Effects of the foam roller on athletes' jumping ability: a systematic review

Miguel Alarcón Rivera[1], Pablo Valdés Badilla[2,3], Aldo Martínez Araya[4], Sebastián Astorga Verdugo[4], Leonardo Lagos[5], Mario Muñoz[5], Eduardo Guzmán Muñoz[6]

[1]Escuela de Ciencias del Deporte. Facultad de Salud. Universidad Santo Tomás. Chile. [2]Departamento de Ciencias de la Actividad Física. Facultad de Ciencias de la Educación. Universidad Católica del Maule. Talca. Chile. [3]Carrera de Entrenador Deportivo. Escuela de Educación. Universidad Viña del Mar. Viña del Mar. Chile. [4]Grupo de investigación GIMH. Facultad de Salud. Universidad Autónoma de Chile. Chile. [5]Departamento de Kinesiología. Facultad de Medicina. Universidad de Concepción. Concepción. Chile. [6]Escuela de Kinesiología. Facultad de Salud. Universidad Santo Tomás. Chile.

doi: 10.18176/archmeddeporte.00116

Received: 11/11/2021
Accepted: 27/07/2022

Summary

Introduction: It is proposed that the use of the foam roller (FR) in the sports field can be a good complement to optimize the acute improvement of range of motion and to cause an analgesic effect, however, its use in warm-up to improve neuromuscular variables such as vertical jump is controversial in athletes. Therefore, the objective of this systematic review was to analyze the effects of FR on jumping ability in athletes.
Material and method: A comprehensive, exhaustive, and structured search was carried out following PRISMA recommendations in the following databases: Pubmed/MEDLINE, Cochrane, Scopus, Sciencedirect and Web of Science. The studies that met the inclusion criteria were assessed for their methodological quality using the PEDro scale.
Results: A total of 262 records were found in the study identification phase. In the screening phase, duplicates were eliminated, and the studies were filtered by selecting the title, abstract and keywords, obtaining 47 references as a result. A total of 18 studies were analyzed in full text, 12 of which were excluded. Therefore, the total number of studies that met all the selection criteria was six.
Conclusions: The selected studies show that the application of RF is a technique that contributes to increasing the performance of jumping capacity in athletes and its effect can last up to 10 minutes after its application. However, protocols and duration times should be standardized to maximize results.

Key words:
Massage. Fascia. Athletic performance. Sports.

Efectos del *foam roller* sobre la capacidad de salto en deportistas: una revisión sistemática

Resumen

Introducción: Se plantea que la utilización del *foam roller* (FR) en el ámbito deportivo puede ser un buen complemento para optimizar la mejora aguda del rango de movimiento y para provocar un efecto analgésico, no obstante, su utilización en el calentamiento con el fin de mejorar las variables neuromusculares como el salto vertical es controversial en deportistas. Es por esto que el objetivo de esta revisión sistemática fue analizar los efectos del FR sobre la capacidad de salto en deportistas.
Material y método: Se realizó una búsqueda comprensiva, exhaustiva y estructurada siguiendo las recomendaciones PRISMA en las siguientes bases de datos: Pubmed/MEDLINE, Cochrane, Scopus, Sciencedirect y Web of Science. Los estudios que cumplieron los criterios de inclusión fueron valorados en cuanto a su calidad metodológica a través de la escala PEDro.
Resultados: Un total de 262 registros se encontraron en la fase de identificación de estudios. En la fase de screening se eliminaron los duplicados y los estudios fueron filtrados seleccionando el título, resumen y palabras clave obteniendo como resultado 47 referencias. Un total de 18 estudios fueron analizados a texto completo, siendo 12 de ellos excluidos. Por lo tanto, el número total de estudios que cumplió con todos los criterios de selección fue de seis.
Conclusiones: Los estudios seleccionados muestran que la aplicación del FR es una técnica que contribuye a aumentar el rendimiento en la capacidad de salto en deportistas y puede perdurar su efecto hasta 10 minutos después de su aplicación. Sin embargo, se debe estandarizar los protocolos y tiempos de duración para maximizar los resultados.

Palabras clave:
Masaje. Fascia. Rendimiento deportivo. Deportes.

