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# Acute Effects of Mini Trampoline Training Session on Leg Stiffness and Reactive Power

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**Abstract:** The purpose of this study was to evaluate the acute effects of a mini trampoline training session (SuperJump®) on leg stiffness and reactive power ($R_P$) while examining its relation to participants' sex. A total of 20 participants (11 females, age: 24.4 ± 1.0 yrs; 9 males, age: 27.3 ± 2.9 yrs) performed continuous jump repetitions (RJs), measured on a force plate, before (PRE) and after (POST) a 30 min Superjump® session. Linear repeated measures mixed models were used to examine the effects of the Superjump® session on the leg stiffness mean ($K_{MEAN}$), mean of the best RJs ($K_{BEST}$), and $R_P$ in relation to sex. Before and after the mini trampoline training session, females showed lower $K_{MEAN}$ and $K_{BEST}$ values compared with males. Despite the significant ($p < 0.002$) decreases in $R_P$ after the Superjump® session in both males (PRE: 23.1 ± 6.5 W/kg; POST: 21.2 ± 6.1 W/kg) and females (PRE: 23.6 ± 5.5 W/kg; POST: 21.9 ± 5.3 W/kg), leg stiffness remained unchanged, suggesting a potential protective effect of mini trampoline training on leg stiffness during acute adaptations. These findings suggest that Superjump® training might exert a protective effect on leg stiffness, which prevents acute decreases that are commonly observed in other training modalities. The sex-related differences emerging from the present study emphasize the need for personalized approaches when integrating this innovative training tool into athletes' regimens.

**Keywords:** plyometric training; jump training; Superjump® workout; healthy young students



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## 1. Introduction

The concept of stiffness originates in physics, particularly as a part of Hooke's Law, which defines objects as deformable bodies that are capable of storing and returning elastic energy. Hooke's Law states that the force (F) required to deform a material is related to a proportionality constant (k) and the distance (x) that the material is deformed, provided that its shape is not permanently changed. Mathematically, this relationship is expressed as $F = kx$. The proportionality constant 'k' is referred to as the spring constant, which describes the stiffness of an ideal spring and mass system. Stiffness in the human body, or in body segments, describes the body's ability to resist displacement when subjected to ground reaction forces or moments. In this context, stiffness can be described at various levels, ranging from a single muscle fiber to creating a model for the entire body as a mass and spring system [1]. For instance, lower limbs are often modeled as springs supporting the mass of the body, and the existing literature suggests that the stiffness of the human body is a combination of all individual stiffness values that are contributed by tendons, ligaments, muscles, cartilage, and bone [2].

Leg stiffness is a critical concept in sport biomechanics, and it has significant implications for both performance and injury prevention. Consequently, finding the right balance of stiffness is crucial as excessively high or low levels can lead to negative outcomes or injuries [1]. Therefore, training programs should aim to determine the optimal range of leg stiffness to achieve the desired athletic effects.

Jumping performance, a key aspect of many sports and human activities, is influenced by leg stiffness and related training protocols. Repeated jumps and plyometric training [3] show analogies with the mass-spring model [4–10] and are considered crucial for improving leg stiffness. Particularly, plyometric training has been found to have a substantial impact on joint stiffness during drop jumps, with a significant increase (+63.4%) in stiffness being reported after a 12-week program [11]. Conversely, insufficient stiffness can lead to soft tissue injuries, as demonstrated by a decrease (−32.7%) in ankle joint stiffness following 7 weeks of plyometric training using sinusoidal perturbations [1,11,12].

Leg stiffness plays a crucial role in the stretch-shortening cycle, which allows for the storage and release of elastic strain energy in the musculotendinous unit [13]. This capability contributes to improved muscle reactive power ($R_P$) and jump height [14], suggesting that maximum power production during jumps is highly related to lower level of limb stiffness in adults [15]. Interestingly, hopping frequency has also been shown to increase leg stiffness, potentially due to an increase in ankle stiffness [16,17]. However, the relationship between leg stiffness and athletic performance is not solely dependent on the athlete's physiological structure. Factors such as fatigue protocols, methods used to calculate leg stiffness, and the training surface can all influence the findings reported on leg stiffness [18]. One method to alter the surface is through mini trampoline training, which has been demonstrated to simultaneously enhance strength, balance, body stabilization, fitness, lower limb asymmetry, and spatial orientation [19–21]. The use of an elastic surface during mini trampoline training leads to an increase in leg stiffness, reducing the average force required to execute jumps and thus increasing the mechanical work done by the surface [17].

