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REVISIÓN

METHODOLOGICAL QUALITY OF STRETCHING PROGRAMS: SYSTEMATIC REVIEW

CALIDAD METODOLÓGICA DE LOS PROGRAMAS DE ESTIRAMIENTO: REVISIÓN SISTEMÁTICA

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ABSTRACT

The objective of this systematic review was to analyze the design, sample characteristics and methodological quality of scientific articles on stretching programs. These articles were selected based on the following criteria: (a) experimental design, (b) the analysis of the performance of systematic stretching routines; and (c) the inclusion of flexibility assessment tools to measure the range of motion. Thirty-four articles were finally analyzed. The methodological quality of the studies ranged from 2 to 8 points, with an average of 5.2 points. Further studies are required to analyze the chronic effects of stretching on flexibility using: longitudinal repeated measures designs, populations with different levels of fitness and flexibility, and blind assessors.

KEY WORDS: flexibility, PEDro, quality, method, design.

RESUMEN

El objetivo de esta revisión fue analizar el diseño, características de la muestra y calidad metodológica de los artículos existentes en lo relativo al diseño de programas de estiramiento. Material y método. La selección de estudios estuvo basada en los siguientes criterios: estudios experimentales; la intervención debía estar basada en la realización sistemática de ejercicios de estiramiento; y las pruebas de valoración debían medir el rango de movimiento. Resultados. 34 artículos fueron analizados. Conclusiones. La calidad metodológica de los estudios osciló entre los 2- 8 puntos, con una media de 5.2 puntos. Son necesarios más estudios que analicen el efecto crónico del estiramiento empleando: diseños longitudinales de medidas repetidas; poblaciones con distinto nivel de condición física y flexibilidad; y evaluadores ciegos.

PALABRAS CLAVE: flexibilidad, PEDro, calidad, método, diseño.

1. INTRODUCTION

The main reason for working on flexibility and introducing stretching programs into physical conditioning sessions is the relationship that has always existed between flexibility training and its benefits. The main benefits are the following: increased muscle temperature (Shellock & Prentice, 1985), less pain (Henricson, Fredriksson, Persson & Pereira, 1984), an improved range of motion in the joint in both healthy and injured people (Gajdosik, Giuliani, Bohannon, 1990; Mahnusson, Simonsen, Aagaard, Gleim, McHugh y Kjaer, 1995; Murphy, 1991), increased tolerance to stretching (Halbertsma, VanBolhuis & Goeken, 1996; Law, Harvey, Nicholas, Tonkin, De Sousa & Finniss, 2009; Magnusson, 1998; Magnusson, Simonsen, Aagaard, Sorensen & Kjaer, 1996), its contribution to the recovery of the body after intense effort, (Bandy, Iron & Briggler, 1997; Borms, Van Roy, Santens & Haentjens, 1987; Halbertsma, VanBolhuis & Goeken, 1996; Hartig & Henderson, 1999; Henricson et al., 1984; Letterme, Cordonnier, Mournier & Falempin, 1994) and improved sports performance (Anderson & Burke, 1991; Worrell, Smith, & Winegardner, 1994). However, in many circumstances the main aim of flexibility is to maintain and/or improve the range of motion of one or more joints, depending on the users' initial condition.

In this sense, a great number of research studies have shown a chronic increase in flexibility related to systematically developed stretching programs (Ayala & Sainz de Baranda, 2010, Bandy e Irion, 1994; Chan, Hong y Robinson.2001; Cipriani, Abel, Pirrwitz, 2003; Halbertsma & Goeken, 1994; Nelson & Bandy, 2004; Oduanaiya, Hamzat & Ajayi, 2005; Roberts & Wilson 1999; Russell, Decoster & Enea, 2010; Sainz de Baranda & Ayala 2010). Nevertheless, the methodological heterogeneity of the literature on stretching programs design means that sports coaches, trainers, doctors, and so on, find it difficult to identify the best strategy to improve flexibility (Decoster, Scanlon, Horn & Cleland, 2004).

Therefore, the aim of this systematic review was to analyze the design, the characteristics of the sample and the methodological quality of the scientific articles which study the effectiveness of stretching routines in order to improve flexibility.

