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# Effects of Stretching and Resistance Training on Psychophysical Awareness: A Pilot Study

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## Abstract

Muscle–joint flexibility is defined as the ability of a muscle to stretch in a controlled manner, allowing a wide range of movement at the joints. While numerous methodologies exist for improving flexibility, few studies have investigated the role of athletes' perceptual processes and awareness related to their own body and movement control during such training. In this pilot study, we explored how two different training protocols—static and dynamic stretching (control group, CON) and multi-joint resistance training (experimental group, EXP)—influence both flexibility and psychophysical awareness, understood as a multidimensional construct involving perceived flexibility improvements, self-assessed control over exercise execution, and cognitive-emotional responses such as engagement, motivation, and satisfaction during physical effort. The study involved 24 male amateur track-and-field athletes (mean age 23 ± 2.5 years), randomized into two equal groups. Over 12 weeks, both groups trained three times per week. Flexibility was assessed using the Sit and Reach Test at three time points (pre-, mid-, and post-intervention). A 2 × 3 mixed ANOVA revealed a significant group × time interaction ($F = 20.17$, $p < 0.001$), with the EXP group showing greater improvements than the CON group. In the EXP group, Sit and Reach scores increased from pre = 28.55 cm (SD = 4.91) to mid = 29.39 cm (SD = 4.67) and post = 29.48 cm (SD = 4.91), with a significant difference between pre and post ($p = 0.01$; d = 0.35). The CON group showed minimal changes, with scores of pre = 28.66 cm (SD = 4.92), mid = 28.76 cm (SD = 5.03), and post = 28.84 cm (SD = 5.10), and no significant difference between pre and post ($p = 0.20$; d = 0.04). Psychophysical awareness was assessed using a custom questionnaire structured on a 5-point Likert scale, with items addressing perception of flexibility, motor control, and exercise-related bodily sensations. The questionnaire showed excellent internal consistency (Cronbach's $\alpha = 0.92$). Within the EXP group, psychophysical awareness increased significantly (from 3.50 to 4.17; $p = 0.01$; d = 0.38), while no significant change occurred in the CON group ($p = 0.16$). Post-hoc power analysis confirmed small to moderate effect sizes within the EXP group, although between-group differences lacked sufficient statistical power. These results suggest that resistance training may improve flexibility and concurrently enhance athletes' psychophysical self-awareness more effectively than traditional stretching. Such findings offer practical implications for coaches seeking to optimize flexibility training by integrating alternative methods that promote both physical and perceptual adaptations.

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## 1. Introduction

Flexibility is an essential component for optimal physical performance both in sports and in daily life [1,2]. It refers to the ability of a joint or muscle group to move through its full range of motion without restrictions [3]. Flexibility is characterized by both anatomical factors, such as the elasticity of muscle tissues [4], tendons, and ligaments [5], as well as neurological and biomechanical factors [6]. The degree of flexibility varies among individuals and is influenced by genetics, age, sex, and levels of physical activity. It is a conditional capacity and, therefore, can be improved through specific training protocols, which include stretching, dynamic exercises, and resistance-based movements. More recently, scientific research has shown that external resistances, such as weights, can also enhance the range of movement [7,8]. Scientific advancements have led to an evolution in flexibility training methodologies. Traditional static and dynamic stretching exercises remain fundamental, but recent studies emphasize the role of progressive resistance training in promoting greater mobility [9,10]. However, the timing of stretching is crucial. Static stretching, while effective post-exercise to restore muscle length, may negatively affect force production if performed immediately before training, as shown by Behn and Chaouachi [11].

