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ACUTE EFFECTS OF DYNAMIC STRETCHING ON VERTICAL JUMP: A SYSTEMATIC REVIEW AND META-ANALYSIS

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ABSTRACT

The aim of the study was to determine the quantity of dynamic stretching exercises for the lower limbs that cause better vertical jump. This study followed the systematic review methodology that was proposed in PRISMA statement. The studies were identified in electronic databases during October of 2013 to February of 2014. Literature searches were conducted in Google Scholar, Research Gate, PubMed, Medline, Scielo, Dialnet and in CAPES journals. The studies that were included in this systematic review and meta-analysis had a total of 14 studies. The effect size of 1 to 5 dynamic stretching exercises was of 13,19±28 (great effect) and the effect size of 6 to more dynamic stretching exercises was of 0,48±0,4 (small effect). Shapiro Wilk test determined that the data are not normal and the histogram showed the data not normal. Mann-Whitney U test detected no significant difference (U = 15, p = 0,52) between 1 to 5 dynamic stretching exercises versus 6 to more dynamic stretching exercises. However, 1 to 5 dynamic stretching exercises had better countermovement jump. In conclusion, it seems that 1 to 5 dynamic stretching exercises cause a better countermovement jump, however, more studies on this theme are needed with the objective of corroborate this affirmation.

Key words: Muscle Strength. Exercise. Physical Fitness. Warm-up Exercise.

RESUMO

Efeito agudo do alongamento dinâmico no salto vertical: uma revisão sistemática e meta-análise

O objetivo do estudo foi determinar a quantidade de exercícios de alongamento para os membros inferiores que causa melhor salto vertical. Esse estudo seguiu a metodologia proposta pelo PRISMA para revisão sistemática e meta-análise. Os estudos foram identificados na base de dados no período de outubro de 2013 a fevereiro de 2014. A pesquisa na literatura foram realizadas no Google Acadêmcico, no Research Gate, no PubMed, no Medline, no Scielo, Dialnet e no periódicos CAPES. Os estudos que foram incluídos na revisão sistemática e meta-análise tiveram um total de 14 pesquisas. O tamanho do efeito de 1 a 5 exercícios de alongamento dinâmico foi de 13,19±28 (grande efeito) e o tamanho do efeito de 6 a mais exercícios de alongamento dinâmico foi de 0,48±0,4 (pequeno efeito). O teste Shapiro Wilk determinou que os dados não são normais e o histograma mostrou os dados não normais. O teste U de Mann-Whitney detectou diferença não significativa (U = 15, p= 0,52) entre 1 a 5 exercícios de alongamento dinâmico versus 6 a mais exercícios de alongamento dinâmico. Entretanto, 1 a 5 exercícios de alongamento dinâmico tiveram melhor salto com contramovimento. Em conclusão, parece que 1 a 5 exercícios de alongamento dinâmico causa um melhor salto com contramovimento, entretanto, mais estudos sobre esse tema são necessários com o objetivo de corroborar esta afirmação.

Palavras-chave: Força Muscular. Exercício. Aptidão Física. Exercício de Aquecimento.

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Revista Brasileira de Prescrição e Fisiologia do Exercício
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INTRODUCTION

The stretching is an exercise practiced during the warm-up (Donti, Tsolakis and Bogdanis, 2014). The acute effect of static stretching causes significant ($p \leq 0.05$) reduction on strength, power, agility, sprint and in the height of the vertical jump (Kay and Blazevich, 2012; Mc Hugh and Cosgrave, 2010; Simic, Sarabon and Markovic, 2013).

However, the acute effects of dynamic stretching causes an improvement during the practice of some physical capacities (strength, power, velocity, agility and others) (Behm and Chaouachi, 2011; Ribeiro and Del Vecchio, 20111) and during the execution of a motor skill of the sport - vertical jump (Gonçalves, Pavão and Baptista, 2013), putt golf (Gergley, 2009), kick soccer (Amiri-Khorasani, Osman and Yusof, 2010), tennis serve (Gelen and collaborators, 2012) and others.

The activity of the dynamic stretching involves controlled movement through the active range for a joint (Ayala, Baranda and Cejudo, 2012; Herda and collaborators, 2012).

The objective of the dynamic stretching is causes an increase in body temperature, decrease the viscous resistance of muscles and joints, increase in nerve conduction, increased supply of oxygen to the muscles, muscle action performed in several sports (specific flexibility) and others benefits during the warm-up (Bishop, 2003; Fortier, Lattier and Babault, 2013; Tsolakis and Bogdanis, 2012). The literature of the dynamic stretching does not have a consensus about the quantity of exercises for the lower limbs with the objective of improve the vertical jump.

For example, Chaouachi and collaborators (2009) prescribed for high level athletes of several sports (ball games, swimming, athletics, gymnastics, combat sports and dance), five dynamic stretching exercises for lower limbs to result a better countermovement jump (result of 49.43 ± 5.13 cm).

In the study by Little and Williams (2006), professional soccer players practiced five dynamic stretching exercises for lower limbs before of the countermovement jump, the result was of 40.2 ± 4.5 cm. In others studies, the quantity of dynamic stretching exercises for the lower limbs before of the countermovement jump was different, eleven exercises in the study of Thompsen and collaborators (2007) (countermovement jump of 43,6±6,5 cm), nine exercises in the study of Pearce and collaborators (2009) (countermovement jump with result in percentage) and nine exercises in the study of Faigenbaum and collaborators (2006) (countermovement jump of 41.3 ± 5.4 cm).

For Leon, Oh and Rana (2012) there are several dynamic stretching exercises for lower limbs, the quantity of this exercise varies according to the sport and the preference of the physical education teacher to prescribe a session.

Then, the physical education teacher has a problem to prescribe the quantity of dynamic stretching exercises for the lower limbs before of the countermovement jump because the literature does not inform the number of exercises that result in a better vertical jump.

Which the quantity of dynamic stretching exercises for the lower limbs with the objective of result a better vertical jump performance?

The studies on this theme do not have information to answer this question (Coledan and collaborators, 2012; Gelen, 2011; Paradisis and collaborators, 2014; Rubini, Costa and Gomes, 2007).

Therefore, the aim of the study was to determine the quantity of dynamic stretching exercises for the lower limbs that cause better vertical jump.

MATERIALS AND METHODS

This study followed the systematic review methodology proposed in Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement (Moher and collaborators, 2009).

The studies were identified in electronic databases during October of 2013 to February of 2014. Literature searches were conducted in Google Scholar, Research Gate, PubMed, Medline, Scielo, Dialnet and in CAPES journals. In electronic databases were consulted using the following keywords: acute effects of stretching in athletes, dynamic and static stretching in sports, stretching in volleyball, dynamic stretching, dynamic stretching in sports, dynamic stretching in athletes, warm-up in sports and acute effects of dynamic stretching on vertical jump. Relevant articles were obtained in full, and

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assessed against the inclusion and exclusion criteria described below.