Correspondence: Eduardo Guzmán Muñoz
E-mail: eguzmanm@santotomas.cl

Introduction

The fascia is a connective tissue, mainly made up of collagen and elastin, that surrounds the muscles, nerves and blood vessels and connects the body's structures[1]. Fascia mobility can be restricted due to an injury, disease, inactivity or inflammation, affecting its normal function[2]. This can cause pain and change physical performance, reducing flexibility, muscle strength, endurance and coordination[2]. Some studies have demonstrated that fascia relaxation and stretching techniques have positive effects on the range of motion (ROM) and the muscle reaction time, generating improvements in flexibility of muscle groups such as quadriceps and hamstrings[3,4]. Over the last few years, in the field of rehabilitation and sports science, use of the Foam Roller (FR) has grown quickly as a technique to relax the fascia to prepare for exercise and recover muscle functions[5].

The FR is a self-myofascial release tool in the shape of cylinder, which comes in different sizes and densities. Its action mechanisms are based on the pressure exerted by the body mass on the FR.[6,7] It has been reported that using an FR improves the range of articular movement[8-10], reduces pain[7], assists post-exercise recovery[9,11] and improves neuromuscular performance[7].

On the other hand, jumping ability has been a focus of interest among sports-related researchers as it directly affects performance. In this respect, strategies such as dynamic stretching and myofascial release techniques have been used to improve jumping ability[12,13]. The assessments most used to measure the jumping ability include the Squat Jump (SJ), the counter movement jump (CMJ) and the Abalakov[14,15]. It has been highlighted that the reduction of muscle-tendon and myofascial structure flexibility causes a delay in muscle activation, affecting motor performance in sporting skills such as jumping[15]. It is also suggested that using an FR in sport can provide a good complement to optimise the acute improvement in the ROM and cause an analgesic effect. However, its use in warm-up to improve neuromuscular variables such as vertical jumping is controversial among athletes[16]. Consequently, the purpose of this systematic review was to analyse the effects of the FR on jumping ability among male and female athletes aged over[18].

Material and method

Search strategy

A comprehensive, exhaustive and structured search was performed following PRISMA-P recommendations in five generic databases: Pubmed/MEDLINE, Cochrane, Scopus, Sciencedirect and Web of Science, between 21 March and 21 May 2021. All the articles found in the search were downloaded and cross-referenced manually to identify duplicates. The titles and abstracts were selected for subsequent review of the complete text. The articles included in this search ranged from 2011 to 2021. The following key words were used to build the information search chain in the aforementioned databases: ("**foam roller"** OR *"roller massager"* OR *"self myofascial release"* OR *"foam rolling")* AND *("jump"* OR *"squat jump"* OR *"countermovement jump"* OR *"performance").*

Eligibility criteria

Controlled experimental (clinical trials), quasi-experimental and pre-experimental studies were considered. The inclusion criteria for this review were as follows:

- original articles written in English, Spanish or Portuguese;
- published between 1 January 2011 and 21 May 2021;
- the study population is adult athletes, irrespective of gender. Adults are understood to be over the age of 18;
- interventions that use a foam roller;
- with or without a control group;
- that include at least one jumping ability assessment before and after the intervention.

On the other hand, the exclusion criteria were:

- cross-discipline, retrospective and prospective studies or when the intervention is not focused on using the foam roller;
- studies that are not original research publications (such as letters to the editor, translations, notes, book reviews);
- duplicate articles;
- review articles (such as meta-analysis, systematic reviews, narrative reviews);
- case studies (meaning studies that only use one person).

Selection of the studies and data compilation

The studies were exported into the EndNote reference administrator (version X8.2, Clarivate Analytics, Philadelphia, PA, USA), where they were filtered once the title, abstract and keywords had been selected. It was only necessary to use the complete text of the article in a few cases. Two authors (MAR, EGM) carried out the process independently. Any possible discrepancies between the two reviewers on the study conditions were resolved by consensus with a third author (PVB). Subsequently, the full text of potentially eligible studies was reviewed and the reasons for excluding studies that did not meet the selection criteria were justified. The study data was extracted by two authors independently, using a form created in Microsoft Excel (Microsoft Corporation, Redmond, WA, USA).

