

## Thermotherapy associated with flexibility training does not increase the knee range of movement of healthy adults: systematic review and meta-analysis of randomized clinical trials

### Termoterapia associada com treinamento de flexibilidade não aprimora a amplitude de movimento de joelhos em adultos saudáveis: revisão sistemática de ensaios clínicos randomizados com meta-análise

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#### ABSTRACT

The stretching with thermotherapies associated have been related in the literature as a way to increase the range of motion (ROM), but still are not consensus about this efficacy and cost-effectiveness. The muscle stretching is a useful technique in rehabilitation and in physical activities programs, either to gain or maintain the flexibility, as a recovery of musculoskeletal and joint injuries. **Objective:** To determine the effects of thermotherapies associated to flexibility training in ROM of knee extension in healthy adults. **Method:** The search strategy was conducted in main databases, as Cochrane Library, LILACS, PEDro, PUBMED/ Medline, Scopus and Web of Science. The searches were done in 2016, and renewed in 2023, in order to achieve new publications along this time. Were selected only randomized clinical trials that have executed a training of hamstrings stretching, associated or not with one or more thermotherapies in healthy young adults, as long as the outcome was knee extension ROM. Only papers in Portuguese or English were assessed. To evaluate risk of bias was used the Cochrane Collaboration's Risk of Bias Tool, and the methodological quality assessment was rated following the PEDro Scale. **Results:** Eight articles were included, totalizing 260 participants. The papers showed low methodological quality, and uncertain risk of bias. Only chronic effect of local warming and cryotherapy plus stretching showed a statistically significant difference versus control group. However, the thermotherapy action associated with stretching is still unclear, once the results suggest that even without the thermotherapy there are ROM increases. **Conclusion:** The stretching is effective in knee extension ROM improvement in healthy adults, with or without thermotherapy. New studies with higher methodological rigor and standardized protocols are needed.

**Keywords:** Muscle Stretching Exercises, Thermotherapy, Hyperthermia, Induced, Cryotherapy

#### RESUMO

Os alongamentos com termoterapias associadas têm sido relatados na literatura como forma de aumentar a amplitude de movimento (ADM), mas ainda não há consenso sobre sua eficácia e custo-efetividade. O alongamento muscular é uma técnica útil na reabilitação e em programas de atividades físicas, tanto para ganho ou manutenção da flexibilidade, quanto para recuperação de lesões musculoesqueléticas e articulares. **Objetivo:** Determinar os efeitos das termoterapias associadas ao treinamento de flexibilidade na ADM de extensão do joelho em adultos saudáveis. **Método:** A estratégia de busca foi realizada nas principais bases de dados, como Cochrane Library, LILACS, PEDro, PUBMED/ MedLine, Scopus e Web of Science. As buscas foram realizadas em 2016, e renovadas em 2023, a fim de alcançar novas publicações ao longo deste tempo. Foram selecionados apenas ensaios clínicos randomizados que tenham executado um treinamento de alongamento de isquiotibiais, associado ou não a uma ou mais termoterapias, em adultos jovens saudáveis, desde que o desfecho fosse ADM de extensão de joelho. Apenas artigos em português ou inglês foram avaliados. Para avaliar o risco de viés foi usado o Risk of Bias Tool da Cochrane Collaboration, e a avaliação da qualidade metodológica foi classificada de acordo com a Escala PEDro. **Resultados:** Foram incluídos oito artigos, totalizando 260 participantes. Os artigos apresentaram baixa qualidade metodológica e risco incerto de viés. Apenas o efeito crônico de aquecimento local e crioterapia associados ao alongamento mostrou uma diferença estatisticamente significativa em relação ao grupo controle. No entanto, a ação da termoterapia associada ao alongamento ainda não está clara, uma vez que os resultados sugerem que mesmo sem a termoterapia há aumento da ADM. **Conclusão:** O alongamento é eficaz na melhora da ADM de extensão do joelho em adultos saudáveis, com ou sem termoterapia. Novos estudos com maior rigor metodológico e protocolos padronizados são necessários.