2. METHOD

2.1. Inclusion and exclusion criteria

The selection of studies was based on the following criteria: (a) experimental studies (randomized controlled designs) and quasi-experimental studies (for instance, pretest/posttest); (b) the intervention (independent variable) should be based on the performance of systematic stretching routines (prolonged over time) of the hamstring muscle from the clinical and sporting

points of view; and (c) the hamstring flexibility assessment tools should measure the range of motion (ROM) of the knee joint and/or the hip joint in degrees (angular measurement tests).

The main reason for focusing the analysis of this systematic review on stretching programs aimed at improving chronic hamstring flexibility was that this musculature receives by far the greatest attention in different studies, mainly due to its involvement with low back pain (Caillet, 1988) and because its shortness could affect the integrity of various structures of the lower limb (Witvrouw, Lysens, Bellemans, Cambier & Vanderstraeten, 2000; Witvrouw, Bellemans, Lysens, Danneels & Cambier, 2001). In addition, studies whose methodological designs lacked a control group were also included in this systematic review due to the well-documented fact that groups that do not perform systematic stretching exercises have not shown a significant chronic increase of hamstring flexibility over time (Ayala & Sainz de Baranda, 2010; Bandy & Irion, 1994; Bandy, Irion & Briggler, 1998; Ford, Mazzone & Taylor, 2005; Sainz de Baranda & Ayala, 2010).

On the other hand, the exclusion criteria established were the following: (a) scientific studies published as abstracts, short communications and/or those for which no data were published; (b) studies written in a language other than English or Spanish; (c) studies which evaluated the acute effect of a stretching routine on hamstring flexibility; (d) studies whose participants present orthopedic and/or neurological disorders that prevent the chronic improvement of hamstring flexibility; and (e) studies in which tests for estimating hamstring flexibility were based on linear measurements (sit-and-reach test).

There was no limit regarding the age of the participants of the various scientific studies, nor with regard to their level of fitness (sedentary people, physically active people, high-level athletes) and their flexibility of the hamstring (shortness, normal values, above-normal values).

In addition, the evaluation of the effectiveness of stretching programs was determined based on whether significant chronic changes were obtained in the hamstring flexibility from a quantitative point of view, that is, if they achieved increases in the ROM of the hip and/or knee joint. In this way, the qualitative analysis of the programs was disregarded (effect on the viscoelastic properties of the muscle-tendon unit), given the limited number of scientific studies that address this subject and the often speculative nature of their conclusions.

Table 1 provides a schematic description of all inclusion and exclusion criteria outlined above.

Table 1. Criteria used to determine the eligibility of scientific studies.

Inclusion criteria
▪ Experimental and quasi-experimental studies with and without a control group. ▪ The intervention (independent variable) should be based on the performance of systematic stretching routines of the hamstring muscle.

▪ The hamstring flexibility assessment tools should measure the range of motion (ROM) of the knee joint and/or the hip joint in degrees (angular measurement tests).
Exclusion criteria
▪ Scientific studies published as abstracts, short communications and/or those for which no data were published. ▪ Studies written in a language other than English or Spanish. ▪ Studies which evaluated the acute effect of a stretching routine on hamstring flexibility. ▪ Studies whose participants present orthopedic and/or neurological disorders that prevent the chronic improvement of hamstring flexibility. ▪ Studies in which tests for estimating hamstring flexibility were based on linear measurements (sit-and-reach test).

2.2. Bibliographic search strategy

Articles were taken from the two principle online databases in the Sport Sciences field:

- PubMed (http://www.ncbi.nlm.nih.gov/pubmed): database of the US National Library of Medicine and the National Institute of Health.
- SportsDiscus (http://www.sirc.ca/products/sportsdiscus.cfm): database of the Sport Information Resource Centre (SIRC) created by the Coaching Association of Canada.

The word “stretching” was always used as a search criterion, together with other subordinated fields preceded by the word “and” plus one of the following key terms: lower extremity stretching, contract-relax stretching, ballistic stretching, static stretching, range of motion, flexibility, knee, hip, skeletal muscle, proprioceptive neuromuscular facilitation and chronic gains. There was no limitation regarding the year of publication of the studies. The search ended on November 2010.