Assessment of the methodological quality

The selected studies were assessed using the PEDro scale. This scale assesses the methodological quality of the research, considering 11 points that include bias procedure, statistical analysis, information on randomising and presentation of the results in the research being assessed[17]. Criterion 1 assesses external validity, and it is not included in the final result. Criteria 2 to 11 assess the internal validity of the article using a standardised scoring system (ranging from 0 to 10). Studies with a ≥6 score on the PEDro scale were considered to have excellent methodological quality, 4-5 regular and ≤3 poor[18].

Results

The search process is explained in Figure 1. A total of 262 records were found in the study identification phase (PubMed/MEDLINE = 21, Cochrane = 67, SCOPUS = 64, Sciencedirect = 59, Web of Science = 51). The screening phase removed any duplicates, and the studies were filtered by selecting the title, abstract and keywords which selected 47 references. A total of 18 studies were analysed using the full text, and six were excluded because the sample was not athletes; one because comparisons were not made pre and post intervention; one because it did not assess jumping ability and two because they did not use the foam roller as the main intervention method. After this process, six studies met all the selection criteria[19-24].

The general data for the studies included in this systematic review are shown in Table 1. The 6 studies found by the systematic search were published between 2017 and 2020.

Out of the articles selected, five correspond to randomised clinical trials and one corresponds to a non-randomised clinical trial. Table 2 shows the results of the assessment of the methodological quality, where five of the studies were assessed to have excellent methodological quality and one as regular. Therefore, all these studies were considered for the systematic review.

Sample characteristics

Regarding the quantity of sample studied in the interventions, two studies assessed between 40 and 42 participants[20,21], three studies between 23 and 30 participants[19,22,24] and one studied assessed[18,22].

In relation to the age and gender of the sample, some studies considered participants from both genders within the research. Lin *et*

Figure 1. Selection procedure for articles in the bibliographic searches.

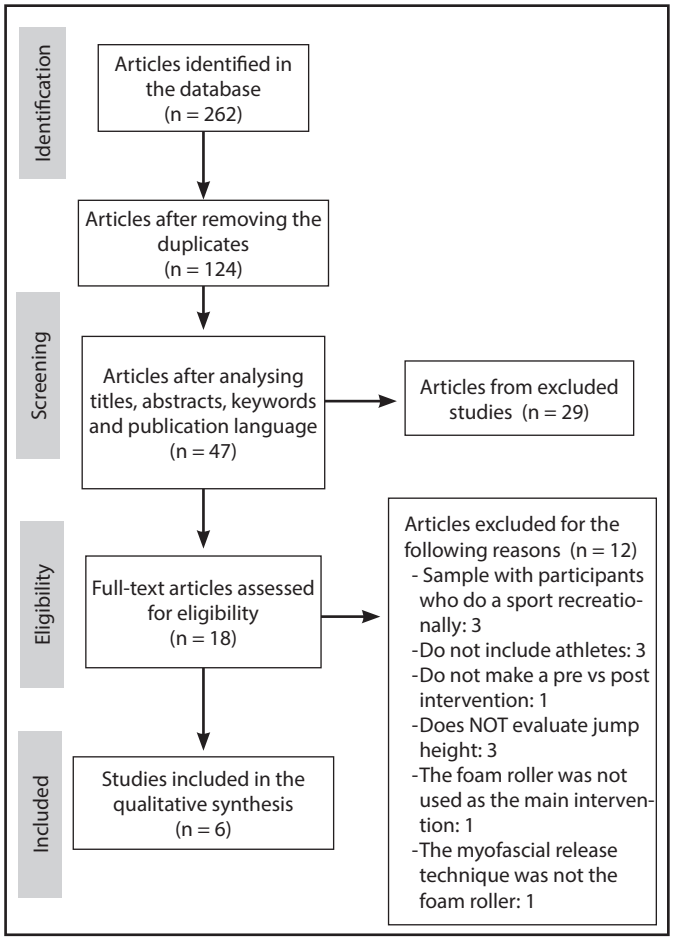

Table 1. Summary of the studies included in the systematic review.