**Palavras-chave:** Exercícios de Alongamento Muscular, Termoterapia, Hipertermia Induzida, Crioterapia

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#### Conflict of Interests

Nothing to declare

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## INTRODUCTION

The muscle stretching is a useful technique in rehabilitation and in physical activities programs, either to gain or maintain the flexibility, as a recovery of musculoskeletal and joint injuries.<sup>1</sup>

The associated benefits of this technique, like the most of sporting and therapeutic techniques, depend on the patient biological individuality. However, some improvements are global, as extensibility increase of soft tissues, the range of motion (ROM) and the recovery or improvement of balance joint.<sup>2,3</sup>

Therefore, the stretching training may be implemented in different ways. 1) In regard to the movement, the stretching training can be dynamic (or ballistic), when there is joint movement, or static, when the flexibility is trained with a maintaining position.<sup>4,5</sup> 2) As the muscular action, the stretching may be active, when there is no external action on the joint, but the gravity or muscular contraction, or passive, when the stretching is improved for another person, or with equipment help.<sup>6,7</sup> There are also, less common, the pre contraction techniques (PNF techniques or neurodynamics).<sup>6</sup>

Many studies have related the utilization of thermal resources with the stretching training, in order to maximize this practice benefits. Such resources can be 1) the warming, implemented with application of short waves or continuous ultrasound, or with thermal bags,<sup>8,9</sup> or the 2) cooling (or cryotherapy), most used with local ice application.<sup>1,10,11</sup> However, in regard to thermotherapies associated with the stretching, studies are still inconsistent and discordant. Concerning the warming, when some authors report be ROM gain with the superficial warming application (hot water bags) or deep warming (short waves or continuous ultrasound)<sup>9,12,13</sup> others authors report there is no significant difference between groups study and control, showing not statistically significant ROM decrease.<sup>14</sup> Still, there is a study<sup>1</sup> that reported greater ROM gain in the cryotherapy plus PNF group, when compared to ultrasound plus PNF group. The final paper<sup>12</sup> observed shows that a group submitted to stretch plus deep warm (by short wave) have better results than a group submitted to the same intervention, but with cryotherapy.

Although already have been broadcast the benefits of flexibility training in scientific circles, either to musculoskeletal recovery, as for ROM increase,<sup>2,15</sup> there are an inconsistency in literature and an consensus absence between the authors when regards to thermotherapies benefits to reach this benefits.

Therefore, this study is justified for the needed definition about the effects of warm or cold localized, associated with flexibility training, in the ROM. Due this discussion about thermotherapeutics resources associated with the flexibility training, we aim to review systematically randomized clinical trials.

## OBJECTIVE

To determine the effects of thermotherapies associated to flexibility training in ROM of knee extension in healthy adults, compared with control groups.

## METHODS

This study is a systematic review of randomized clinical trials, designed following the recommendations of the Cochrane Collaboration To Intervention Systematic Reviews Book,<sup>16</sup> the Brazilian Journal of Physical Therapy Tutorial,<sup>17</sup> and the PRISMA Statement.<sup>18</sup> Also, are registered in PROSPERO, under the code

CRD42015032515.

## Search Strategy

The selection of eligible papers occurred in June 2020, on following databases: Cochrane Library, LILACS, PEDro, PUBMED/MedLine, Scopus and Web of Science. Furthermore, we have done searches on Google Scholar, in order to find references of the selected papers. The utilized descriptors were: "Muscle Stretching Exercises", "Hyperthermia, Induced", "Cryotherapy", "Range of Motion, Articular", "Pliability" and "Randomized Clinical Trial", and their synonymous, associated by the Booleans Operators AND, OR and NOT. The search strategy used on PUBMED database:

### #1 (Intervention)

(Muscle Stretching Exercises[MESH] OR "Static Stretching" OR "Stretching, Static" OR "Passive Stretching" OR "Static Passive Stretching" OR "Relaxed Stretching" OR "Stretching, Relaxed" OR "Isometric Stretching" OR "Stretching, Isometric" OR "Active Stretching" OR "Static Active Stretching" OR "Ballistic Stretching" OR "Dynamic Stretching" OR "Proprioceptive Neuromuscular Facilitation (PNF) Stretching" OR Stretching) AND (Hyperthermia, Induced[MESH] OR "Fever Therapy" OR Thermotherapy OR "Local Hyperthermia" OR "Hot Temperature" OR "Hot Pack" OR Cryotherapy[MESH] OR "Cold Therapy" OR "Ice Pack" OR "Cold Temperature" OR "Water Immersion" OR "Ice Bath" OR "Cold Compress" OR "Ice" OR "Thermal agents" OR "Thermal Therapy")

