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Strength and conditioning for combat sports athletes
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CHAPTER 6
Developing flexibility for combat sports athletes

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Abstract

The range of motion of a joint is extremely important in combat sports, especially when there is a need to execute a certain motor gesture with maximum range of movement, as in throwing techniques such as *uchi-mata* in judo, certain types of guards in Brazilian jiu-jitsu or the high kicks common in a variety of striking combat sports. Therefore, in this chapter, we will discuss the elements related to flexibility response during training sessions or combat sports competitions, flexibility tests commonly used for these athletes, and the monitoring and control of the evolution of flexibility in athletes. We will also present the means and methods used for the development of flexibility and longitudinal studies on the development of flexibility in combat sports athletes. Finally, this chapter supports based on the evidence the inclusion of flexibility development within training sessions is an important consideration to maximize performance and other physical capabilities that may be affected both acutely or in the long-term by flexibility.

Keywords: Martial arts; combat sports; flexibility; range of motion; stretching.

1. Introduction

Flexibility is defined as the range of motion in a joint or a group of joints [1]. A good level of flexibility, in addition to the execution of movements, helps to prevent injury [2-4]. The range of motion of a joint is extremely important in combat sports, especially when there is a need to execute a certain motor gesture with maximum range of movement [5], as in throwing techniques such as *uchi-mata* in judo [6], certain types of guards in Brazilian jiu-jitsu [7] or the high kicks common in a variety of striking combat sports [5].

In fact, in striking combat sports, such as karate, studies have shown greater flexibility in combat sports athletes compared to physically active controls [8]. One study conducted with children showed that six months of karate practice resulted in improved flexibility that was more pronounced than when practicing team sports [9]. In addition, the introduction of dynamic stretching exercises, used as a means of warming up in Olympic wrestling training sessions, have been shown to improve various physical capacities (e.g., maximum strength, muscle power, and muscular resistance) compared to warming up without stretching exercises [10]. On the other hand, there are reports that indicate that long-duration static stretching before strength and muscle power sessions can be counterproductive from an acute point of view [11-13]. Longitudinal studies, however, note greater performance in activities involving maximum strength and torque [12]. This conflict between the long-term benefits and the short-term performance decreases that could occur led the European College of Sport Science to label stretching exercises a paradox [2] and recommend isolated sessions for the development of flexibility.

In this sense, a recent review [14] concluded that there is strong evidence suggesting that static stretching causes only trivial negative effects on subsequent strength and power performances if the accumulated duration per muscle group does not exceed 60 s. The authors state that static

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stretching is an important warm-up component in recreational sports duet to its potentially long-term positive effect on flexibility and musculotendinous injury prevention but in high-performance athletes, minimum performance differences can have a major impact on athletes' success in competition, and such intervention should be avoided before competition.

Furthermore, there are no detailed studies comparing flexibility in different joints between elite athletes and non-elite practitioners in sports such as karate, although, considering the type of techniques prevailing in international competitions, reaching extreme values in the range of motion is probably unnecessary for athletes [5,15]. Something similar may occur in other sports, since high kicks - requiring great flexibility - are not among the most frequently used techniques in striking combat sports [16,17] and, in the example of kickboxing, do not represent a difference in receiving a medal or not [18]. On the other hand, limited flexibility could be a serious disadvantage among mixed martial arts fighters, a sport in which practitioners stretch their range of motion to an extreme [19].

An important and not yet explored aspect of the evaluation of flexibility in combat sports is dynamic flexibility, which consists of performing fast or slow movement of the joint as a result of the contraction of the antagonist muscles throughout the range of motion [20] and which is arguably more important in such sports, versus static flexibility, mean slowly applied a passive movement of a muscle to the maximum range of motion, followed by maintenance of the position for a long period [20] and is the type most commonly measured in athletes [5]. In fact, studies conducted in combat sports such as Brazilian jiu-jitsu [21], judo [22], Olympic wrestling [23], karate [5], mixed martial arts [24] and taekwondo [25] have used the sit and reach test — a static test — for its ease of application. However, the use of these tests among combat sports athletes has been questioned [5,25]. In addition, results obtained have been contradictory. Recent reviews [25] report that athletes have high values of flexibility (that is, above the 80th percentile for males and between the 70th and 100th percentile for female), whereas other studies have found values close to the average for the general or physically active population [26]. In addition, the wide range in the results is likely due to different equipment and evaluation methodologies, for example some equipment may present an advantage of 26 cm [27]. Taekwondo coaches consider flexibility as a variable of medium importance for the performance of the sport [28]. Judo coaches classify flexibility as less important, positioning this attribute after speed, sport-specific resistance, and variables associated with strength training, coordination and balance [29]. Although Yoon [23] indicated in his review that the best-ranked Olympic freestyle wrestlers had greater flexibility than lower-ranked athletes, higher-level athletes are more flexible than lower-level athletes [30]. A case study with a four-time world champion demonstrated lower values in trunk and shoulder flexibility compared to national standards, yet higher values on the sit and reach test [31]. In fact, Yoon [23] mentions that there may be an adaptation in terms of flexibility, since there are indicators of greater rotation and adduction/abduction of the shoulder and flexibility in the neck region among Olympic wrestlers compared to non-athletes, but less flexibility in the wrist, suggesting adjustments or the selection of wrestlers with specific flexibility combinations. Thus, there is controversy about the influence of flexibility on performance in different combat sports.