Author	Sample	Age range	Sport	Intervention protocol	Duration of the training	Types of jumps assessed	Results
Kyranoudis *et al*. (2019).	24 male participants divided into 2 groups Control group (n=11) FR group (n=13)	20 to 22 years old	Football	Both groups warmed up for 5 minutes. FR group: Sliding along adductor, hip, quadricep, hamstring and gastrocnemius muscles. Furthermore, static stretching was included on each muscle group. Duration: 30 seconds of FR and 10 seconds of static stretching on per muscle group. It was done on both sides. Control group only did 10 seconds of static stretching on the same muscle groups as the FR group.	1 session	CMJ ABK	Control group: CMJ (cm) pre: 37.07 ± 3.12 post: 38.25 ± 5.20* Abalakov (cm) pre: 44.68 ± 4.92 post: 45.57 ± 5.19 FR group: CMJ (cm) pre: 35.36 ± 6.5 post: 36.72 ± 6.48* Abalakov (cm) pre: 43.29 ± 6.84 post: 43.79 ± 6.19

(continue)

Table 1. Summary of the studies included in the systematic review (continuation).

Author	Sample	Age range	Sport	Intervention protocol	Duration of the training	Types of jumps assessed	Results
Portilla-Dorado *et al.* (2017).	23 male participants divided into 3 groups Control group, FNP group and FR group (no information provided on participant distribution)	20 to 28 years old	Football	Weekly FR protocol: Day 1: sliding along gluteal muscles and external hip rotators, tensor fasciae latae, hamstrings, biceps femoris and quadriceps. Day 2: sliding along calf, biceps femoris, hamstrings, medial calf, peroneal and tibia muscles. Day 3: sliding along quadricep, gluteal, external hip rotator, hamstring and biceps femoris muscles. Duration: 2 repetitions of 30 seconds, 20 seconds of rest. It was done on both sides. The FNP group also performed 3 weekly sessions, with the same characteristics as the FR group on both the muscle groups and the volume of work.	8 weeks Frequency of 3 times a week	CMJ ABK	Control group: CMJ (cm) Pre: ~30 post: ~29 ABK (cm) Pre: ~35 Post: ~31 FNP group: CMJ (cm) Pre: NR post: NR ABK (cm) Pre: ~38 Post: ~39* FR group CMJ (cm) Pre: ~30 Post: ~34* ABK (cm) Pre: ~36 Post: ~39*
Romero-Franco *et al.* (2019).	30 participants (18 men and 13 women) divided into 2 groups Control group (n=15) FR group (n=15)	18 to 25 years old	Athletics (discipline not mentioned)	Both groups warmed up for 8 minutes. FR group: Sliding on hamstrings, quadriceps and triceps surae. Duration: 45 seconds for each muscle group. 15 seconds of rest. It was done on both sides.	1 session	CMJ	Immediately post intervention Control group (cm) Pre: 34.4 ± 10.4 Post: 36.4 ± 9.1* 10 min: 35.9 ± 7.7 FR group (cm) Pre: 31.6 ± 7.7 Post: 35.6 ± 8.0* 10 min: 33.3 ± 8.1*
Lin *et al.* (2020).	40 participants (25 men and 15 women) took part in 2 interventions. Dynamic stretching and vibratory FR.	20 to 30 years old	Badminton	FR protocol: sliding along quadriceps, hamstrings, gastrocnemius, rotator cuff and lumbar spinal. Duration: 20 seconds for each muscle group. It was done on both sides.	1 session	CMJ	Dynamic stretching group (cm) Pre: 37.7 ± 9.5 Post: 39.6 ± 10.5* FR group (cm) Pre: 37.4 ± 9.3 Post: 38.2 ± 9.6*
Pişirici *et al.* (2020).	42 participants (21 men and 21 women) divided into 3 groups Dynamic stretching group (n= 14) Graston instrumental manual technique group (n=14) FR group (n=14)	18 to 35 years old		Recreational running.	1 session	CMJ	Dynamic stretching group (cm) Pre: 19.85 ± 7.17 Post: 24.57 ± 9.31* Graston instrumental technique group (cm) Pre: 21.28 ± 7.40 Post: 26.57 ± 8.17* FR group (cm) Pre: 17.14 ± 5.69 Post: 20.78 ± 5.72*
Rey *et al.* (2017).	18 participants divided into 2 groups: Control group (n=9) FR group (n=9)	22 to 30 years old	Football	Both groups carried out a 60-minute football session between the pre and post assessment. FR protocol: sliding along quadricep, hamstring, adductor, gluteal and gastrocnemius muscles. Duration: 45 seconds on each muscle group, 15 second rest. It was done on both sides.	1 session	CMJ	Control group (cm) Pre: 32.33 ± 5.43 Post: 30.36 ± 4.53* FR group (cm) Pre: 31.32 ± 4.28 Post: 30.26 ± 3.34

FR: Foam Roller; CMJ: counter-movement jump; ABK: Abalakov jump.
*Significant differences (p <0.05).