AND

### #2 (Outcome)

Range of Motion, Articular[MESH] OR "Joint Range of Motion" OR "Joint Flexibility" OR "Range of Motion" OR "Passive Range of Motion" OR Pliability[MESH]

AND

### #3 (Type of study)

randomized controlled trial [pt] OR controlled clinical trial [pt] OR randomized controlled trials [mh] OR random allocation [mh] OR double-blind method [mh] OR single-blind method [mh] OR clinical trial [pt] OR clinical trials [mh] OR ("clinical trial"[tw]) OR ((singl\*[tw] OR doubl\*[tw] OR trebl\*[tw] OR tripl\*[tw]) AND (mask\*[tw] OR blind\*[tw])) OR ("latin square"[tw]) OR placebos [mh] OR placebo\*[tw] OR random\*[tw] OR research design [mh: noexp] OR comparative study [mh] OR evaluation studies [mh] OR follow-up studies [mh] OR prospective studies [mh] OR crossover studies [mh] OR control\*[tw] OR prospectiv\*[tw] OR volunteer\*[tw]) NOT (animal [mh] NOT human [mh])

## Eligibility Criteria

The inclusion criteria were randomized clinical trials that have executed a training of hamstrings stretching, associated or not with one or more thermotherapies, in healthy young adults, with knee extension ROM outcomes, and published in Portuguese or English. We did not use time delimitations. The exclusion criteria were studies that realized the thermotherapies without flexibility training, with missing or incomplete data, crossover without phase one data (before the crossing). Studies with multiples publications were included only one time.

## Studies Selection

The studies selection has occurred in two phases, by two blinded and independent reviewers (ARO and LFF). On first phase

were analyzed title and abstracts. When selected, the articles were maintained in the list for at least one reviewer. On the second phase were read the selected full texts papers. Having disagreement between reviewers, a third reviewer (LHTR) was necessary.

### Methodological quality assessment

Two independent reviewers (ARO e LFF) assessed the methodological quality of studies, using the Physiotherapy Evidence Database (PEDro) Scale.<sup>19</sup> This scale evaluates for one to 10 points, with eleven criteria, considering the external validity (criteria one – do not counted in final assess), internal validity (criteria two to nine) and statistical information (criteria 10 and 11).

### Risk of bias assessment

To assess the risk of bias was applied the Cochrane Collaboration Method,<sup>20</sup> that classifies the articles in three groups: 1) Low risk of bias; 2) High risk of bias and; 3) Uncertain risk of bias, following seven domains (generation of random sequence, blind allocation, therapists and professionals blinded, outcome assessors blinded, incomplete outcomes, selective outcome report and another bias sources).

### Data Extraction

The data extraction was executed by two independent reviewers (ARO e LFF) following standardized forms. The following data was collected: Publish year, sample, patient kind, gender, mean of age, intervention model, training model, protocol duration, outcome, mean and standard deviation pre and post intervention.

### Synthesis and data analyses

To quantitative analyses was employed the statistic method Inverse Variance, with analysis model in Random Effects, and the effect measures Mean Difference. The heterogeneity assessment of studies was made with the Cochran's Q Test, and the inconsistency with I<sup>2</sup> Test, which values above 25% and 50% are considered, respectively, mean and high heterogeneity.

A p value lower than 0,05, and confidence interval of 95% was considered statistically significant. All analyses were conducted in Software Review Manager, version 5.3. Because the different thermotherapeutics realized, and the different intervention and assessment times (acute and chronic effects), was realized eight different meta-analysis: 1) Acute and 2) chronic effects of warming associated with stretching, versus stretching alone; 3) Acute and 4) chronic effects of cryotherapy associated with stretching, versus stretching alone; 5) Acute and 6) chronic effects of warming associated with stretching, versus control group; 7) Acute and 8) chronic effects of cryotherapy associated with stretching, versus control group. The sensibility analysis has not been realized, due to low number of selected papers in each thermotherapy.

## RESULTS

The first search was made in 2016, where 826 papers were found after search strategy application. Removing duplicates, 776 titles and abstracts been maintained to eligibility selection.

Then, 15 articles were selected to full read and, at this phase, eight papers were excluded, remaining seven papers eligible to

this systematic review.<sup>1,12,15,21,22</sup> In order to renew the atrategy, updating its results, a new search were carried out in January 2023, where 16 papaers were found. After a selection, only one article was selected.<sup>23</sup> The PRISMA flowchart is presented in Figure 1.