Another important aspect to consider is that there are no specific tests to evaluate the flexibility of combat sports athletes or recommended protocols to follow.

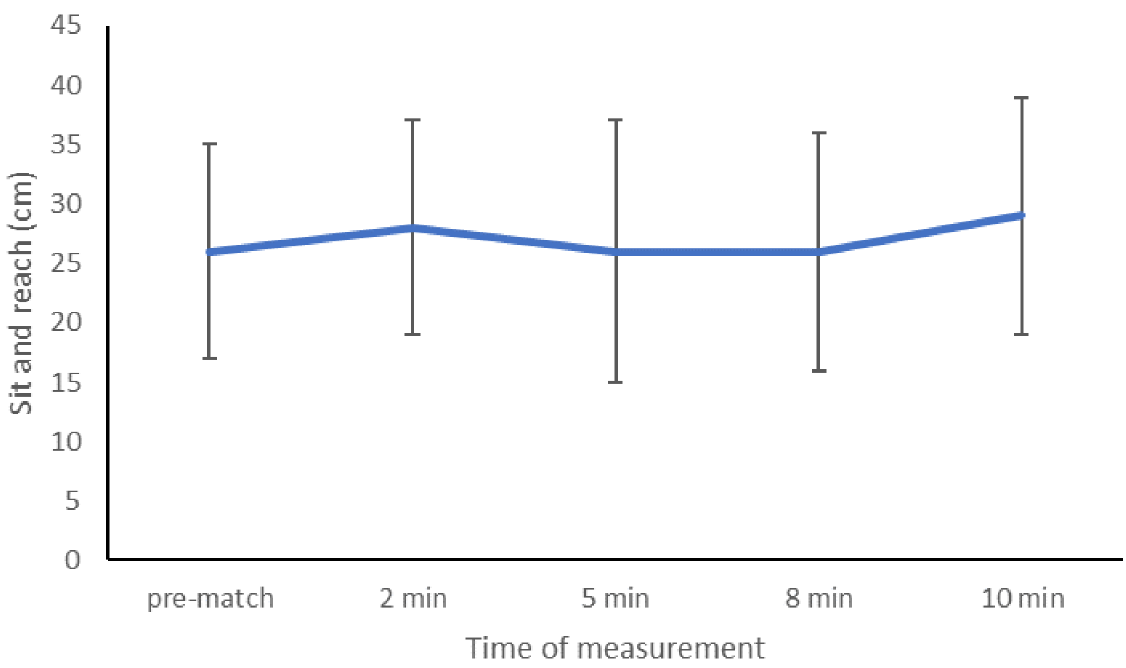
Therefore, in this chapter, we will discuss the elements related to flexibility response during training sessions or combat sports competitions, flexibility tests commonly used for these athletes, and the monitoring and control of the evolution of flexibility in athletes. We will also present the means and methods used for the development of flexibility and longitudinal studies on the development of flexibility in combat sports athletes.

2. Flexibility response in different combat sports during training sessions or competitive matches

Some papers have attempted to verify the contribution of flexibility for the execution of certain taekwondo kicking techniques [32,33]. Yu et al. [33] concluded that the stature and flexibility of an athlete were related to the height of the *neryo-chagi* kick. In the study, the authors analyzed 3D film recordings of advanced taekwondo athletes (n = 8, with an average of 5 years of experience in the sport) and professionals (n = 4; with an average of fifteen years of experience). The two groups were compared using a 14-segment model to determine the relative contribution of the flexibility of different joints to kick performance. The technique was divided into four phases: decoy (preparation), power load (main phase of the technique), drive (descending phase of the technique), and landing and stabilization. During the power load phase, the range of motion was greater for professional athletes, reaching 206.1 ± 9.1º for the hip and 99.6 ± 6.7º for the knee, respectively, whereas the equivalent figures for the advanced group were 183.6 ± 8.9º and 27.4 ± 8.3°, respectively. Although professionals had higher values, the time spent at this stage (power load) was significantly shorter (0.06s, 17% faster) than the time taken by athletes in the other group. For the drive phase, professionals also generated a greater range of motion in the hip (139.1 ± 6.2 °) compared to advanced athletes (122.4 ± 5.7 °), with a movement that was 0.04s faster. Results indicate that flexibility contributes to technical effectiveness.

