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Original Research

Effect of joint distraction exercises with elastic band during warm-up on maximum strength performance in male bodybuilders: A cross-sectional study

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Abstract: We aimed to evaluate the effect of joint distraction exercises with elastic band as a warm-up method versus an only standard warm-up on lower-body maximal strength performance in male bodybuilders and to determine possible moderator variables affecting performance. In the study, seventeen male bodybuilders who met the inclusion criteria were evaluated. The bodybuilders performed two sets of four joint distraction exercises with 30 seconds of rest following the standardized warm-up versus the standardized warm-up only. The maximal strength performance of bodybuilders was measured with an interval of 96 hours. Joint distraction exercises with the elastic band following the standardized warm-up moderately increased lower-body maximal strength performance of the bodybuilders (p = 0.00; Cohen'd = 0.45, 95%CI = 0.30-0.60). In addition, age (p = 0.34, β = 0.03), height (p = 0.92, β = 0.00), body weight (p = 0.61, β = 0.00), training experience (p = 0.66, β = -0.02) and body mass index (p = 0.55, β = 0.01) were not moderator variables for this training method. Our study showed that joint distraction exercises with elastic bands could acutely improve lower-body maximal strength performance in male bodybuilders regardless of anthropometric characteristics. Practitioners and coaches may prefer this training method before strength training to increase the strength performance of their athletes.

Keywords: muscle strength, physical fitness, muscle stretching exercises, joint range of motion, functional mobility

1. Introduction

Strength performance is one of the most critical components of athletic performance, and strength levels can directly affect performance (Granacher et al., 2016; Ishida et al., 2020; Suchomel et al., 2016). Researchers suggested that increased muscular strength can improve an athlete's performance in various sport-related activities, including jumping, sprinting, and change of direction tasks (Granacher et al., 2016; Ishida et al., 2020; Suchomel et al., 2016). A study also identified that stronger athletes could perform better sport-specific tasks (Suchomel et al., 2016). Moreover, it was reported that maximum strength was linked to increased power output and several factors associated with sports performance (Ishida et al., 2020).

The strength level can show an alternation between athletes due to factors such as maximal potential strength, motor unit involvement, muscle architecture, motor unit synchronization, muscle hypertrophy, and neuromuscular inhibition (Suchomel et al., 2016). Besides physiological factors, external factors such as warm-up can also affect athletes' maximal strength performance (Silva et al., 2018).

Warm-up exercises can provide the improvement of athletic performance by increasing muscle temperature and range of motion, improving the muscle length-tension relationship (Takeuchi et al., 2021). Many studies evaluated the effect of various warm-up methods on athletic performance (Andrade et al., 2015; Silva et al., 2018), and elastic band exercises were one of the warm-up methods whose effects on athletic performance are examined (Guillot et al., 2019; Peng et al., 2021).

Elastic bands are affordable and portable equipment that can be utilized in effective warm-up protocols. The use of elastic band exercises as a warm-up method can trigger post-activation potentiation (PAP) to enhance sprinting, change of direction (COD) ability, and jump (Peng et al., 2021). When applied with joint distraction exercises, elastic band exercises also can improve joint range of motion (Reiman & Matheson, 2013). Joint distraction exercises with elastic band aim to separate the articular surfaces in an optimum range, and the elastic bands act as a wedge throughout the movement (Rosengart, 2013). This mechanism can facilitate the flow of synovial fluid around the joint and reduces the friction between the articulating surfaces (Jay et al., 2007). Researchers have stated that exercises with a broader range of motion can provide greater strength gains (Pinto et al., 2012; Schoenfeld & Grgic, 2020). Joint distraction exercises with elastic bands can be preferred to increase the joint's range of motion (Guillot et al., 2019). While this method is frequently preferred for physical therapy, usage by strength and conditioning coaches to increase strength performance can offer an original approach to the field.

To our knowledge, no study has examined the acute effects of joint distraction exercises with elastic bands on strength performance. We aimed to evaluate the acute effects of joint distraction exercises performed with elastic bands on male bodybuilders' lower-body maximal strength performance, and to determine possible moderator variables that affect lower-body maximal strength performance. Therefore, the present study presents an original approach to the literature in terms of examining the effect of joint distraction exercises on strength performance. In this study, we expected that joint distraction exercises performed with an elastic band would acutely improve lower body maximal strength performance.

2. Materials and Methods

Participants - Because strength performance is vital in bodybuilding, the present research aimed to explore the target population of young bodybuilders performing in strength training. The accessible universe of the study was defined as young male bodybuilders who participated in strength training at the Batı Pilates Studio in Istanbul. A purposive sampling method known as homogeneous group sampling was preferred in the study protocol (Campbell et al., 2020). Inclusion criteria for participants of the study were as follows: (i) male bodybuilders aged between 20 and 30 years, (ii) a minimum of three years of experience in strength training, (iii) no reported health problems in the past six months, (iv) squat-body mass ratio of at least 1. A total of 20 bodybuilders were evaluated for eligibility, while two did not meet the age criterion, and one did not meet the training experience criterion. All athletes not meeting the inclusion criteria were excluded from the study.

