Effects of a Resistance Training Program in Multiple Sclerosis Spanish Patients: A Pilot Study

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Context: Physical exercise is regarded as a useful tool in the treatment of multiple sclerosis (MS). Generally, physical rehabilitation have been based on the prescription of aerobic exercises, while fewer programs have been aimed at developing muscular strength. Objective: To establish whether the physical fitness of MS sufferers can be improved by a training program for developing muscular strength. Design: Before and after study Setting: University multipurpose room Participants: 36 patients, all able to walk, belonging to the Leon Multiple Sclerosis Association. Interventions: The physical exercise programme consisted in resistance training sessions, based mainly on callisthenic, or bodyweight, exercises, during six weeks. Key Words: neuroscience

Multiple sclerosis (MS) is an inflammatory illness of the central nervous system (CNS) affecting those genetically predisposed exposed in their childhood to environmental factors as yet only partially understood, but probably of a viral nature. The inflammation is the product of the self-damaging action of the immune system on the white matter of the CNS, which results in the destruction of myelin. The symptoms and signs of the illness vary depending on the areas affected and on how badly affected they are. MS can cause fatigue, loss of balance, muscular weakness, and other impairments of the patient’s autonomy and quality of life.

As a result of the illness and as there is no cure, patients are not infrequently in poor physical condition, exacerbated by the inactivity involved, so any neuromuscular rehabilitation program must obviously include physical exercise. Several studies report a noticeable improvement in the physical fitness of these patients after certain training programs. Generally speaking, such programs have been based on the prescription of aerobic exercises with a view to ascertaining how much exercise MS patients can do, along with its potential benefits in reduction of symptoms such as fatigue, while far fewer programs have been aimed at developing muscular strength. On the other hand, the programs require complex installations and qualified personnel, quite different from the sports services offered by gymnasia and the like today. Furthermore, many chronic patients find it extremely difficult to leave...
their homes and get to places with the appropriate facilities, which impedes adherence to programs. For all these reasons, the purpose of this study is to establish whether the physical fitness of MS sufferers can be improved by a training program for developing muscular strength, based on simple physical exercises easy to carry out with hardly any equipment after a period of learning.

**Materials and Methods**

The 36 patients selected (14 men and 22 women) were all volunteers belonging to the *Asociación Leonesa de Esclerosis Múltiple* (León Multiple Sclerosis Association). All were able to walk and met Poser’s criteria for the diagnosis of MS and Shumacher’s criteria for the progressive forms. All suffered from the secondary progressive form, with an average score on the Expanded Disability Status Scale (1-6) of 1.5.

The physical exercise program consisted in resistance training sessions, based mainly on calisthenic or bodyweight exercises, where the patient’s body weight is the load to be lifted, with no additional equipment. The program took place in October and November, when the temperature was never over 17ºC. The sessions lasted 60 minutes and there were three per week for six weeks. Before and after the program, a number of functional tests were run to establish the patients’ original fitness and any changes.

**Physical Fitness Tests**

Physical fitness tests were chosen for their ease of organization and control, their lack of need of apparatus, and their low demand on the patients. The abilities measured and the tests used were as follows:

- Walking speed: a zig-zag (Z-Z) run of 9 meters. Distance run in meters noted.
- Mobility of arms and time-space orientation. Clapping test (CT) and dynamic flexibility test (DF). Number of repetitions noted.
- Explosiveness of arms: throwing a medicine ball over the head (MB).
- Explosiveness of legs: vertical jump with feet together, hands on hips (VJ, measured in cm).
- Trunk strength: abdominal test (AT), back muscle test (BM), leg lifts (LL), scored as repetitions, and a Kraus-Weber (KW) test, with length of lift scored in seconds.
- Balance: flamingo balance test (FB), positions kept for the longest possible time(s).

**Session Structure**

All the sessions took place in a multipurpose room measuring 20 × 15 m. They began with a warm-up consisting always of the same balance and coordination exercises, based chiefly on walking around the room in different manners and direc-
tions: in line, on tiptoe, on the heels, sideways, backwards, and with eyes closed (individuals and group). All these exercises were combined as much as possible to give variety and avoid monotony.