Despite the potential benefits and multiple effects of mini trampoline training on movement patterns, there is currently a lack of research investigating the acute effects of trampoline training on leg stiffness and $R_P$. Therefore, given the potential of mini trampoline training for optimizing jump training while minimizing joint stress and the risk of injuries [22], our study aimed to evaluate the sex-related acute effects of a single mini trampoline training session on leg stiffness and $R_P$ in young adults.

## 2. Materials and Methods

### *2.1. Experimental Approach to the Problem*

Stiffness and $R_P$ are essential parameters that are often evaluated in strength and conditioning investigations, particularly during vertical, countermovement, and repetitive jumps, in relation to both performance and injuries. However, there is a lack of research specifically focused on stiffness and strength in the context of plyometric training on different jumping surfaces. To address this gap and provide scientific evidence regarding leg stiffness and $R_P$, our study took a new methodological approach. A higher level of leg stiffness is believed to enhance the dynamic mechanism's ability to generate rebound movements during the stretch-shortening cycle [23,24] and reduce the risk of excessive load on passive knee structures [25]. Plyometric training is known to enhance these characteristics, and by using the mini trampoline as a training tool, we aimed to gain valuable insights beyond what traditional vertical jumps, countermovement jumps, and repetitive jumps can offer. Additionally, our study considered the influence of sex on leg stiffness and $R_P$, providing a comprehensive understanding of how these factors interact. In this investigation, we measured leg stiffness (K) in (kilograms*Newton)/(meters) and $R_P$ in Watt/kilograms as dependent variables; sex (female and male) and testing time (PRE vs. POST) were used as independent variables.

To ensure direct comparability with previous studies, we estimated leg stiffness using the methods originally described by Cavagna [26], in which leg stiffness is defined as the ratio between the peak vertical ground reaction force ($F_{max}$) and the maximum vertical displacement of the center of mass ($\Delta$CoM), which is the difference in the center of mass's vertical position at initial ground contact and at the lowest point. The equation for leg stiffness is given as follows (Equation (1)):

$$\mathrm{K} = \frac{Fmax}{\Delta \mathrm{CoM}}\ [\mathrm{kN/m}] \tag{1}$$

This method has been extensively utilized in evaluating leg stiffness during hopping tasks in various studies [27–30].

To assess $R_P$, we employed the following Equation (2) [31], which involves dividing the product of gravity acceleration (g), time of flight (TF), and total time (TT) (the sum of the time of contact (TC) and TF) by the product of 4 and the TC:

$$\mathrm{R_P} = \frac{g^2 * (\mathrm{TF} * \mathrm{TT})}{4 * \mathrm{TC}}\ [\mathrm{Watt/kg}] \tag{2}$$

A 2-way mixed effects model was utilized to assess the reliability of the measurements recorded by the force plate. The force platform demonstrated high intra-class correlation coefficients (ICCs) for both stiffness (ICCs = 0.92; 95% confidence interval [CI]: 0.82–0.96) and $R_P$ (ICCs = 0.90; 95% CI: 0.79–0.96) [32,33]. These high ICC values indicate strong consistency and agreement in the measured stiffness and $R_P$ values obtained from the force plate, which confirms the reliability of the force platform's data for our study.

### 2.2. Subjects

Twenty college students (11 females, 9 males) participated in the study, with the average age being 25.7 ± 2.5 years spanning a range of 23 to 32 years. The study was conducted following the guidelines of the Declaration of Helsinki and received approval from the Institutional Review Board of the Department of Human Science, Society, and Health of the University of Cassino and Lazio Meridionale. Prior to participating, all subjects read and signed a written consent form, and they were informed of their right to withdraw from the study at any time without facing any consequences. To ensure the homogeneity of the sample, individuals with prior experience in Superjump® and those who reported preexisting limitations such as cardiovascular, respiratory, metabolic diseases, and musculoskeletal injuries of the back or lower extremities were excluded from the study.

In accordance with the Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016, also known as the General Data Protection Regulation (GDPR), which safeguards the rights and privacy of individuals with respect to the processing of personal data, we took measures to ensure the appropriate security and confidentiality of the participants' personal data. To maintain anonymity, each participant was assigned a unique identification code, and their personal data were solely used for statistical purposes.

### 2.3. Procedures

The timeline of the experimental procedures is shown in Figure 1.