The G*Power (Duesseldorf University, Germany) package program was utilized to determine the sample size. A previous study was reviewed and considered for the power analysis (Guillot et al., 2019). The power analysis established a two-sided hypothesis, with the following criteria: ($\alpha = 0.05$, $\beta = 0.80$, effect size = 0.75; Means: Difference between two dependent means [matched pairs]). The results indicated that at least 16 bodybuilders were required for the study. Ultimately, 17 young male bodybuilders who met the inclusion criteria participated in the study. The anthropometric characteristics of the bodybuilders are detailed in Table 1.

Table 1. Anthropometric and physical characteristics of the participants (Mean ± SD)

Age (y)	Height (cm)	Body Mass (kg)	BMI	1 RM/ BM ratio	Training experience (years)
25.71 ± 3.05	179 ± 5.35	82.29 ± 10.36	25.63 ± 2.63	1.60 ± 0.33	4.76 ± 1.52

Note. BMI: Body mass index; 1 RM: One maximum repeat; BM: Body mass.

In this study, all bodybuilders participated voluntarily and were informed of the potential advantage and disadvantage of the exercise protocol before enrolling. Each bodybuilders signed the phrase "I voluntarily agree with the test protocols to be applied in this study" on the informed consent form. Participants were also assured that they could withdraw from the study without any negative consequences. The study protocol was designed according to the Declaration of Helsinki, which sets ethical standards for using human subjects in research. The study was approved by the Burdur Mehmet Akif Ersoy University Non-Invasive Clinical Research Ethics Committee (Approval no: 2023/1).

Study design - This study was carried out with a cross-sectional study design. According to the cross-sectional study design, same the bodybuilders formed both the control and intervention groups. Our study was designed according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) criteria (Elm et al., 2007). The STROBE checklist of the study is given in Appendix-1. The study protocol was pre-registered through the Open Science Framework (OSF) (https://doi.org/10.17605/OSF.IO/BC7FH).
All documents regarding the study process were provided access via OSF

(https://osf.io/a93nq/?view_only=58d45b8d0f924697874202e2c2e2da59).

Measures –

Maximal strength performance measurement- The bodybuilders' one maximal repetition (1RM) squat performance was evaluated according to the standards recommended by the researchers (Haff & Triplett, 2015). The 1 RM squat performance was measured using a smith machine. The process included a standard eight-minute warm-up on the treadmill at 50-55% of maximum heart rate followed by a squat set of 10 repetitions with a weight chosen by the bodybuilders under the personal trainer's supervision. Bodybuilders warmed up with the same weights on both trial days and started the testing protocol. Five sets of squat exercises were performed on both trial days to determine the 1RM squat performance of the bodybuilders. The lifted load was increased by 10% for each set. While the bodybuilders were given 2 minutes of rest for the first exercise set, the rest time was increased by 50% for the following each exercise set (i.e., 2, 3, 4.5, 7, and 10.5 min). The one maximal squat test was continued until the bodybuilders could not perform the second repetition squat exercise. To standardize the exercise technique, the bodybuilders reached 90 degrees of knee flexion at each squat repetition. Boxes of various heights were used to adjust the 90-degree knee angle. Participants were not allowed to sit on the box during repetitions. Bodybuilders were instructed to adopt a shoulder-width stance by their normal anatomical posture, avoid hip tilt while squatting, maintain a vertical posture, and keep their feet flat on the floor. Bodybuilders were verbally encouraged throughout the 1 RM squat test.

Anthropometric measurements- Bodybuilders' height and body weight were measured to assess their anthropometric characteristics. While body weight was measured using an intelligent scale (Aprilla ABS 10809), height was evaluated using a tape measure. These data were used to calculate the Body Mass Index (BMI) of the bodybuilders using the formula: Body Weight [kg] / Body Height [cm]^2. The anthropometric measurements and the training experiences of the participants were noted. These data were also used for moderator analyses.

Testing Procedure - The test procedure of the study was adapted from previous studies examining the acute effect on strength performance (Boullosa et al., 2013; Jagim et al., 2018). The study protocol consisted of two non-consecutive test days. Before the test days, the bodybuilders were informed verbally and practically about joint distraction exercises and 1 (RM) squat test. The experienced personal trainers performed the squat exercise, and they answered questions about the squat technique to reduce the learning effect. In the first testday, bodybuilders applied a standardized warm-up protocol for 15 minutes, and rested for 5 minutes following the warm-up (Boullosa et al., 2013). Afterward, the lower-body strength performance of the bodybuilders was determined with the 1 RM squat test. Participants rested 96 hours to prevent fatigue between test days (Boullosa et al., 2013; Jagim et al., 2018). In the second test days, bodybuilders performed approximately 10 minutes of joint distraction exercises with an elastic band in addition to the standardized 15-minute warm-up. After a 5-minute rest, the bodybuilders' 1 RM squat test performance were re-evaluated. Detailed information about the study protocol is given in Figure 1.

