Review

Physical exercise as non pharmacologic therapy in knee osteoarthritis

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A R T I C L E   I N F O

Article history:
Received September 25, 2008
Accepted December 1, 2008

Keywords:
Osteoarthritis
Joint disorder
Exercise
Physical activity
Strength

A B S T R A C T

Knee osteoarthritis is one of the most frequent joint disorders, and its major symptoms are pain and physical disability. Cartilage regeneration therapies are still under development, and current treatments target pain and disability. Physical activity could be a cheap and effective therapeutic option. However, it is not yet known which types of exercise are the most beneficial, as well as its load or intensity. Therefore, the objective of this work is to integrate all the information about the design of training programs for knee osteoarthritis treatment. All of the selected articles by Talbot and colleagues1 (except one), showed significant improvement in knee pain, physical performance, or both. However, many authors do not describe the main elements of the programs, so its application as a therapy or for contrasting the results is not possible.

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Introduction

Among the different types of treatments that can be used as an intervention for knee osteoarthritis, exercise seems to have the least side effects or sequelae. However, there is considerable controversy regarding what type of exercise is appropriate and what the recommended doses are. This paper aims to help define, from a practical standpoint, the characteristics of the treatments used in clinical trials.

Background

It is estimated that symptomatic knee osteoarthritis (defined as pain on most days, in addition to evidence of the disease on a radiograph of the affected knee) has a prevalence of 11% in individuals older than 65 years of age. In Spain, according to the National Health Survey 2003, 10% of Spaniards have SLE or other rheumatic problems that combined reduce the quality of life of those affected. The most characteristic symptoms of osteoarthritis are pain and physical disability, which combined reduce the quality of life of those affected.

Pain in the affected joint is the most common symptom, and contributes to a significant decline in the persons functional capacity. The anatomic cause is unclear and is likely to vary between individuals; some recent studies confirm the heterogeneity of arthritic pain by location, severity, etc. Impact on risk factors may reduce the symptoms and disability associated with osteoarthritis. Many authors mention overweight and obesity as risk factors, and some studies suggest that the reduction of symptoms correlates more with the reduction in fat...
mass than to total body weight reduction. Weakness of the quadriceps, is the variable that in itself predicts further functional limitation of the lower extremity, even more than pain, which may be a risk factor for knee osteoarthritis. On the other hand, some studies show that a reduced sense of position contributes to the development of osteoarthritis, in addition to the fact that proprioception is significantly decreased in older adults with osteoarthritis.

Finally, given the impact it has on the design of possible clinical trials, it should be noted that the most decisive risk factor for both radiologic osteoarthritis as for the radiologic osteoarthritis in any joint, is age. In spite of this, subjects in most of the studies discussed below have an average age around 65, which only allows conclusions for this age group.

Current treatments do not focus on improving the state of cartilage (currently there are no drugs that succeed in this sense), but to treat pain caused by the disease, in addition to attempting to maximize functional independence and improve quality of life.

Given this orientation of therapies and risk factors, we have observed that a possible non-pharmacological treatment that may have an impact on them (and potentially reduce the symptoms of osteoarthritis), is exercise. This concept refers to any bodily movement performed with a specific methodology and pursuing a defined objective.

This idea of using exercise is supported by the consensus of several organizations and researchers (AGS, EULAR, OARSI and ACR) to include in their guidelines the recommendation of the use of exercise as therapy in osteoarthritis. In addition, experts agree that arthritic pain management should be approach holistically and in a multidisciplinary way that includes both nonpharmacologic and pharmacologic therapy. They also mention that initial treatment should be non-pharmacological, making physical activity an important tool in the early stages of the disease.

However, the causes by which pain occurs in osteoarthritis are not entirely clear and certainly, until these are better defined, it will be difficult to clarify the mechanism by which exercise reduces these symptoms.

Furthermore, most studies that consider physical exercise as an intervention have been performed on knee osteoarthritis, but the same principles are likely to be applied to other anatomic locations.

Despite these recommendations and the many studies that have found improvements in pain and functional capacity through exercise programs used as treatment, there is a lack of practical information. That is, it is less clear what type of exercise to use or the core features of the program (duration, volume, intensity, etc.).