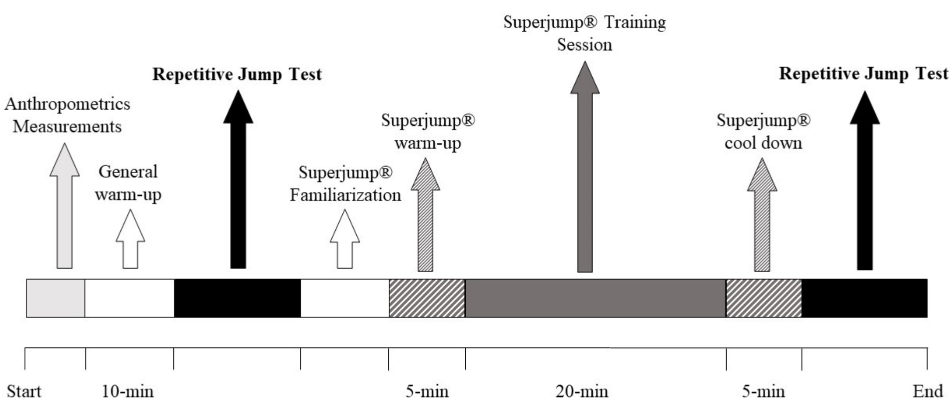


**Figure 1.** Timeline of the experimental procedures.

*Testing Protocols:* Data collection took place at the Sport and Exercise Physiology Laboratory of the University of Cassino and Lazio Meridionale. The entire testing was conducted in a single session. Prior to the baseline evaluations, all subjects were familiarized with the experimental protocols. At the start of the official testing procedures, following a 10-min warmup of low-intensity running (1–2 AU), which was monitored using the rating of perceived exertion (RPE) on the category-ratio (CR-10) scale [21,34], subjects underwent a familiarization jumping session involving a total of 50 free jumps on a mini trampoline. To assess exercise session intensity, the session RPE was recorded using the CR-10 scale 30 min after the completion of the Superjump® training session, which is consistent with similar studies [21,34].

*Anthropometric Measurements*: Before starting the testing sessions, anthropometrical parameters, including height (in meters) and body mass (in kilograms), were collected for each subject. The measurements were obtained using a scale with an integrated stadiometer (Seca, model 709; Vogel & Halke, Hamburg, Germany) with an accuracy of 0.1 kg for body mass and 0.1 cm for height. The body mass index (BMI) of each subject was calculated as weight (kg) divided by height squared ($m^2$). The anthropometric characteristics of the participants are presented in Table 1.

**Table 1.** Mean values and standard deviations (SDs) of the subjects' characteristics.

| | ***Females*** | ***Males*** | ***Total*** |
|---|---|---|---|
| ***N*** | **11** | **9** | **20** |
| *Age (years)* | 24.4 ± 1.0 | 27.3 ± 2.9 | 25.7 ± 2.5 |
| *Body height (m)* | 1.60 ± 0.1 | 1.70 ± 0.1 | 1.70 ± 0.1 |
| *Body mass (kg)* | 56.5 ± 6.2 | 74.0 ± 10.7 | 64.4 ± 12.2 |
| *BMI* ($kg \cdot m^{-2}$) | 22.4 ± 2.0 | 24.4 ± 2.8 | 23.3 ± 2.6 |

N = number; BMI = body mass index.

*Repetitive Jump Test*: Following a familiarization jumping session, the subjects performed a repetitive jump test to assess lower limb stiffness and muscle $R_P$ before (PRE) and after (POST) the Superjump® training session. The RJs testing session comprised three trials, with each trial consisting of five continuous jump repetitions (RJs) at the subject's preferred jumping frequency. A 1-min recovery period was provided between each trial. During the RJs, subjects were instructed to begin from a standing position, jump upwards without bending their knees, and keep their hands on their hips. The goal was to achieve maximum height and speed in each jump while minimizing contact times between jumps. Data collection during the RJs was performed by using a force plate (Kistler 9290AD, Kistler, Winterthur, Switzerland) with a measurement range from 0 N to 10,000 N, and linearity of $\leq \pm 0.5\%$ FSO. The data acquisition system (Tektronix TBS 1202B, Tektronix, Beaverton, OR, USA) and charge amplifier (Kistler 5001, Kistler, Winterthur, Switzerland) were used to record the data.

The leg stiffness mean ($K_{MEAN}$) and $R_P$ mean of the five repetitive jumps (RJs) in each of the three trials along with the mean of the best RJs (one per trial) ($K_{BEST}$) over the five jumps for each subject were utilized for the subsequent analysis.