Bodybuilders were instructed to avoid stimulants (such as cigarettes or caffeine) and not eat for at least 2 hours before the tests.

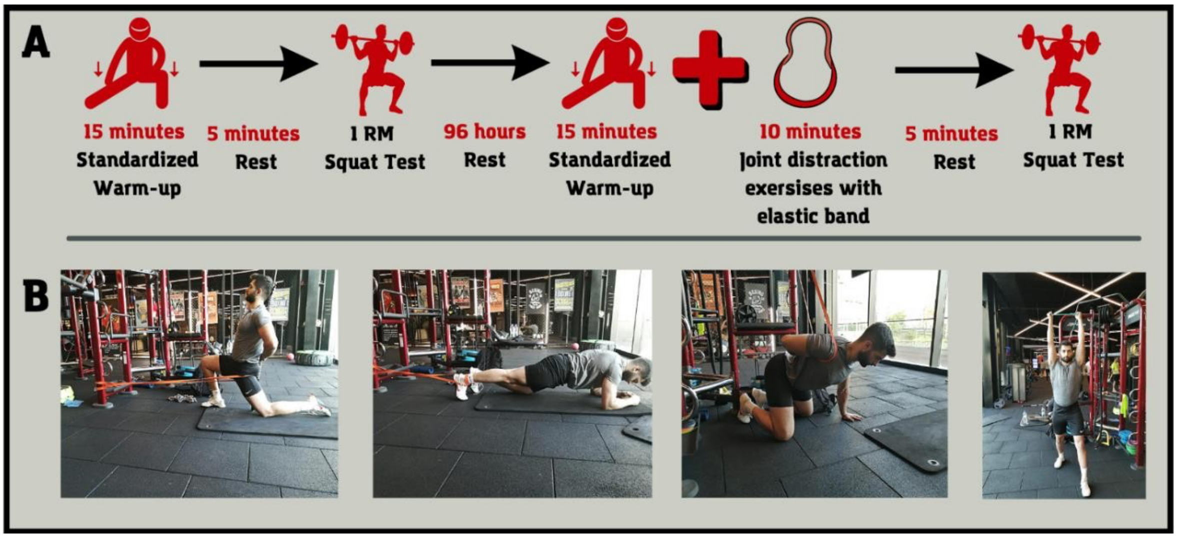

Figure 1. Schematic protocol of the study. A: The test procedure for assessment of the acute effect; B: Joint distraction exercises with elastic band.

Table 2. Joint distraction exercises program with elastic band

Exercises	**Set**	**Left and right (sec)**	**Rest between sets (sec)**	**Rest between exercises (sec)**
Joint Distraction for Ankle	2	30″-30″	15 “	30″
Joint Distraction for Hip Flexion	2	30″-30″	15 “	30″
Joint Distraction for Hip Abduction	2	30″-30″	15 “	30″
Joint Distraction for Shoulder	2	30″-30″	15 “	30″

Sec: Second; “: Second.

Additionally, bodybuilders did not participate in any exercise before the sessions. Both test protocol were conducted at the same time of day to minimize the risk of bias. A one-sided blinding method was applied to eliminate evaluator bias. While two researchers (E.T.Ç. and M.D.) worked directly with bodybuilders, and a third researcher (H.Ş.U.) performed the statistical analysis.

Training Program - The bodybuilders performed joint distraction exercises specific-ankle, hip, trocal spine, and shoulder joints. Joint distraction exercises were performed dynamically in the broadest range of motion. Thus, the elastic band acted as a wedge in various joint areas of the bodybuilders. While each exercise consisted of two sets, the bodybuilders performed joint distraction exercises for four different joint areas with an elastic band for 30 seconds. They were given 30-second rest intervals between sets. Detailed information on the training protocol is given in Table 2.

Statistical Analysis - Standard descriptive statistics (Mean ± SD) were used to present the bodybuilders' characteristics and assess the impact of joint distraction exercises with an elastic band on maximal strength performance. Outlier analysis was performed to check homogeneity in bodybuilders' lower-body maximal strength performance before testing. The distribution of the dependent data was checked using the Skewness-Kurtosis test, and the results indicated that the data had a normal distribution. As a result, the measurements were analyzed using paired sample t-test to identify differences in bodybuilders' lower-body maximal strength performance. The percentage of difference between the only warm-up performed season 1 RM results and 1 RM results of joint distraction exercise with the elastic band following warm-up was calculated following the formula: (([1 RM results of joint distraction exercise with the elastic band following warm-up – only warm-up performed season 1 RM results / only warm-up performed season 1 RM results) x 100).