Inclusion criteria of the articles were evaluated under the following search strategies: (1) type of participants (adult and/or athletes), (2) type of task (dynamic stretching on vertical jump), (3) type of data collection (occurred a pretest of the vertical jump and after of the dynamic stretching occurred a posttest of the vertical jump) and (4) type of result (determined the acute effect of dynamic stretching on countermovement jump).

Exclusion criteria of the articles were following: (1) children were the participants of the study, (2) result of the vertical jump without the pre-test and (2) not studied the acute effects of dynamic stretching on vertical jump.

The search summary was the following: the researcher identified 36 relevant articles about acute effects of dynamic stretching on vertical jump. After reading of the articles, the total was reduced to 24 potentially relevant articles for inclusion (see figure 1).

The researchers used the scale of Galna and collaborators (2009) for the quality assessment of the studies. The scale of Galna and collaborators (2009) uses questions (internal validity, external validity and others) about the article and the researcher determined the point (0 to 1) of each item. The studies were considered low quality with an average below of 0.6 points. The use of the scale of Galna and collaborators (2009) occurred in two moments with the objective to check the reliability and determine the level of agreement between the two scores on this instrument. The researcher determined the quality of the studies during an assessment, after 15 days, practiced new assessment of the studies of dynamic stretching (total of 14 studies).

The reliability of the quality of the studies by the scale of Galna and collaborators (2009) was checked via intraclass correlation coefficient ($p \leq 0.05$). Cohens`s Kappa was calculated to determine the level of agreement between the two assessments of the studies of dynamic stretching ($p \leq 0.05$). Bland and Altman (1986) method was applied to assess the level of agreement between the first and second quality assessment of the studies by the scale of Galna and collaborators (2009). All these statistical treatments were performed according to the procedures of the GraphPad Prism, version 5.0.

The data of the studies about the acute effects of dynamic stretching on vertical jump were treated for various calculations in this meta-analysis. The countermovement jump height in centimeters (cm) was transformed to effect size (*d*) by the equation of Glass, McGaw and Smith (1981) and the classification of the effect size followed the scale of Cano-Corres, Sánchez-Álvarez and Fuentes-Arderiu (2012). The effect size was corrected with the equation of Hedges and Olkin (1985). The formula and the classification of the effect size were the following:

Effect Size = [(posttest mean **–** pretest mean) **:** pretest standard deviation] **.** Correction Factor
Classification of the Effect Size: 0.20 or less is very small the effect, 0.21 to 0.49 is small the effect, 0.50 to 0.79 is medium the effect and 0,80 or more is great the effect.
Correction Factor = 1 – [3 : (4 . **m**) – 9)]

m = N - 1

N: sample size of the pretest.

The study estimates a limitations on the effect size, the fail safe *n* represents the number of studies with null result, that the author does not use in its results because reduces the average of the effect size (Hagger, 2006). The calculation was the following (Mann and collaborators, 2007):

Fail Safe *n* = [sum of the standard deviation **:** 1,96]^2 **–** Quantity of Studies

The standard error, the 95% confidence interval (95% CI), the variance, the study weight and the weighted effect size were determined with a simple calculation (Neyloff, Fuchs and Moreira, 2012):

Standard Error = effect size **/** $\sqrt{\text{effect size . n}}$
95% Confidence Interval = effect size ± (1.96 **.** standard error)

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ISSN 1981-9900 *versão eletrônica*
Periódico do Instituto Brasileiro de Pesquisa e Ensino em Fisiologia do Exercício
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Variance = standard error^2
Study Weight = 1 **:** standard error
Weighted Effect Size = study weight **.** effect size

The heterogeneity was determined using the I^2 index, first the Q test was calculated. The calculations and the classification of the heterogeneity were the following (Higgins and collaborators, 2003):

Q = [sum of the study weight **.** (sum of the effect size)^2] **–** [(sum of the study weight **.** sum of the effect size)^2 **:** sum of the study weight]
I^2 **=** [(Q . **df**) **:** Q] **.** 100 = ?%
df = total of studies – 1
df: degrees of freedom
Classification of the Heterogeneity (I^2 index): 25% the heterogeneity is low, 50% the heterogeneity is moderate and 70% the heterogeneity is high.

The recommendations of Neyeloff, Fuchs and Moreira (2012) were performed, when the heterogeneity is low (25%), the researcher should use the fixed effects model, but with a moderate heterogeneity (50%) or high (70%), the random effects model deserves to be used. The calculations were the following:

Fixed Effects Model
Effect Summary = (sum of the study weight **.** sum of the effect size) **:** sum of the study weight
Standard Error = $\sqrt{1 : \text{sum of the study weight}}$
95% Confidence Interval = effect summary ± (1.96 **.** standard error)

Random Effects Model

The calculations were designed to determine the effect summary, the standard error and 95% confidence intervals, but first some calculations are performed before (variability in the population of effects and new weight of study) to reach these values.

Variability in the Population of Effects = [Q test – (quantity of studies – 1)] : [sum of the study weight – (sum of the study weight^2 : sum of the study weight)]
New Weight of Study = 1 – (standard error^2 + variability in the population of effects)
Effect Summary = (sum of the new weight of study. sum of the effect size) : sum of the new weight of study
Standard Error = $\sqrt{1 : \text{sum of the new weight of study}}$
95% Confidence Interval = effect summary ± (1.96 . standard error)

All calculations of the meta-analysis were performed in Excel® 2010 of the Windows 7. The forest plots were also made in Excel® 2010 of the Windows 7.

After these procedures the effect size of the countermovement jump received a statistical treatment. The results are expressed as means and standard deviations. The normality of the data was assessed by the Shapiro Wilk test (p≤0.05) and was observed the normality of the data through of the histogram. In case of data normal, the difference between the quantity of dynamic stretching exercises (one to five exercises versus six to more exercises) were analyzed using an Independent T test with results accepted a level of significance of p≤0.05. In case of data not normal, the difference between the quantity of dynamic stretching exercises (one to five exercises versus six to more exercises) was analyzed using a Mann-Whitney U test with results accepted a level of significance of p≤0.05.

All these statistical treatments were performed according to the procedures of the GraphPad Prism, version 5.0. The histogram and the bar graph of the effect size were elaborated according to the procedures of the SPSS 14.0 for Windows.

RESULTS

In the first phase of analysis, 4122 studies were found using the keywords listed in

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the previous section and read the title of the study. After the reading the title and/or the abstract of each study (4 moths), the second phase of analysis the total was reduced to 36 relevant studies about acute effects of dynamic stretching on vertical jump.

The researchers were able to read the 36 studies in a period of 30 days and the total was reduced to 24 potentially relevant studies of acute effects of dynamic stretching on vertical jump for inclusion.

Of these studies, 12 articles and 2 thesis of master degree were included in this systematic review and meta-analysis (total of 14 studies). The details for the full strategy were listed in a PRISMA flow diagram, as shown in figure 1.