Table 2. PEDro scale for methodological assessment of the included studies.

Study	Criteria											
	1*	2	3	4	5	6	7	8	9	10	11	Total
Kyranoudis *et al.*, 2019.	1	0	0	1	0	0	0	1	1	1	1	5/10
Portilla-Dorado *et al.*, 2017.	1	1	0	1	0	0	0	1	1	1	1	6/10
Romero-Franco *et al.,* 2019.	1	1	1	1	1	0	1	1	1	1	1	9/10
Lin *et al.,* 2020.	1	1	0	1	0	0	0	1	1	1	1	6/10
Pişirici *et al.,* 2020.	1	1	1	1	0	1	1	1	1	1	1	9/10
Rey *et al.*, 2017.	1	1	0	1	0	0	0	1	1	1	1	6/10

*Criterion is not considered in the total score.

al., (2020)[20] included men (n = 25) and women (n = 15) with an average age of 20.35 years old, while Pişirici *et al.,* (2020)21 included participants with an average age of 22.7 years old (men n = 21; women n = 21). On the other hand, Romero-Franco *et al.,* (2019)24 also recruited participants from both genders in the sample studied with an average age of 24.5 (men n = 18; women n = 13).

Finally, three research projects considered an exclusively male sample with an average age of 21.7 years old (n = 24), 24.35 years old (n = 23) and 26.6 years old (n = 18), respectively[19,22,23].

Therefore, this review includes a total sample of 177 athletes, of whom 48 were female and 129 male.

Measuring the jumping ability

To evaluate the effects of the FR in the jumping tests, the selected studies used various instruments which quantified the height in centimetres. Two research projects used the mobile phone app My Jump[20,24], which analyses movement using video photograms. Another two studies[19,21] used the OptoJump system, which is an optical detection system comprising a transmitter and infra-red LED receiver bar that detect interruptions in a defined space. Finally, two research projects used a contact platform called Ergojump[23] and Axon jump[22], respectively.

Concerning the number of attempts, three studies made 3 attempts and selected the greatest height[20,21,24], one study reports 2 attempts[23], and two research projects do not declare the number of attempts made[19,22]. In relation to the above, two studies report 1-minute rests between attempts[20,23] and four research projects do not specify rest protocols[19,21,22,24].

Protocols for FR intervention and dosing

Regarding the duration of the interventions, five of the selected studies analysed the acute effect of the FR on the jumping ability in one intervention session[19-21,23,24]. Within these protocols, it is important to highlight the study by Rey *et al.,* (2017)[23], where, after their initial assessments, the athletes took part in a 60-minute football training session. The FR was used after this training session, and they were assessed after these activities to determine how the FR affected recovery. In turn, the research by Portilla-Dorado *et al.*, (2017)[22] lasted 8 weeks with 24 FR intervention sessions (3 sessions a week), where the jumping assessments took place before and after the 8 weeks of interventions.

The intervention protocols consisted of sliding the FR along various muscle groups. All the studies used the FR on both extremities and on most muscle groups on the lower limbs, including gluteal, tensor fasciae latae, hamstring, quadriceps and triceps surae muscles[22-24]. The study by Portilla-Dorado *et al.*, (2017)[22] used two 30-second series per muscle group, while two interventions[23,24] used one 45-second series on each muscle group. Kyranoudis *et al.*, (2019)[20] in 1 series combined sliding the FR for 30 seconds with 10 seconds of static stretching on quadriceps, hamstring, abductor and gastrocnemius muscles on each limb. In turn, Pişirici *et al*., (2020)[21] applied 1 series of FR lasting 3 minutes on hamstrings, 3 minutes on gastrocnemius and 2 minutes on the plantar fascia. Finally, the study by Lin *et al.*, (2020)[20] applied 1 series of vibrating FR bilaterally on muscles in the lower limbs, lumbar region and rotator cuff for 20 seconds on each muscle group.

Regarding the intensity, the modified Borg scale was used to control the degree of force. However, the ranges of values were not indicated[22]. The intensity was also controlled using self-regulation of force, working with the maximum tolerable intensity[20,21]. The rest of the studies did not report the intensity applied in their interventions[19,23,24].

