increase in the degree of disability[3] that has a negative impact on work, family and social life.[4]

Regular physical exercise may lead to decreased fatigue[5] and improvements in spasticity[6-8] in patients with MS (PwMS). This is a therapeutic complement in rehabilitation programs,[9] which prioritize mobility, aerobic and strength exercises. However, classic progressive strength training (PRT) in PwMS is a relatively new approach.[10]

Research has shown that whereas healthy people manage to activate between 94 and 100% of their motor units, PwMS activate between 47 and 93%.[11-13] Muscle strength has been noted to be an important determinant of gait velocity in PwMS,[14] mainly due to the observable correlations between different gait parameters and quadriceps and hamstring muscle strength.[15]

Chronic eccentric stimuli produce rapid and important muscle adaptations[16] by requiring the activation of a greater number of muscle fibers, which are the producers of more strength.[17] This type of stimuli is also an effective method for reducing the muscle damage caused by an unaccustomed exercise.[18]

Some studies have shown the beneficial effects of eccentric strength-enhanced training (EST) on healthy adults[19-21] and given that MS is a neurological disease, this type of training may be advantageous for eliciting a higher stimulation of the cerebral cortex and gains in muscle power and hypertrophy.[22] It has also been shown that this type of training can be safely used by people with some types of chronic diseases.[19,23,24] However, it has not been clarified whether this type of training could produce the same benefits in PwMS.

Usually, studies comparing the effects of PRT *versus* EST are performed on people with characteristics other than MS. The hypothesis was that the EST had increases in muscle-strength and functional capacity more accentuated than the PRT in people with MS with at least 1 year of experience in strength training. Thus, the objective of this investigation was to compare the effects of PRT *versus* EST on the performance of functional tests and different strength manifestations in the knee extensors of PwMS.

Methods

Participants

We evaluated 52 PwMS belonging to six MS rehabilitation centers within the region of Castilla y León/Spain, that had already been participating in a strength training program. After a group meeting where the details of the investigation were described to the patients, including possible risks and discomfort associated to the intervention, a formal invitation to take part in the study was offered. All patients had a confirmed diagnosis of MS according to the McDonald criteria.[25]

The inclusion criteria were walking (with or without assistance) at least 20 meters; ability to perform the proposed exercises; minimum experience of one year with strength training; and attendance of at least 80% of the training sessions. All subjects provided written informed consent. The study was conducted in accordance with the Helsinki Declaration and approved by the Institutional Ethics Committee.

Research design

Participants were assigned to one of two groups: control group and experimental group, depending on their geographical location, so that they could be assigned to the training unit closer to their home. The experimental group did EST, and the control group performed PRT. We trained the knee extensor muscles in both groups. The trainings were conducted twice a week for 12 weeks, and all assessment procedures were monitored and supervised in person by a physician. The research design is showed in the Figure 1.

Evaluation procedures

The degree of disability was determined using the Expanded Disability Status Scale (EDSS),[27] which was administered by a physician. The functional capacity tests were the timed 8-foot up and go test (TUG) and the chair stand test (CST), which were carried out according to the Rikli and Jones[28] protocol.

All strength evaluations were performed on a multistation machine[A], bilaterally exercising the knee extensors.

The evaluation of maximal voluntary isometric contraction (MVIC) was performed with a strain gauge[B] and software[C]. We used a 90 degree angle of knee flexion, as determined using a goniometer[D], following the protocol used in other studies.[29-31] Two separate attempts were made, with an interval of three minutes between each attempt. The highest value obtained was considered the valid result.

For maximum dynamic strength evaluation, we used the one repetition maximum (1RM) protocol.[32] For the four warm-up repetitions, a load corresponding to 50% of the MVIC was used. Under the supervision of the trained evaluator and after indicating the patient's subjective perception of the effort through the OMNI-RES (OMNI-Resistance Exercise Scale),[33] the load was progressively increased between 5 and 8 kg. Two repetitions were performed with each load until the patient was able to perform only a single repetition; this load mobilized only once was considered the 1RM. In case of not even achieving one repetition, an intermediate load was placed between the one that had moved twice and the one that had not been able to move. A maximum of five loads was allowed, with an interval of three minutes between each of the loads.