The titles and abstracts of the articles found were firstly analyzed by only one expert researcher (Doctor in Physical Education and Sport Sciences with more than 10 years’ experience in the research field) in order to determine whether they fulfilled the established inclusion and exclusion criteria. Therefore, titles and abstracts of the articles found were categorized as: (a) apt; (b) doubtful; and (c) unfit. Those articles whose title and abstract did not provide enough information to decide on their selection were read in full in order to categorize them as apt or unfit. When some doubt existed a second expert’s opinion was sought.

Once the articles had been selected they were obtained in electronic format.

2.3. Data extraction

All methodological variables were taken, recorded and analyzed on all the selected articles by the same researcher. Those articles that did not specify one

or more of the variables above were categorized as “do not inform”, but they were not removed from the analysis process. This data extraction process was recommended by “Cochrane Collaboration Back Review Group” in order to make systematic reviews (Van Tulder, Furland, Bombardier & Bouter, 2003) and has also been previously used by a great number of authors (Decoster, Cleland, Altieriy Russell, 2005; Herbert & Gabriel, 2002; Simons, Wollersheim & Thien, 2009).

2.4. Assessment of methodological quality

The “Physiotherapy Evidence Database (PEDro)” is a scale used to measure the methodological quality of all the articles selected (Verhagen et al, 1998; Maher, Sherrington, Herbert, Moseley & Elkins, 2003). This tool is designed to assess the methodological quality of clinical designs (Table 2) and it is used in many bibliographic reviews (Decoster et al., 2005; Herbert & Gabriel, 2002; Maher et al., 2003). It is based on the list developed by Verhagen et al. (1998) who used the Delphi method in gaining consensus.

The PEDro scale presents a total of 11 items. Item number 1 refers to the external validity of the studies, while items 2-9 refer to their internal validity. Items 10 and 11 show whether the statistical information reported by the authors explains the results suitably. All items in this list are classified into the categories “yes”, “no” or “do not inform”. Items in the “yes” list added 1 point, while the ones in “no” or “do not inform” do not get any points.

The first item was not considered in this review, since it relates to the assessment of the studies’ external validity. Therefore, only items 2-11 were used for the methodological quality analysis. The maximum score of an article would therefore be 10, and the minimum 0.

Although the PEDro scale is commonly used to assess the methodological quality of randomized controlled designs, in this systematic review it was also used to assess the quality of the studies with pretest-posttest single group design, and therefore to permit the methodological comparison of both designs.

Table 2. Scale “Physiotherapy Evidence Database (PEDro)” to analyze the methodological quality of the clinical studies.

Criteria	Yes	No
1. Eligibility criteria were specified (not included in score).	1	0
2. Subjects were randomly allocated to groups.	1	0
3. Allocation was concealed.	1	0
4. The groups were similar at baseline regarding the most important prognostic indicator.	1	0
5. There was blinding of all subjects.	1	0
6. There was blinding of all therapists who administered the therapy.	1	0
7. There was blinding of all clinicians who measured at least one key outcome.	1	0
8. Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups.	1	0

9.	All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by intention to treat.	1	0
10.	The results of between-group statistical comparisons are reported for at least one key outcome.	1	0
11.	The study provides both point measures and measures of variability for at least one key outcome.	1	0

3. RESULTS

3.1. Selection of studies

The strategy to search for and select the articles used in this review obtained a total of 42 articles (n=42) whose titles and abstracts seemed to fulfill the inclusion and exclusion criteria previously established by the authors. Four of the forty-two titles and abstracts selected could not be obtained in electronic format due to restricted access. Therefore, a final total of 38 electronic articles was obtained. However, a further four of these were dropped either because their methodology was poorly described (n=2), or because unusual stretching techniques were described, such as “micro-stretching” (n=1) and “myofascial stretching” (n=1). As a result, 34 articles were analyzed and included in this review (figure 1), all of which analyzed the chronic effect of different stretching routines to improve hamstring flexibility.