The main part of the session consisted principally of simple calisthenic exercises designed to tone up the muscles and increase balance. Standing exercises were always alternated with ones done lying down so that the patients had to get up and lie down many times during a session, which also meant an effort that also developed their strength, balance, and coordination. Some of the fitness tests were included in the training because of its specific nature. The exercises and the order in which they were done are as follows:

- In pairs, standing with the legs together, bending and stretching knees, each with his hands on the other’s shoulders.
- Sit-ups with knees bent and a partner holding the ankles (AT).
- Standing back-to-back in pairs and rotating the trunk both ways, clapping hands.
- Lying face up holding the ankles of a standing partner from behind, raising the legs together to form a right angle with the trunk. Legs lowered without touching the floor (LL).
- Individual sit-ups.
- Lying face up, knees bent and ankles raised, bending the hips so that the knee move horizontally to the chest.
- Standing back-to-back, legs apart, bending the trunk to clap hands between the legs and stretching to clap over the head.
- Lying face down, a partner holding the ankles, stretching the trunk (back muscle test).
- Standing, resting on a partner’s shoulder, and with one leg on the ground, the other one is repeatedly bent and stretched.

The sequence was repeated once or twice per session, with the intensity depending on the patients themselves, as from the outset it was decided that no exercise should be pushed to its limits, that is the patient should be able to intuit the approximate number of repetitions that he could carry out in each exercise and always do two or three under that number. This way, as the training process progressed, so did the intensity of the exercises, always monitored by each individual.

Then a balance exercise was done in pairs, each resting on the other’s shoulder and raising a foot to the buttocks and holding it with a hand, eyes closed. Once the patient felt sufficiently stable, he stood apart from his partner and tried to remain standing on one leg (FB).

To end the main part of the session, medicine balls of 2-5 kg were chosen by each pair. The exercises consisted in a number of one- or two-hand overhead throws to the partner, twisting the trunk, facing, sideways or with the back turned, varying the throw every two minutes or so.

For the final stage of the session, each individual lay down face up with the knees bent and tried to press the hands against the floor, under the back. Thus, the return to calm was used to carry out a simple abdominal exercise.
Statistical Method

Statistical analysis was carried out by means of the SPSS, Epiinfo 6.0 and Epidat 3.0 programs. For descriptive statistics, the mean and median were used as centralizing measurements, with standard deviation and range and measurements of dispersion. For the bivariate analysis of qualitative variables, the chi-squared test was applied with Yates’ corrections or Fisher’s exact test, according to cases.

In the bivariate analysis of qualitative and quantitative variables, after checking for normality of distributions with the Kolmogorov-Smirnoff test, the variance analysis test (ANOVA) was used in the case of normality and the Mann-Whitney non-parametric test in the case of abnormality of distributions. To value changes undergone among the variables measured before and after training, a comparison was made of the measurements by means of the t-test in the case of normal distributions, and Wilcoxon’s non-parametric test in the case of abnormal ones.

Results

Of the initial group of 36, six left the program for reasons of work. Six of those who attended the sessions normally suffered from relapses on the days of the final tests, so the data shown are for 24 patients (15 women and 9 men), who attended more than 85% of the sessions and took part in the program with complete normality from start to finish.

The characteristics of the sample are given in Table 1. Table 2 shows the overall condition of patients, with the results of the original physical tests, and it will be observed that some patients were unable to carry out the original trunk and leg strength test, along with those of movement and balance.

Table 1 Characteristics of the Sample

<table>
<thead>
<tr>
<th>Patients (n)</th>
<th>Age</th>
<th>Height</th>
<th>Weight</th>
<th>Years as Sufferers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group (24)</td>
<td>44.4 ± 9.5</td>
<td>161.4 ± 1.7</td>
<td>61.5 ± 11.5</td>
<td>8.17 ± 8.3</td>
</tr>
<tr>
<td>Men (9)</td>
<td>42.2 ± 10.6</td>
<td>169 ± 7</td>
<td>63.2 ± 9.6</td>
<td>9.7 ± 9.8</td>
</tr>
<tr>
<td>Women (15)</td>
<td>45.4 ± 9.1</td>
<td>160.2 ± 4.8</td>
<td>60.8 ± 12.4</td>
<td>7.4 ± 7.7</td>
</tr>
</tbody>
</table>