Systematic literature search

To recover all of the recently performed studies that investigated the efficacy of exercise as a treatment for osteoarthritis of the knee, we performed a literature search in all of the major databases: PubMed, Dialnet and Sportdiscus. The search phrases were composed by “ejercicio OR exercise” or “actividad física OR physical activity” and “artrosis rodilla OR knee osteoarthritis”. This review was conducted following the systematic search procedure proposed by Benito et al. in which a search phrase is established with keywords that are then entered into the major national and international databases of the area under study. After obtaining the results of different searches, the researcher chooses items according to predetermined inclusion criteria. The references of the selected articles are also reviewed in order to obtain potentially interesting new studies.

Inclusion criteria for selecting clinical trials for review were: articles published during the past 10 years, i.e the period between 1999 and 2008, Spanish or English languages, osteoarthritis only on the knee joint, with a detailed description of the training program (mentioning its main features: volume, intensity, duration and progression of the program), specifying which had a control group that did not exercise or comparing before and after training values for the same group (clinical studies), and the variables of knee pain and/or self-perceived functional capacity and/or performance on functional capacity tests.

Publications rejected were those in which it was not possible to obtain the full text version as well as those in which subjects received a combination of non-pharmacological treatments or had undergone surgical treatment.

Selected studies

Figure shows the literature search protocol for this study, detailing the number of items found and those included and excluded.

Of all the items found after the literature search, we selected a total of 12 trials and a systematic review. The results of all selected trials, except one, showed significant differences with respect to baseline or the control group. The differences occurred in either knee pain or perceived and/or proven functional capacity (by specific physical tests) or in both procedures at once. Moreover, the results of studies comparing different training programs showed no differences between groups for perceived pain in any of the cases. However, in the study by Topp et al there was a significant difference between groups for the WOMAC Index (Western Ontario and McMaster Universities Osteoarthritis Index) subscale which assesses functional limitation.

![Figure. Systematic review protocol used for the selection of original articles.](image-url)
Analysis of selected studies

Strength or aerobic training?

As for the main feature to be developed, we found that both aerobic and resistance exercise have shown their validity in clinical studies. But, to our knowledge, there is only one systematic review aimed to compare the efficacy of the two types of exercise indirectly. According to their results, we concluded that although both training regimens reduce pain and functional disability, there are no differences in their effectiveness.2,23 That is, both programs are equally effective in the treatment of symptomatic pain in the absence of any further evidence for this comparison. This conclusion is derived from the recommendations of the osteoarthritis research organizations, which recommend performing both types of exercise; however, load training has shown greater efficiency in strength gain and muscle mass in middle-aged men, than other forms of exercise.24

It has been stated that muscle weakness is a risk factor for and a major cause of dysfunction; therefore, strength exercise should be obligatory for patients with osteoarthritis. Reduced strength in the lower extremity is associated with poorer balance,25 and it has been seen that increasing it leads to improved proprioception.26 On the other hand, aerobic exercise improves the subjects ability for individual tasks that involve the transfer of body weight, such as walking or climbing stairs.27

General characteristics of the programs

Table 1 summarizes these characteristics, in which we have included the training objectives, methodology and materials used, the duration of the program, the anatomic location upon which the program acted and whether or not there were warm-up and cool-down periods.

Objectives of the program and methodology

Basically, we could reduce the objectives pursued to two: development of strength (in whatever form) and aerobic training. Based on these objectives and the environment in which the exercise program was developed, we found a great variety of methods and materials.

The definition of the objectives in clinical studies follow the recommendations, both for the general population as well as for persons suffering from osteoarthritis,4,8-10,12,27 that advise developing these two physical qualities. Although the development of these two qualities in patients with osteoarthritis is essential, it is also necessary to work on flexibility or range of motion and balance, physical characteristics that are important to improve the quality of life, prevent falls and improve the subjects proprioception.28-30

Flexibility training as an objective only appears in two of the reviewed studies,13,32 but its effect cannot be differentiated because the treatment is given in conjunction with other physical qualities.

On the other hand, balance training in many cases is performed in an indirect way along with other exercises, but the reviewed articles did not find an exercise that directly pursued the development of this quality, nor was its development mentioned in the recommendation guidelines consulted.