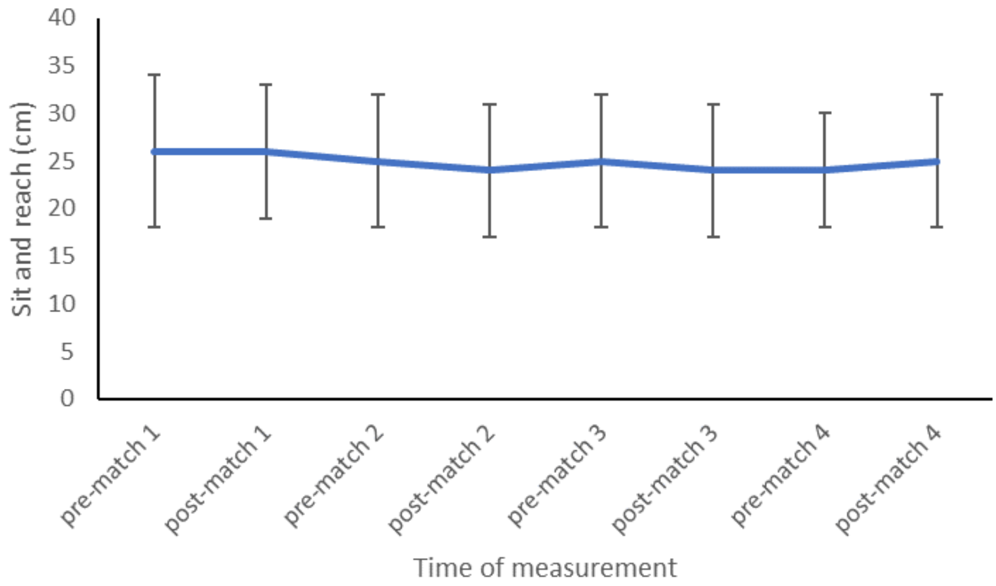
Professional athletes use a greater range of motion to generate a higher kick, which would be difficult for athletes with low levels of flexibility. In addition, the extreme angle between the two thighs at the end of the power load phase provides the initial conditions necessary to increase the length of the hip flexors before contraction. According to the authors, this dynamic pre-stretch results in greater muscle strength, based on the relationship between length and muscle tension, which increases kick effectiveness. In fact, the athletes had a higher maximum height during the execution of the kick. Finally, the researchers suggest that hip flexibility, muscle power (not addressed in this chapter) and the whip-type movement of the leg that kicks are key factors in the quality of the technique. The combined effect of these factors can explain the 15% difference in action time, the 12% difference in kick height and the 20% difference in maximum speed between professionals and advanced athletes. A study by Wasik and Chan [32] complement the work Yu and colleagues [33]. These authors indicate that during the rise of the leg in preparation for the kick, the slight flexion of the trunk in the direction of the leg executing the kick is responsible for increasing the range of motion of the hip joint, emphasizing that this increase would generate a pre-stretching of the extensor muscles of the hip and contribute to a higher final kick height.

We found only one study that analyzed the variation of flexibility during a match [34] and another the investigated this variation during the jiu-jitsu simulated competition [35]. No difference was found when the results of the sit and reach test considered different durations of a simulated match (Figure 1) [34] or during the four simulated matches (Figure 2) [35], indicating that flexibility remains stable both during the match and throughout the competition.



Values are mean ± standard deviation.