Classic progressive resistance training: Control Group

PRT was conducted using the same multistation machine[A] on which evaluation of the knee extension exercise had been performed. Simultaneously, with both legs between 90° and 180° of extension, patients were encouraged to perform the extension at maximum speed and slow braking of the load in flexion. The training was personalized and prescribed following the general recommendations of the American College of Sports Medicine[34] and according to the load obtained after the 1RM evaluation. Table 1 shows the PRT program.

Eccentric strength-enhanced training: Experimental Group

EST sessions were conducted on the Multi-gym flywheel device[E]. In each training session, 4 sets of 8 repetitions were executed, with an interval of 2 minutes between sets. The training was performed as described by Tesch et al.[35] In short, the subject, from a starting position of 80-90° knee angle, pushes against a footplate with your maximal concentric force. Once the pushing or concentric phase has been completed at almost full knee extension (160-170º), the Yoyo inertial flywheel machine generate a kinetic energy in an opposite direction and, thus, returns the footplate. In an attempt to resist the force produced by the pull of the flywheel, the subject then performs an eccentric muscle action. The next cycle is initiated after the flywheel(s) has come to a stop.

Initially, the Yoyo inertial flywheel machine was adjusted such that the knee angle could not exceed 170° during extension. This individual setting was kept throughout the entire series of experiments. Any session was preceded by a standardized 5-min on the stationary bicycle. After, four sets of eight maximal coupled concentric and eccentric actions were performed from approximately 80 to 170° knee angle using the Yoyo. Subjects were requested to perform a maximal concentric action through that range and were then asked to resist gently during the initial 20° of the subsequent eccentric action, and then aim at bringing the wheel(s) to a stop at 80° before initiating a subsequent concentric action. Two minutes of rest were allowed between each bout of eight coupled muscle actions. All repetition were performed with strong, verbal encouragement.

Due to the peculiarities of the PwMS and to maintain their security, an adaptation was made to the original chair, by including a back on the chair for support. Training data were checked and recorded using the optical encoder[F] and software[G], and with each repetition, the volunteers were verbally encouraged to try to use their maximum possible strength (all out).

Statistical analysis

Data analyses were performed using the statistical software[H]. Data were subjected to the Kolmogorov-Smirnov with Lilliefors corrections normality test; the logarithmic transformation (base 10) was performed for dependent variables that did not show a normal distribution. The descriptive analysis was presented with both mean and standard deviation (SD). The baseline comparison of variables between groups was performed using the Student’s t-test for parametric variables and the Mann-Whitney U-test for non-parametric variables. The homogeneity of variances was determined by Box's M test. Intragroup (pre x post) and intergroup (PRT x EST) comparisons were performed using general linear models (GLM) multivariate analysis of covariance (MANCOVA). This utilized two factors: the time factor for intragroup comparison and the group factor for intergroup comparison. To control a possible effect of disability degree on the analyzed variables, EDSS values were used as a covariate in the analysis. Statistical significance was set at $p<0.05$.

Results

General sample characteristics can be seen in Table 2. No differences in the initial values of any variables were observed between the groups. All 52 participants completed the study. Multivariate analysis of covariance (M value) on the primary outcomes confirmed the homogeneity of variances between the EST and PRT groups (Table 3).

The results analysis of functional tests and different strength manifestations are presented in Table 3. It must be noted that no musculoskeletal injuries or unpleasant effects were attributable to training during the intervention period in either PRT or EST. We believed that working with patients who had already participated in a strength-training program constituted a safety factor as we were unaware of the possible side effects of a high intensity (EST) workout on PwMS.

The results of multivariate test statistics are showed in Table 4. It is possible to observe that the time factor and the group factor have significant influence on the functional test CST. In the same line, both factors also have significant influence on TUG. However, the 1RM only show to be affected by the factor time. The MVIC wasn´t influenced by any factor (time and group).

Thus, seems that the both training types, PRT and EST, can improve the performance of PwMS in functional tests and 1RM. However, it seems that the EST is more effective than PRT to promote gains in functional capacity, as suggested for the group comparison (Table 4). On the other hand, both training types seem to produce the same effect on 1RM and MVIC.