### Description of Studies

The studies characteristics are presented in Chart 1. This systematic review has included 260 participants (mean 32,5 participants per study, with variation between 25 to 50). The publish year were from 1995 to 2021. Most selected papers are originally Brazilians.<sup>1,12,21-23</sup> The others are from Canada and United States of America.<sup>9,13,14</sup>

The session's duration was for one to four weeks. The sessions mean was 4,6, with range between one and 12 sessions, in intervention groups. The mean age of participants were 22,03 years, showing characteristics of young people. In all studies, the thermotherapy was before the stretching, and implemented in different ways.

### Methodological Quality Assessment

Only one paper showed six points on PEDro Scale.<sup>1</sup> Three papers showed five points,<sup>12,13,21</sup> more three earned four points,<sup>9,14,22</sup> and one paper showed three points.<sup>23</sup> The mean between the eight articles were 4.5, showing the low quality of published papers. All results of quality assessment are showed Chart 2).

### Risk of Bias

Four studies reported suitable randomization process, but no article reported secret allocation. Only Busarello et al.<sup>22</sup> reported blinding of outcome evaluators, and Draper et al.<sup>13</sup> reported the participants and outcome evaluators non-blinding. The rest of studies did not make it clear. Five studies showed complete outcome data,<sup>1,9,12,13,21</sup> or related the data lost in suitable way. All studies showed low risk of bias in concern to selective outcome report. Only one paper<sup>12</sup> showed high risk in others sources of bias, because they have presented the p value inadequately in the results (Figure 2).

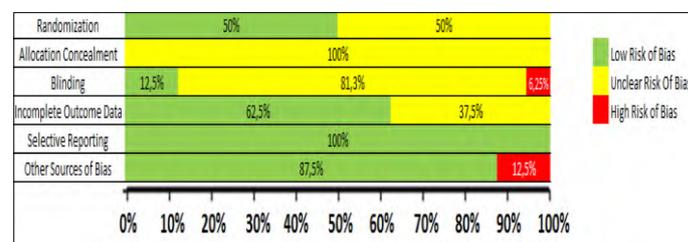


Figure 2. Included Studies – Risk of Bias Summary

### Details of cooling interventions

The cooling interventions were implemented locally and superficially, with ice cubes,<sup>1,12,22</sup> or cooling pads.<sup>14,21</sup> The application lengths were from ten to 25 minutes.

### Details of heat interventions

The most of heat interventions were deep heating agents – By ultrasound or shortwave diathermy.<sup>12,21,23</sup> One study used superficial warm with hot bags.<sup>14</sup> The warm duration was from five to 25 minutes.