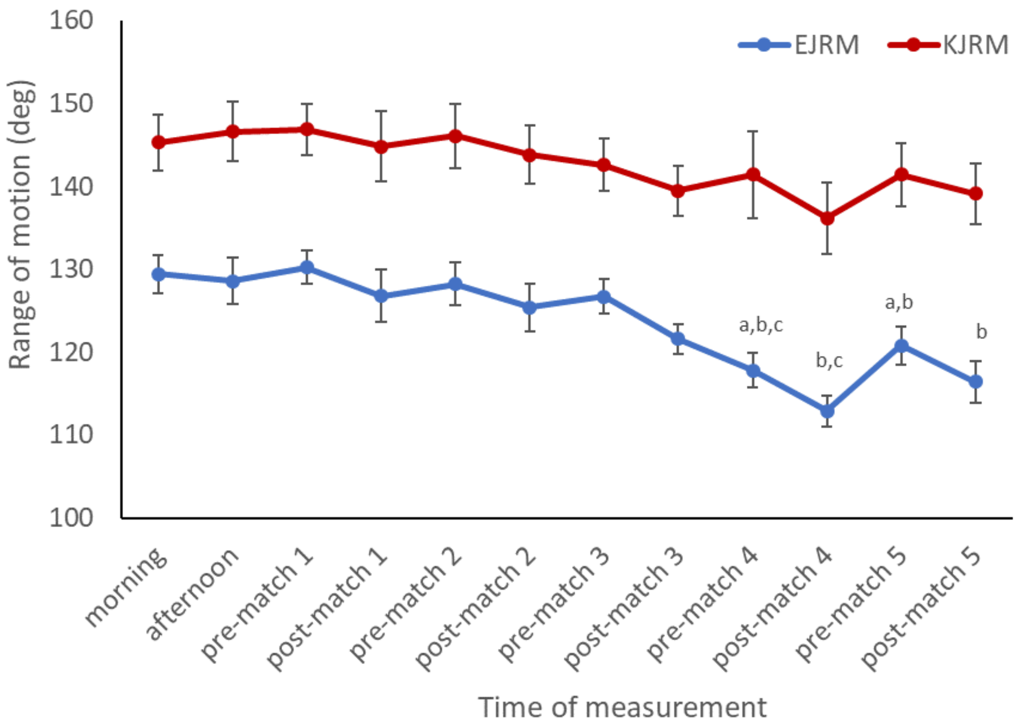
Figure 1: Sit and reach test performance, before and after jiu-jitsu different duration matches (Adapted from Andreato [34]).



Values are mean ± standard deviation.

Figure 2: Sit and reach test performance, before and after four simulated jiu-jitsu matches (Adapted from Andreato [35]).

Although the objective of the study was to evaluate flexibility, Barbas et al [36] analyzed the effect of successive matches on the range of motion of the knee and elbow joints. More specifically, knee and elbow movements were used as an index of muscular edema resulting from match performance, using the angle in which the athletes reported discomfort as the reference to determine the maximum range of pain-free movement. Although the authors did not report flexibility measures to verify how this capacity would be associated with the response, differences may help to understand how performance in a simulated competition may restrict the flexibility of athletes. Figure 3 shows the main results observed in this study.



a = different from the base condition ($p < 0.05$); b = different from match 1 ($p < 0.05$); c = different from previous match ($p < 0.05$).

Figure 3: Range of motion measurements of elbow (EJRM) and knee movements (KJRM) of Olympic Greco-Roman wrestling during baseline measurement (morning and afternoon) and simulated competitions (Adapted from Barbas et al. [36]).

As shown in Figure 3, only the range of motion of the elbow joint decreased during the simulated competition. According to the authors, this response is due to an increase in the blood creatine kinase concentration, which results from micro-ruptures of muscle tissue. Thus, the pressure and edema around broken tissues generate muscle pain, loss of strength and a decrease in the range of motion, which could negatively affect the technical performance of athletes, due to the compensatory movements made in an attempt to protect the injured tissues. The decrease in range of motion in the upper limbs may be the result of a more pronounced request in this region during the matches.

In turn, Dezan et al. [37] reported that during Olympic wrestling matches it is common for athletes to perform fast trunk flexion movements, resulting in a front pelvic tilt, which requires high flexibility of the hamstring muscles. This type of movement is also present in other combat sports and in the practice of mixed martial arts, indicating that athletes should improve the flexibility of this muscle group.

3. Flexibility tests commonly used for combat sports athletes

Sterkowicz and Franchini [38] suggested testing the flexibility of karate athletes using the *mawashi-geri* technique. The athlete attempts to achieve the highest possible height over five repetitions, which would be considered in relationship to the height of the performer by means of the following equation:

Index = maximum amplitude of kick / height of the athlete.

Table 1 presents the classification indicated by the authors for the different results of amplitude.

Table 1: Classification of flexibility results of the mawashi-geri kick (Adapted from Sterkowicz and Franchini [38])

Index result	Classification
< 0.97	Very low
0.98 a 1.05	Low
1.06 a 1.07	Regular
1.08 a 1.14	Good
> 1.15	Excellent

According to the authors, the athletes with the highest level of technical competence had the highest flexibility values measured using this test, in comparison to lower-level athletes (fourth and third *kyu*). However, no difference was observed in the index between athletes of different weight categories (-70 kg = 1.1 ± 0.07; -80 kg = 1.1 ± 0.05; +80 kg = 1.1 ± 0.05).