Discussion

Despite an increase in strength following participation in a PRT program has already been demonstrated in PwMS,[29,31,37] this study was undertaken for two reasons: findings in scientific publications regarding the effects of EST improving function in patients suffering from, e.g., neurological pathologies, age-induced sarcopenia or muscle-tendinous problems[38-40]; and because there is an absence of studies verifying the effects of these two training systems in PwMS. Attempts have also been made to analyze the effects, not only on strength, but also on functional tests—such as CST and

TUG—which are similar to daily life activities and are frequently used in studies of PwMS.[31,37,41-43]

As far as we know, the only study that deals with work eccentrically enhanced in PwMS is that carried out by Samaei et al.[41], who subjected PwMS to 12 weeks of treadmill training. The individuals were divided into two groups, one walking with 10% inclination (concentric group), and one walking with a 10% slope (eccentric group). The authors observed significant improvements in the eccentric group for fatigue, mobility, functionality, balance, and quadriceps strength, as seen in the main results for this study.

In the CST, which can be considered an indicator of lower-limb strength/power[44] in PwMS, it was observed that both time factor (pre- and post-comparisons) and group factor (intergroup comparisons) produced significant improvements in this variable. These findings agree with the study by Dalgas et al.,[37] who state that 12 weeks of PRT produced increases in the CST in PwMS. However, intergroup comparisons show that EST induced a greater increase in CST performance than PRT. One possible explanation for this finding may lie in the fact that, while both training types can promote strength gain, EST can also provide neuromuscular stimuli induced by different muscle activation strategies during eccentric exercise,[45] thereby promoting more pronounced adaptations and reflecting the improvements in functional capacity.

For the TUG, which is an indicator of gait speed with change of direction, it was observed that both time and group factors produced improvements, reducing the time needed to carry out the displacement of the marked distance; however, this improvement is greater in EST. Studies presented by De Souza-Teixeira et al.,[31] Dalgas et al.,[37] and Samaei et al.,[41] observed improvements in TUG results for PwMS under different types of training. In our opinion however, lack of a significant difference in the

PRT is probably due to people having previous training experience.[36] Likewise, Pearson, Dieberg, and Smart[47] conducted a meta-analysis considering four studies that evaluated TUG after different types of training, such as strength, aerobic, and combined training. The decrease in gait speed that is usually presented by PwMS may be due to a loss of muscle strength and increased in lower-limbs fatigue,[48] among other factors. In this sense, the performance of strength training, whether classic or eccentrically enhanced, can lead to improvements by inducing neuromuscular adaptations that have a reflex in increasing strength levels, muscular endurance, and coordination.[29,31,37] Therefore, PwMS who undergo a lower-limb strength-training program may benefit from an improvement in their walking ability regarding muscle strength and power per incremental means.

We believe that the experienced sample influenced all outcomes as strength gains in already trained people are smaller than in untrained individuals.[36] The two types of strength training employed in this study improved 1RM (according to the time factor), similarly to that of other studies on PwMS.[29,42,49] These results may be a consequence of muscle hypertrophy or the improvement of nervous components, such as an improvement in the recruitment of motor units or the reduction of inhibitory impulses.[9]

No significant differences were seen in MVIC regarding both time factor and group factors. Other studies that evaluated the effect of PRT on MVIC[30,31,41] found that this type of training increased isometric strength; this is inconsistent with the findings of the present study. One possible explanation for this discrepancy may be the fact that this research was developed using a sample populated by individuals with at least one year's experience with strength training; this fact was not reported in other studies that found improvements in MVIC.

Muscle strength can be considered an independent predictor of mortality, since the hazard ratio between mortality and quadriceps strength is 1.36 for men and 1.56 for women[50]. In addition, strength loss is associated with an impairment of functional capacity by 1.86 times[51]. Thus, it is important to emphasize the clinical significance, since increases in the lower limbs strength in PWMS can be reflected in improved walking ability and overall functionality. Although we didn't evaluate the minimally clinically important difference, we infer from our results that both types of training may result in improvement of muscle strength. These strength gains could be related to the functional improvements, especially, in the ability to walk with changes of directions.

The practical consequences of this study's findings would concern activities relating to daily life; patients with previous strength-training experience could benefit from the implementation of eccentric exercise.

Study limitations

The present findings have a few limitations that must be considered when interpreting the results. First being that the sample of this study presents mild to moderate disabilities and is composed of several types of MS. PwMS with different clinical features may exhibit different responses to the exercise protocols used in this intervention. The other possible limitations are is the lack of randomization and the different proportion in the numbers the males in the groups. Moreover, the results should be cautiously generalized to other muscle groups and/or other patients who are affected by this disease. The participants and the supervising investigators were not blinded to the intervention. However, it is difficult to blind participants (and trainers) to an exercise intervention, because a placebo exercise intervention will be revealed by participants. Nonetheless, we conclude that supervised PRT performed in small groups of patients with MS is effective in improving muscle strength and functional capacity. Therefore, future studies are needed to confirm the effects of the protocols employed here in more disabled PwMS, in different muscle groups and in those with different experience levels of strength training.