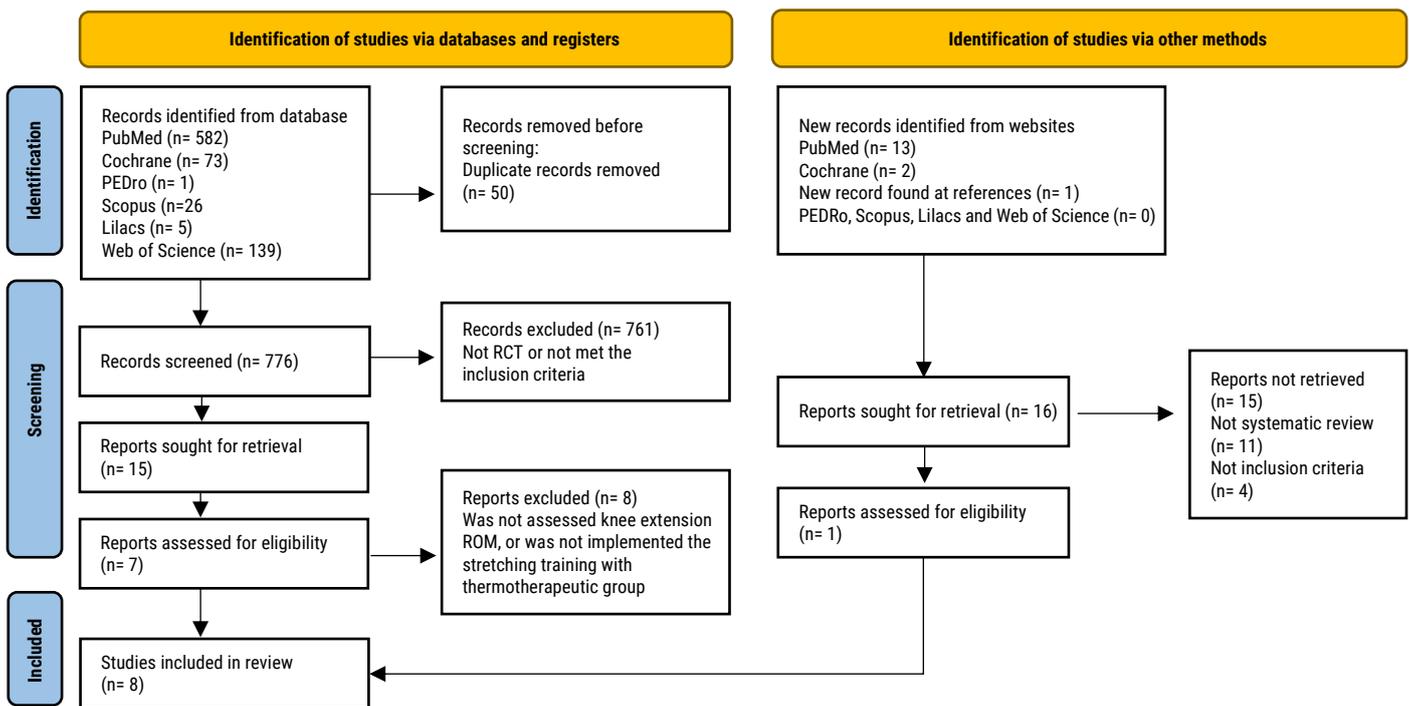


Figure 1. PRISMA Flowchart

Chart 1. Study characteristics

Author (year)	n	Age (mean)	Intervention description	Intervention duration	Total sessions	Control group	Follow-up	ROM results
Magalhães et al. <sup>1</sup> (2015)	32	22,4	G1: Previously cryotherapy +FNP; G2: US warming + FNP	4 weeks	12	FNP	no	3 intervention groups showed ROM increases. There is no difference intergroup
Rosário et al. <sup>9</sup> (2015)	50	23	G1: Previously SW warming + Passive Stretching; G2: Previously Active treadmill warming + Passive Stretching; G3: Previously 30 seconds passive stretching; G4: Previously 10 minutes passive stretching	3 days	3	No intervention	Post 24 hours	All intervention groups showed Rom Increase. Acute effects: G2 and G4 are most effectiveness; Chronic effects: G4 is most effectiveness
Costa et al. <sup>12</sup> (2008)	24	21,3	G1: Only SW; G2: Cryostretching	1 day	1		no	3 groups showed significant differences, but not intergroup
Draper et al. <sup>13</sup> (2004)	30	21,5	G1: Previously SW warming + Static hamstring stretching ; G2: Sham warming	1 week	5	Static hamstring stretching	Post 72 hours	Booth intervention groups showed ROM increases. G1 is more significant after 5 treatment-days
Taylor et al. <sup>14</sup> (1995)	24	25.46	G1: Previously stretching + Static hamstring stretching; G2: Previously cryotherapy + Static hamstring stretching	3 weeks	3 <sup>1</sup>	Static hamstring stretching	no	Booth experimental groups showed significant differences, but not intergroup
Brasileiro et al. <sup>21</sup> (2007)	40	21,5	G1: Stretching FNP; G2: Cryotherapy with ice compresses + Stretching FNP; G3: Previously warming by SW + Stretching FNP	2 weeks	10	No intervention	Post 24 hours – after treatment	Acute effects: 3 intervention groups showed ADM increases. G2 showed greater results; Chronic effects: 3 intervention groups showed ROM increases
Busarello et al. <sup>22</sup> (2011)	20	22,5	G1: Previously Cryotherapy + Static hamstring stretching	2 days	2 <sup>1</sup>	Only Static hamstring stretching	no	Booth groups showed immediately ROM increases, but without significant differences intergroup
Silva et al. <sup>23</sup> (2010)	40	21.97	G1 – Static Stretching; G2 – SW previously +stretching; G3 – Cryotherapy previously + stretching	5 days	5	No intervention	Post 72 hours	3 groups showed significant differences, but not intergroup