As sports training can generate negative adjustments due to the high volume and intensity of training, it has been suggested that the monitoring of imbalances in contralateral and ipsilateral segments may be important due to the increase in the probability of injury occurrence [8]. In this sense, measurement - by means of goniometry - of the flexibility of specific segments, such as flexion and extension of the knee and hip, medial and lateral rotation of the hip, flexion and dorsiflexion plantar, and inversion and eversion of the foot has been recommended for karate athletes [8] and could be extended to other combat-sports athletes who frequently use kicks as part of their sport.

Undoubtedly, the most frequently used test to evaluate flexibility is the sit and reach test [39], which is also frequently used for combat-sport athletes [26]. Schwartz et al. [26] evaluated many combat-sport athletes and reported mean values for all groups compared to the values established by the American College of Sports Medicine: Brazilian jujitsu (n = 136) = 27.3 ± 9.1 cm; judo (n = 180) = 29.0 ± 8.4 cm; karate (n = 229) = 30.3 ± 8.0 cm; kung fu (n = 140) = 31.5 ± 8.6 cm; taekwondo (n = 250) = 30.2 ± 9.0 cm. The authors reported that the average classification in the striking combat sports are due to the fact that movements that require high levels of flexibility are not common in training situations. For example, kicking techniques are performed at the level of the chest and not at head height.

Among judo athletes, values between 28.0 ± 6.3 cm have been observed in Belgian athletes in the lighter categories (<71 kg at the time of the study) [40] to 72.98 ± 11.21 cm in Croatian youth athletes [41]. In a study conducted in 36 judo athletes between 10 and 13 years of age [42], it was noted that flexibility - measured by the sit and reach test – was higher in children who practiced the morote-seoi-nage technique in relation to a control group who did not practice any technique. Therefore, the inclusion of the sit and reach test has been recommended as part of the evaluation of athletes who practice techniques that include hip flexion [43]. The results of one study with a large number of subjects (n= 729) is presented in Figure 4 [44]. High values are noted for all, with the exception when compared with Croatian athletes. It is important to note that the flexibility test results shown in Figure 4 do not differ between categories [44], indicating that flexibility seems to have the same degree of importance in all categories.

On the other hand, Toskovic et al. [45] did not observe any difference in performance on the sit and reach test between beginner and experienced taekwondo athletes. The more experienced taekwondo athletes, however, outperformed the other group in the lateral split leg test, a result that was attributed to the greater specificity of the test. For judo, Taylor and Brassard [46] found no significant correlation between the performance in the sit and reach test and skill level of athletes.

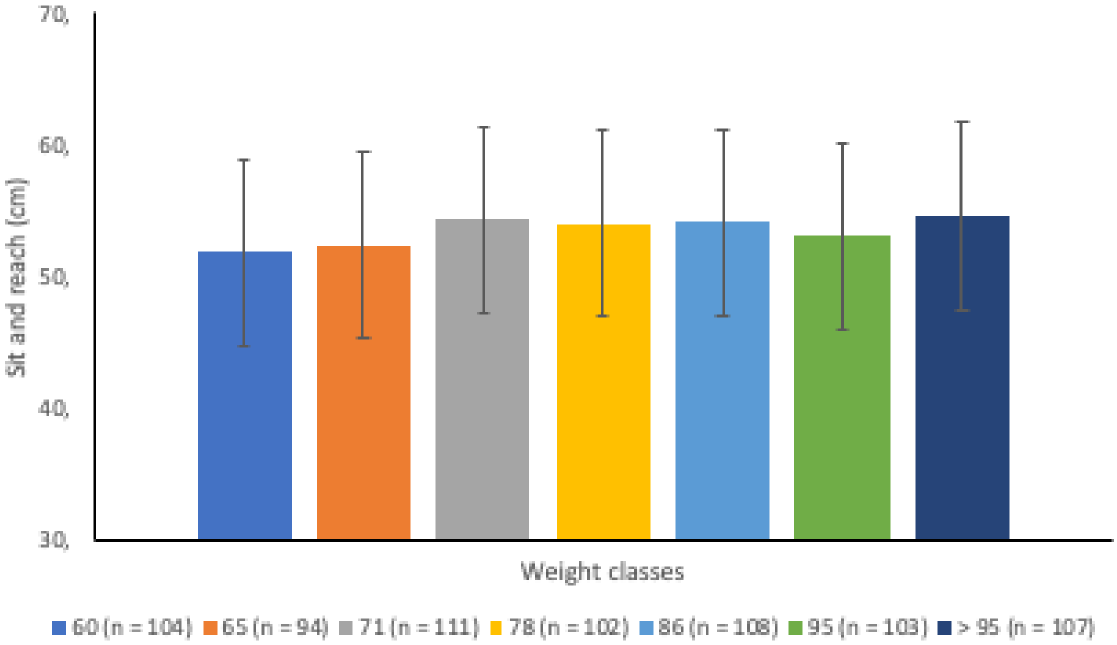


Figure 4: Performance in the sit and reach test among Japanese university judo athletes of different weight categories (in kg) (Adapted from Iida et al [44]).