Conclusions

EST produces similar effects as PRT on the improvement of 1RM, TUG, and CST for PwMS. However, for patients who participated in this study the EST seems to promote a better transfer of strength adaptations to the functional tests, which are closer to daily-living activities.

Suppliers

A.

A Multistation machine BH® fitness Nevada Pro-T was employed in the present study for all test procedures and for the training in the group control. Supplier: EXERCYCLE S.L. 22 Zurrupitieta, Pol. Ind. Júndiz, Vitoria-Gasteiz 01015. Spain. Telephone: +34 945 290 258; Fax: +34 945 290 049.

B.

A Globus Ergometer® strain gauge with a sampling frequency of 1000 Hertz was employed in the present study for the evaluation of maximal voluntary isometric contraction of all participants. Supplier: Domino srl. 52 Via Vittorio Veneto, Codognè 31013. Italia. Telephone: 0039 0438 7933; Fax 0039 0438 793363.

C.

A Globus Ergo Tester v1.5 software was used for recording and transcribing the evaluation of maximal voluntary isometric contraction test data of all participants. Supplier: Domino srl. 52 Via Vittorio Veneto, Codognè 31013. Italia. Telephone: 0039 0438 7933; Fax 0039 0438 793363.

D.

A goniometer TEC® was used to determine a knee flexion of 90 degree angle. Supplier: Sport-Tec Physio & Fitness. 255 Lemberger Straße, 66955 Pirmasens. Germany. Telephone: +49 (0) 63 31/14 80-0; Fax: +49 (0) 63 31/14 80-220.

E.

The Multi-gym flywheel device YoYo™ Technology Inc was employed for the training sessions of the experimental group. Supplier: YoYo Technology AB (Inc) Pryssgränd 10 B, 118 20 Stockholm, Sweden. Telephone: +46 (0) 70 819 31 10.

F.

A SmartCoach® optical encoder was used for and recorded experimental group training data. Supplier: SmartCoach Europe AB. Pryssgränd 10B. 11820 Stockholm, Sweden. Telephone: +46 (0) 70 819 31 10.

G.

A SmartCoach® software v3.1.3.0. was employed to record and transcribe the experimental group training data. Supplier: SmartCoach Europe AB. Pryssgränd 10B. 11820 Stockholm, Sweden. Telephone: +46 (0) 70 819 31 10.

H.

A statistical software IBM SPSS (Statistical Package for the Social Sciences) version 21 was used to make the statistical analysis. Supplier: IBM Corporation, 1 New Orchard Road, Armonk, New York, 10504-1722, USA. Telephone: +1 914 499 1900

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Figure 1. Experimental design.

Legend: PRT: classic progressive resistance training; EST: eccentric strength-enhanced training; EDSS: Expanded Disability Status Scale.

Table 1. Classic progressive resistance training program.

Weeks	Set 1		Set 2		Set 3	
	Load (% 1RM)	reps	Load (% 1RM)	reps	Load (% 1RM)	reps
1-2	35	10-12	50	8-10	35	10-12
3-4	40	10-12	55	8-10	40	10-12
5-6	45	10-12	60	8-10	45	10-12
7-8	50	10-12	65	8-10	50	10-12
9-10	55	10-12	70	8-10	55	10-12
11-12	55	10-12	70	8-10	55	10-12

1RM: one repetition maximum; reps: repetitions

Table 2. General sample characteristics.