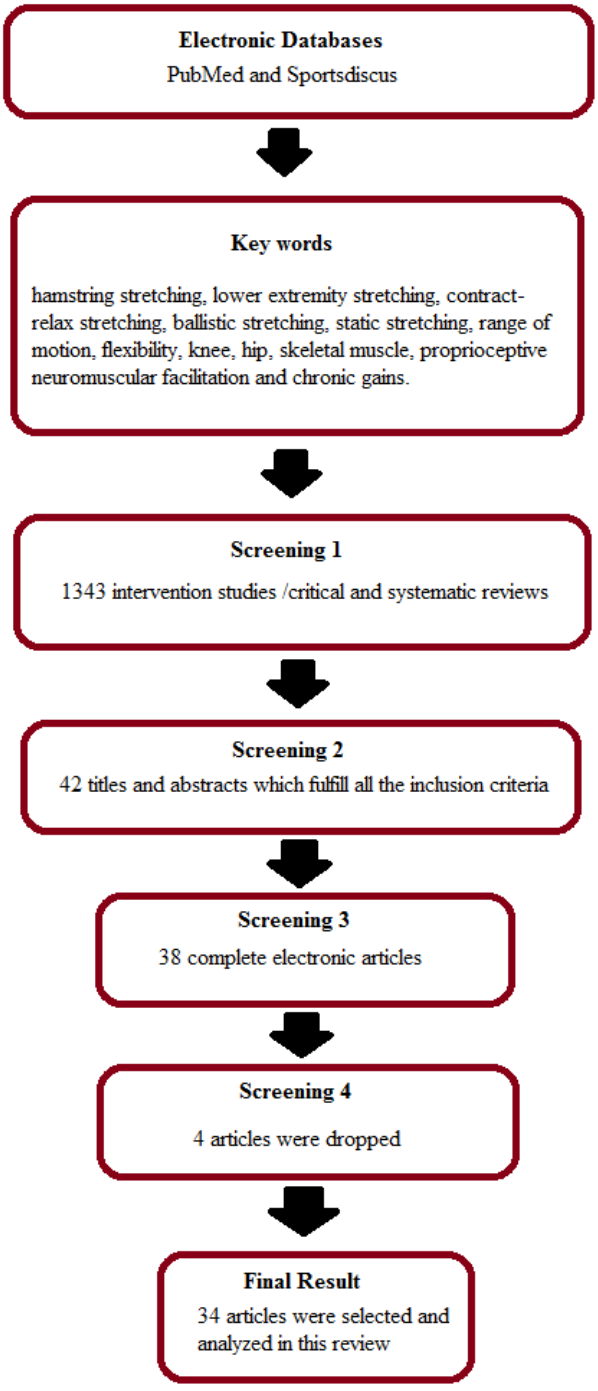

Figure 1. Diagram of the selection phases of the scientific studies on the chronic effect of stretching on hamstring flexibility.

3.2. Design

Table 3 shows the number and percentage of studies which use each of the most usual experimental and quasi-experimental designs to assess the efficiency of an intervention program. It should be pointed out that pretest and

posttest design with a control group is the most common one [48.5% of the studies], followed by the repeated measures design [36.4%].

Table 3: Designs of the scientific studies selected (n=33).

Design type	Number of studies (n)	Percentage of studies (%)
Repeted measure	12	36.4%
Pretest and posttest with a control group	17	48.5%
Pretest and posttest without acontrol group	5	15.1%
Familiarization session	10	30.3%

3.3. Population

A total of 1,886 participants were included in the different studies analyzed (table 4). Seventeen of the studies used men and women as study samples (Ayala & Sainz de Baranda, 2010, Bandy & Irion, 1994; Bandy, Irion & Briggler, 1997; Bandy, Irion & Briggler, 1998; Chan, Hong & Robinson. 2001; Cipriani, Abel, Pirrwitz, 2003; Covert, Alexandre, Petronis & Davis, 2010, Davis, Ashby, McCale, McQuain & Wine, 2005; Decoster et al., 2004; Feland, Myrer, Schulthies, Fellingham & Meason, 2001; Halbertsma & Goeken, 1994; Meroni et al., 2010; Oduanaiya, Hamzat & Ajayi, 2005; Roberts & Wilson 1999; Russell, Decoster & Enea, 2010; Sainz de Baranda & Ayala 2010; Webright, Randolph & Perrin, 1997), 6 estudios incluían solo hombres (Akbari, Moodi, Moein & Nazok, 2006; Ford, Mazzone & Taylor, 2005; Laroche & Connolly, 2006; Nelson & Bandy, 2004; Voigt, Vale, Abdala, Freitas, Novaes & Dantas, 2007; Yuktasir & Kaya, 2009), 6 solo mujeres (Ayala, Sainz de Baranda & De Ste Croix, 2010; Borms et al., 1987; Gribble, Guskiewicz, Prentice & Shields,1999; Law et al., 2009; Rowlands, Marginson & Lee, 2003; Sady, Wortman & Blanke, 1982) and 5 studies did not specify the gender of the participants (Hartig & Henderson, 1999; Marques, Vasconcelos, Cabral & Sacco, 2009; Prentice, 1983; Santonja, Sainz de Baranda, Rodríguez, López & Canteras, 2007; Worrell, Smith & Winegardner, 1994).