Therefore, the development of specific flexibility tests may be necessary to improve the evaluation of combat-sport athletes.

4. Longitudinal studies on flexibility development in combat-sport athletes

There are few published studies on the effect of different types or phases of training on the flexibility of combat sports athletes [47].

Herman and Smith [10] reported that among Olympic freestyle wrestlers, the inclusion of dynamic stretching movements during the warm-up phase of a four-week program affected a number of variables when compared with a warm-up without stretching. More precisely, the authors reported increases in: peak torque in the extension of both knees, standing long jump distance, medicine ball throw distance, the number of abdominal repetitions, and the number of push-up repetitions. They also noted decreases in 600m running time and time to complete an agility test. It is important to highlight that in this study both groups had the same training program, with the only difference being the dynamic stretching exercises included in the warm-up before each specific session training for the experimental group.

Mirzaei et al. [31] found that four weeks of training in the general preparation phase, was sufficient to increase flexibility, as measured by the sit and reach test, in young Olympic freestyle wrestlers, from 33.00 ± 5.35 cm to 34.66 ± 5.91 cm. Conversely, Crnogorac et al. [48] found that three weeks of training during the general preparation phase resulted in decreased flexibility of the shoulder (from 69.00 to 67.15 cm) and lower values on the sit and reach test (from 39.22 cm to 37.77 cm) among female judo athletes. The authors did not offer explanations for this decrease in flexibility performance, however, it is possible that with the exception of the specific judo sessions, in which some kind of flexibility practice may have been incorporated, there is no description of this type of exercise in other training sessions, such as strength and power training, aerobic and anaerobic conditioning.

In an analysis of a four-week judo training program in preparation for a national level competition, Fukuda et al. [49] observed increases in flexibility, measured through the sit and reach test, in a group of children (9.9 ± 1.6 years; pre = 26.4 ± 4.3 cm; post = 29.4 ± 3.5 cm), but not in the adolescent group (15.3 ± 2.0 years, pre = 34.1 ± 6.9 cm, post = 35.3 ± 7.7 cm). The lack of change in the adolescent group may be explained by the fact that pre-training values were already reasonably high among adolescents compared to children. However, the authors stated that the focus of training (learn to train in the case of children, and train to train in the case of adolescents) could better explain the different results observed in the study.

For striking combat sports training (e.g., taekwondo), it has been observed that 12 weeks of low-frequency training (twice a week for 50 minutes each day, plus two weekly school physical education classes of 50 minutes each) was enough to improve flexibility, measured through the sit and reach test, among female adolescents (16.2 ± 7.0 cm before intervention and 18.2 ± 6.4 cm after the intervention). No change was observed in the control group exposed to physical school education only (15.9 ± 8.8 cm before the intervention and 15.6 ± 7.0 cm after the intervention) [50]. These results are consistent with the hypothesis of the researchers and can be attributed to the fact that taekwondo training involves multiple series of static and ballistic stretching, which was adequate to improve flexibility [39].

A common concern among combat sports coaches and athletes is how increased strength training may limit the range of motion. In fact, this concern seems to have originated in the fact that high levels of muscle development could limit flexibility by mechanical blockage, that is, muscle volume would be a barrier to the maximum range of motion. However, at present, it is known that strength training does not appear to adversely interfere with flexibility and may even improve it, especially when load weight-bearing exercises are performed with a high range of motion [39] and when resistance exercises are executed in order to prevent hypertrophy, which would result in a change in the weight category [47]. However, there are few studies on the influence of strength training on flexibility in combat sports athletes.

Recently, researchers [51] studied the effect of strength training and the order of exercises on flexibility among judo athletes and found that the use of a sequence of exercises for the upper-body, followed by exercises for the lower-body resulted in a difference in flexibility compared to the reverse order. However, for the groups subjected to each order of exercises, there was an increase in the flexibility in flexion, extension, adduction and abduction of the shoulder, and flexion and extension of the trunk and hip. Thus, typical resistance exercises can be used to increase the flexibility of judo athletes when completed with the full range of motion for each exercise.