Characteristics	PRT	EST	Normality (p-value)	Baseline comparisons (p-value)
Number (♂/♀)	21 (6/15)	31 (13/18)	-	-
Age (yars)	50.6 (9.3)	46.0 (11.7)	0.737	0.164
Body weight (kg)	65.1 (11.1)	68.8 (13.3)	0.754	0.269
Heigth (m)	1.64 (0.9)	1.67 (0.9)	0.499	0.141
BMI (kg/m²)	24.0 (2.9)	24.3 (4.0)	0.807	0.802
EDSS (a.u.)	3.9 (1.2)	3.3 (1.4)	0.099	0.085
Type of ME	14 RR/6 CP/1 ND	20 RR/6 PP/2 CP/3 ND	-	-
Disease duration	11.7 (8.5)	11.0 (7.6)	0.241	0.829
CST (rep.)	14.8 (4.1)	14.2 (5.0)	0.181	0.667
TUG (s)	9.3 (3.4)	9.5 (6.1)	0.005	0.484
MVC (kg)	79.1 (27.1)	89.4 (31.8)	0.496	0.234
1RM (kg)	72.0 (22.9)	80.8 (27.0)	0.476	0.224

PRT: Progressive Resistance Training; EST: Eccentric Strength-Enhanced Training; BMI: Body Mass Index; EDSS: Expanded Disability Status Scale; RR: relapsing-remitting; CP: chronic progressive; PP: primary progressive; ND: not determined; CST: chair stand test; TUG: timed 8-foot up and go test; MVC: maximal voluntary isometric contraction; 1RM: one repetition maximum; a.u.: arbitrary units; rep.: repetitions; s: seconds; kg: kilograms.

Table 3. Chair stand test, timed 8-foot up and go test and muscle strength pretrial and posttrial and comparison of the results of the variables between PRT and EST. Mean ±SD.

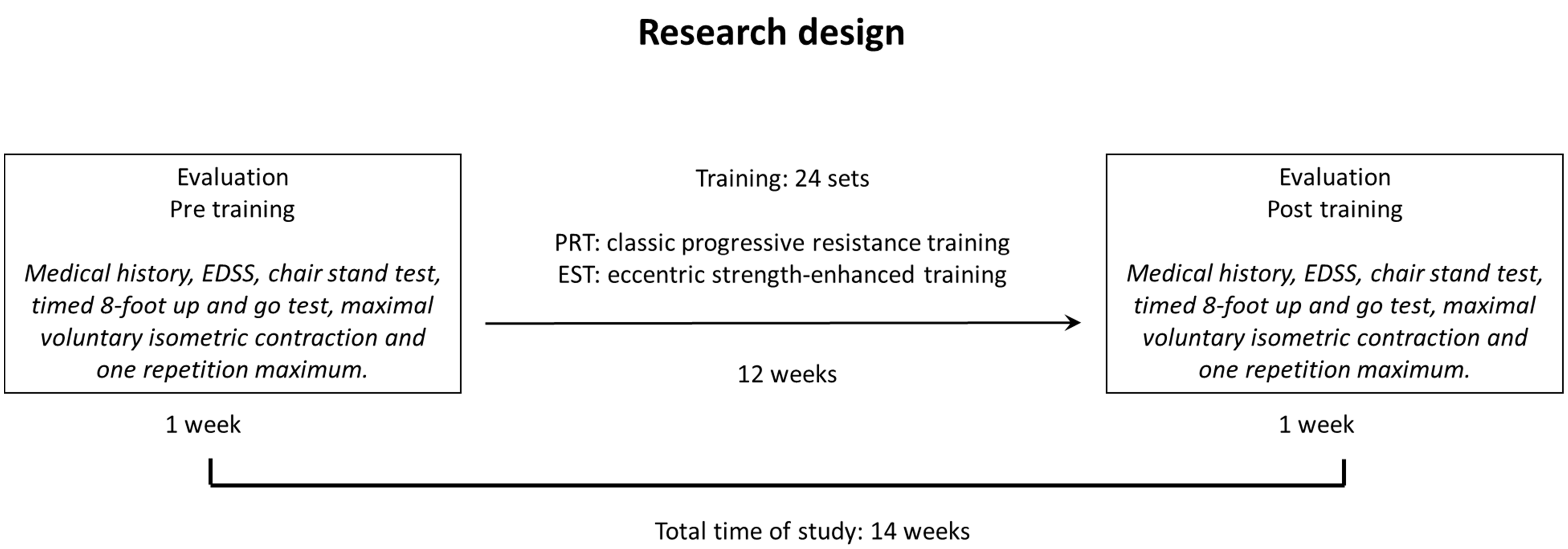
	PRT (n=21)		EST (n=31)		Homoscedasticity		Time factor Pre x Post		Group factor PRT x EST	
	PRE	**POST**	**PRE**	**POST**	**M**	**p**	**F**	**p**	**F**	**p**
CST (rep)	14.8 ±4.1	16.6 ±5.4	14.2 ±5.0	18.9 ±6.2	0.820	0.854	35.5	0.000	9.3	0.004
TUG (s)	9.3 ±3.4	8.4 ±7.6	9.5 ±6.1	6.6 ±2.3	14.241	0.004	4.3	0.043	5.3	0.026
MVIC (kg)	79.1 ±27.1	79.7 ±28.3	89.4 ±31.8	95.6 ±31.5	1.712	0.652	2.3	0.135	1.7	0.192
1RM (kg)	72.0 ±22.9	79.7 ±27.7	80.8 ±27.0	94.5 ±25.8	6.446	0.104	9.3	0.004	3.7	0.061