Resistance training, typically associated with strength development, contributes to flexibility improvements through mechanisms such as increased muscle stiffness regulation, enhanced neuromuscular control, and connective tissue remodeling [12,13]. When resistance exercises are performed through a full range of motion, they induce structural adaptations in muscle fibers and tendons, improving their extensibility and joint stability [14]. Protocols such as eccentric training, loaded stretching, and isometric contractions have been shown to improve flexibility. Eccentric training increases sarcomere length, loaded stretching enhances tissue adaptation through added resistance, and isometric contractions reduce muscle resistance to stretching via neurological responses [15,16]. The incorporation of these techniques into flexibility regimens allows for more significant and long-lasting improvements [17]. The benefits of flexibility span different areas, from performance to post-traumatic functional recovery [18]. Good flexibility contributes to improving the optimal quality of movement, reducing the risk of muscle and joint injuries [19]. Athletes practicing disciplines such as dance [20], gymnastics [21], martial arts [22], and even team sports like football [23] or basketball [24], gain significant advantages from an optimal range of motion, which allows them to perform technical movements with greater precision and fluidity. Furthermore, better flexibility aids post-training recovery, promoting blood circulation and muscle relaxation, thereby reducing accumulated tension [25]. Outside the sports context, flexibility plays an essential role in psychophysical well-being [26]. A flexible body is less prone to chronic muscle tension, often caused by incorrect postures or sedentary lifestyles. Improving flexibility can reduce pain, such as lower back or neck pain, and enhance the overall sense of well-being, as it contributes to better body functionality [27]. Postural alignment is another crucial aspect associated with flexibility. Individuals with poor flexibility often experience musculoskeletal imbalances that can lead to compensatory movement patterns, resulting in discomfort and increased injury risk [28]. By incorporating flexibility training into daily routines, individuals can prevent such issues and sustain a healthier musculoskeletal system [29]. This positive impact is also reflected at the psychological level: performing stretching or mobility exercises has been shown to reduce stress, facilitating the achievement of a relaxed and focused mental state [30]. In daily activities, flexibility is essential for maintaining autonomy and preventing stiffness that can impair basic movements, such as bending, lifting objects, or simply walking. As age progresses, the loss of flexibility becomes a risk factor for the decline in quality of life, as it can have repercussions on functional limitations, increasing the likelihood of falls [31,32]. In recent years, research has highlighted the effectiveness of innovative approaches to improving flexibility, including the use of counter-resistances [33–35]. This methodology, traditionally associated with strength training, seems to have a positive impact on joint mobility, enhancing tissue elasticity and joint stability. Unlike conventional stretching techniques, resistance-based flexibility training provides additional mechanical stimuli that can lead to neuromuscular, structural, and connective tissue adaptations, improving both passive and active range of motion and overall movement efficiency [8]. These effects may manifest in an acute manner immediately after training sessions or accumulate progressively over time with consistent practice, leading to sustained improvements in flexibility and movement efficiency.

While the scientific literature presents various methodologies for increasing physical and performance-related flexibility, the psychophysical aspects of individuals in relation to flexibility enhancement—including elements such as perception and awareness—remain underexplored [36,37]. In this context, perception refers to the ability to sense and interpret bodily information such as muscle tension, joint position, and movement feedback, typically mediated by proprioceptive and kinesthetic systems [38]. Awareness, on the other hand, involves the conscious recognition and cognitive integration of these internal signals into motor behavior, contributing to a coherent body schema [39]. Physiologically, these processes rely on afferent input from muscle spindles, Golgi tendon organs, and mechanoreceptors, with central integration occurring in the somatosensory cortex and cerebellum [40]. Psychologically, awareness is influenced by attention, interoception, and self-monitoring—mechanisms that affect motor control and emotional regulation [39]. Despite their relevance, the roles of perception and awareness in sports performance and motivation are rarely addressed in flexibility training research. Developing bodily awareness may help athletes refine technique, prevent injury, and enhance training adherence by improving their understanding of how their bodies respond to physical effort. Studies have suggested that psychological factors, including motivation, perceived effort, and mind–muscle connection, influence the effectiveness of flexibility training [40,41].

The objective of this pilot study is to explore the relationship between the physical effects of specific resistance-based training protocols, particularly the increase in flexibility, and athletes' perceptions and awareness of psychophysical aspects. The study specifically aims to assess whether multi-joint resistance training, compared to traditional stretching, can simultaneously improve measurable flexibility and enhance participants' subjective awareness of their bodily states. This dual focus addresses a current gap in the literature that often separates performance outcomes from perceptual and psychological dimensions of training. Although the training methods employed are well-established in practice, the novelty of this study lies in its integrated evaluation of both physical adaptations and psychophysical awareness, which are rarely investigated together in the context of flexibility development. We hypothesize that a 12-week multi-joint resistance training program will lead to greater improvements in both flexibility and psychophysical awareness compared to a traditional static stretching protocol. This study may offer practical insights for coaches and practitioners seeking to combine physical training with perceptual development to optimize athletic performance.