Main results

The selected studies show that applying the FR is a technique that helps to increase the performance in jumping ability among athletes[19-22,24], and its effect can last up to 10 minutes after application[24]. Prior to the intervention, Lin *et al.,* (2020)[20] recorded an average jump of 37.4 cm and after use of FR, they measured 38.2 cm in CMJ, which was a statistically significant increase ($p < 0.05$). In turn, Kyranoudis *et al.*, (2019)[19] saw significant differences ($p < 0.05$) in the CMJ height when applying static stretches + FR (pre: 35.36 ± 6.5 cm; post 36.72 ± 6.48 cm) but not in Abalakov (pre: 43.29 ± 6.84 cm; post: 43.79± 6.19 cm). Romero-Franco *et al.,* (2019)[24], analysed the effects of FR on the CMJ height among athletes,

where the intervention with FR had major changes (pre: 31.6 cm; post: 35.6 cm) compared to the control group (pre: 34,4 cm; post 36,4 cm), where the comparison between the groups was significant. This study carried out an assessment 10 minutes after applying the FR, where it was seen that the effect on the jumping capacity was maintained in this period of time, a result that was statistically significant.

Pişirici *et al.,* (2020)[21] compared three techniques to observe changes in the CMJ height. In the three groups, significant increases were seen in the jumping height ($p<0.05$): FR (pre:17.14 cm; post 20.78 cm), dynamic stretching (pre: 19.85 cm; post: 24.57 cm) and Graston technique (pre: 21.28 cm; post: 26.57 cm). There were no significant differences ($p >0.05$) when comparing the percentage change between the three techniques. Portilla-Dorado *et al*., (2017)[22], analysed the jumping ability among football players using CMJ observing significant favourable changes ($p <0.05$) in favour of the FR protocol in the jump height (pre: 30 cm; post 34 cm) compared to the control group (pre: 30 cm; post 29 cm).

Rey *et al*., (2017)[23] analysed the effects of the FR on the jump height after a 60-minute football training session. The jump height performance does not demonstrate significant changes with the use of FR (pre: 31.32 cm; post: 30.26 cm) compared to the control group (pre: 32,33 cm; post 30,36 cm) there was a significant decrease in the jump height ($p <0.05$).

Discussion

The aim of this systematic review was to analyse the effects of applying the FR on the athletes' jumping ability. 262 studies were reviewed for this purpose and 6 met the inclusion criteria. The main finding in this review suggests that a myofascial release protocol with FR is an effective technique to increase athletes' vertical jumping performance. The intervention protocols analysed in this review are important, as 5 studies analysed the effects of the FR acutely in a single session[19-21,23,24], while only one study analysed the effect of the FR during 24 sessions over 8 weeks[22]. Four of the studies reported a statistically significant acute effect on jumping capacity ($p <0.05$) when working with FR compared to the control groups. This is relevant as other training protocols such as plyometrics[25], traditional strength and Olympic movements[26,27] must be applied for several weeks to show positive results in vertical jumping performance.

In our review, the results show that among athletes, FR use has a favourable acute effect on jumping ability performance. It has been proposed that the use of the FR, as a self-myofascial release technique, reduces rigidity in muscles and tendons, eases tissue relaxation through afferent signals to the central nervous system[28]. Therefore, like static stretching, the self-myofascial release with FR could also increase tolerance to neural stretching, causing an increase of ROM[28]. However, several research projects have demonstrated that static stretching does not improve muscle performance[29,30]. In fact, this relaxation of the muscles and neural inhibition have been presented as causes of reducing post static stretching performance. Therefore, the FR has other mechanisms which cause an increase in muscle performance. It has been demonstrated that rolling along soft tissue with an FR could increase both tissue temperature and local blood flow. This would make the tissues more elastic, which encourages the generation of explosive force in jumps that include a counter movement due to a greater accumulation and release of energy during the motor movement[31]. This explains why we believe that in the results of our review, all the studies analysed included CMJ to determine gain in vertical jump height after FR use. Furthermore, it is one of the most popular tests in intermittent and explosive sports.