As to the methods used to develop an aerobic capacity, both using a static cycle as well as walking have been employed, although the latter method was used in combination with strength training.

For the development of strength we found that isometric exercises were used,2,9,11-33 isotonic exercises in an open or closed chain,13,15,17,31,32,34-36 isokinetic exercises,13 and electrostimulation.13,33

Coping with isotonic and isometric exercises (the two methods most accessible to the general population), we saw that the limitation of those studies employing isometric training is that the strength gain occurs at small joint angles, but a possible advantage of this type of training is that the joint might be under less stress.9 On the other hand, it has been seen that dynamic strength training is correlated with an improvement in neuromuscular performance,9 which could positively influence other risk factors that is also seen in those affected by osteoarthritis: reduced proprioception.

Isokinetic exercises require special machines, which are not common in the recovery room, making them expensive and inaccessible, and no significant improvements have been seen different from those produced by conventional strength exercises.13 The same thing happens with electrostimulation,31 despite being more accessible than the isokinetic machines.

Another key issue to address is how to link the exercises in strength training, ie the method used. At this point we found that all studies that detail this aspect develop a program in the form of a series. One possible line of research, therefore, is to compare two different methodologies (in the form of series or circuit), since they affect the development of strength and hypertrophy differently and could influence the effects of the intervention.

In the materials used for the development of strength training programs there is also great diversity, although the most used are ankle weights, dumbbells and/or autoloader. Six of the twelve studies reviewed used this type of material.13,15,17,31,32,36

The use of light with ankle weights (low intensity) can be justified by the fact that patients with severe osteoarthritis may not tolerate training with heavier weights, but in two articles that used a percentage of intensity greater than 50% of load for one repetition maximum (RM) or 10 RM, there were significant improvements in both pain and functional capacity.13,34

Program length

The program duration varies from the four weeks employed by Deylen et al11 to 6 months used by Messier et al,36 the average value being a period of approximately 11 weeks. Although the program by Deylen et al might seem insufficient stimuli due to its brevity, these authors observed a significant improvement when comparing the beginning and ending of the program, in the distance walked in 6 min (10% improvement) and in the WOMAC index (26% improvement).31 However, even having seen improvements with this short intervention, it would be ideal to perform a program of indefinite duration, given the results of follow-up conducted by Talbot et al after the intervention, which sees a loss of the improvements obtained with the program. In relation to the duration mentioned above, some studies show that the effects of exercise on osteoarthritis are temporary and that the performance declines when exercise ceases.19

Anatomic location

Although the muscle groups worked upon differ between studies, most are very analytical. A third of programs focuses solely on the quadriceps, or on this and the ischiobital muscles,13,15,31,33 and only one study acts not only on the lower body but on the top as well.36

If the objective of the training program is the localized improvement of an anatomical region, it may be much more convenient to use an analytical program, but we must not forget that there is a strong association of osteoarthritis with age and it seems clear that a program working with general loads can provide added health benefits.29,30

Warm up and cool down

We did not find evidence of the influence of warm-up and cool-down periods and symptoms of osteoarthritis. However, in the general population, regarding the initial part, even when stretching does not
appear to reduce the rate of injury among athletes,\textsuperscript{37,38} warming is related to this fact.\textsuperscript{39}

We found that only five of the papers\textsuperscript{9,13,34,36,40} mention that they carried out warm-up periods, while only four included a cool-down period.\textsuperscript{9,34,36,40}

In general, studies used between 5 and 10 minutes for warm-up, with the same interval for cool-down. The methods used for warm-up are mostly aerobic, sometimes also including stretching and joint movements.\textsuperscript{9,13,34,36,40} For cooling methods differ a little more: application of cold\textsuperscript{34} stretching,\textsuperscript{9} walking and breathing exercises.\textsuperscript{40}

### Characteristics of the training load

These features, which are summarized in Table 2 and 3, include information on the duration of the sessions, weekly frequency, the volume of exercise performed and its progression during the program (in number of exercises, number of sets and number of repetitions), exercise intensity and its progression, the breaks between exercises, sets or repetitions, and the pace of implementation in the case of dynamic strength exercises.