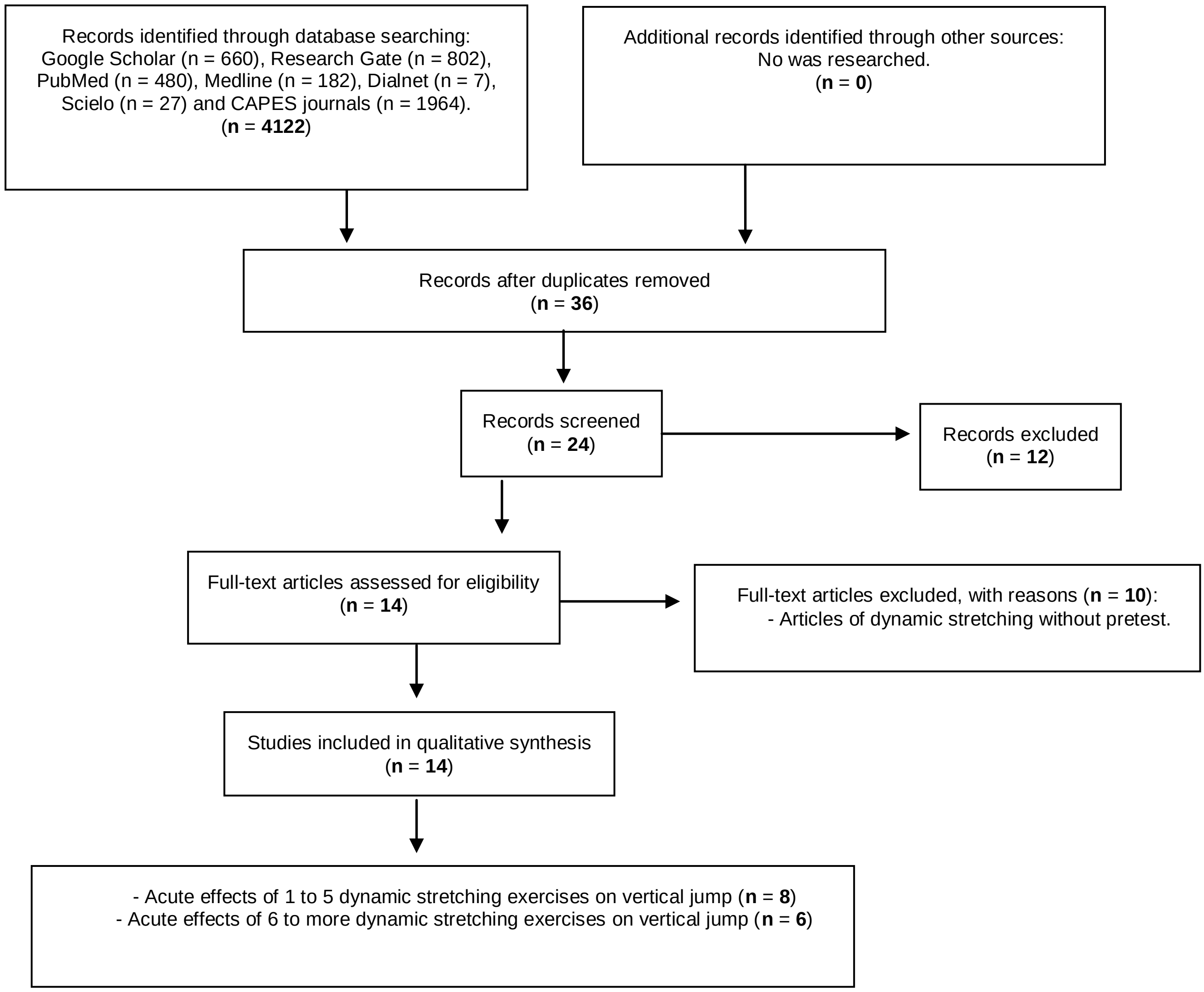

Figure 1 - PRISMA flow diagram of the selection of articles.

Intra-observer reliability exhibited Cohen`s Kappa values of 0.69 (p = 0.006), was a good agreement that is appointed by the literature (Gaya, 2008; Landis and Koch, 1977). The reliability of the quality of the studies by the scale of Galna and collaborators (2009) was checked via intraclass correlation, the result was of 0.62 and there was no significant difference (p = 0.68).

Bland and Altman (1986) method was applied to assess the level of agreement between the first and second quality assessment of the studies by the scale of Galna and collaborators (2009). Although the difference between the assessment 1 and 2

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Periódico do Instituto Brasileiro de Pesquisa e Ensino em Fisiologia do Exercício
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was low (bias = - 0.0178571), the limits of agreement ranged from – 0.0970741 (lower limit of agreement) to 0.0613598 (upper limit of agreement), suggesting low medium agreement between the assessment 1 and 2 (practiced the assessment 2 after of 15 days) because the bias stayed located near of the zero (increase the agreement) and the limits of agreement stayed located distant of the zero (decreases the agreement). The Bland and Altman method shows in figure 2 the agreement between assessments 1 and 2.

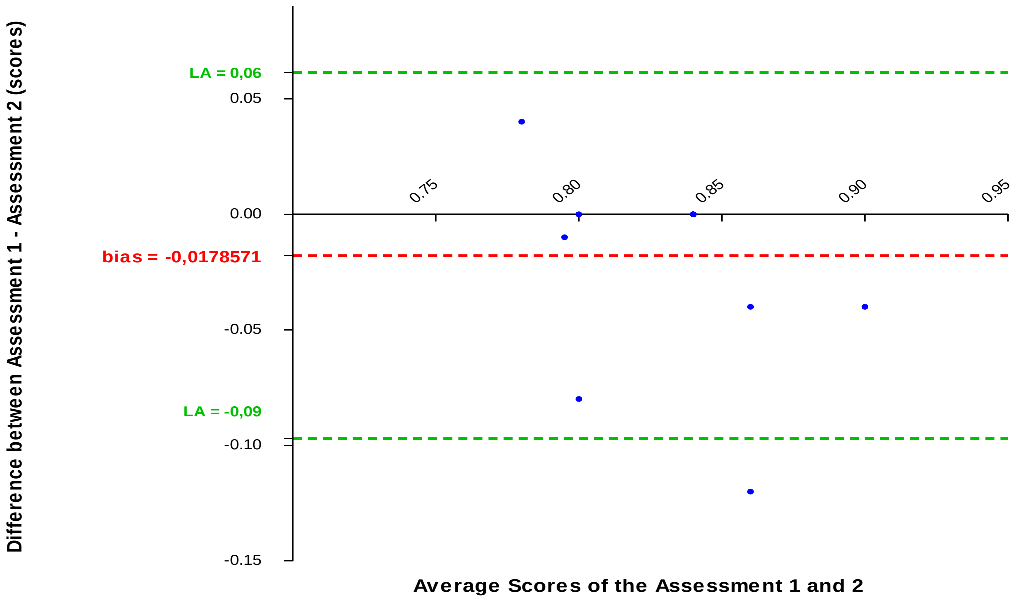

Figure 2 - Bland and Altman plot the 95% limits of agreement (LA) between the assessment 1 and 2 by the scale of Galna and collaborators (2009).

Table 1 - Summary of the quality assessment of the studies selected.