## 2. Materials and Methods

### 2.1. Study Participants

The study sample consisted of 24 male amateur track-and-field athletes aged between 18 and 26 years, with a mean age of 23 years (±2.5 years), all regularly registered with an amateur sports association affiliated with the university sports center in Salerno and actively competing in athletics. They specialized in various track and field disciplines, including running, jumping, and throwing, reflecting diverse athletic demands. The participants had an average weight of 75.4 ± 6.5 kg, an average height of 178.2 ± 5.8 cm, and an average body mass index (BMI) of 23.8 ± 1.4. All participants were actively engaged in regular athletic activities, ensuring they were physically active, but had not participated in any resistance-based training programs aimed at improving flexibility in the six months prior to the study. The inclusion criteria required that athletes consistently engaged in resistance training for at least one year, had no significant injuries, and were free from chronic conditions that could interfere with the study. The exclusion criteria included recent injuries, pre-existing medical conditions that could affect flexibility, or prior participation in resistance-based training programs aimed at improving flexibility within the six months preceding the study. The sample was selected through simple randomization performed by random draw. Complete randomization was applied without controlling for factors such as age or sport level. All participants were informed in advance about the study's objectives, methodology, and duration, and they provided written informed consent before participation.

### 2.2. Study Design

The sample was divided into two groups: an experimental group (EXP) and a control group (CON), each consisting of 12 participants. Participants were randomly assigned to one of the two groups to ensure balanced baseline characteristics. The EXP group followed resistance training protocols, while the CON group performed active and passive stretching protocols. While this comparison may appear to involve different training interventions, it allows for a broad evaluation of different approaches to flexibility improvement. To ensure comparability between groups, the training workload was standardized as much as possible. Both the experimental and control groups trained three times per week for twelve weeks, with session durations matched. Although the types of exercises differed (resistance training vs. stretching), the total volume and intensity were monitored and kept similar to balance the quantitative effort across groups. This approach aimed to minimize differences in overall workload as a confounding factor in flexibility improvements. To reduce the risk of bias, data were collected by independent evaluators who were not informed about the group assignments. Additionally, the training sessions were supervised by a certified instructor, who ensured the correct execution of exercises and the progression of the load.

### 2.3. Procedure

Before the start of the training program, during its progression, and upon completion, participants were assessed using the Sit and Reach Test, a standardized measure of trunk and lower limb flexibility [42]. The test was performed according to the standard protocol [43] under controlled conditions, including consistent time of day, temperature, and location, to enhance reliability. Participants familiarized themselves with the procedure before each assessment. While the Sit and Reach Test primarily assesses flexibility in the posterior chain, its limitations in reflecting overall flexibility are acknowledged. In particular, we recognize that the test involves lumbar spine flexion, which can introduce compensatory movement patterns and may not accurately isolate hamstring flexibility.

Furthermore, the outcomes can be influenced by individual anthropometric differences, such as limb and trunk length, which may affect test performance independently of true flexibility levels. Despite these limitations, the test remains a widely accepted, practical tool, and was used consistently across three time points (pre-, mid-, and post-intervention) to monitor relative changes over time within individuals. After initial measurements, participants were randomly assigned to one of two groups using simple randomization to ensure balanced baseline characteristics. Both groups followed their respective twelve-week training programs with three weekly sessions, maintaining habitual physical activity but refraining from additional flexibility or resistance training.