*Superjump® Training:* The Superjump® training used in this study was an elastic mini trampoline (CoalSport, Rome, Italy) with the following specifications: diameter of 122 cm, height of 26 cm, weight of 15 kg, equipped with 40 springs, 8 folding feet, and capable of supporting up to 150 kg. For this study, the Superjump® Original was employed, which is designed for untrained and/or beginner subjects. Participants were instructed to follow the workout instructions that were provided via a DVD disc [21]. The video workout was displayed on a computer screen that was positioned in front of the mini trampoline. The Superjump® training session consisted of a period of free practice on the mini trampoline followed by a 30-min workout. The session included a 5-min warmup and a 5-min cooldown phase, during which subjects were required to engage in continuous jumping and perform upper limb exercises (e.g., alternating arm swing) and breathing exercises. The central phase of the workout, which lasted 20 min, involved various jumping exercises that alternated between upper and lower limb movements. Subjects were instructed to perform continuous jumping without any breaks throughout this phase. The jumping exercises in the central phase were combined with swing movements of the upper limbs and included the following:

- Double leg jumps on the frontal and sagittal planes;
- Single leg jumps on the frontal and sagittal planes;
- Double leg jumps alternating between the sagittal and frontal planes;
- Single and double leg lateral jumps;
- Jumping jacks;
- Standing Russian twist;
- Shuffle forward and backward (alternating feet back and forth with each jump).

Throughout the Superjump® workout, participants completed an average of 3425.5 total jumps with a range of 3226 to 3625 jumps, including the warmup and cooldown phases.

### 2.4. Statistical Analysis

The Shapiro–Wilk test was employed to assess the normal distribution of the data. Means, standard deviations (SDs), and 95% confidence intervals (95% CIs) were calculated for $K_{MEAN}$, $K_{BEST}$, and $R_P$. The statistical analysis was conducted using STATA statistical software version 14.2 (Stata-Corp, LLC, College Station, TX, USA).

Linear repeated measures mixed models were performed to examine the effects of a Superjump® training session on the subjects' stiffness ($K_{MEAN}$ and $K_{BEST}$) and $R_P$ performances in relation to sex. In the model, subjects were considered as the random effect, whereas sex (female vs. male) and testing time (PRE vs. POST) were treated as fixed effects. The models were fitted using maximum residual likelihood to account for the small sample size. For assessing the significance of main effects and interactions, a repeated-measures analysis of variance (ANOVA) test was utilized to compute the degrees of freedom of a t-distribution as subjects were tested in both PRE and POST training sessions. The contrast method was subsequently employed to test whether the means of the dependent variables (i.e., stiffness, $R_P$) for sex (female vs. male) and testing time (PRE and POST) were equivalent. The contrast method tests included ANOVA-style tests of the main effects, which were used to perform the comparison against the reference categories (i.e., PRE vs. POST; female vs. male). The main effect and interaction statistical significance were set at $p < 0.05$. In case significant main effects and interactions were found, a post hoc analysis was conducted using Bonferroni correction for multiple comparison adjustments across all terms. For the post hoc pair-wise comparisons, significance was set at $p < 0.008$ to provide a meaningful analysis for the comparisons in small groups. In order to provide an estimate of the measurement error of the linear repeated measures mixed models, standard errors (SEs) and intra class correlation coefficients (ICCs) were used. Additionally, Cohen's effect sizes (ESs) were calculated to ascertain practical significance. An ES of 0.2 or less was considered trivial, an ES ranging from 0.3 to 0.6 was considered small, an ES less than 1.2 was considered moderate, and an ES greater than 1.2 was regarded as large [35].

## 3. Results

PRE and POST means and standard deviations of the RJs test performances have been reported in Table 2 in relation to sex.

The linear repeated measures mixed model analysis showed a significant main effect for $K_{MEAN}$ regarding sex ($F_{(3,18)} = 7.65$; $p < 0.0001$; 95% CI = 6.91–20.30, ES = 2.06, SE = 3.18, ICC = 0.84), indicating that males demonstrated superior values compared with their female counterparts. Following Bonferroni correction, significant differences in $K_{MEAN}$ were observed between sexes during both the PRE intervention ($p < 0.0001$; 95% CI = 7.36–19.85; ES = 1.97) and POST intervention ($p < 0.0001$; 95% CI = 8.65–21.14; ES = 2.04). Significant differences ($p < 0.0001$; 95% CI = 7.33–19.82; ES = 1.79) in the $K_{MEAN}$

were observed between males in the POST intervention and females in the PRE intervention. Likewise, significant differences ($p < 0.0001$; 95% CI= −21.17–−8.68; ES = 2.26) were identified in males in the PRE intervention and females in the POST intervention (Figure 2).