Study	1	2	3	4	5	6	7	8	9	10	11	12	13	Average and Quality of each Study
Rogan and cols. (2012)	1	1	1	1	1	1	1	1	0	0	1	1	1	**0.84** (high)
Behm and cols. (2011)	1	1	1	0.5	1	1	1	1	0.5	0	1	1	1	**0.84** (high)
Chtourou and cols. (2013)	1	1	1	0.5	0.5	1	1	1	0	0	1	1	1	**0.76** (medium)
Ferreira, Muller and Achour Junior (2013)	1	1	1	1	0.5	1	1	1	0	0	1	1	1	**0.80** (medium)
Dalrymple and cols. (2010)	1	1	1	1	1	1	1	1	0	0	1	1	1	**0.84** (high)
Shaji and Isha (2009)	1	1	1	1	1	1	1	1	0	0	1	1	1	**0.84** (high)
Murphy and cols. (2010)	1	1	1	1	0.5	1	1	1	0	0	1	1	1	**0.80** (medium)
Jaggers (2006)	1	1	1	0.3	0.5	1	1	1	0.5	0	1	1	1	**0.79** (medium)
Pagaduan and cols. (2012)	1	1	1	1	0.5	1	1	1	0	0	1	1	1	**0.80** (medium)
Fletcher (2010)	0.5	1	1	0.5	1	1	1	1	0.5	0	1	1	1	**0.80** (medium)
Curry and cols. (2009)	1	1	1	1	1	1	1	1	0.5	0	1	1	1	**0.88** (high)
Ryan and cols. (2014)	1	1	1	1	0.5	1	1	1	0.5	0	1	1	1	**0.84** (high)
Perrier (2009)	1	1	1	1	1	1	1	1	0	0	1	1	1	**0.84** (high)
Kruse and cols. (2013)	1	1	1	1	0.5	1	1	1	0.5	0	1	1	1	**0.84** (high)
Average of each Question	**0.96**	**1**	**1**	**0.77**	**0.75**	**1**	**1**	**1**	**0.21**	**0**	**1**	**1**	**1**	

Legenda: The numbers from 1 to 13 are the questions of the scale of Galna e collaborators (2009): **1.** Research aims or questions stated clearly (Scoring Criteria: 1 – yes; 0.5 – yes, lacking detail or clarity; 0 – no); **2.** Participant detailed (number, age, sex, height, weight) (Scoring Criteria: 0 to 1); **3.** Recruitment and sampling methods described (1 – yes; 0.5 – yes, lacking detail or clarity; 0 – no); **4.** Inclusion and exclusion criteria detailed (1 – yes; 0.5 – yes, lacking detail or clarity; 0 – no); **5.** Controlled co-variates (walking speed, age, gender) (0 to 1); **6.** Key outcome variables clearly described (1 – yes; 0.5 – yes, lacking detail or clarity; 0 – no); **7.** Adequate methodology able to repeat study (participant sampling, equipment, procedure, data processing, statistical) (0 to 1); **8.** Methodology able to answer research question (participant sampling, equipment, procedure, data processing, statistical) (1 – yes; 0- no). **9.** Reliability of

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the methodology stated (1 – yes; 0- no); **10.** Interval validity of the methodology stated (1 – yes; 0- no); **11.** Research questions answered adequately in the discussion (1 – yes; 0- no); **12.** Key findings supported by the results (1 – yes; 0- no); **13.** Key findings interpreted in a logical manner which is supported by references (1 – yes; 0- no). **Quality of the Studies:** 0 to 0.59 is low, 0.60 to 0.80 is medium and 0.81 to 1 is high.

Table 2 - Summary of the studies selected with 1 to 5 dynamic stretching exercises.

Study	Participants	Dynamic Stretching	Results of the CMJ in cm
Rogan and cols. (2012)	Male ice hockey players of high level (n = 6, age: 18.8±1 years, height: 180.2±3.4 cm, body mass: 80.3±10.8 kg).	**Sets x Repetitions and/or Time x Pause:** 30 s x 10 s of pause **Total of Exercise:** 1 **Type of Exercise:** dynamic stretching for the gluteus maximus.	28.2±12.3 (pretest) 26.4±11.6 (posttest)
Behm and cols. (2011)	Young males (n = 10, age: 22±1.4 years, height: 180.1±4.2 cm, body mass: 81.6±6.8 kg) and middle-aged males (n = 8, age: 46.3±6.5 years, height: 175.2±5.9 cm, body mass: 90.9±16.1 kg) practitioners of exercise (strength training, ice hockey, basketball, soccer, walking and squash).	**Warm-up:** 5 min on cycle ergometer at 70 rpm and 1kp (70 W) (before of the stretching). **Sets x Repetitions and/or Time x Pause:** 1 set x 20 rep x 30 s **Total of Exercise:** 3 **Type of Exercise:** hip extension and knee flexion, hip flexion and knee flexion (lunge), ankle flexion.	36±0.03 (pretest) 38±0.05 (posttest)
Chtourou and cols. (2013)	Male soccer players of the first division of the Tunisian soccer league (n = 22, age: 18.6±1.3 years, height: 174.6±3.8 cm, body mass 71.1±8.6 kg).	**Warm-up:** 5 min of light aerobic running (before of the stretching). **Sets x Repetitions and/or Time x Pause:** 3 sets x 20 s x 7 to 8 s **Total of Exercise:** 3 **Type of Exercise:** calf stretch, hamstrings stretch and quadriceps stretch.	31 cm (pretest) 32 cm (posttest)
Ferreira, Muller and Achour Junior (2013)	Male soccer players of the first division of the Gaúcho Championship, Brazil (n = 13, age: 26.3±3.9 years, height: 176.9±6.7 cm, body mass: 75.7±8.1 kg).	**Warm-up:** 10 min of light aerobic running (before of the stretching). **Sets x Repetitions and/or Time x Pause:** 1 set x 10 rep x without pause **Total of Exercise:** 4 **Type of Exercise:** ankle dorsiflexion, hip flexion, hip extension, knee extension.	39.85±4.62 (pretest) 41.59±4.35 (posttest)
Dalrymple and cols. (2010)	Female volleyball players of the NCAA Division II (n = 12, age: 19.5±1.1 years, height: 171±0.06 cm, body mass: 71.3±8.5 kg).	**Warm-up:** 5 min of light aerobic running and 2 min of walk (before of the stretching). **Sets x Repetitions and/or Time x Pause:** 2 sets x 20 s of pause **Total of Exercise:** 4 **Type of Exercise:** calf raises, slow butt-kicks, leg swing to opposite hand and knee tuck.	31±0.05 (pretest) 29±0.05 (posttest)
Shaji and Isha (2009)	Male basketball players of collegiate level (n = 15), age between 18 to 25 years old.	**Warm-up:** 6 min of static stretching and 6 min of jogging (before of the stretching). **Sets x Repetitions and/or Time x Pause:** the study does not inform. **Total of Exercise:** 5 **Type of Exercise:** split lunge, seated side lunge, sitting leg "fence" rhythm stretch, split lunge bounce and single leg wall bounce.	46.86±2.60 (pretest) 52.06±2.01 (posttest)
Murphy and cols. (2010)	Males practitioners of sports with jump (n = 13, age: 20±2 years, height: 176.62±9.33 cm, body mass: 73.90±8.14 kg).	**Sets x Repetitions and/or Time x Pause:** 1 set x 20 s (approximately 10 rep) x 10 s of pause **Total of Exercise:** 5 **Type of Exercise:** ankle flexion, hip extension, hip flexion and knee extension, hip extension and knee flexion, knee flexion.	63.39±8.58 (pretest) 64.66±9.85 (posttest)
Jaggers (2006)	Male college students of the Health and of the Sports Sciences department (n = 10, age: 27.1±4 years, height: 179.9±6.7 cm, body mass: 81.8±14 kg).	**Warm-up:** 5 min of light walk on a treadmill (before of the stretching). **Sets x Repetitions and/or Time x Pause:** 2 sets x 15 rep x without pause **Total of Exercise:** 5 **Type of Exercise:** hip extension and knee flexion, hip and knee flexion, ankle dorsiflexion, hurdle step over, hip flexion and knee extension.	54.2±11.7 (pretest) 58.3±11 (posttest)