The capacity of the FR to affect other factors such as the ROM can influence mechanisms leading to positive effects on jumping ability. Thirty to forty seconds of FR sliding, 3 times a week, demonstrates positive effects on the ROM[32]. It has also been reported that the FR can affect the ROM acutely, increasing the dorsiflexion of the ankle up to 60 minutes after the intervention[33]. The increase of the ROM can also influence vertical jumping height performance, as it allows the muscle-tendon unit to generate a greater quantity of force.

One limitation of this review was that it was impossible to meta-analyse the data due to the diversity of instruments and protocols used by the research projects being analysed. The strengths of this review include the use of an internationally recognised scale for the methodological quality of the studies being reviewed. Another strength of this review is that it followed the PRISMA-P recommendations and so it can ensure a comprehensive, exhaustive and structured search for the information compiled.

Conclusions

Interventions with FR produce an acute improvement in athletes' jumping ability (recreational, elite, amateur). There is a favourable trend linking the use of the FR and the increase in the ROM and performance, although the scientific evidence should go into greater depth on the mechanisms which bring about these improvements. The optimum volume of work suggested by this review is 1-2 series of sliding on each muscle group for 30-45 seconds, although protocols and durations should be standardised to maximise the results.

Conflicts of interest

The authors declare that there is no conflict of interest.

Bibliography

1. Freiwald J, Baumgart C, Kühnemann M, Hoppe MW. Foam-rolling in sport and therapy–potential benefits and risks: part 1–definitions, anatomy, physiology, and biomechanics. *Sports Orthop Traumatol.* 2016;32:258-66.
2. Schroeder AN, Best TM. Is self-myofascial release an effective preexercise and recovery strategy? A literature review. *Curr Sports Med Rep.* 2015;14:200-8.
3. Kuruma H, Takei H, Nitta O, Furukawa Y, Shida N, Kamio H, *et al.* Effects of myofascial release and stretching technique on range of motion and reaction time. *J Phys Ther. Sci.* 2013; 25:169-71.
4. Škarabot J, Beardsley C, Štirn, I. Comparing the effects of self-myofascial release with static stretching on ankle range-of-motion in adolescent athletes. *Int J Sports Phys Ther.* 2015;10:203-12.