<sup>1</sup>Cross-studies; n: Number of patients; ROM: Range of movement; G#: Group intervention #; FNP: Facilitation neuromuscular proprioceptive; SW: Short waves; US: Ultrasound

**Chart 2.** Assessment of methodological quality – PEDro Scale

Author (year)	1	2	3	4	5	6	7	8	9	10	11	Total
Magalhães et al. <sup>1</sup> (2015)	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Rosário et al. <sup>9</sup> (2015)	Yes	Yes	No	Yes	No	No	No	No	No	Yes	Yes	4
Costa et al. <sup>12</sup> (2008)	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	5
Draper et al. <sup>13</sup> (2004)	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	5
Taylor et al. <sup>14</sup> (1995)	Yes	Yes	No	Yes	No	No	No	No	No	Yes	Yes	4
Brasileiro et al. <sup>21</sup> (2007)	No	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	5
Busarello et al. <sup>22</sup> (2011)	Yes	Yes	No	No	No	No	Yes	No	No	Yes	Yes	4
Silva et al. <sup>23</sup> (2010)	Yes	Yes	No	No	No	No	No	No	No	Yes	Yes	3

**Details of stretching intervention**

The passive static stretching was the most implemented in included studies,<sup>8,12,14,19,22</sup> followed by PNF stretching.<sup>1,21</sup> The stretching durations was from 30 seconds to ten minutes.

**Follow-up**

All studies recorded outcomes before and immediately after the intervention. Four studies realized follow-up in 24 hours,<sup>9,21</sup> and 72 hours<sup>13,23</sup> after the last intervention.

**Effects of stretching training with thermotherapies**

All studies reported difference between the control and experiment groups, in all treatment ways. However, the thermotherapy action associated with stretching is still unclear, as the results suggest that even without the thermotherapy there are ROM increases. The exceptions are the study of Brasileiro et al.<sup>21</sup> that showed the cold previous to stretching has better acute affect, when compared with previous warm or stretching alone, and Draper et al.<sup>13</sup> that demonstrated the heat by shortwave showing better increases after five days treatment.

**Data Analysis**

The meta-analysis been realized crossing all interventions models and times as possible, resulting in eight different analyses (Figure 3). One papers included in this review was excluded for the analysis, for contain unreliable data.<sup>12</sup> One of the analyses not been realized, for not have been showed for any one selected paper: Acute effect of local cryotherapy (LC) versus control group (CG).

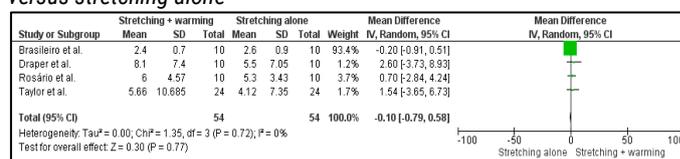
**Acute Effect of Local Warming Plus Stretching (LW) Versus Control Group (CG)**

Of three studies that analyze this variable, only one shows the results of control group, making impossible the meta-analysis in this case.

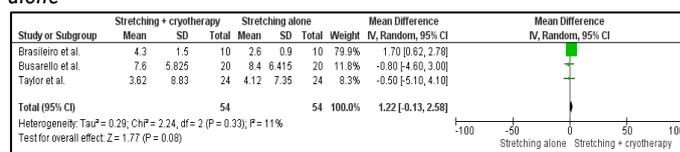
**Acute Effect of Local Warming (LW) or Cryotherapy (LC) Plus Stretching Versus Stretching Alone (SA)**

The groups did not show significant differences, although it presented homogeneity ( $I^2=0\%$ ). These results are in figure 3.1 (LW) and 3.2 (LC). The first analyze (LW) was made with 108 patients, and reports by four authors.<sup>9,13,14,21</sup> The second (LC) was made with 108 patients, and reports by three authors.<sup>14,21,22</sup>

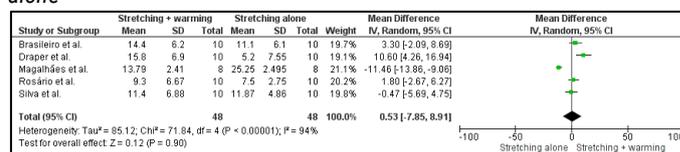
**(3.1) Meta-analysis of acute effect of local warming plus stretching versus stretching alone**