The average age of the participants in the studies could not be established because certain studies do not reveal this information (Marques et al., 2009; Sady, Wortman y Blanke, 1982) or simply show an age range without providing the average age (Akbari et al., 2006; Borms et al., 1987; Meroni et al., 2010; Prentice, 1983).

Table 4. Characteristics of the sample used un each of the studies selected.

Study	Number	Sex (men, women)		Age (years ± SD)	Initial level of flexibility*	Fitness level †
Akbari et al. (2006)	50	50	0	12-14	Low	-
Ayala, Sainz de Baranda y De Ste Croix (2010)	18	0	18	21.3±2.5	-	Sportsmen (five a side football)
Ayala y Sainz de Baranda (2010)	150	106	44	21.3±2.5	Normal	Active

Bandy e Irion (1994)	57	40	17	26.1±5.3	Low	-
Bandy, Irion y Briggler (1997)	93	61	32	26.2±5.1	Low	-
Bandy, Irion y Briggler (1998)	68	41	17	26.2±5.6	Low	-
Borms et al. (1987)	20	0	20	20-30	-	Sedentary
Chan, Hong y Robinson (2001)	40	24	16	20±3	-	-
Cipriani, Abel, Pirrwitz (2003)	23	5	18	22.8±4.7	Low	-
Covert et al. (2010)	32	16	16	21.9±2.6	Low	-
Davis et al. (2005)	19	11	8	23.1±1.5	Low	-
Decoster et al. (2004)	29	7	22	25.9±6.1	Normal	-
Feland et al. (2001)	60	14	46	84.7±5.6	Low	Sedentary
Ford, Mazzone y Taylor (2005)	35	24	11	22.7±2.4	Low	Active
Gribble et al. (1999)	45	-	-	19.7±1.5	Low	-
Halbertsma y Goeken (1994)	18	8	10	26.5	Low	-
Hartig y Henderson (1999)	298	298	0	20	-	Active
Laroche y Connolly (2006)	29	29		31.6±15.2	-	Active
Law et al. (2009)	30	15	15	40±12	Low	-
Marques et al. (2009)	31	-	-	-	Low	-
Meroni et al. (2010)	50	29	21	23-44	Low	-
Nelson y Bandy (2004)	69	69	0	16.4 ±0.9	Low	-
Oduanaiya, Hamzat y Ajayi (2005)	60	37	23	23.5±2.6	Low	-
Prentice (1983)	40	-	-	18-34	-	-
Roberts y Wilson (1999)	24	19	5	20.5±1.3	-	Active
Rowlands, Marginson y Lee (2003)	37	0	37	20±1.3	-	-
Russell, Decoster y Enea (2010)	47	22	25	21.5±2.4	Normal	Active
Sady, Wortman y Blanke (1982)	31	0	31	-	-	-
Sainz de Baranda y Ayala (2010)	173	122	51	21.3±2.5	Normal	Active
Santonja et al. (2007)	62	-	-	10.3±0.5	-	Active
Voigt et al. (2007)	59	59	0	23.8±3.6	-	-
Webright, Randolph y Perrin (1997)	40	22	18	21.4±3.5	Low	-
Worrell, Smith y Winegardner (1994)	19	10	9	26.2±3.3	-	Athletes
Yuktasir y Kaya (2009)	28	28	0	21.8±1.9	-	-

SD: standard deviation; -: not specified; *: this variable presents 3 levels: Low, Normal, Above Normal; †: *: this variable presents 4 levels: sedentary, physically active, sportsman (sport).