#### Session length

Although not all studies mention this, the variability in this feature is great, ranging from 15 to 60 min. The interventions that used electrostimulation were those with shorter sessions (15-20 min),\textsuperscript{13} while the other programs only used sessions of less than 50 min in the early stages.

**Weekly**

The frequency of training, except in three of the reviewed studies\textsuperscript{9,31,33} was always 3 days per week. This is no coincidence, since most studies use the work guidelines of ACSM (American College of Sports Medicine) for the elderly, that propose two days a week as the minimum frequency for strength training.\textsuperscript{28,29,41} For aerobic training, the frequency recommended by this association is 5 days. With this statement we note that, although studies in osteoarthritis have demonstrated efficacy with only three days a week, a better design of the program should be aimed at improving health comprehensively, so this frequency should be respected as the stipulated minimum.

**Initial volume and its progression**

In strength training, analysis of the number of exercises per muscle group indicates that most programs used a single exercise. And if we have found beforehand that most of the studies involved only work the affected joint, this could be an impediment to the continuity in the program by the subject (although this is not reflected in the studies), because a single exercise with a single joint
working involves a monotony that could be avoided by increasing and varying the number of exercises as the subject’s experience and fitness improves.

The number of sets used is between 1 and 10, without showing a common pattern among studies. Regarding the number of repetitions, the most common finding in the studies is 8-12. Here we find agreement with the recommendations of the ACSM, making this another pattern to follow.

With regard to progression, increasing sets and repetitions is employed only in two studies. Despite an increase in the number of sets and repetitions necessary for an adequate adjustment, this pattern is not observed in studies and is not recommended for use in the reviews on the subject.

Initial intensity and its progression

In aerobic training programs, the intensity employed is between 40% and 75% of the maximum heart rate. That is, moderate-high intensity, which allowed significant differences from baseline, although in no case was a progression in intensity scheduled. Both cases showed significant differences in terms of pain and physical ability, so that this degree of intensity can be used without affecting the osteoarthritis symptoms. It is necessary to clarify at this point that, in the case of the use of an ergometer, the intensity required is always reached without using pedal resistance, but an increase in cadence.

Although the intensity shows large heterogeneity between studies, the authors show moderate loads between 60% of 1 RM and 50% to 100% of 10 RM.

Only three of the twelve studies reviewed did not program an increase in intensity, because from the beginning of the program, they require a maximum contraction. The rest of the programs progress very differently from the use of subjective scales or perceptions of the effort and ranges to use materials to add strength, such as dumbbells or elastic bands. In this regard, we found a common pattern of progression, and since all programs showed favorable results, we can say that any progress that respects the adaptation of the subject itself is correct, despite the fact that progression in some cases seems overly cautious.

In this regard, we must also note the role that joint pain has in the progression of the burden to overcome. Some items on recommendations and guidelines address this issue and advise that when pain increases after exercise is maintained, the weight at the next session is to be reduced.

Breaks

Although not all studies report this information, we identified a more or less constant interval for those that do detail it: between 50 s and 1 min for rest between sets and 5 min between exercises or legs.

Speed of execution

This concept refers to the speed with which concentric and eccentric phases of dynamic strength exercises were performed. In the case of isokinetic exercise, the pace is determined by the angular speed of execution.

Table 2
Characteristics of the training load of the programs (studies from 2003 to 2008)