**Table 2.** Mean and standard deviations of leg stiffness ($K_{MEAN}$; $K_{BEST}$) and reactive power ($R_P$) before (PRE) and after (POST) the 30-min Superjump® mini trampoline training session in female and male participants.

| | *PRE* | | *POST* | |
|---|---|---|---|---|
| | **Females** | **Males** | **Females** | **Males** |
| $K_{MEAN}$ *(kN/m)* | 25.1 ± 3.8 * | 38.7 ± 9.4 | 23.8 ± 2.7 * | 38.7 ± 10.4 |
| $K_{BEST}$ *(kN/m)* | 30.9 ± 4.8 * | 49.0 ± 11.9 | 31.6 ± 4.1 * | 47.3 ± 13.1 |
| $R_P$ *(W/kg)* | 23.6 ± 5.5 | 23.1 ± 6.5 | 21.9 ± 5.3 # | 21.2 ± 6.1 # |

Abbreviations: $K_{MEAN}$ = Mean leg stiffness of five repetitive jumps over three trials; $R_P$ = mean reactive power of five repetitive jumps over three trials; $K_{BEST}$ = mean leg stiffness of the best jump (one per trial) of five repetitive jumps over three trials. * Significantly ($p < 0.0001$) different from males; # significantly ($p < 0.002$) different from PRE.

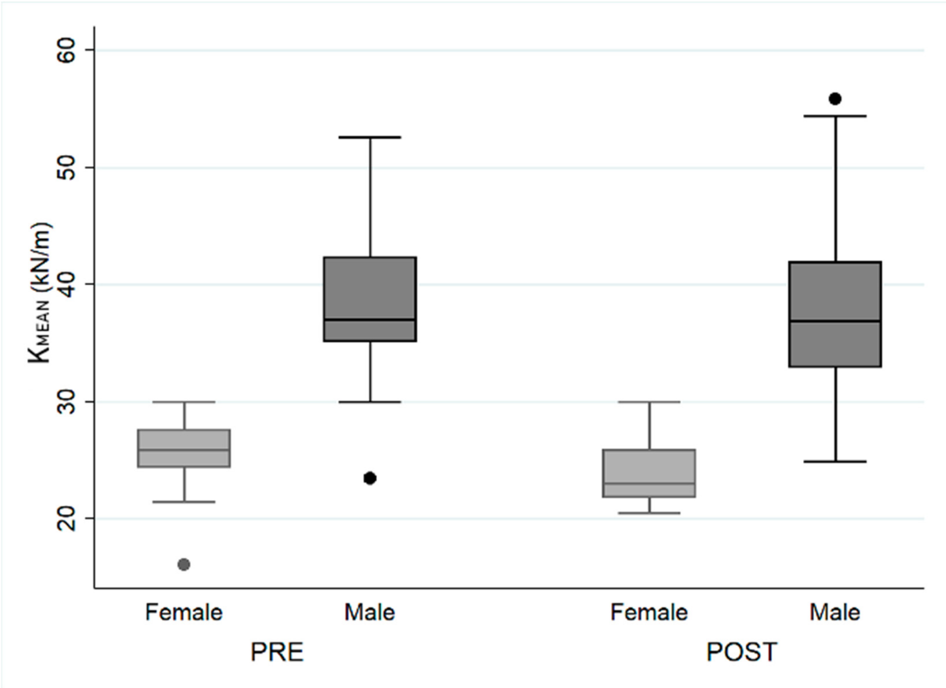


**Figure 2.** Distribution of leg stiffness ($K_{MEAN}$) before (PRE) and after (POST) Superjump® interventions among male and female subjects.

Similarly, the linear repeated mixed model analysis revealed a significant main effect for $K_{BEST}$ with respect to sex ($F_{(3,18)} = 6.69$; $p < 0.0001$; 95% CI = 9.57–26.60; ES = 1.91; SE = 4.05; ICC = 0.84). The results indicate that males demonstrated superior values compared with their female counterparts. After applying the Bonferroni correction, significant differences were observed between female and male $K_{BEST}$ values in both the PRE intervention ($p < 0.0001$; 95% CI = 10.14–26.03; ES = 2.06) and POST intervention ($p < 0.0001$; 95% CI = 7.73–23.62; ES = 1.68). Significant differences ($p < 0.0001$; 95% CI= 8.45–24.34) in $K_{BEST}$ were evident between males in the POST intervention and females in the PRE intervention (ES = 1.72). Moreover, significant differences ($p < 0.0001$; 95% CI= −25.31–−9.42) emerged between males in the PRE intervention and females in the POST intervention (ES = 2.03) (Figure 3).