Legends: s: seconds, rep: repetitions, min: minutes, CMJ: countermovement jump, rpm: revolutions per minute.

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In quality assessment of each study was found medium scientific quality (six studies, four studies of 0.80 points, a study of 0.79 points and a study of 0.76 points) to high scientific quality (eight studies, seven studies of 0.84 points and a study of 0.88 points). The selected studies are of good quality because the medium quality studies have points near of the high quality studies (from 0.81 points). The table 1 shows the methodological quality of the studies.

In table 2 and 3 is presented a summary of each study selected for the systematic review and meta-analysis.

The subjects of the studies with 1 to 5 dynamic stretching exercises (total of eight studies, table 2) were formed by seven males and one female. The age of the subjects was between 18 to 27 years, only one study had an age over of the sample, 46.3±6.5 years old.

The sports practiced by subjects of these studies have six sports with jump (basketball, soccer, volleyball and sports with jump), a sport without jump (ice hockey) and a study of healthy people. The figure 3 illustrates the sample of the studies with 1 to 5 dynamic stretching exercises.

The subjects of the studies with 6 to more dynamic stretching exercises (total of six studies, table 3) were formed by four males and two female.

The age of the subjects was between 19 to 26 years old. The sports practiced by subjects of these studies have three sports with jump (soccer, collegiate games players and volleyball), a study of recreational sports and two studies of healthy people. The figure 4 illustrates the sample of the studies with 6 to more dynamic stretching exercises.

The studies of the sample with 1 to 5 dynamic stretching exercises were similar to the studies of the sample with 6 to more dynamic stretching exercises. However, the sample with 1 to 5 dynamic stretching exercises had more males (total of 7) and more sports with jump (total of 6) than sample with 6 to more dynamic stretching exercises (total of 4 males and 3 sports with jump). Perhaps this can result in better countermovement jump of the sample with 1 to 5 dynamic stretching exercises.

The effect size of the sample 1 to 5 dynamic stretching exercises had three studies with null result, they were not used in the meta-analysis (Effect size: - 0,11 of the study of Rogan and collaborators, 2012; 0 of the study of Chtourou and collaborators, 2013 and – 36,57 of the study of Dalrymple and collaborators, 2012). Then, the sample 1 to 5 dynamic stretching exercises were with five studies. The Fail Safe *n* had result of 49.98.

The table 4 and 5 is presented of each study the effect size, the standard error, 95% confidence interval (lower limit to upper limit), the variance, the study weight and the weighted effect size.

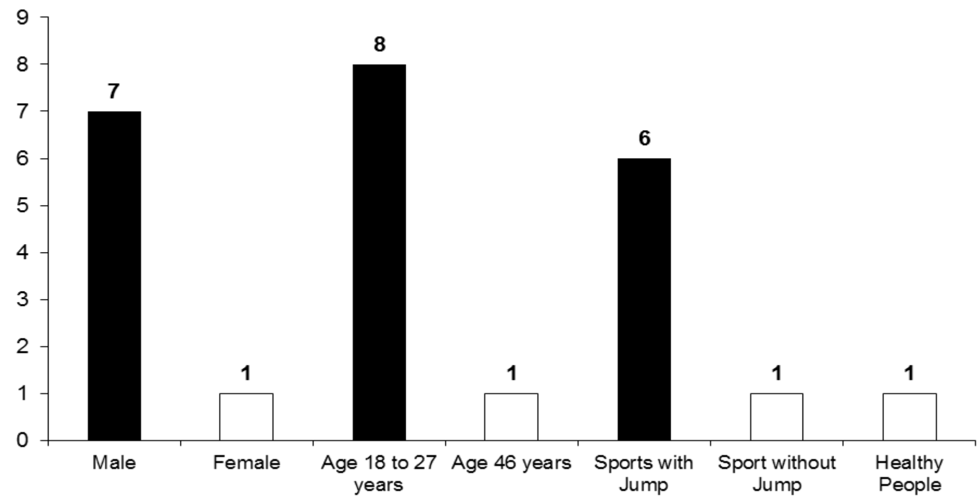

Figure 3 - Characteristics of the sample with 1 to 5 dynamic stretching exercises (the numbers correspond to the total).

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Table 3 - Summary of the studies selected with 6 to more dynamic stretching exercises.