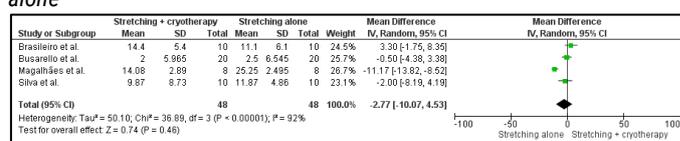
**(3.2) Acute effect of local cryotherapy plus stretching versus stretching alone**



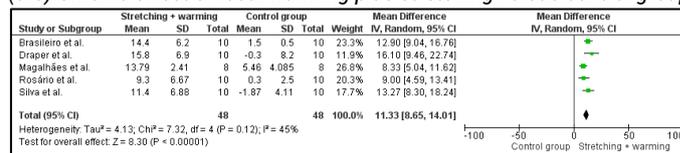
**(3.3) Chronic effect of local warming plus stretching versus stretching alone**



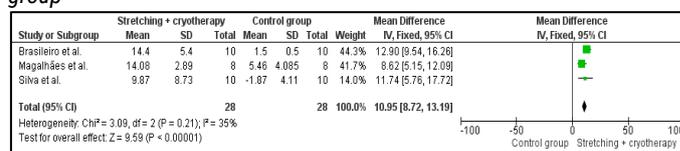
**(3.4) Chronic effect of local cryotherapy plus stretching versus stretching alone**



**(3.5) Chronic effect of local warming plus stretching versus control group**



**(3.6) Chronic effect of local cryotherapy plus stretching versus control group**



**Figure 3.** Meta-analysis to ROM of knee extension

### Chronic Effect of Local Warming (LW) and Cryotherapy (LC) Plus Stretching Versus Stretching Alone (SA)

The groups did not show significant differences, and it presented high heterogeneity (LW:  $I^2=94\%$ ; LC:  $I^2=92\%$ ). These results are in figure 3.3 (LW) and 3.4 (LC). The first analyze (LW) was made with 96 patients, and reports by five authors.<sup>1,9,13,21,23</sup> The second (LC) was made with 96 patients, and reports by four authors.<sup>1,21,22,23</sup>

### Chronic Effect of Local Warming (LW) and Cryotherapy (LC) Plus Stretching Versus Control Group (CG)

The groups showed significant differences when compared with the control group, showing mean heterogeneity ( $I^2=45\%$  and  $35\%$ , respectively). In LW, cited by five authors,<sup>1,9,21,23</sup> was assessed 96 patients, and the results are: MD=11,33; 95% CI; 8,65 to 14,01 SD;  $I^2=45\%$ , and in LC, cited by three authors,<sup>1,21,23</sup> was assessed 56 patients: MD=10,95; 95% IC; 8,72 to 13,16 SD;  $I^2=35\%$ . This results are presented in figures 3.5 (LW) and 3.6 (LC).

## DISCUSSION

Most of the excluded papers were suspended because hip flexion was assessed, instead of knee extension, by goniometry or Wells Bench Test (WBT). Besides, the WBT assess the torso flexion as well. Another limitation for including papers in this review was the thermotherapy implementation, since some works reported a comparison between groups submitted to thermotherapy alone and other groups that received the flexibility training with and without thermotherapy. Some authors assessed only men, others only women,<sup>9,12</sup> and another evaluated both.<sup>1,13,14,21-23</sup>

These difference between studies make impossible the results generalization. Various authors<sup>15,24,25</sup> reported that women are more flexible than men from menarche to adult age, occurring an inversion in aging. This is probably due to women's different hormone cycle, which can interfere in the results, mainly on premenstrual cycle and during menopause. Men can have a movement limitation due to muscular tonus and a denser muscular fiber structure, thereby limiting the ROM.

Another important finding in this review is that all included studies assessed young adults, which have different characteristics on muscular, neuronal and conjunctive tissues when compared with elderly or children. Therefore, the results are irreproducible to other populations but young adults. Although the inclusion criteria for this study was delimited only to young adults, no other paper was found on pre selection with another population.

The intervention time varied between 30 to 600 seconds on the analyzed works. This discrepancy makes unfeasible a comparison between the studies. Rosario et al.<sup>9</sup> implemented a flexibility training in four different groups. One of them, in 30 seconds of stretching, and another in ten minutes of the same intervention, obtaining a positive result to ten-minute group.