<table>
<thead>
<tr>
<th>Study</th>
<th>Group</th>
<th>Time of session</th>
<th>Weekly frequency</th>
<th>Initial volume and progression (exercises/series/repetitions)</th>
<th>Initial intensity and progression</th>
<th>Breaks</th>
<th>Rate of execution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silva et al (2008)</td>
<td>Water: Room</td>
<td>50 min</td>
<td>3 days</td>
<td>Stretching: 1 series/2 20 s repetitions; Isometric strength: 2/1/7-10 of 6 s; Isotonic strength: (10 exercises): weeks 1-3: 20 repetitions; week 4: 40 repetitions</td>
<td>Isotonic strength: week 1: no resistance; week 2-4: elastic band or 1 kg weight</td>
<td>No detail</td>
<td>No detail</td>
</tr>
<tr>
<td>Jan et al (2008)</td>
<td>High intensity strenght</td>
<td>30 min</td>
<td>3 days</td>
<td>1/3/8</td>
<td>60%, 1 estimated RM. Every 2 weeks: 1 RM Retest. Increase in 5% 10%, 1 estimated RM</td>
<td>1 min between series; 5 min between legs</td>
<td>1-1</td>
</tr>
<tr>
<td>Low intensity strenght</td>
<td>50 min</td>
<td></td>
<td></td>
<td>1/10/15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lin et al (2007)</td>
<td>Closed chain strenght</td>
<td>No details</td>
<td>3 days</td>
<td>1/10/10</td>
<td>Initial: 10% of body weight. Increase in 5% every 2 weeks</td>
<td>1 min between series; 5 min between legs</td>
<td>1-1</td>
</tr>
<tr>
<td>Durmus et al (2007)</td>
<td>Electrostimulation</td>
<td>20 min</td>
<td>5 days</td>
<td>10 s contraction</td>
<td>In apparent muscle contraction (between 70 and 120 mA)</td>
<td>10 s –</td>
<td>50 s</td>
</tr>
<tr>
<td>Deyle et al (2005)</td>
<td>Execution at the subjects house</td>
<td>No details</td>
<td></td>
<td>7 days: flexibility; 3 days: strength; In strength: (3 exercises): 10 repetitions or until completing 30 s. Maintain 3 s isometrically in each repetition</td>
<td>Self administered. Self administered increase in intensity</td>
<td>No detail</td>
<td>No detail</td>
</tr>
<tr>
<td>Talbot et al (2003)</td>
<td>Electrostimulation</td>
<td>15 min</td>
<td>3 days</td>
<td>10s contraction</td>
<td>Weeks 1-4: 10%-20% of MVC; weeks 5-8: 20%-30% of MVC; weeks 9-12: 30%-40% of MVC</td>
<td>50s –</td>
<td></td>
</tr>
</tbody>
</table>

MVC indicates maximum voluntary contraction; RM, maximum repetition.
velocity used. Among the studies, only three papers detailing this aspect, two of them employed a 1-1 rate (1 s for the concentric exercise, and 1 s for the eccentric), and the other simply states that it was carried out in slow motion.

The effects of the implementation rate on muscle mass has been previously described: we observed that, when the rest of the training was the same, a higher speed produces a greater increase in muscle mass and strength.

**Conclusions**

All trials except one, showed significant differences in knee pain, perceived and/or proven functional capacity (by specific physical evidence) or in both variables at once.

After review, we can reach conclusions on the characteristics of a standard program for the treatment of osteoarthritis of the knee. These are detailed in Table 4 and have been selected with the criterion of a greater concordance between the reviewed studies.

The standard program described has limitations arising from the heterogeneity of the studies selected. Scientific evidence from sturdier studies regarding design could lead to different conclusions. When describing the training programs employed, many of the authors forgets crucial elements to the definition of the program, making it impossible to implement these programs with a therapeutic objective or to contrast the results to other populations.

Future research in this area should concern the comparison of different methods and types of training in a long-term intervention, besides attempting to verify the type of strength that is more beneficial to the disease, and the most appropriate content of an exercise program for treatment of osteoarthritis of the knee. On the other hand, studies with much greater range of age groups are needed to obtain conclusions in older age groups.