Table 2 Results of the Initial Physical Tests

<table>
<thead>
<tr>
<th>Total</th>
<th>MB (cm)</th>
<th>CT (rpts)</th>
<th>K-W (s)</th>
<th>Z-Z (s)</th>
<th>DF (rpts)</th>
<th>LL (rpts)</th>
<th>FB (s)</th>
<th>VJ (cm)</th>
<th>BM (rpts)</th>
<th>AT (rpts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.3</td>
<td>16.7</td>
<td>35.5</td>
<td>17.4</td>
<td>17.1</td>
<td>8.0</td>
<td>2.2</td>
<td>14.4</td>
<td>5.7</td>
<td>4.4</td>
</tr>
<tr>
<td>SD</td>
<td>1.1</td>
<td>3.5</td>
<td>32.1</td>
<td>9.1</td>
<td>7.1</td>
<td>7.7</td>
<td>3.1</td>
<td>7.9</td>
<td>8.5</td>
<td>5.8</td>
</tr>
<tr>
<td>Median</td>
<td>3.3</td>
<td>16.0</td>
<td>22.0</td>
<td>17.6</td>
<td>16.0</td>
<td>6.0</td>
<td>0.0</td>
<td>14.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Maximum</td>
<td>7.1</td>
<td>28.0</td>
<td>120.0</td>
<td>46.8</td>
<td>33.0</td>
<td>26.0</td>
<td>10.0</td>
<td>29.0</td>
<td>24.0</td>
<td>23.0</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.7</td>
<td>9.0</td>
<td>2.0</td>
<td>3.0</td>
<td>0.0</td>
<td>3.0</td>
<td>0.0</td>
<td>0.0</td>
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<td>0.0</td>
</tr>
</tbody>
</table>

MB = throwing a medicine ball over the head; CT = clapping test; K-W = Klaus Weber Test; Z-Z = a zig-zag run of 9 m; DF = dynamic flexibility test; LL = leg lifts; FB = flamingo balance test; VJ = vertical jump with feet together, hands on hips; BM = back muscle test; AT = abdominal test.
### Table 3  Effects of the Exercise Sessions on the Physical Condition Before and After the Training Program

<table>
<thead>
<tr>
<th>Total</th>
<th>MB ** (cm)</th>
<th>CT ** (rpts)</th>
<th>K-W (s)</th>
<th>Z-Z * (s)</th>
<th>DF * (rpts)</th>
<th>LL * (rpts)</th>
<th>FB (s)</th>
<th>VJ (cm)</th>
<th>BM** (rpts)</th>
<th>AT** (rpts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.2</td>
<td>3.7</td>
<td>16.2</td>
<td>19.2</td>
<td>31.0</td>
<td>34.2</td>
<td>21.3</td>
<td>17.6</td>
<td>16.2</td>
<td>19.3</td>
</tr>
<tr>
<td>SD</td>
<td>0.9</td>
<td>0.7</td>
<td>3.2</td>
<td>2.4</td>
<td>28.9</td>
<td>24.3</td>
<td>14.6</td>
<td>7.9</td>
<td>6.9</td>
<td>3.9</td>
</tr>
<tr>
<td>Median</td>
<td>3.3</td>
<td>3.5</td>
<td>16.0</td>
<td>20.0</td>
<td>20.0</td>
<td>24.5</td>
<td>19</td>
<td>16</td>
<td>16.0</td>
<td>19.5</td>
</tr>
<tr>
<td>Maximum</td>
<td>5.8</td>
<td>5.8</td>
<td>23.0</td>
<td>23.0</td>
<td>120.0</td>
<td>88.0</td>
<td>75</td>
<td>38</td>
<td>30.0</td>
<td>26.0</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.7</td>
<td>2.3</td>
<td>9.0</td>
<td>15.0</td>
<td>2.0</td>
<td>5.0</td>
<td>8</td>
<td>9</td>
<td>3.0</td>
<td>11.0</td>
</tr>
</tbody>
</table>

*P < .05; **P < .001. MB = throwing a medicine ball over the head; CT = clapping test; KW = Kraus-Weber test; Z-Z = a zig-zag run of 9 m; DF = dynamic flexibility test; LL = leg lifts; FB = flamingo balance test; VJ = vertical jump with feet together, hands on hips; BM= back muscle test; AT = abdominal test.