5. Faigenbaum AD, McFarland JE, Schwerdtman JA, Ratamess NA, Kang J, Hoffman JR. Dynamic warm-up protocols, with and without a weighted vest, and fitness performance in high school female athletes. *J Athl Train.* 2006;41:357-63.
6. Mohr AR, Long BC, Goad CL. Effect of foam rolling and static stretching on passive hip-flexion range of motion. *J Sport Rehabil.* 2014;23:296-9.
7. Moraleda BR, Rosillo AL, González J, Martínez EM. Efectos del *foam roller* sobre el rango de movimiento, el dolor y el rendimiento neuromuscular: revisión sistemática. *Retos.* 2020;38:879-85.
8. Bushell JE, Dawson SM, Webster MM. Clinical relevance of foam rolling on hip extension angle in a functional lunge position. *J Strength Cond Res.* 2015;29:2397-403.
9. MacDonald GZ, Penney MD, Mullaley ME, *et al.* An acute bout of self-myofascial release increases range of motion without a subsequent decrease in muscle activation or force. *J Strength Cond Res.* 2013;27:812-21.
10. Su H, Chang NJ, Wu WL, Guo LY, Chu IH. Acute effects of foam rolling, static stretching, and dynamic stretching during warm-ups on muscular flexibility and strength in young adults. *J Sport Rehabil.* 2017;26:469-77.
11. Pearcey GE, Bradbury-Squires DJ, Kawamoto JE, Drinkwater EJ, Behm DG, Button DC. Foam rolling for delayed-onset muscle soreness and recovery of dynamic performance measures. *J Athl Train.* 2015;50:5-13.
12. Faigenbaum AD, McFarland JE, Schwerdtman JA, Ratamess NA, Kang J, Hoffman JR. Dynamic warm-up protocols, with and without a weighted vest, and fitness performance in high school female athletes. *J Athl Train*. 2006;41:357-63.
13. Kyranoudis Á, Nikolaidis V, Ispirlidis I, Galazoulas C, Alipasali F, Famisis K. Acute effect of specific warm-up exercises on sprint performance after static and dynamic stretching in amateur soccer players. *J Phys Educ Sport.* 2018;18:825-30.
14. Bosco C, Riu JMP. *La valoración de la fuerza con el test de Bosco*. Barcelona: Paidotribo; 1994.
15. Mendez-Rebolledo G, Ramirez-Campillo R, Guzman-Muñoz E, Gatica-Rojas V, Dabanch-Santis A, Diaz-Valenzuela F. Short-term effects of kinesio taping on muscle recruitment order during a vertical jump: a pilot study. *J Sport Rehabil.* 2018;27:319-26.
16. Moraleda BR, Rosillo AL, González J, Martínez, EM. Efectos del *foam roller* sobre el rango de movimiento, el dolor y el rendimiento neuromuscular: revisión sistemática. *Retos.* 2020;38:879-85.
17. Ribeiro CC, Gómez-Conesa A, Montesinos MH. Metodología para la adaptación de instrumentos de evaluación. *Fisioterapia*. 2010;32:264-70.
18. Moseley AM, Herbert RD, Sherrington C, Maher CG. Evidence for physiotherapy practice: a survey of the physiotherapy evidence database (PEDro). *Aust J Physiother.* 2002;48:43-9.
19. Kyranoudis E, Metaxas T. The acute effects of combined foam rolling and static stretching program on hip flexion and jumping ability in soccer players. *J Phys Educ Sport.* 2019;19:1164-72.
20. Lin WC, Lee CL, Chang NJ. Acute effects of dynamic stretching followed by vibration foam rolling on sports performance of badminton athletes. *J Sports Sci Med.* 2020;19:420-8.
21. Pişirici P, Ekiz MB, İlhan CA. Investigation of the acute effect of myofascial release techniques and dynamic stretch on vertical jump performance in recreationally active individuals. *J Phys Educ Sport.* 2020;20:1569-79.
22. Portilla-Dorado E, Villaquiran-Hurtado A, Molano-Tobar N. Potencia del salto en jugadores de fútbol sala después de la utilización del rodillo de espuma y la facilitación neuromuscular propioceptiva en la musculatura isquiosural. *Rev Acad Colomb Ci Exact.* 2019;43:165-76.
23. Rey E, Padrón-Cabo A, Costa PB, Barcala-Furelos R. Effects of foam rolling as a recovery tool in professional soccer players. *J Strength Cond Res.* 2019; 33:2194-201.
24. Romero-Franco N, Romero-Franco J, Jiménez-Reyes P. Jogging and practical-duration foam-rolling exercises and range of motion, proprioception, and vertical jump in athletes. *J Athl Train.* 2019;54:1171-8.
25. Stojanović E, Ristić V, McMaster DT, Milanović Z. Effect of plyometric training on vertical jump performance in female athletes: a systematic review and meta-analysis. *Sports Med.* 2017;47:975-86.
26. Berton R, Lixandrão ME, Pinto E Silva CM, Tricoli V. Effects of weightlifting exercise, traditional resistance and plyometric training on countermovement jump performance: a meta-analysis. *J Sports Sci.* 2018;36:2038-44.
27. Sperlich PF, Behringer M, Mester J. The effects of resistance training interventions on vertical jump performance in basketball players: a meta-analysis. *J Sports Med Phys Fitness.* 2016;56:874-83.
28. Kelly S, Beardsley C. Specific and cross-over effects of foam rolling on ankle dorsiflexion range of motion. *Int J Sports Phys Ther.* 2016;11:544-51.
29. Behm DG, Blazevich AJ, Kay AD, McHugh M. Acute effects of muscle stretching on physical performance, range of motion, and injury incidence in healthy active individuals: a systematic review. *Appl Physiol Nutr Metab.* 2016;41:1-11.
30. Simic L, Sarabon N, Markovic G. Does pre-exercise static stretching inhibit maximal muscular performance? A meta-analytical review. *Scand J Med Sci Sports.* 2013; 23:131-48.
31. Kopec TJ, Bishop PA, Esco MR. Influence of dynamic stretching and foam rolling on vertical jump. *Athl Train Sports Health Care.* 2017;9:33-8.
32. Junker DH, Stöggl TL. The foam roll as a tool to improve hamstring flexibility. *J Strength Cond Res.* 2015;29:3480-5.
33. Yoshimura A, Schleip R, Hirose N. Effects of self-massage using a *foam roller* on ankle range of motion and gastrocnemius fascicle length and muscle hardness: a pilot study. *J Sport Rehabil.* 2020;29:1171-8.