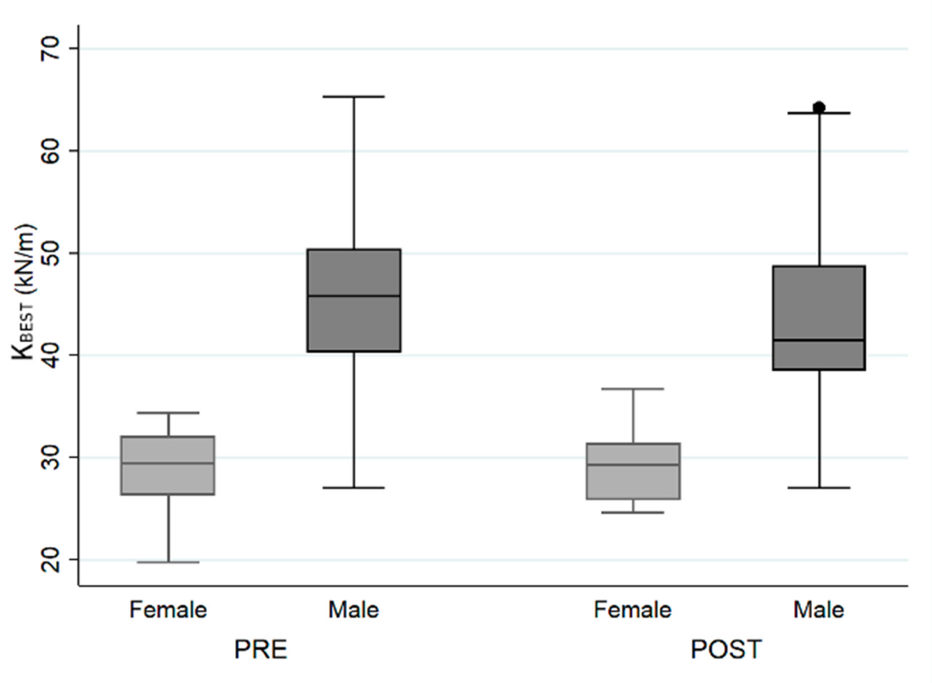


**Figure 3.** Distribution of leg stiffness ($K_{BEST}$) before (PRE) and after (POST) Superjump® interventions among male and female subjects.

In addition, the analysis revealed a significant main effect for testing time ($F_{(3,18)} = 6.58$; $p < 0.006$; 95% CI = −2.8–−0.55; ES = 0.30; SE = 0.53; ICC = 0.95), indicating a noticeable effect on $R_P$ values irrespective of sex. After Bonferroni correction, significant differences were found for both male ($p < 0.002$; 95% CI = −3.03–−0.69; ES = 0.29) and female ($p < 0.002$; 95% CI = −2.74–−0.63; ES = 0.31) $R_P$ values in the PRE and POST interventions, respectively (Figure 4).