### Table 4  Effects of the Training on the Physical Condition in Men

<table>
<thead>
<tr>
<th>TOTAL</th>
<th>MB ** (cm)</th>
<th>CT ** (rpts)</th>
<th>KW (s)</th>
<th>Z-Z * (s)</th>
<th>DF ** (rpts)</th>
<th>LL * (rpts)</th>
<th>FB (s)</th>
<th>VJ (cm)</th>
<th>BM** (rpts)</th>
<th>AT** (rpts)</th>
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</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.8</td>
<td>4.0</td>
<td>17.4</td>
<td>18.9</td>
<td>39.3</td>
<td>44.7</td>
<td>20.8</td>
<td>19.1</td>
<td>13.6</td>
<td>17.8</td>
</tr>
<tr>
<td>SD</td>
<td>1.0</td>
<td>0.8</td>
<td>3.4</td>
<td>3.3</td>
<td>33.8</td>
<td>30.4</td>
<td>13.3</td>
<td>9.9</td>
<td>6.4</td>
<td>3.9</td>
</tr>
<tr>
<td>Median</td>
<td>4.0</td>
<td>4.0</td>
<td>18.0</td>
<td>18.0</td>
<td>30.0</td>
<td>33.0</td>
<td>21</td>
<td>20</td>
<td>12.0</td>
<td>17.0</td>
</tr>
<tr>
<td>Maximum</td>
<td>6.0</td>
<td>6.0</td>
<td>23.0</td>
<td>23.0</td>
<td>120.0</td>
<td>88.0</td>
<td>47</td>
<td>35</td>
<td>23.0</td>
<td>23.0</td>
</tr>
<tr>
<td>Minimum</td>
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<td>13.0</td>
<td>15.0</td>
<td>13.0</td>
<td>13.0</td>
<td>8</td>
<td>9</td>
<td>3.0</td>
<td>11.0</td>
</tr>
</tbody>
</table>

*P ≤ .05; **P < .001. MB = throwing a medicine ball over the head; CT = clapping test; KW = Kraus-Weber test; Z-Z = a zig-zag run of 9 meters. DF = dynamic flexibility test; LL = leg lifts; FB = flamingo balance test; VJ = vertical jump with feet together, hands on hips; BM= back muscle test; AT = abdominal test.

### Table 5  Effects of the Training on the Physical Condition in Women

<table>
<thead>
<tr>
<th>TOTAL</th>
<th>MB ** (cm)</th>
<th>CT ** (rpts)</th>
<th>KW (s)</th>
<th>Z-Z * (s)</th>
<th>DF * (rpts)</th>
<th>LL * (rpts)</th>
<th>FB (s)</th>
<th>VJ (cm)</th>
<th>BM** (rpts)</th>
<th>AT** (rpts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.9</td>
<td>3.4</td>
<td>15.4</td>
<td>19.4</td>
<td>25.9</td>
<td>27.9</td>
<td>21.5</td>
<td>16.7</td>
<td>17.7</td>
<td>20.2</td>
</tr>
<tr>
<td>SD</td>
<td>0.7</td>
<td>0.6</td>
<td>2.9</td>
<td>1.9</td>
<td>25.4</td>
<td>18.1</td>
<td>15.8</td>
<td>6.8</td>
<td>6.8</td>
<td>3.7</td>
</tr>
<tr>
<td>Median</td>
<td>3.3</td>
<td>3.0</td>
<td>15.0</td>
<td>20.0</td>
<td>17.0</td>
<td>23.0</td>
<td>18</td>
<td>16</td>
<td>16.0</td>
<td>21.0</td>
</tr>
<tr>
<td>Maximum</td>
<td>4.5</td>
<td>5.0</td>
<td>20.0</td>
<td>21.0</td>
<td>100.0</td>
<td>77.0</td>
<td>75</td>
<td>38</td>
<td>30.0</td>
<td>26.0</td>
</tr>
<tr>
<td>Minimum</td>
<td>2.2</td>
<td>2.0</td>
<td>9.0</td>
<td>15.0</td>
<td>2.0</td>
<td>5.0</td>
<td>9</td>
<td>10</td>
<td>8.0</td>
<td>13.0</td>
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</tbody>
</table>