The protocol adopted by the experimental group focused on multi-joint exercises performed against resistance, aiming to increase both flexibility and muscle strength. The selected exercises included complex movements engaging multiple muscle groups simultaneously to enhance neuromuscular coordination and movement control. During each training session, participants performed five fundamental exercises targeting both lower and upper body strength. Each exercise was executed in three sets of eight repetitions, with a 90-s rest period between sets. This prescription was chosen based on evidence supporting strength and hypertrophy development while balancing neuromuscular fatigue and recovery [44]. The three-set structure provided adequate training volume for adaptation [45], while eight repetitions per set optimized both strength and muscular endurance [46]. The 90-s rest period was selected to allow sufficient recovery while maintaining training intensity and minimizing excessive fatigue, which is crucial for sustained performance and injury prevention [47]. The load was adjusted based on individual capabilities, following a gradual progression principle to promote optimal adaptation and reduce injury risk. The lower-body exercises included the stiff-leg deadlift, which emphasized the hamstrings and glutes through a hip-hinge movement, and the squat, a compound exercise targeting the quadriceps, glutes, and core stability. For the upper body, participants performed the bench press, focusing on the pectorals, triceps, and shoulders, the military press, which develops shoulder strength, and the landmine press, a unilateral pressing movement engaging the shoulders, triceps, and core stability. This structured program ensured progressive overload and balanced muscle development. The complete training protocol is detailed in Table 1. The resistance load started at 50% of the participant's estimated one-repetition maximum (1RM) and was progressively increased every two weeks by approximately 5–10%, ensuring continued overload and adaptation. The 1RM value was estimated through a submaximal test, in which participants performed the maximum number of possible repetitions with a known load. Subsequently, the 1RM value was calculated using the Brzycki's 1-RM calculation formula (1RM = weight ÷ [(1.0278) − (0.0278 × repetitions)] [48]) to ensure a reliable estimate without exposing the athletes to the risk of injury. The control group followed a static stretching protocol focused on improving flexibility in the spine, shoulders, and lower limbs as shown in Table 2. The design choice to include a stretching program as a control group is addressed with caution, given its direct relationship to flexibility**.** Each session consisted of five exercises, performed in three sets of 30 s with a one-minute rest in between. Participants were instructed to stretch to the point of mild discomfort, not pain, while focusing on breathing and relaxation. The exercises included Cat-Cow [49], a dynamic movement that alternates between arching and rounding the back to improve spinal mobility. Wall Angel involved raising and lowering the arms against a wall to enhance shoulder mobility [50]. Spinal Extensions were performed in a prone position to stretch the spine. The Quadriceps Stretch targeted the quadriceps and hip flexors while standing, and the Glute Bridge helped strengthen the glutes and hamstrings while stretching the hip flexors [51]. This program aimed to gradually improve joint mobility and flexibility over time.

**Table 1.** Experimental group training protocol.

| Exercise | Repetitions | Rest | Initial Intensity | Progression (Weeks 1–12) |
| --- | --- | --- | --- | --- |
| Stiff-Leg Deadlift | 3 × 8 | 1′ | 60% 1RM | +2.5% 1RM every 2 weeks |
| Squat | 3 × 8 | 1′ | 60% 1RM | +2.5% 1RM every 2 weeks |
| Landmine Press | 3 × 8 | 1′ | 60% 1RM | +2.5% 1RM every 2 weeks |
| Bench Press | 3 × 8 | 1′ | 60% 1RM | +2.5% 1RM every 2 weeks |
| Military Press | 3 × 8 | 1′ | 60% 1RM | +2.5% 1RM every 2 weeks |

**Table 2.** Control group training protocol.

| Exercise | Repetitions | Rest | Initial Intensity | Progression (Weeks 1–12) |
| --- | --- | --- | --- | --- |
| Cat-Cow | 3 × 30″ | 1′ | 30 s | +5 s every 2 weeks |
| Wall Angel | 3 × 30″ | 1′ | 30 s | +5 s every 2 weeks |
| Spinal Extensions | 3 × 30″ | 1′ | 30 s | +5 s every 2 weeks |
| Quadriceps Stretch | 3 × 30″ | 1′ | 30 s | +5 s every 2 weeks |
| Glute Bridge | 3 × 30″ | 1′ | 30 s | +5 s every 2 weeks |

Throughout the intervention period, constant supervision was ensured to guarantee the correct execution of exercises and adherence to the prescribed protocols. Two trained professionals supervised all training sessions to ensure correct posture and prevent injuries. The same instructors oversaw both groups to maintain consistency in supervision. Participants were also encouraged to report any discomfort or adverse effects immediately.

### 2.4. Survey

To evaluate potential differences in perception between the EXP and CON groups regarding the impact of resistance training on flexibility and psychophysical awareness, a survey was designed and administered at three time points: before training (pre-training), midway through the program (mid-training), and after program completion (post-training). The survey consisted of multiple-choice questions structured on a 1-to-5 Likert scale and was distributed using Google Forms. To ensure validity, internal consistency was assessed using Cronbach's alpha with 95% confidence intervals (CI). A Cronbach's alpha of 1 indicates perfect reliability, while a value of 0.7 or higher is considered acceptable [52]. The internal consistency of the survey was excellent (Cronbach's $\alpha$ coefficient [95% CI]: 0.92 [0.89–0.94]; $p < 0.001$). Data collection occurred at three time points: before training (pre-training), midway through the program (mid-training), and after program completion (post-training). Since the survey included different questions at each stage, which were tailored to capture the evolving perceptions of participants over time, direct longitudinal analysis of identical items was not possible. Instead, an item-wise thematic approach was used, grouping questions into three consistent themes across stages: perceived flexibility improvement, training engagement and perception of effectiveness, and psychophysical awareness. The questions at each stage were aligned with these themes. For pre-training, questions focused on participants' beliefs about flexibility enhancement and readiness to engage in the program. At mid-training, participants were asked about their perceived progress in flexibility and their ability to perform the exercises, along with their perception of the training's balance of challenge and usefulness. Finally, post-training questions assessed the perceived improvement in flexibility, increased awareness of exercise execution, and overall satisfaction with the program's results. While the questions varied between stages, comparisons were made based on these consistent thematic dimensions. By categorizing responses into these themes, changes in participants' perceptions over time could be tracked despite differences in specific questions. Descriptive statistics were used to represent the distribution of responses within each theme, and trends across stages were analyzed to understand the changes in perceptions resulting from the training program. The full survey is presented in Table 3.