CST: chair stand test; TUG: timed 8-foot up and go test; MVIC: maximal voluntary isometric contraction; 1RM: one repetition maximum; rep: repetitions; s: seconds, kg: kilograms; M: Box's M test value.

Table 4. Results of multivariate test statistics for MANCOVA analysis, using time and group factors.

Variable	Effect		Value	F	Hypothesis df	Error df	Sig.
CST	Time	Pillai's Trace	0.440	38.546	1.000	49.000	0.000
		Wilks' Lambda	0.560	38.546	1.000	49.000	0.000
		Hotelling's Trace	0.787	38.546	1.000	49.000	0.000
		Roy's Largest Root	0.787	38.546	1.000	49.000	0.000
	Time * Group	Pillai's Trace	0.160	9.302	1.000	49.000	0.004
		Wilks' Lambda	0.840	9.302	1.000	49.000	0.004
		Hotelling's Trace	0.190	9.302	1.000	49.000	0.004
		Roy's Largest Root	0.190	9.302	1.000	49.000	0.004
TUG	Time	Pillai's Trace	0.081	4.335	1.000	49.000	0.043
		Wilks' Lambda	0.919	4.335	1.000	49.000	0.043
		Hotelling's Trace	0.088	4.335	1.000	49.000	0.043
		Roy's Largest Root	0.088	4.335	1.000	49.000	0.043
	Time * Group	Pillai's Trace	0.097	5.261	1.000	49.000	0.026
		Wilks' Lambda	0.903	5.261	1.000	49.000	0.026
		Hotelling's Trace	0.107	5.261	1.000	49.000	0.026
		Roy's Largest Root	0.107	5.261	1.000	49.000	0.026
MVIC	Time	Pillai's Trace	0.045	2.305	1.000	49.000	0.135
		Wilks' Lambda	0.955	2.305	1.000	49.000	0.135
		Hotelling's Trace	0.047	2.305	1.000	49.000	0.135
		Roy's Largest Root	0.047	2.305	1.000	49.000	0.135
	Time * Group	Pillai's Trace	0.034	1.748	1.000	49.000	0.192
		Wilks' Lambda	0.966	1.748	1.000	49.000	0.192
		Hotelling's Trace	0.036	1.748	1.000	49.000	0.192
		Roy's Largest Root	0.036	1.748	1.000	49.000	0.192
1 RM	Time	Pillai's Trace	0.159	9.261	1.000	49.000	0.004
		Wilks' Lambda	0.841	9.261	1.000	49.000	0.004
		Hotelling's Trace	0.189	9.261	1.000	49.000	0.004
		Roy's Largest Root	0.189	9.261	1.000	49.000	0.004
	Time * Group	Pillai's Trace	0.070	3.684	1.000	49.000	0.061
		Wilks' Lambda	0.930	3.684	1.000	49.000	0.061
		Hotelling's Trace	0.075	3.684	1.000	49.000	0.061
		Roy's Largest Root	0.075	3.684	1.000	49.000	0.061

CST: chair stand test; TUG: timed 8-foot up and go test; MVIC: maximal voluntary isometric contraction; 1RM: one repetition maximum.


Research design
Evaluation
Pre training
Medical history, EDSS, chair stand test, timed 8-foot up and go test, maximal voluntary isometric contraction and one repetition maximum.
1 week
Training: 24 sets
PRT: classic progressive resistance training
EST: eccentric strength-enhanced training
12 weeks
Evaluation
Post training
Medical history, EDSS, chair stand test, timed 8-foot up and go test, maximal voluntary isometric contraction and one repetition maximum.
1 week
Total time of study: 14 weeks