On the other hand, only 16 of the articles selected used participants with a low level of hamstring flexibility (depending on the different normality values determined for each test) (Akbari et al., 2006; Bandy & Irion, 1994; Bandy, Irion & Briggler, 1997; Bandy, Irion & Briggler, 1998; Cipriani, Abel, Pirrwitz, 2003; Covert et al., 2010; Davis et al., 2005; Feland et al., 2001; Gribble et al., 1999; Halbertsma & Goeken, 1994; Law et al., 2009; Marques et al., 2009; Meroni et al., 2010; Nelson & Bandy, 2004; Oduanaiya, Hamzat & Ajayi, 2005; Webright, Randolph & Perrin, 1997). Four of them used participants with normal values of hamstring flexibility (Ayala & Sainz de Baranda, 2010, Decoster et al., 2004, Russell, Decoster & Enea, 2010; Sainz de Baranda & Ayala 2010) and fourteen articles did not specify the initial level of flexibility of their participants (Ayala, Sainz de Baranda & De Ste Croix, 2010; Borms et al., 1987; Chan, Hong & Robinson. 2001; Ford, Mazzone & Taylor, 2005; Hartig & Henderson, 1999; Laroche & Connolly, 2006; Prentice, 1983; Roberts & Wilson 1999; Rowlands, Marginson & Lee, 2003; Sady, Wortman & Blanke, 1982; Santonja et al., 2007; Voigt et al., 2007; Worrell, Smith & Winegardner, 1994; Yuktasir & Kaya, 2009). As far as we know, no tests used participants with a high level of flexibility.

Regarding the participants' fitness level, 24 of all the analyzed articles used sedentary people (Borms et al., 1987; Feland et al., 2001) or did not specify quantitative data about their regular physical activity (Akbari et al., 2006; Bandy & Irion, 1994; Bandy, Irion & Briggler, 1997; Bandy, Irion & Briggler, 1998; Chan, Hong & Robinson. 2001; Cipriani, Abel, Pirrwitz, 2003; Covert et al., 2010; Davis et al., 2005; Decoster et al., 2004; Gribble et al., 1999; Halbertsma & Goeken, 1994; Law et al., 2009; Marques et al., 2009; Meroni et al., 2010; Nelson & Bandy, 2004; Oduanaiya, Hamzat & Ajayi, 2005; Prentice, 1983; Rowlands, Marginson & Lee, 2003; Sady, Wortman & Blanke, 1982; Voigt et al., 2007; Webright, Randolph & Perrin, 1997; Yuktasir & Kaya, 2009), whereas 8 of them used physically active people as samples (regular exercise 2-4 days a week, 45 minutes a day minimum for at least 3 months) (Ayala & Sainz de Baranda, 2010; Ford, Mazzone & Taylor, 2005; Hartig & Henderson, 1999; Laroche & Connolly, 2006; Roberts & Wilson, 1999; Russell, Decoster & Enea, 2010; Santonja et al., 2007); only 2 studies used sportsmen with a high initial level of fitness (Ayala, Sainz de Baranda & De Ste Croix, 2010; Worrell, Smith & Winegardner, 1994).

3.4. Methodological quality

The methodological quality of the analyzed studies was between 2 and 8 points, with a mean of 5.2 points (table 5). Two articles (6%) obtained a score of 8 points, 5 articles (15%) 7 points, 11 articles (33%) 6 points and 9 articles (23%) 5 points, whereas 8 articles (23%) scored under 5 points.

Despite the relative heterogeneity of the analyzed studies, there were certain common quality criteria amongst all of them. In table 5 we can see that the most frequent criterion was item number 9 "All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome

was analyzed by intention to treat" (97.1%), followed by item number 10 "The results of between-group statistical comparisons are reported for at least one key outcome" and number 11 "The study provides both point measures and measures of variability for at least one key outcome" (91.2%). As a negative aspect we can say that only one article (Law et al., 2009) fulfilled item number 3 (Allocation was concealed), and none of the studies could fulfill item number 5 (There was blinding of all subjects).

Table 5. Analysis of the selected studies' methodological quality (n = 34).