**Table 3.** Survey on the perceived effects of resistance training.

| | |
|---|---|
| Pre-training: | • To what extent do you believe a structured training program can enhance your flexibility?<br>• How committed are you to following a training regime designed to improve mobility?<br>• How physically prepared do you feel to begin this training program? |
| Mid-training: | • To what degree do you feel the training program is enhancing your flexibility?<br>• How much progress do you perceive in your ability to perform the exercises compared to the start of the program?<br>• How would you rate the balance between challenge and usefulness of the training program in helping you reach your goals? |
| Post-training: | • How much do you believe your flexibility has improved as a result of the program?<br>• To what extent has your awareness of proper exercise execution increased?<br>• How satisfied are you with the overall results achieved through this training program? |

### *2.5. Statistical Analysis*

The descriptive data are presented as mean (M) values along with their corresponding standard deviations (SD). To assess the normality of data distribution, the Shapiro–Wilk test was employed. Prior to the training program, an independent-samples *t*-test was conducted to confirm the absence of significant differences in baseline Sit and Reach test scores between the groups. A 2 (Group) × 3 (Test Occasions) repeated measures ANOVA was utilized to analyze interactions and variations within groups. Additionally, the Friedman test was applied to examine changes in survey scores across the three measurement points (pre, mid, and post) within each group. To further investigate specific differences over time, post-hoc analyses were conducted. The Bonferroni post-hoc test was used for sit-and-reach measurements, while pairwise comparisons of survey data were performed using the Wilcoxon signed-rank test. This methodology enabled the identification of significant variations across the pre-mid, pre-post, and mid-post phases for each group [37].

The power analysis was performed using G*Power software (version 3.1) to contextualize the significance and reliability of the results given the limited sample size. Statistical significance was determined at $p \leq 0.05$, with a 95% confidence interval applied to all comparisons. Effect sizes were evaluated based on standard thresholds (d = 0.2 for small, d = 0.5 for medium, and d = 0.8 for large) [53]. All data analyses were conducted using IBM SPSS Statistics (version 25.0, IBM, SPSS Inc., Armonk, NY, USA).

## 3. Results

Table 4 presents the Sit and Reach Test scores (expressed in centimeters) collected at different time points (pre, intermediate, and post) for both the experimental (EXP) and control (CON) groups. For each time point, the means and standard deviations were calculated, highlighting the trend of flexibility improvements over time in both groups. The CON group, which followed a stretching protocol aimed at improving flexibility, showed minimal changes over time. In contrast, the EXP group, which followed a multi-joint resistance training program, demonstrated more significant improvements.

**Table 4.** Sit and reach test data for EXP and CON groups.

| Athletes (n = 24) | EXP Pre | EXP Mid | EXP Post | CON Pre | CON Mid | CON Post |
|---|---|---|---|---|---|---|
| Mean | 28.55 | 29.39 | 29.48 | 28.66 | 28.76 | 28.84 |
| SD | 4.91 | 4.67 | 4.91 | 4.92 | 5.03 | 5.10 |

The EXP group showed a significant improvement in flexibility over time, with the most notable increase observed between the initial test (pre-test) and the final test (post-test), suggesting the effectiveness of the multi-joint resistance training protocol in improving flexibility. In contrast, the CON group demonstrated only slight and consistent increases in flexibility, indicating minimal impact from the stretching protocol.