*P ≤ .05; **P < .001. MB = throwing a medicine ball over the head; CT = clapping test; KW = Kraus-Weber test; Z-Z = a zig-zag run of 9 m; DF = dynamic flexibility test; LL = leg lifts; FB = flamingo balance test; VJ = vertical jump with feet together, hands on hips; BM= back muscle test; AT = abdominal test.
The effects of the training on the physical condition of all the patients finishing the program are shown in Table 3. Significant improvements are to be noticed especially in the strength tests BM (0.4 ± 0.5 m); MB (8.4 ± 9 rpts); LL (4.1 ± 4.9 rpts) and AT (3.9 ± 5.1 rpts). Significant progress was also made in the walking speed test, Z-Z (3.7 ± 2.3 s.). Gender-based analysis is shown in Tables 4 and 5. Men, despite showing a significant improvement only in two strength tests, LL (4.3 ± 5.6 rpts) and AT (3.9 ± 3.8 rpts) and one orientation test, DF (4.2 ± 3.3 rpts), demonstrate a positive tendency in other similar tests. On the other hand, women registered significant changes in practically all the tests of strength, MB (0.6 ± 0.5 m); BM (11.1 ± 9.5 rpts); AT (3.9 ± 5.9 rpts); LL (3.7 ± 4.8 rpts); VJ (1.9 ± 3.1 cm), and in one of the space-time tests, CT (4.1 ± 3.2 rpts). Figure 1 shows the most significant changes overall and by gender.

Comments

The present study was carried out on volunteer patients with a good degree of autonomy, with a low score on the extended invalidity scale. All were members of a sufferers’ association, meaning a major selection bias, which makes it impossible
to extrapolate the results to MS sufferers in general, but only to those with similar characteristics. For ethical reasons, a before and after study was made, which makes it difficult to assess the results as there was no control group. An additional problem was not finding similar studies on the exercises in the literature most commonly consulted to facilitate comparison.

As our purpose was to ascertain the effects of a simple training program with nothing to do with controlled laboratory situations, we chose a series of tests responding to the same philosophy. Some of them are included in the Eurofit battery and others, like the Kraus-Weber Test, are habitually used for special populations. They all allowed us to assess and compare our patients’ physical fitness and are easily reproduced.

In the light of the initial results, when these are compared with healthy populations of similar ages and nationality, it is clear that MS sufferers are less able to develop muscular strength. Similar findings have been found previously, although the tendency is less clear regarding the arms, perhaps because, as is well known, the illness usually affects the legs earlier.

The lesser muscular strength of MS sufferers is due to muscular metabolic disturbances, such as a lower oxidation capacity, smaller section, fiber atrophy, and reduced activity of the enzyme Succinate dehydrogenase (SDH), all factors indicating muscular unfitness derived from physical inactivity. In any event, there are factors directly linked to the nervous affection characteristic of the illness, such as difficulty in achieving complete muscular action, greater tension from the cross-bridge mechanism, nerve conductivity blocking, and the normal fatigue brought on by MS, which prevents sufferers from keeping up muscular tension for any length of time. The low values for speed of movement and for balance in our sample match the results of other studies, while the problems of coordination evidenced by the test reflect the speed with which this is lost with the onset of the illness.

It has been suggested that MS sufferers could improve their strength by means of progressive resistance exercise and water exercise. In our study, a significant improvement in the strength of the trunk and hip muscles (Figure 1) was noticed in both men and women. In the case of the clapping and lumbar tests, the improvements are significant in the women and over the whole sample, but are not significant in the case of the men (Figure 1). It is thus borne out that muscular strength training, applied in moderation and adapted to the sufferers’ needs, can reduce muscular weakness, provided that it is not too severe and that the illness is progressing slowly.