Study	1	2	3	4	5	6	7	8	9	10	11	Score
Akbari et al. (2006)	+	+	-	+	-	-	-	+	+	+	+	6
Ayala, Sainz de Baranda & De Ste Croix (2010)	+	+	-	+	-	-	+	?	+	+	+	6
Ayala & Sainz de Baranda (2010)	+	+	-	+	-	-	+	?	+	+	+	6
Bandy e Irion (1994)	+	+	-	+	-	-	+	+	+	+	+	7
Bandy, Irion & Briggler (1997)	+	+	-	+	-	-	-	-	+	+	+	5
Bandy, Irion & Briggler (1998)	+	+	-	+	-	-	+	+	+	+	+	7
Borms et al. (1987)	+	+	-	?	-	-	-	-	+	-	+	3
Chan, Hong & Robinson (2001)	+	+	-	-	-	-	-	-	+	+	+	4
Cipriani, Abel, Pirrwitz (2003)	+	+	-	+	-	-	+	-	+	+	+	6
Covert et al. (2010)	+	+	-	+	-	-	+	-	+	+	+	6
Davis et al. (2005)	+	+	-	+	-	-	+	-	+	+	+	6
Decoster et al. (2004)	+	+	-	+	-	+	+	+	+	+	+	8
Feland et al. (2001)	+	+	-	+	-	+	?	+	+	+	?	6
Ford, Mazzone & Taylor (2005)	+	+	-	+	-	+	?	+	+	+	+	7
Gribble et al. (1999)	+	+	-	+	-	-	-	+	+	+	+	6
Halbertsma & Goeken (1994)	+	?	-	-	-	-	-	-	+	-	+	2
Hartig & Henderson (1999)	+	+	-	-	-	-	-	-	-	+	?	2
Laroche & Connolly (2006)	+	+	-	+	-	-	-	-	+	+	+	5
Law et al. (2009)	+	+	+	+	-	-	?	+	+	+	+	7
Marques et al. (2009)	+	+	-	+	-	-	-	-	+	+	+	5
Meroni et al. (2010)	+	+	-	+	-	-	?	+	+	+	+	6
Nelson & Bandy (2004)	+	+	-	-	?	?	?	+	+	+	+	5
Oduanaiya, Hamzat & Ajayi (2005)	+	+	-	+	-	-	-	-	+	+	+	5
Prentice (1983)	+	-	-	-	-	-	-		+	?	+	2
Roberts & Wilson (1999)	-	+	-	+	?	?	-	-	+	+	+	5
Rowlands, Marginson & Lee (2003)	+	+	-	-	-	-	-	+	+	+	+	5
Russell, Decoster & Enea (2010)	+	+	-	+	-	+	+	+	+	+	+	8
Sady, Wortman & Blanke (1982)	+	-	-	?	-	-	-	-	+	+	+	3
Sainz de Baranda & Ayala (2010)	+	+	-	+	-	-	+	-	+	+	+	6
Santonja et al. (2007)	-	+	-	?	-	-	+	+	+	+	+	6
Voigt et al. (2007)	+	-	-	+	-	-	-	+	+	+	+	5
Webright, Randolph & Perrin (1997)	+	+	-	+	-	-	-	+	+	+	+	6

Worrell, Smith & Winegardner (1994)	+	-	-	+	-	-	-	-	+	+	+	4
Yuktasir & Kaya (2009)	-	+	-	+	-	-	+	?	+	+	+	6

The numbers of the columns corresponded to the following items of the PEDro scale.

1. Eligibility criteria were specified (not included in score)
2. Subjects were randomly allocated to groups.
3. Allocation was concealed.
4. The groups were similar at baseline regarding the most important prognostic indicator.
5. There was blinding of all subjects.
6. There was blinding of all therapists who administered the therapy.
7. There was blinding of all consultants who measured at least one key outcome.
8. Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups.
9. All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by intention to treat.
10. The results of between-group statistical comparisons are reported for at least one key outcome.
11. The study provides both point measures and measures of variability for at least one key outcome.

The final score was determined by the sum of items that fulfill the criteria established, except for item 1, which was not taken into consideration.

+ Indicates that the item was clearly fulfilled, - indicates that the item was not fulfilled, ? indicates that the item was not clearly fulfilled and it does not count in the final score.

4. DISCUSSION

It is important that professionals in the fields of physical education, sport training and sport medicine know how to examine the methodological quality of the scientific studies they have access to, since this would allow them to select appropriately the safest and most efficient methods for their patients, students and/or sportsmen. Along these lines, studies with better methodological quality provide better scientific proof about the most suitable stretching parameters to improve flexibility.