The results of the mixed-design ANOVA in Table 5 revealed significant main effects of Group ($F = 1350.94$, $p < 0.0001$) and Time ($F = 29.33$, $p < 0.0001$), as well as a significant Group × Time interaction ($F = 14.89$, $p < 0.0001$). The partial eta squared values indicate moderate effect sizes for Group ($\eta^2 = 0.058$) and Time ($\eta^2 = 0.003$), and a small but meaningful effect for the interaction ($\eta^2 = 0.0013$). These results suggest that flexibility improved over time, particularly in the experimental group, and that the resistance-based protocol was more effective than stretching. Post-hoc Bonferroni-adjusted pairwise comparisons confirmed a significant improvement in flexibility in the EXP group between Pre and Mid ($p = 0.0012$) and between Pre and Post ($p = 0.0156$), while no significant change was observed between Mid and Post ($p = 1.0000$). The between-group comparison at post-test did not reach statistical significance ($p > 0.05$), indicating that despite a favorable trend in the EXP group, the difference was not statistically confirmed. In contrast, the CON group did not exhibit any statistically significant differences across the time points (all $p > 0.80$), confirming the limited effect of the stretching protocol.

**Table 5.** Mixed-design ANOVA and Bonferroni-adjusted post-hoc results for the sit and reach test. Cohen's d values are reported for within-group comparisons to indicate effect size magnitude.

| Effect/Comparison | F/t | *p*-Value | Effect Size |
|---|---|---|---|
| Main Effect: Group | 1350.94 | <0.0001 | $\eta^2 = 0.058$ |
| Main Effect: Time | 29.33 | <0.0001 | $\eta^2 = 0.003$ |
| Group × Time Interaction | 14.89 | <0.0001 | $\eta^2 = 0.0013$ |
| EXP: Pre vs. Mid | 4.55 | 0.0012 | d = 1.83 |
| EXP: Pre vs. Post | 3.49 | 0.0156 | d = 2.16 |
| EXP: Mid vs. Post | 0.46 | 1.0000 | d = 0.19 |
| CON: Pre vs. Mid | 0.87 | 1.0000 | d = 0.39 |
| CON: Pre vs. Post | 1.30 | 0.8120 | d = 0.50 |
| CON: Mid vs. Post | 0.43 | 1.0000 | d = 0.31 |

A post-hoc power analysis was conducted based on the effect sizes observed in the main outcome measures. For the between-group comparison at post-test, the observed effect size was small (Cohen's d = 0.13), based on the following values: experimental group (M = 29.48, SD = 4.91) and control group (M = 28.84, SD = 5.10). The computed statistical power was only 6.0%, indicating a high risk of Type II error and limited sensitivity to detect small effects between groups. In contrast, the within-group improvement in the experimental group from pre- to post-test showed a small effect size (Cohen's d = 0.19; Pre: M = 28.55, SD = 4.91; Post: M = 29.48, SD = 4.91), while the control group showed a negligible change over time (Cohen's d = 0.036; Pre: M = 28.66, SD = 4.92; Post: M = 28.84, SD = 5.10). These findings suggest that the study was adequately powered to detect large effects within groups, but not modest differences between groups.

Survey results presented in Table 6 indicate the mean scores for the EXP (experimental) and CON (control) groups at pre-, mid-, and post-training. For the EXP group, the score increased progressively from 3.00 (SD = 0.52) at pre-training to 3.50 (SD = 0.67) at mid-training, and further to 4.17 (SD = 0.58) at post-training, reflecting a significant improvement in perceived flexibility and psychophysical awareness over time. In contrast, the CON group had a pre-training score of 2.83 (SD = 0.83), a slight increase to 3.00 (SD = 0.42) at mid-training, and only a small rise to 2.91 (SD = 0.51) at post-training, showing minimal improvement over the course of the program.

**Table 6.** Mean survey scores for the EXP and CON groups across the three time points.

| Athletes | EXP Pre | EXP Mid | EXP Post | CON Pre | CON Mid | CON Post |
|---|---|---|---|---|---|---|
| Mean | 3.00 | 3.50 | 4.17 * | 2.83 | 3.00 | 2.91 * |
| SD | 0.52 | 0.67 | 0.58 | 0.83 | 0.42 | 0.51 |

* Significant difference between groups at $p < 0.05$ (independent-samples *t*-test).