### Table 3: Characteristics of the training load of programs ii (studies from 1998 to 2002)

<table>
<thead>
<tr>
<th>Study</th>
<th>Group</th>
<th>Session frequency</th>
<th>Weekly frequency</th>
<th>Initial volume and progression (series and repetitions)</th>
<th>Initial intensity</th>
<th>Breaks</th>
<th>Rate of execution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gür et al (2002)</td>
<td>Isokinetic concentric</td>
<td>No details</td>
<td>3 days</td>
<td>12 flexoextensions of the knee, all concentric</td>
<td>Maximum effort</td>
<td>5 min between legs</td>
<td>Angular speed</td>
</tr>
<tr>
<td></td>
<td>Isokinetic concentric</td>
<td></td>
<td></td>
<td>6 concentric extensions and 6 eccentric flexions</td>
<td>in a range of angular speeds</td>
<td>1 s for the concentric exercise, and 1 s for the eccentric</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Excentric</td>
<td></td>
<td></td>
<td>(alternatives); 6 eccentric extensions and 6 concentric</td>
<td>between 30º/s</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Excentric</td>
<td></td>
<td></td>
<td>flexions (alternatives)</td>
<td>and 180º/s</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>every week; weeks 9-16: 3 series/12 repetitions</td>
<td>medium tension;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eyigor et al (2004)</td>
<td>Isokinetic exercise</td>
<td>No details</td>
<td>3 days</td>
<td>1 exercise/4 angular speed/3 series/6 repetitions</td>
<td>Maximum effort</td>
<td></td>
<td>Angular speed</td>
</tr>
<tr>
<td></td>
<td>Progressive resistance</td>
<td>5 days</td>
<td></td>
<td>1 exercise/3 series/10 repetitions with 5 s isometrics</td>
<td>at 60º/s,</td>
<td></td>
<td>Slow movement</td>
</tr>
<tr>
<td></td>
<td>exercises</td>
<td></td>
<td></td>
<td>in each repetition in each</td>
<td>90º/s, 120º/s,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>180º/s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baker et al (2001)</td>
<td>At the house of the subject</td>
<td>No detail</td>
<td>3 days</td>
<td>7 exercises/2 series/12 repetitions</td>
<td>Maximum effort</td>
<td></td>
<td>No details</td>
</tr>
<tr>
<td>Messier et al (2000)</td>
<td>In room</td>
<td>1 h</td>
<td>3 days</td>
<td>Aerobic: 2 series of 10 min walking. Strength: 7 exercises/1 series/10-12 repetitions</td>
<td>Aerobic: 50%-75% of maximum heart rate.</td>
<td>Strenght: 1-1.5 min between exercises</td>
<td>No detail</td>
</tr>
<tr>
<td>Mangione et al (1999)</td>
<td>Low intensity</td>
<td>1 h</td>
<td>3 days</td>
<td>25 min continuous pedaling</td>
<td>40% of maximum heart rate, no pedal resistance</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td>cycloergometer</td>
<td></td>
<td></td>
<td></td>
<td>70% of maximum heart rate, no pedal resistance</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>

RM indicates maximum repetiton.
Table 4
Characteristics of the standard program for the treatment of knee osteoarthritis

<table>
<thead>
<tr>
<th>Objective</th>
<th>Dynamic strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methodology</td>
<td>Self load exercises</td>
</tr>
<tr>
<td>Materials</td>
<td>Weights and dumbbells</td>
</tr>
<tr>
<td>Duration of the program</td>
<td>11 weeks, although a program with undefined duration is recommended to avoid the loss of the improvements gained by exercise</td>
</tr>
<tr>
<td>Anatomical localization</td>
<td>Lower extremities, although all important muscle groups must be worked</td>
</tr>
<tr>
<td>Warm up and cool down</td>
<td>Warm up: aerobic. Cool down: depending on the effect of training, ice, stretching or breathing exercises; 5 min for each one</td>
</tr>
<tr>
<td>Duration of the session</td>
<td>50 min-1 h</td>
</tr>
<tr>
<td>Weekly frequency</td>
<td>3 days</td>
</tr>
<tr>
<td>Initial volume and progression</td>
<td>Exercises: 1 per muscle group. Series and repetitions: 1 series, 8-10 repetitions. Progression: no progression, although we recommend increasing the number of exercises performed by the muscle group to avoid monotony and program abandonment</td>
</tr>
<tr>
<td>Initial intensity and progression</td>
<td>Light to moderate, around 60% of 1 RM or 50%-100% of 10 RM. Progression: must respect the capacity of adaptation of the subject</td>
</tr>
<tr>
<td>Breaks</td>
<td>50 s-1 min between series and 5 min between exercises</td>
</tr>
<tr>
<td>Rythm of execution</td>
<td>Medium-Slow</td>
</tr>
</tbody>
</table>

RM indicates maximum repetition.

References