Brasileiro et al.<sup>21</sup> led a chronic training with 15 seconds interventions, found statistically significant results, positive to the training, when compared to his control group, in contrast with Draper et al.<sup>13</sup> that applied a training in ten minutes total time, and did not find significant differences between the control and test group. However Brodowicz et al.<sup>26</sup> that applied a 20 minutes

training, found significant results when compared with stretch alone group. Several references implemented the stretch training with different times, obtaining various results. However, according to Nakamura et al.<sup>2</sup> 90 seconds are already enough to a significant improvement of the ROM.

Only four articles<sup>9,13,21,25</sup> assessed the acute and the chronic effect. Evaluating the results, one can compare the acute and chronic effects on the other four studies selected. It is possible to realize that there is no significant difference on the periods. However, the cited papers assessed the chronic effect only 24 and 72 hours after.

It is important to emphasize that, between the selected papers, been found a low methodological quality, and an uncertain risk of bias, which makes the found results not trustworthy. Some methodological and results errors highlight that is necessary, by the authors and periodic, a better care with articles treatment. For example, there are some papers<sup>1,9,14,23</sup> that have not describe if the participants or evaluators were blinded, which, according to Opplert,<sup>27</sup> can generate a high risk of performance and detection bias, leading the evaluator to overestimate or underestimate the results, and the patient can be biased, knowing which group belongs.

Costa et al.<sup>12</sup> showed a p value equal to 66 ( $p= 66$ ), probably for a simple data inversion in their final table. Besides, none of selected studies have secret allocation, making impossible the comparison between the initial groups, which, according the same author,<sup>12</sup> can generate a selection bias.

The most RCT realized were the local warm, or deep warm with shortwave, or continuous ultrasound. If, for one side, the deep warm reach soft tissues, like muscles, connective tissue and skin in homogeneously and continuously, for another side the superficial warm and cooling reach objectively the skin and the adipose tissue, limiting the deep thermotherapy.<sup>28,29</sup> Besides, it is very hard to keep a constant temperature superficially, once these therapies are applied with hot or cold water bags, or even ice packs.<sup>29</sup>

The kind of stretch most found was the static,<sup>9,12,13,14,23</sup> presenting important results. In literature, there is a disagreement about the difference between the static stretching and the PNF training in ROM. When some authors report that booth show similar results,<sup>2,6,7,30</sup> others authors report that the PNF stretch show even better results.<sup>31,32</sup>

About thermal modalities, still there is a great disagreement between the authors and the models. When some authors have better results with only stretching, or with warm than cold,<sup>22</sup> another have significant better results in association cold and stretching, against the heat association.<sup>26</sup>

Besides that, Opplert et al.<sup>27</sup> in their job, found better results in only warm than the stretching group. This raises important questions about the modalities efficacy, associated to stretch training and, if have, what the modality is more adequate to ROM improvement. In addition, it is necessary to emphasize that the most works (7 out of 8 selected to this review<sup>1,12,14,21-23</sup>) implemented the thermotherapy previously to the flexibility training, and not concomitantly. This question is, in part, answered for Brodowicz et al.<sup>26</sup> that shows a higher significant result in group that associates the cryotherapy and the stretching. It is possible that exist a loss of thermotherapy action in interval between the withdrawal of therapy, until the next assess, which can generate any one bias source.

## Limitation

It is known that exists a great bias of publish literature, because occurs a tendency to only publish papers with statistical significance in their results, almost ever with positive results. Another limitation due to methodological quality and risk of bias, which make impossible a result generalization.

## CONCLUSION

Answering the aim of this study, it can be possible to say that the booth thermotherapy and only stretching training are important to knee extension ROM improvement in young adults. However, according to data showed in this review, we can infer that the thermotherapy cost-effectiveness, when implemented in here showed conditions, turns low effectiveness, once the ROM improvement are not expressively higher than without it, doing unnecessary the logistic to prepare, and the cost with this therapy, to reach results possible without the use.

Also new studies are necessary, with careful methodological treatment, and standardized assessment and therapies techniques. Thus, we suggest to new studies what follows: randomized clinical trials, with blind, at least for the evaluators of major outcome, with thermotherapies concomitantly to the stretch, and with time implementation of 90 seconds per session, and at least one session to cute effect, and five sessions to chronic results. Besides, we suggest that the studies perform a follow-up with adequate time to washout, to can be possible assess the remnants of applied technique.

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