Study	Participants	Dynamic Stretching	Results of the CMJ in cm
Pagaduan and cols. (2012)	Male soccer players from the Tuzla University (n = 29, age: 19.4±1.1 years. height: 179±5.1 cm, body mass: 73.1±8 kg).	**Warm-up:** 5 min of light jogging (before of the stretching). **Time Duration of the Session:** 7 min of stretching. **Sets x Repetitions and/or Time x Pause:** 2 sets x 10 s x 10 s of pause **Total of Exercise:** 7 **Type of Exercise:** straight leg march, hip extension and knee flexion, carioca, hip and knee flexion, reverse lunge with twist, power shuffle (step slide) and jogging with squats.	33.7±3.8 (pretest) 39.1±4.8 (posttest)
Fletcher (2010)	Male collegiate games payers (n = 24, age: 21±0.3 years, height: 176±6.17 cm, body mass: 77±8.2 kg).	**Sets x Repetitions and/or Time x Pause:** 2 sets x 10 rep x without pause **Total of Exercise:** 8 **Type of Exercise:** hip flexion and knee extension, ankle flexion and dorsiflexion, hip abduction, hip flexion and knee flexion, hip extension and knee flexion, 90º squats, forward lunge and sit ups. **Execution:** slow dynamic stretching with rhythm of 50 beats per minute (bpm), fast dynamic stretching with rhythm of 100 bpm.	Slow Dynamic Stretching 47±7.7 (pretest) 48.5±8.7 (posttest) Fast Dynamic Stretching 47.2±8.4 (pretest) 48.3±9.2 (posttest)
Curry and cols. (2009)	Females of the University of Alberta (Canada, n = 24, age: 26±3 years, height: 165.1±8.8 cm, body mass: 61.5±8.1 kg).	**Warm-up:** 5 min of light aerobic activity on a stationary cycle ergometer (before of the stretching). **Time Duration of the Session:** 10 min of stretching. **Sets x Repetitions and/or Time x Pause:** 2 sets x 10 rep x walk during the pause (The study did not report the time) **Total of Exercise:** 9 **Type of Exercise:** hip flexion and knee extension, lateral side step, hip abduction, hip flexion and knee flexion, hip extension and knee flexion, bilateral hops, running cycles (mimic), straight leg skipping and walking lunges.	41.5±6.5 (pretest) 42.3±6.1 (posttest)
Ryan and cols. (2014)	Males (n = 25, age: 22.2±1.3 years, height: 179±7 cm, body mass: 83±10.3 kg) practitioners of exercise (strength training and recreational sports).	**Warm-up:** 5 min of light jog on a treadmill (before of the stretching). **Time Duration of the Session:** 6.7±1.3 min (dynamic stretching 1), 12.1±1.6 min (dynamic stretching 2). **Sets x Repetitions and/or Time x Pause:** 42 s to 1 min and 17 s (dynamic stretching 1), 8 s to 1 min and 35 s (dynamic stretching 2). **Total of Exercise:** 11 **Type of Exercise:** walking knee lift, walking butt kick, walking leg cradle, dog and bush, straight leg march, forward lunge with opposite arm reach, forward lunge with an elbow instep, lateral lunge, high knee run, running butt kick and high knee skip.	Dynamic Stretching 1 51.27±7.47 (pretest) 54.40±7.93 (posttest) Dynamic Stretching 2 51.60±7.55 (pretest) 54.41±7.78 (posttest)
Perrier (2009)	Male university students (n = 21, age: 24.4±4.5 years, height 180±0.06 cm, body mass: 81.1±14 kg) practitioners of exercise (strength training, sprint, jump and others activity).	**Warm-up:** 5 min of treadmill jog at self-selected (before of the stretching). **Time Duration of the Session:** 13.8±1.7 min of stretching. **Sets x Repetitions and/or Time x Pause:** 2 rep x 20 s of pause **Total of Exercise:** 11 **Type of Exercise** (Observation: each exercise was performed at a distance of 18 m)**:** easy skip with arm swings, skip for distance using arms to drive forward, skip for height using arms to drive upward, backward run, lateral low shuffle, step into single leg Romanian dead lift, walking diagonal lunges, high knee pulls, carioca, straight leg strides and gradual accelerations.	41.4±6.8 (pretest) 43±6.3 (posttest)
Kruse and cols. (2013)	Female volleyball players of the NCAA Division I (n = 11, age: 20±1.55 years, height: 178±0.08 cm, body mass: 74.55±12.18 kg)	**Warm-up:** 5 min on cycle ergometer at 60 rpm with 1 kg of resistance (before of the stretching). **Time Duration of the Session:** 7 min of stretching. **Sets x Repetitions and/or Time x Pause:** 30 s of each exercise **Total of Exercise:** 14 **Type of Exercise:** light jog, leg cross-overs, high knees pull, high lunge pull, high knees to chest, quad pull, hip cradle, lunge with twist, reverse kick, high kicks/reach, spiderman, skip hop, back pedal and high kicks.	48.91±3.08 (pretest) 52.45±3.05 (posttest)

Meaning of the Abbreviation: s: seconds, rep: repetitions, min: minutes, CMJ: countermovement jump, rpm: revolutions per minute.

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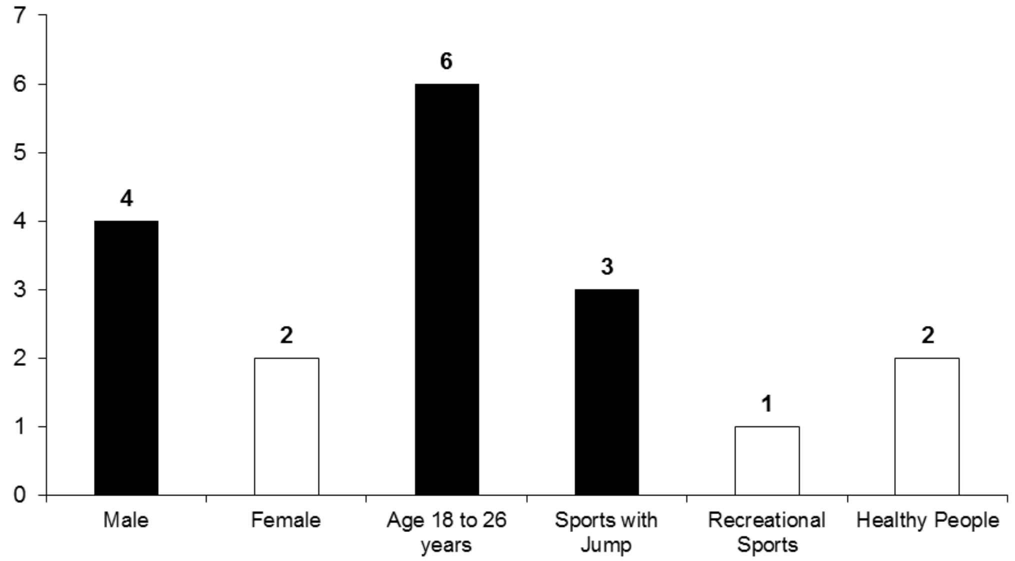

Figure 4 - Characteristics of the sample with 6 to more dynamic stretching exercises (the numbers correspond to the total).

Table 4 - Results of the studies selected with 1 to 5 dynamic stretching exercises.

Study	Effect Size and Classification	Standard Error	95% confidence interval (lower limit to upper limit)	Variance	Study Weight	Weighted Effect Size
Behm and cols. (2011)	63.28 (great)	1.87	59.6148 to 66.9452	3,4969	0.28	18.09
Ferreira, Muller and Achour Junior (2013)	0.35 (small)	0.16	0.0364 to 0.6636	0,0256	39.06	13.67
Shaji and Isha (2009)	1.87 (great)	0.35	1.184 to 2.556	0,1225	8.16	15.26
Murphy and cols. (2010)	0.14 (very small)	0.10	- 0.056 to 0.336	0,0001	1000000	1400
Jaggers (2006)	0.31 (small)	0.18	- 0.0428 to 0.6628	0,0324	30.86	9.56

Table 5 - Results of the studies selected with 6 to more dynamic stretching exercises.