The Friedman test results indicate a statistically significant shift in the perceived outcomes of athletes within the experimental group over time ($\chi^2$ F = 8.71; $p = 0.01$). Post-hoc comparisons using the Wilcoxon test reveal no significant difference between the initial and intermediate assessments ($p = 0.60$). However, notable differences arise when comparing the initial and final scores ($p = 0.02$) and the intermediate and final scores ($p = 0.02$), suggesting an evolving perception over time. The effect size for both the pre-to-post and mid-to-post comparisons was moderate (d = 0.38; 95% CI: 0.20, 0.56). Conversely, the Friedman test conducted for the control group does not yield statistically significant findings ($\chi^2$ F = 3.56; $p = 0.16$). Post-hoc analysis further supports the lack of meaningful change across the three time points: pre-to-intermediate ($p = 0.13$), pre-to-post ($p = 0.09$), and intermediate-to-post ($p = 0.27$). These results suggest that athletes' perceptions in the control group remained stable over time. A summary of the Friedman test outcomes and post-hoc analyses detailing perceptual changes across the three time points for both groups is presented in Table 7.

**Table 7.** Friedman test results and post-hoc analysis for athlete perceptions.

| Variable | $\chi^2$ F | *p*-Value | Comparison | *p*-Value | d (95% CIs) |
|---|---|---|---|---|---|
| | | | Pre vs. Mid | 0.60 | 0.62 (0.45, 0.78) |
| EXP | 8.71 | 0.01 | Pre vs. Post | 0.02 | 0.38 (0.20, 0.56) |
| | | | Mid vs. Post | 0.02 | 0.38 (0.20, 0.56) |
| | | | Pre vs. Mid | 0.13 | 0.22 (0.10; 0.34) |
| CON | 3.56 | 0.16 | Pre vs. Post | 0.09 | 0.30 (0.15; 0.45) |
| | | | Mid vs. Post | 0.27 | 0.18 (0.08; 0.28) |

## 4. Discussion

This study's findings suggest that the multi-joint resistance training program had a significantly greater impact on flexibility compared to the traditional stretching protocol. These results are consistent with previous research, which indicates that well-designed resistance training not only enhances muscle strength but also improves flexibility [54,55]. Several studies have demonstrated that resistance exercises performed with a wide range of motion can lead to significant increases in joint mobility. Wang et al. [56] found that participants who followed a resistance training cycle focused on full-range joint movements showed marked improvements in flexibility. This approach allows muscles to work through a broader range of motion, which promotes tendon elongation and enhances overall flexibility. Asan et al. [57] reported similar findings in athletes involved in high-mobility sports such as gymnastics and dance. These athletes participated in a multi-joint resistance training program and experienced improvements in flexibility and joint mobility, important factors for executing complex and dynamic movements. While our study did not directly measure muscle strength, the observed improvements in flexibility in the experimental group align with the idea that multi-joint resistance training may positively influence flexibility. However, it is important to consider the characteristics of the resistance training program, as exercise prescription (e.g., lighter loads with higher repetitions and shorter rest periods for strength-endurance training versus heavier loads with lower repetitions and longer rest for maximum strength training) can significantly affect flexibility outcomes. Both types of training could enhance flexibility, but the magnitude of improvement may vary based on intensity, load, and recovery strategies used. One possible explanation for these improvements lies in the physiological adaptations induced by resistance training. Resistance exercises, particularly those incorporating eccentric movements and full range of motion, stimulate muscle fiber elongation, improve neuromuscular coordination, and increase tendon stiffness, all of which contribute to enhanced flexibility. Moreover, resistance training enhances the structural integrity of connective tissues, reducing stiffness and allowing greater joint mobility [58].

The statistical analysis demonstrated that the multi-joint resistance training program had a more pronounced effect on flexibility compared to the traditional stretching protocol. A two-way repeated-measures ANOVA revealed a statistically significant interaction between group and time ($p < 0.05$), indicating differing patterns of flexibility changes over time between groups. Within the experimental group, significant improvements from pre- to mid-test and pre- to post-test were observed, with moderate effect sizes. In contrast, the control group showed no significant changes and negligible effect sizes. Although the between-group comparison at post-test showed a favorable trend for the experimental group, it did not reach statistical significance, potentially due to the study being underpowered to detect small-to-moderate differences. Nonetheless, the direction and consistency of results support the functional advantage of the resistance training intervention. Additionally, the athlete perception survey corroborated these findings, with participants in the experimental group reporting significant increases in perceived flexibility and awareness from pre- to post-intervention. This subjective improvement aligns with the significant changes observed in the Sit and Reach Test and underscores the psychological benefits of engaging in training protocols that produce measurable physical outcomes. Increased awareness of progress can enhance motivation and adherence to training, which are critical factors in effective motor learning and skill acquisition. These psychological effects may ultimately contribute to improved sports performance by fostering consistent practice and greater effort during training sessions, as supported by previous literature linking perceived progress with enhanced athletic engagement and long-term commitment [59,60]. In contrast, participants in the control group, who followed a traditional stretching protocol, did not report notable improvements in either flexibility or self-perception, reflecting the limited physical gains measured in their performance tests. The convergence of objective data and subjective reports in the experimental group reinforces the value of multi-joint resistance training, not only for its physical benefits but also for its impact on psychophysical awareness and motivation. This dual improvement is especially relevant in athletic populations, where both physical readiness and psychological engagement play a crucial role in performance and progression.