This progress, reflected in the BM, LL, and AT tests, must depend on the specific nature of the training, as the tests were proposed as fundamental training exercises. There was also significant progress in the CT coordination test, perhaps because coordination benefits directly from an improvement in fitness. Balance, however, despite specific training, achieved no improvement, owing perhaps to the absence of exhaustive training in this field and especially to the difficulty of using an instrument sufficiently sensitive to measure it. Other similarly designed studies achieved an improvement in strength, but not in the balance of sedentary women or adults nearing old age. Neither were there any significant changes in the Kraus-Weber Test, possibly because training was not specific for it, or because the initial level was quite high, meaning that training would not have
been intensive enough to bring on significant changes. On the other hand, this test
requires prolonged isometric muscular contraction, and MS sufferers find it difficult
to keep up muscular tension over time, mainly because of a certain neuromotor
handicap. This nervous dysfunction is hardly likely to be improved by training,
as it is caused by demyelization while, moreover, isometric contraction was not
included in the programmed exercises, so the lack of progress in this regard should
come as no surprise. As for speed of movement, both men and women tended
toward improvement, with a significant change in the group as a whole. Gutiérrez
et al\textsuperscript{39} proposed an eight-week training program using protocols of strength based
on maximum repetitions (MR). There were two sessions per week, dedicated
mainly to leg and trunk muscles. Improvements were noticed in fatigue, disability
level, and strength of the muscles trained, while there was also a positive change
in walking patterns, attributed to the great correlation between flexing strength of
the hip muscles plus the extending strength of the knee and efficiency of walking.
In our protocol, some exercises, such as sit-ups and leg-lifts, develop these muscles,
which would explain the changes observed in the zig-zag test. Another point of
agreement between the two studies concerned commentaries by participants to the
effect that they found it easier to perform such tasks as climbing stairs, crossing
streets, or walking without a stick. White et al\textsuperscript{40} designed a program for developing
the strength of the legs by means of conventional weight machines and achieved
significant improvements in the extending muscles of the knee and the flexing
of the sole. Nevertheless, walking speed did not increase, although there were
improvements in the number of steps taken in three minutes, so these authors
conclude that if the walking test (25-feet walking speed) had been longer, then the
results would have been more noticeable, which supports the use of such tests as
the zig-zag in these measurements.

It is interesting that the training should not have affected the sexes alike. The
strength of the arms improved significantly in the women, while in the men there
was only a slightly positive tendency in this regard. This may be due to the greater
initial strength of the men, meaning that the weight of the medicine balls was not
enough to stimulate muscle development efficiently. On the other hand, it is to be
supposed that the lack of notable changes in the vertical jump test were due to the
need for basic balance and great neuromuscular activation in a very short time.
Women, however, benefited significantly from the training, perhaps because they
had lower initial levels of strength and balance, so the intensiveness of the training
may have been sufficient to bring on a slight improvement leading to a higher final
jump. For the same reason, the higher initial level of the men would require a greater
intensity of training to achieve similar changes, which would explain the lack of
variation in the men’s results for this test. On the other hand, the men progressed
significantly in the DF test, while women just showed a tendency to improve. As
this test requires a certain level of flexibility and mobility of joints, it would be
appropriate to think that the lower initial level of the men meant that they benefited
more from the training, while the women would require more specific exercises, as
they naturally enjoy greater flexibility and joint mobility. The different response to
the strength training by sex is nothing new in MS. Surakka et al\textsuperscript{41} suggested strength
training based on pressurized air resistance machines or weight sack machines, first
for instructing patients, who carried on the training in their homes using elastic
bands in combination with aerobic exercises. At the end of the program, the women
showed less motor fatigue. For these authors, the length of the program (6 months) may have been the cause, as the disability progresses more quickly in men, who could have become more affected by their MS while the research was going on. Our study only lasted 6 weeks, so the hypothesis that the intensity of training was not right for the initial level of the patients in some exercises gains credit and goes further to suggest that strength training may not affect men and women to the same extent, but should be adapted to individual needs.

As for other studies with the aim of developing a program of simple strength exercises for patients to do at home, we have only found one. De Bolt et al. worked for six months on the muscular strength of 19 MS patients with weighted vests, who then took part in a 23-week “home-based resistance exercise program.” The structure and frequency of the sessions and the exercises done were similar to ours, with the exception that they used ankle weights and steps for some of them. The patients improved their leg extensor power significantly, although balance was not affected and a positive though not significant tendency was noted in the increase in speed of movement; these results were similar to ours. No commentaries were made regarding sex, although only 4 men took part in that study.

Finally, it should be pointed out that several patients were not strong enough to do the initial tests, but were able to do the final ones, which we consider should be interpreted as a positive effect of the training. In any event, the great variability of the results shows the need to individualize any type of rehabilitation technique when physical exercise is prescribed to MS sufferers.

**Conclusion**

Our results confirm the usefulness of strength training for the rehabilitation of MS patients and their trainability with simple exercises, which may form part of a home-based exercise program, a valuable solution for those wish to exercise by themselves. On the other hand, it reveals the need for physical exercise to be prescribed individually for these people and that the effects of strength training may have a major impact on the daily life of the patients, while also showing the need for further research.

**References**


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