Labelle et al. (1992) state that in order to be valid, a clinical study must obtain at least 7 points. If we use this reference we can see that only 7 of the analyzed studies fulfill this requirement (Bandy & Irion, 1994; Bandy et al., 1998, Decoster et al., 2004; Feland et al., 2001; Ford, Mazzone & Taylor, 2005; Law et al., 2009; Russell, Decoster & Enea, 2010). However, given the longitudinal nature of studies evaluating the chronic effect of stretching programs and the great difficulty of achieving certain quality criteria, a 7-point score may be too demanding. In this sense, it is difficult to analyze subjects “blind” as a treatment group, and also to maintain them unaware of the different workgroups. Nevertheless, blind assessment needs to be improved, and the assessment process used must be reproducible (Decoster et al., 2005).

Another relevant aspect regarding the methodology of the analyzed studies is the fact that repeated-measures designs are rare and that

uninterrupted longitudinal repeated-measures designs are practically inexistent. Therefore, rigorous scientific studies are needed which use designs that allow analysis of the evolution of flexibility during the systematic stretching programs, as well as establishing the minimum and maximum duration of each of them.

The populations most used as sample for different authors were young adults with joint ROM restriction and young adults with normal mobility, while a very few studies used physically active people and/or high level sportsmen (Table 3).

We have not found studies which make direct comparisons between individuals with different mobility and/or fitness levels. As a result, it is impossible to determine whether the mobility level (restricted, normal values, high values) and the fitness level (sedentary, physically active, high level sportsmen) may be variables which influence stretching programs' efficiency. This knowledge could be of vital importance for coaches, physical trainers, sport doctors and other members of the physical activity and sports field, since it would allow the training load to be regulated depending on the individual needs of the sportsmen.

What seems to be clear is that the participants' gender is not a variable that affects the efficiency of stretching programs as several previous studies had explained (Etnyre & Lee, 1988; Meroni et al., 2010).

If we include in the efficiency analysis of stretching programs all the studies that use participants with low or normal hamstring flexibility and we do not consider the methodological differences, when we compare both populations we see that there is no significant quantitative difference (table 6). In addition, participants with low hamstring flexibility seem to achieve slightly greater ROM increases (∆16.56º) than those with normal mobility values (∆13.16º) after applying a systematic stretching program. However, given the inherent methodological limitations of this hypothesis, it is important to consider its application carefully.

Table 6. Studies that use different populations (criterion: initial flexibility level) for each hamstring flexibility assessment test.

Assessment test Stretching position	Studies (n)	Range of average improvement (degrees)	Mean of improvement of the best group (degrees)*
KE / low flexibility level	11	3.8º-23.7º	13.5º
KE / low flexibility level	8	4.5º-19.2º	9.9º
SLR / low flexibility level	4	5.3º-35.8º	19.6º
SLR / low flexibility level	10	3.0º-33.6º	16.4º

KE: Knee extension test; SLR: Straight Leg Raising Test; * mean of the highest improvement groups in each study.

Therefore, we need scientific studies that compare directly the effect of a systematic stretching program on different study samples using the following

distinction criteria: (a) initial flexibility level (restricted, normal values, high values) and/or (b) fitness level (sedentary, physically active, high level sportsmen).

5. LIMITATIONS AND FUTURE RESEARCH

One of the possible limitations of this review is the fact that only one author carried out the bibliographic search and classified the titles and abstracts found as “apt” or “unfit”. Another possible limitation of this systematic review is the fact that the authors who selected and assessed the articles were not blinded to author names, journal, and institutional affiliation, which has been identified as a source of possible bias (Clarke & Oxman, 2001). In addition, the great heterogeneity of the analyzed studies and their methodological quality prevented conducting a meta-analysis of the results as well as the calculation of the effect size that would allow comparison of articles. Furthermore, the results of this review should not be extrapolated to muscles other than the hamstring.

6. CONCLUSIONS

The methodological quality of the analyzed studies was between 2 and 8 points, with a mean of 5.2 points. The analysis of the scientific literature shows the need for scientific studies of high quality that analyze the chronic effect of stretching programs on the flexibility of the muscle-tendon unit using: (a) longitudinal repeated measures designs, (b) populations with different fitness level and initial flexibility; and (c) blind assessors unrelated to the study.

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