Additionally, a pilot study developed with young judoka [52], applied 5 weeks of suspension-training. The suspension-training program was applied three times per week. All suspension-training sessions begun with a 5-7 minutes period of continuous low-intensity jogging warm-up. Then athletes perform two sets of 30 seconds of static stretching exercises using the suspension gear. The stretching drills were repeated at the end of each suspension-training sessions. The difficulty of the drills and the volume was progressively increased during the 5 weeks of training. A typical suspension-training session last ~ 20 minutes. The results indicated a significant improvement in the seat and reach test after the training program (42.1 ± 8.2 vs 46.2 ± 7.5). The authors propose that the eccentric activation of most of the exercises could have induced sarcomerogenesis, increasing muscle length and therefore flexibility. However, it is important to note that the study only had an experimental group, with a total of ten participants, and without the participation of a control group.

5. Means and methods to develop flexibility in combat sports athletes

Although there are no clear recommendations on the ideal frequency, intensity, and duration of a program to improve flexibility, some indications have been reported to guide program development aimed at improving this capacity [39].

Shellock and Prentice [53] cite four types of frequently used techniques to increase flexibility: static, ballistic, dynamic and proprioceptive neuromuscular facilitation. Hume and Reid [20] define each of these techniques, with advantages and disadvantages as follows:

a) *Static*: a passive movement of a muscle to the maximum range of motion, followed by maintenance of the position for a long period. The main advantages are the increases in the range of motion and the simplicity of the technique. The disadvantages include the reduction of muscular strength after this type of work and the possibility of injuries. The utilization of this technique consists of performing exercises with the help of another person or an apparatus, resulting in the same advantages and disadvantages with the additional difficulty of determining the external force generated by the other person or by the apparatus.

b) *Ballistic*: repetitive ballistic movements at the edge of the range of motion of the stimulated joint. The advantage includes the sharp increase in range of motion, but may increase the likelihood of strength reduction in the exercise performed immediately after the flexibility exercise. In addition, there may be an increased risk of injury.

c) *Dynamic*: fast or slow movement of the joint as a result of the contraction of the antagonist muscles throughout the range of motion. The advantages and disadvantages of this method are unknown.

d) *Proprioceptive neuromuscular facilitation:* involves the activation and reflex inhibition of agonist and antagonist muscles. The advantage is associated with an acute increase in the range of motion, with the disadvantage of a decrease in muscle power immediately after these exercises. This method has an additional disadvantage depending on the experience of the person to regulate the combination of stimuli to the agonist and antagonist muscles.

During static exercises there are resting and stretching of the elongated muscles, slowly and gradually, avoiding the occurrence of the stretching-reflex. For this technique, the recommendation is that this exercise is maintained for 15 to 30 seconds, although the upper limit of this range should be maintained with moderate discomfort, but without feeling pain [39]. Moreover, Hume and Reid [20] reported no significant differences between 30 and 60s exercises. In addition, the authors affirm that the work of a single set is as effective as three sets. It has also been recommended that flexibility exercises be carried out after the completion of the warm-up, as this procedure helps in obtaining a greater range of motion during the flexibility session [39].

With respect to time to improve flexibility, it takes four to six weeks to make significant changes, while a four-week interruption in flexibility training results in a return to pre-training values [20]. Regarding the detrimental effects of static stretching, Blazevich et al. [54] studied the acute response of static stretching of short duration (5 s) and moderate (3 x 10 s), without finding a harmful effect in the tests of sprinting, jumping and change of direction. Therefore, the inclusion of short-duration static stretching is unlikely to affect the performance in these variables when performed as part of a comprehensive warm-up routine. Additionally, a recent review concluded that static stretching less than 60 s only has a trivial effect on strength and power performance [14]. Thus, it could be an appropriate method to use within the warm-up in recreational athletes, but it must be used with caution in high-level athletes, because small losses of strength and power could make the difference between winning and losing at this level. Additionally, in jiu-jitsu athletes the practice of three static stretching exercises with three sets of 20 s each, with a total of 180 s stretching, produced a decrease in maximal strength (1-RM) in the bench-press [11]. Therefore, high level combat sports athletes should avoid static stretching during competitions and sessions aimed at developing maximal strength and muscle power.