Study	Effect Size and Classification	Standard Error	95% confidence interval (lower limit to upper limit)	Variance	Study Weight	Weighted Effect Size
Pagaduan and cols. (2012)	1.38 (great)	0.22	0.9488 to 1.8112	0.0484	20.66	28.51
Fletcher (2010)	0.19 (very small) slow dynamic stretching	0.09	0.0136 to 0.3664	0.0081	123.45	23.45
Fletcher (2010)	0.15 (very small) fast dynamic stretching	0.08	- 0.0068 to 0.3068	0.0064	156.25	23.43
Curry and cols. (2009)	0.12 (very small)	0.07	- 0.0172 to 0.2572	0.0049	204.08	24.48
Ryan and cols. (2014)	0.40 (small) dynamic stretching 1	0.13	0.1452 to 0.6548	0.0169	59.17	23.66
Ryan and cols. (2014)	0.36 (small) dynamic stretching 2	0.12	0.1248 to 0.5952	0.0144	69.44	25
Perrier (2009)	0.23 (small)	0.10	0.034 to 0.426	0.01	100	23
Kruse and cols. (2013)	1.04 (great)	0.31	0.4324 to 1.6476	0.0961	10.40	10.82

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The pooled estimate of the effect size of 1 to 5 dynamic stretching exercises was of 13.19 ± 28, the classification of the effect size based in Cano-Corres, Sánchez-Álvarez and Fuentes-Arderiu (2012) was of great effect. However, the pooled estimate of the effect size of 6 to more dynamic stretching exercises was of 0.48 ± 0.4, the classification of the effect size was of small effect. The best result was of the pooled estimate of 1 to 5 dynamic stretching exercises.

The pooled estimate of 95% confidence interval of 1 to 5 dynamic stretching exercises was of 12,14728 to 14,23272 (lower limit to upper limit). The pooled estimate of 95% confidence interval of 6 to more dynamic stretching exercises was of 0.20935 to 0.8141143 (lower limit to upper limit).

The statistical heterogeneity of the sample of this meta-analysis was high, I^2 index of 1000%. Then, the random effects model was calculated, the results were the following: effect summary of 69,82, standard errors of 3086,94 and 95% confidence interval of –5980,60035756 to 6120,24015756 (lower limit to upper limit).

The Shapiro Wilk test determined that the data are not normal. The histogram shows the data not normal in figure 5.

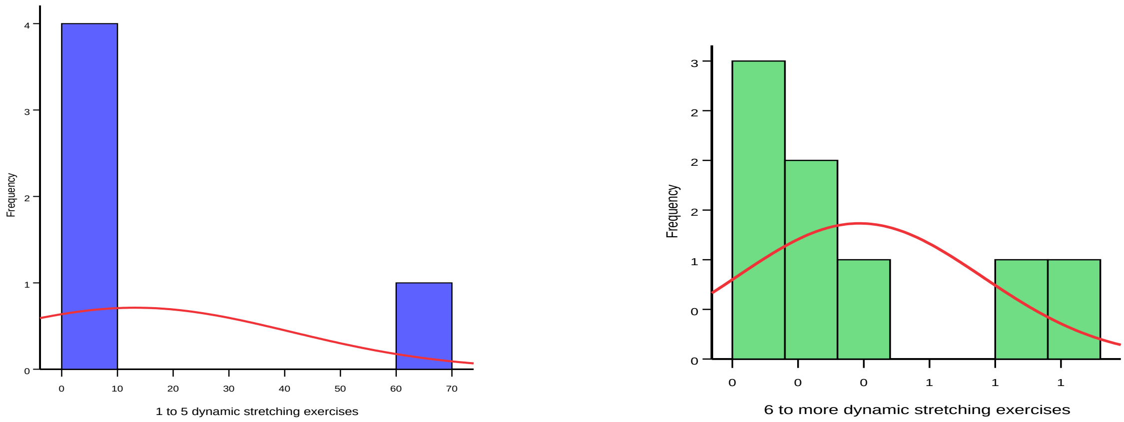

Figure 5 - Histogram of the data two samples.

Mann-Whitney U test detected no significant difference (U = 15, p = 0.52) between 1 to 5 dynamic stretching exercises versus 6 to more dynamic stretching exercises. However, 1 to 5 dynamic stretching exercises had better countermovement jump, the figure 6 illustrates this result.

The figure 7 shows the forest plots.

The confidence interval of the studies in the forest plots does not cross the line of null effect, then, all studies had significant difference. But, the study of Behm and collaborators (2011), the confidence interval stayed further from the line of null effect, then, this study had greater significant difference.

DISCUSSION

The meta-analyses identified no significant difference (p>0.05) between 1 to 5 dynamic stretching exercises versus 6 to more dynamic stretching exercises. However, the result of 1 to 5 dynamic stretching exercises (effect size of the countermovement jump of 13.19 ± 28) was better than 6 to more dynamic stretching exercises (effect size of the countermovement jump of 0.48 ± 0.4). What is the reason of the best countermovement jump after of 1 to 5 dynamic stretching exercises?

The five studies included in the meta-analysis about acute effects of 1 to 5 dynamic stretching exercises on countermovement jump had the following characteristics: warm-up with light aerobic of 5 to 10 minutes, 1 to 2 sets, 15 to 20 repetitions and a study with 20 seconds of each exercise, 10 or 30 seconds of pause and two studies without pause, total of 3 to 4 exercises.

The six studies included in the meta-analysis bout acute effects of 6 to more

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ISSN 1981-9900 *versão eletrônica*
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dynamic stretching exercises on countermovement jump had the following characteristics: warm-up with light aerobic of 5 minutes, 6 to 14 minutes of the duration total of the stretching, sets, 10 repetitions (two studies) or 10 seconds to 1 minute and 35 seconds of exercise of each exercise (four studies), 5 to 10 seconds of pause and two studies without pause, total of 7 to 14 exercises.

The warm-up, the sets and the repetitions were similar in the two simples. However, 1 to 5 dynamic stretching exercises practiced a pause with time greater (10 to 30 seconds) than 6 to more dynamic stretching exercises. Other difference was the total of exercise and the types of exercise. One of the three factors caused a best countermovement jump of the sample that practiced 1 to 5 dynamic stretching exercises.

The literature of the acute effects of dynamic stretching informed that short (composed by 1 to 5 exercises) or long (composed by 6 to more exercises) duration of the session of dynamic stretching improves the countermovement jump (Fradkin, Zazryn and Smoliga, 2010; Turki and collaborators, 2011). Perhaps, 1 to 5 dynamic stretching exercises had a better countermovement jump because it increases more electromyographic activity of the muscles of the lower limbs (Wallmann, Mercer and Landers, 2008), cause greatest power of the legs at the moment of the countermovement jump (Manoel and collaborators, 2008) and cause a greatest recruitment of motor units (Hough, Ross and Howatson, 2009). However, this information needs of more studies.

The prescription of the dynamic stretching has sets, repetitions or time of the exercise and has pause (Ayala and collaborators, 2014; Bishop and Middleton, 2013). However, 6 to more dynamic stretching exercises practiced 7 to 14 exercises and had a pause short, 5 to 10 seconds. The studies with 6 to more exercises, the pause is long, the time is of 15 seconds or more (Beedle and collaborators, 2008; Carvalho and collaborators, 2012).

Perhaps, a short pause and a session more exercises was the motive of worst countermovement jump. Other question about the pause, the literature of the dynamic stretching exercises did not determine the best type of pause, passive or active. According the study, the author uses the active and/or passive pause (Herman and Smith, 2008; Christensen and Nordstrom, 2008).

What is the best pause to execute during the practice of 6 to more dynamic stretching exercises? This question deserves study in the near future.