### 4.1. Study Limitations

This pilot study has several limitations. First, the small sample size and lack of a priori power analysis may have limited the ability to detect meaningful differences between groups, as confirmed by a post-hoc power analysis indicating very low statistical power. The relatively short training duration may have restricted observable improvements, particularly in already flexible athletes. Future studies with larger samples and longer protocols are warranted. Differences between training protocols complicate attributing flexibility gains solely to the resistance training intervention; controlling for training volume, intensity, and participant experience is recommended. The exclusive use of the Sit and Reach Test limits assessment to posterior chain flexibility and overlooks other important areas such as hip and thoracic mobility. Incorporating additional tests (e.g., Functional Movement Screen, goniometry) would provide a more comprehensive flexibility profile. The athlete perception survey's 1-to-5 Likert scale may lack sensitivity to subtle perceptual changes; qualitative methods such as interviews could enrich insights into psychological and motivational factors affecting training adherence. Finally, variations in participants' athletic disciplines, which impose different flexibility demands, were not controlled and should be considered in future research. In addition, the study included only male participants, limiting the generalizability of the findings across sexes. Given known sex-based differences in flexibility and training adaptation, future studies should include female athletes to provide a more comprehensive understanding of the effects.

### *4.2. Practical Implications and Future Directions*

The findings suggest that multi-joint resistance training can effectively enhance flexibility while supporting strength and stability development. This approach is especially relevant for sports requiring integrated flexibility, strength, and power, such as martial arts, gymnastics, and dance. Coaches might consider incorporating multi-joint resistance exercises into warm-ups and conditioning routines to optimize athletic performance. Future research should explore longer interventions, larger and more diverse athlete samples, and more detailed joint mobility and biomechanical assessments (e.g., motion capture, EMG). Additionally, comparing resistance training to hybrid protocols combining stretching and progressive loading could clarify the most effective methods for improving flexibility and performance.

## 5. Conclusions

The results of this pilot study suggest that a multi-joint resistance training protocol may have a positive effect on flexibility compared to traditional stretching; however, the observed improvements were modest and accompanied by small effect sizes and low statistical power. These findings indicate a potential benefit of resistance training on flexibility, particularly when exercises involve multi-joint movements and progressive loading, but should be interpreted with caution due to the study's methodological limitations and limited sample size. The increase in perceived outcomes among participants in the experimental group also points to possible psychological advantages of this training approach. Overall, this exploratory work provides preliminary evidence supporting further investigation into resistance training as a complementary strategy for flexibility enhancement. Future studies with larger sample sizes, longer interventions, and more robust designs are needed to confirm and clarify these initial observations.

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**Institutional Review Board Statement:** All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki. According to Regulation (EU) 536/2014 and Directive 2001/20/EC, research involving minimal risks to participants may be exempt from formal ethical review, as it does not involve invasive or experimental interventions. Additionally, under Legislative Decree No. 211 of 24 June 2003, research that does not pose significant risks and is aimed at improving educational practices might be exempt from the Institutional Review Board (IRB) or Ethics Committee review and approval.

**Informed Consent Statement:** Informed consent was obtained from all participants involved in the study. Each participant was assured of anonymity and was provided with complete and transparent information about the content, purpose, and procedures of the research in a clear and understandable manner. Participation was entirely voluntary, and no one was forced to take part.

**Data Availability Statement:** All data generated or analyzed during this study have been included within the manuscript.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## Abbreviations

The following abbreviations are used in this manuscript:

| | |
|---|---|
| EXP | Experimental Group |
| CON | Control Group |

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