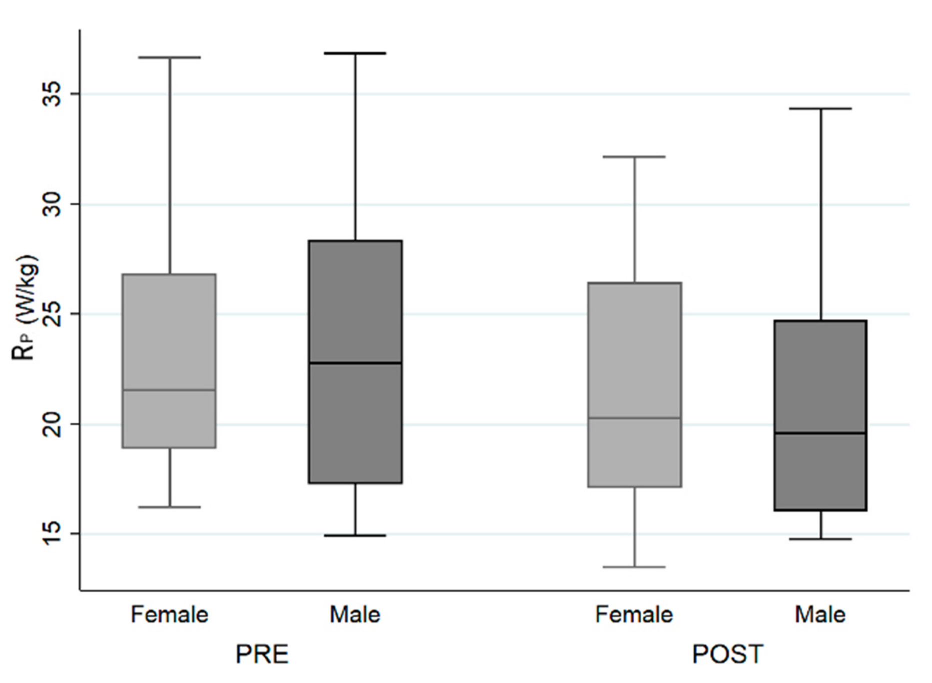


**Figure 4.** Distribution of reactive power ($R_P$) before (PRE) and after (POST) Superjump® interventions among male and female subjects.

## 4. Discussion

Trampoline jumping has become a widely popular fitness trend, with the primary goal being to improve aerobic capacity, balance, inter-limb asymmetries, strength, and power among participants [20]. Despite its popularity, there is a lack of research on this topic, with most studies focusing on the long-term effects of trampoline training and few examining its acute effects. The current study aimed to achieve two objectives: firstly, to assess the immediate effects of a single mini trampoline (Superjump®) training session on leg stiffness and $R_P$ in young adults; and secondly, to investigate potential differences between sexes.

The key finding of this study suggests that, before and after the mini trampoline training session, females exhibited lower $K_{MEAN}$ and $K_{BEST}$ values compared with their male counterparts. Interestingly, despite the training, these sex differences in leg stiffness persisted even after 30 min of mini trampoline training. On the other hand, after the mini trampoline training session, both men and women showed significant differences in $R_P$ values between the testing times (PRE vs. POST). The small SEs found indicate that the estimated effect is likely to be very close to the true effect. Furthermore, the ICC values indicate that the results are replicable within each group, which is valuable when considering that the effects of Superjump® training session are specific to certain groups.

Previous research has shown that plyometric training, including repetitive jumps or mini trampoline training, leads to significant improvements in jump height among trained men and children [36]. These improvements were observed after intervention periods ranging from four weeks to twelve weeks, with multiple sessions occurring per week. Studies have also demonstrated that plyometric training of the lower extremities can enhance performance measures such as jumping power and speed. Similar effects have been observed with training interventions on non-rigid surfaces [22]. Consistent with previous studies, the present research indicated that the decrease in $K_{MEAN}$ could be attributed to subjects developing greater tolerance to the eccentric loading of the muscle–tendon unit during repetitive jumps. Moreover, leg stiffness is regulated by various biomechanical factors, including muscle activation, strength, reflexes, antagonist co-activation, and lower limb kinematics during ground contact. Co-activation of lower limb antagonist muscles is a strategy that can increase muscle stiffness and stability. The jump training used in this study involved quick, short contact times on the elastic surface, which necessitated rapid and powerful hip flexion. It might be therefore assumed that the elastic trampoline surface may impact the muscle's eccentric–concentric cycle, having an effect on the contraction speed and strength, especially in specific lower limb regions. However, future studies should further explore the effect of an acute session of mini trampoline training on hip muscles activation and antagonist co-activation.

Previous studies have shown that during jump landing tasks, women tend to alter lower limb stiffness by recruiting more quadriceps. While this may be an effective mechanism for modulating lower limb stiffness during jumping, it could potentially adversely impact knee joint stability [37]. When stiffness was examined in previous studies, a notable difference between sexes emerged during landings [38], whereas no significant difference was observed during hopping [24]. In contrast, Demirbuken et al. [39] found that absolute leg stiffness was comparable between males and females during hopping at maximum frequency. This led to the conclusion that females possessed the capacity to generate appropriate stiffness for the task. It is plausible that hopping, even at maximal frequency, may not sufficiently challenge leg stiffness capacity in females, whereas in more demanding tasks such as landing, they might not be able to produce the same relative leg stiffness as males. However, it is important to note that the protocols used in the study conducted by Hughes and Watkins [38] did not standardize the landing height, which could have potentially rendered the task incomparable between females and males [40].

In accordance with the previous results for the $K_{MEAN}$ variable, the same pattern emerged for $K_{BEST}$. The non-significant differences for testing time can be attributed to the specific methodology used in the study, i.e., the Superjump® workout. Considering that $K_{BEST}$ is a derivative of $K_{MEAN}$, it follows similar principles in assessing plyometric performance. The results showing no significant differences in testing time can be expected, as the plyometric training effect is primarily associated with the subjects' capacity to generate power during explosive movements and not their ability to sustain the performance over time. When a muscle–tendon unit is repeatedly exposed to increased mechanical loading, muscle strength gains are observed, which is accompanied by an increase in tendon stiffness. Previous research [41,42] has fully investigated the assessment of both tendon stiffness and lower body strength performance, emphasizing the efficacy of mini trampoline training.