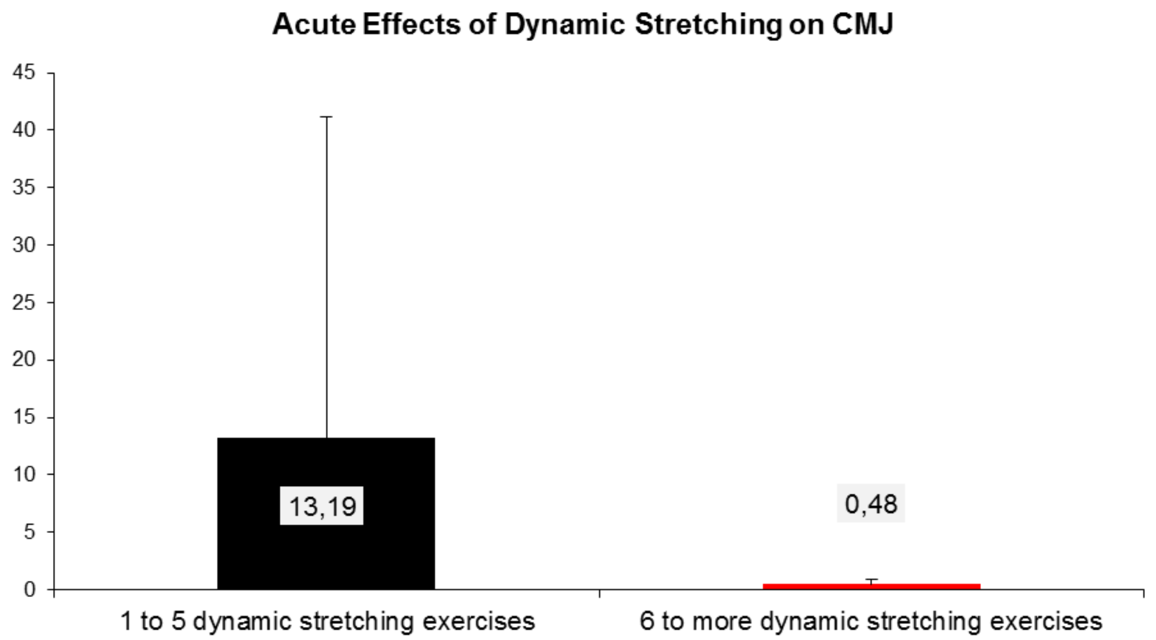

Figure 6 - Effect size of the countermovement jump (CMJ) (the numbers is the average).

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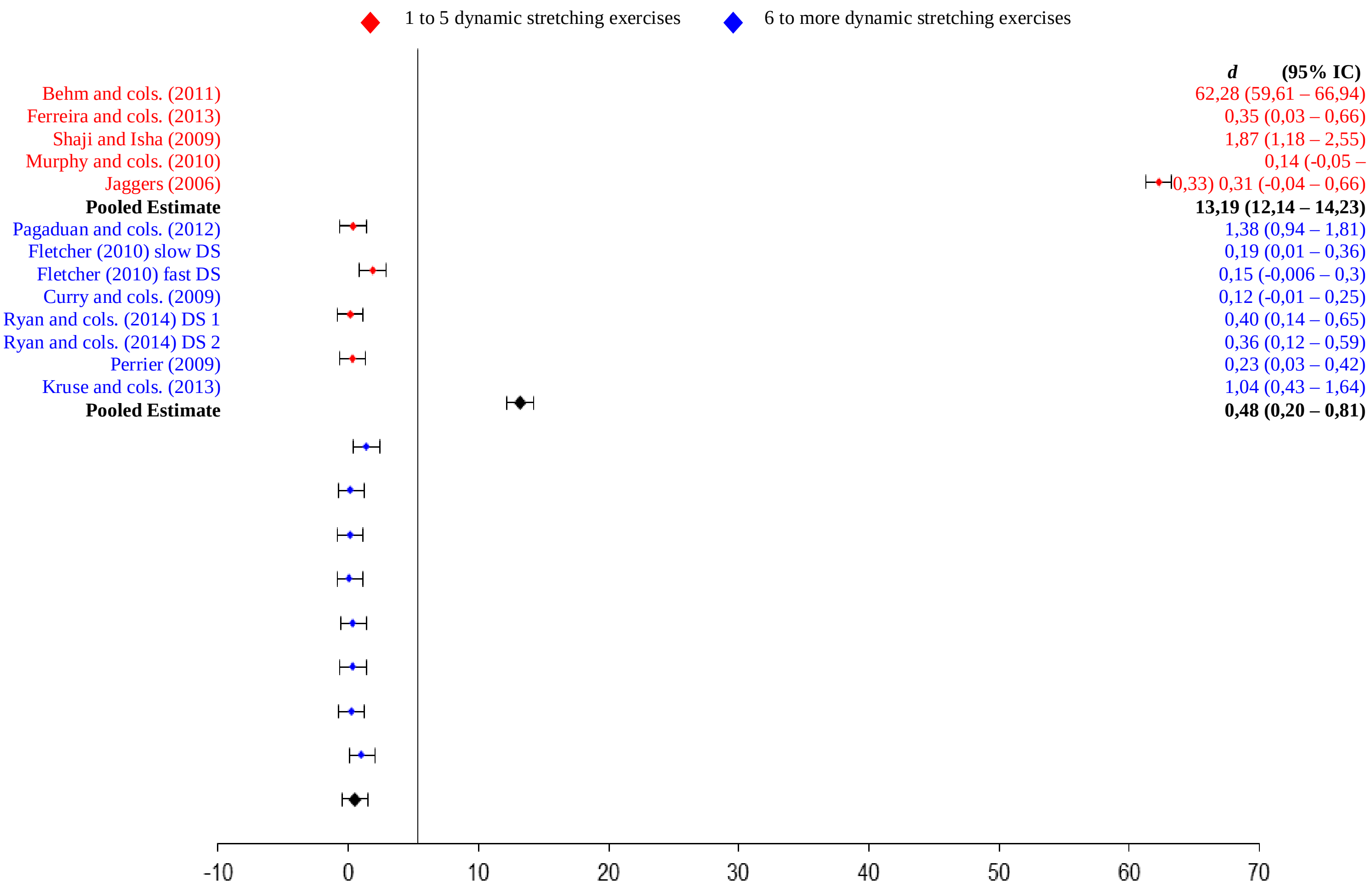

Figure 7 – Florets plots of the acute effects of dynamic stretching on CMJ (Meaning of the Abbreviation: DS: dynamic stretching, *d*: effect size, 95% CI: 95% confidence interval, CMJ: countermovement jump).

Other possible cause of the better countermovement jump of the sample with 1 to 5 dynamic stretching exercises was a greater number of males (total of 5) and had more sports with jump (total of 4) than sample with 6 to more dynamic stretching exercises (total of 4 males and 3 sports with jump). However, the meta-analysis had limitation, few studies were found.

In conclusion, it seems that 1 to 5 dynamic stretching exercises cause a better countermovement jump, however, more studies on this theme are needed with the objective of corroborate this affirmation.

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