In the case of dynamic techniques, specific movements from each sport have been used [20]. Essentially, this type of technique can be seen as the active movement within the range of motion of the joint required in the sport [39]. Thus, when an athlete performs a kicking technique or a maximum range of motion *uchi-mata*, they are performing a dynamic technique to increase flexibility. This technique, to reproduce movements of the sport itself, has been widely used in the warm-up phase [10]. The main difference in the dynamic compared with ballistic techniques refers to the lack of insistence on the final stage of the first technique. In the dynamic technique, the muscle does not relax during the execution of the movement and remains active throughout the range of motion [39].

For the development of a program that involves the dynamic technique, it is important to carefully analyze the main movement patterns involved in a given sport and the required range of motion [39]. For example, for sports that involve kicks, trainings would include kicking techniques typically used by each of the athletes, becoming a specific training to the needs of each fighter. It has been recommended that the initial movements be performed with movements slightly lower than those usually executed, with progression as the repetitions increase. It is also important that the movements used are respected in terms of their structure, in order not to compromise technique [39].

The ballistic technique has been considered less beneficial than the other techniques, since it can increase the risk of injuries as a result of the reflex reaction of type Ia motor neurons and the additional resistance imposed on the muscle by cyclic and repetitive changes in length, although the evidence regarding this possibility is not available [20]. This type of technique involves active movement and the application of insistence in the final phase of the movement, without maintaining the maximum range of motion with central feature [39]. However, given the constraints previously identified [20], this technique is hardly used in programs to improve the flexibility of athletes [39].

The proprioceptive neuromuscular facilitation technique is considered more complex because it includes activation and inhibition. Frequently, in this technique, the athlete is asked to passively move a certain limb until the maximum range of motion is reached, then the muscle group is contracted in order for the muscle to be elongated for 3 to 6s. This process is followed by a rest period during which the muscle is elongated [20]. Three variations of this technique are usually employed [20,39]:

a) *Contraction-relaxation:* this technique begins with a passive pre-stretch that is maintained at a point of moderate discomfort for 10s. The athlete then performs a concentric action throughout the range of motion. Then, immediately following, the athlete relaxes the muscle involved in the action and a separate person helps with passive stretching for 30s. It is expected that autogenic inhibition will occur (i.e., activation of the elongated muscles);

b) *Maintenance-relaxation:* this technique also begins with a passive pre-stretch that is maintained at a point of moderate discomfort. Then the partner tries to move the elongated limb while the athlete prevents movement through the contraction of the muscle. This isometric action is maintained for around 6s. Next, this muscle relaxes and a passive stretch is maintained for 30s. This final stretch should be of greater magnitude due to the autogenic inhibition (i.e., activation of muscle elongating); and

c) *Maintenance-relaxation with agonist contraction:* this technique is identical to the maintenance-relaxation technique in the two primary phases. During the third phase, a concentric action of the agonist is used in addition to passive stretching. That is, after the isometric phase, the athlete directs the joint involved in stretching to a new range of motion. In this situation, the final stretch should be greater as a result of the reciprocal inhibition (i.e., activation of the agonist muscles) and the autogenic inhibition (i.e., activation of the antagonist muscles - which were elongated).

In addition, it is important to consider that with these techniques it is possible to increase strength since there is a contraction phase. Also, the presence of an additional person is required to help [20].

The recommended exercises refer mainly to the muscle groups that are used in the primary techniques of the sport, as well as exercises for muscle groups, such as the quadriceps, hamstrings, pectoralis major and latissimus dorsi.

6. Final considerations

Flexibility is an important variable to consider in the training of combat sports athletes, as various actions taken during matches are performed with a high range of motion. Based on the evidence discussed in this chapter we can mention the following points: (a) The practice of static stretching exercises greater than 60 s has been associated with a decrease in short-term maximal strength and muscle power performance [14]. Even the practice of static stretching exercises consisting of three stretching exercises with three sets of 20 s each, with a total of 180 s of stretch, produced a decrease in maximal strength (1-RM) in the bench-press in jiu-jitsu athletes [11]. Therefore, high level athletes should avoid static stretching before sessions aimed at developing strength and muscle power and during competitions; (b) Four weeks of dynamic flexibility training during the wrestler's warm-up has resulted in improvements in muscle strength, anaerobic capacity and agility [10]. Therefore, combat sports athletes should incorporate dynamic flexibility training as a supplement to strength and conditioning training; c) In recreational subjects, taekwondo practice improved flexibility due to static stretching training added to the movements of the modality, for example kicks (ballistic training) [50]. Therefore, subjects who practice combat sports recreationally, can see their flexibility improved simply with the specific practice of taekwondo-specific tasks and likely combat sports in general; d) In judo athletes, resistance training increased flexibility [52]. Therefore, we recommend strength training with concentric - isometric - eccentric activation as a complement to flexibility training.

Conflict of interest

None declare.

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