However, Granata et al. [23] stated in their work that it is not clear whether the cause of the sex difference in leg stiffness is due to the physical characteristics (i.e., height and weight) of male and female subjects. Furthermore, hopping involves the storage and utilization of strain energy and, therefore, the maintenance of leg stiffness; landing involves the dissipation of strain energy and, therefore, a rapid reduction in leg stiffness following the initial impact phase. Nevertheless, in our results, men still had higher leg stiffness than women.

Our findings reinforce the importance of leg stiffness assessment when evaluating the effects of plyometric training. The use of repeated jumps on the mini trampoline allows for a comprehensive analysis of lower limb mechanics, which provide valuable insights into the subjects' plyometric abilities. Moreover, the similarity in outcomes between $K_{MEAN}$ and $K_{BEST}$ supports the notion that $K_{BEST}$ is a suitable derivative for evaluating plyometric performance in the context of our study. However, the effects of plyometric training on stiffness are unclear, as some studies have found no significant changes in tendon stiffness after plyometric training, while other studies have found significant increases that show improvements in the force transmission to the bone [43].

Significant differences in testing time emerged for $R_P$ with decreases in values after the Superjump® training session. This can be attributed to the fact that, in line with the existing literature, plyometric training has a notable impact on the $R_P$ of the subjects. $R_P$ is the ability of the musculotendinous unit to produce a powerful concentric contraction after a rapid eccentric contraction [44]. Because Superjump® training includes quick and powerful jumping to activate the elastic properties of the major leg muscles, it might have contributed to the decrease, increasing the accumulation of muscular fatigue. It is well-known that plyometric exercise can lead to a temporary reduction in the torque-generating capacity of muscles, which could explain the observed decrease in $R_P$ values in the participants after the Superjump® training session [45]. Additionally, plyometric exercises, such as those performed on the mini trampoline, can induce micro-muscular lesions. These micro-lesions are part of the muscular adaptation process and may contribute to growth and performance improvement in the long term [46]. However, during the immediate recovery period after training, they might negatively impact the ability to generate $R_P$. Although the decrease in $R_P$ might initially be perceived as a negative outcome, it is important to emphasize that this study has provided the acute effects of mini trampoline training on $R_P$. The observed decrease could indicate ongoing muscular and neuro-muscular adaptations which, in the long term, might lead to significant performance improvements.

Despite the observed decrease in $R_P$, leg stiffness remained unchanged. This could imply that mini trampoline training might exert a protective effect on leg stiffness, preventing acute decreases that are commonly observed in other training modalities [47]. Leg stiffness is a crucial biomechanical factor that influences athletic performance and injury prevention. Therefore, Superjump® training could be a great strategy of plyometric training for enhancing the capacity of rapid force production and reducing the risk of musculoskeletal injuries.

## 5. Conclusions

Studies have widely demonstrated how plyometric and mini trampoline trainings could have benefits and multiple effects on movement patterns. However, to date, to the best to our knowledge, this is the first study that evaluates the sex-related acute effects of

Superjump® training session on leg stiffness and $R_P$ in healthy young adults. Our findings confirmed that differences in sex with respect to leg stiffness persisted, even after 30 min of mini trampoline training. Moreover, leg stiffness did not change after a single session of Superjump® training, although the $R_P$ values significantly decreased after the training. These findings suggest that mini trampoline training might exert a protective effect on leg stiffness, preventing acute decreases that are commonly observed in other training modalities. Therefore, Superjump® training could have a high impact on training and evaluations protocols in both field and laboratory settings. However, future studies should explore different populations such as sedentary individuals, and they should examine subjects after a longer period of mini trampoline training.

## 6. Limitations

This study has several limitations that should be taken into account when interpreting the results. First, the sample included a population of healthy young adults. This may limit the generalizability of the results to different populations, such as sedentary individuals, injured subjects, youth, and elderly participants. It is also noteworthy that the study examined the short-term effects of a single session of mini trampoline training. Consequently, the present findings are specific to the acute context, whereas potential long-term effects necessitate further inquiry. Lastly, the lack of a control group might reduce the magnitude and impact of the present results by hindering the differentiation of specific effects of the training itself from other potentially influential factors.

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