Cohen'd effect size was used to calculate the effect level of the intervention method on the dependent variable. The Cohen'd effect size index was interpreted according to the reference values (Cohen, 2013); (0.2) = small, (0.5) = moderate, (0.80) = large. The estimated effect size was determined by calculating sensitivity analysis using G*Power (Duesseldorf University, Germany). According to the following criteria, it was understood that a moderate effect size should be achieved in maximal strength performance as a result of the intervention: (Two-tails hypothesis; α = 0.05, β = 0.80, Sample size = 17, Estimated effect size= 0.72).

Moderator valuable also analyzed in the study. Age, height, body weight, training experience, and body mass index (BMI) were identified as a moderator variables. The PROCESS macro was developed by Hayes was used for moderator analyzes of the study (Hayes, 2018). Details on the moderators of the study and the moderator model created are given in Figure 2.

The level of statistical significance was accepted at $p < 0.05$. The {effsize} package of the R (R Core Team) programming language were used to calculate the effect size. Statistical Package for the Social Sciences (SPSS version 22; SPSS, Inc., Chicago, IL, USA) was preferred for hypothesis testing and moderator analysis.

3. Results

17 bodybuilders were included in the study, and there were no observed injuries to the participants during the study. The bodybuilders' lower-body maximal strength performances were evaluated through the box plot, and there were no significant differences between bodybuilders at baseline measures ($p > 0.05$). This result showed that the bodybuilders had homogeneity in maximal strength performance in the baseline test. Performing joint distraction exercises with elastic bands in addition to standardized warm-up, when compared to only standardized warm-up, provided a statistically significant difference in the bodybuilders' lower-body maximal strength performance ($p < 0.05$). The results showed that joint distraction exercises with an elastic band applied for approximately 10 minutes following warm-up can moderately affect lower-body maximal strength performance acutely ($p = 0.00$; d = 0.45, 95%CI = 0.30 - 0.60). In addition, it observed an improvement in the bodybuilders' lower-body maximal strength performance by 7.37%. Moreover, these results revealed an agreement between the sensitivity analysis and post-intervention results. It was determined that the medium effect size obtained had at least 80% statistical power. Detailed information about the results of the study is given in Table 3.

The moderator analysis showed a slight increase in lower-body maximal strength performance in older and heavier bodybuilders (Figure 3b, Figure 3e), but this increase was not statistically significant ($p > 0.05$). None of the anthropometric features was a moderator on the dependent variables (BMI: $p = 0.55$, $\beta = 0.01$, 95% CI = -0.04 – 0.07; Age: $p = 0.34$, $\beta = 0.03$, 95%CI = -0.03 – 0.10; Training Experience: $p = 0.66$, $\beta = -0.02$, 95%CI = -0.14 – 0.09; Height: $p = 0.92$, $\beta = 0.00$, 95%CI = -0.05 – 0.04; Body weight: $p = 0.61$, $\beta = 0.00$, 95%CI = -0.01 – 0.02). Detailed information on moderator analyses is given in Figure 3.

Table 3. Mean ± SD of lower body maximal strength performance in the study group before and after joint distraction exercises with elastic band

Variable	Only warm-up season (n= 17)	JDE season following warm-up (n= 17)	Comparison Within Group (p - value)	Percentage of difference (%)	Cohen'd (95%CI)	Cohen'd (Interpretation)
1 RM squat	122 ± 20.72	131.24 ± 19.38	0.00**	7.37 ↑	0.45 (0.30 - 0.60)	Moderate

Note. JDE: Joint distraction exercises; RM: Maximum rep; 95%CI: 95% confidence interval lower and upper bound; **: p>0.01.

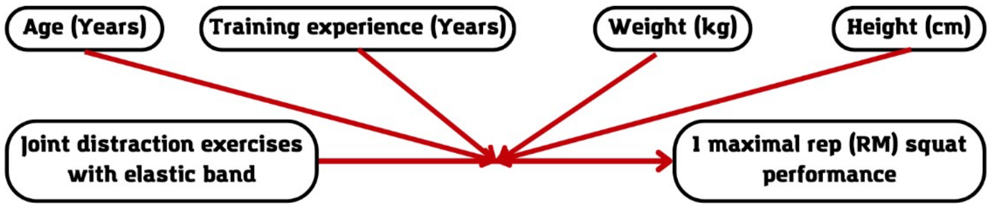

Figure 2. Illustration of moderator model design of the study. Moderator analysis was performed with Hayes' model 4 design

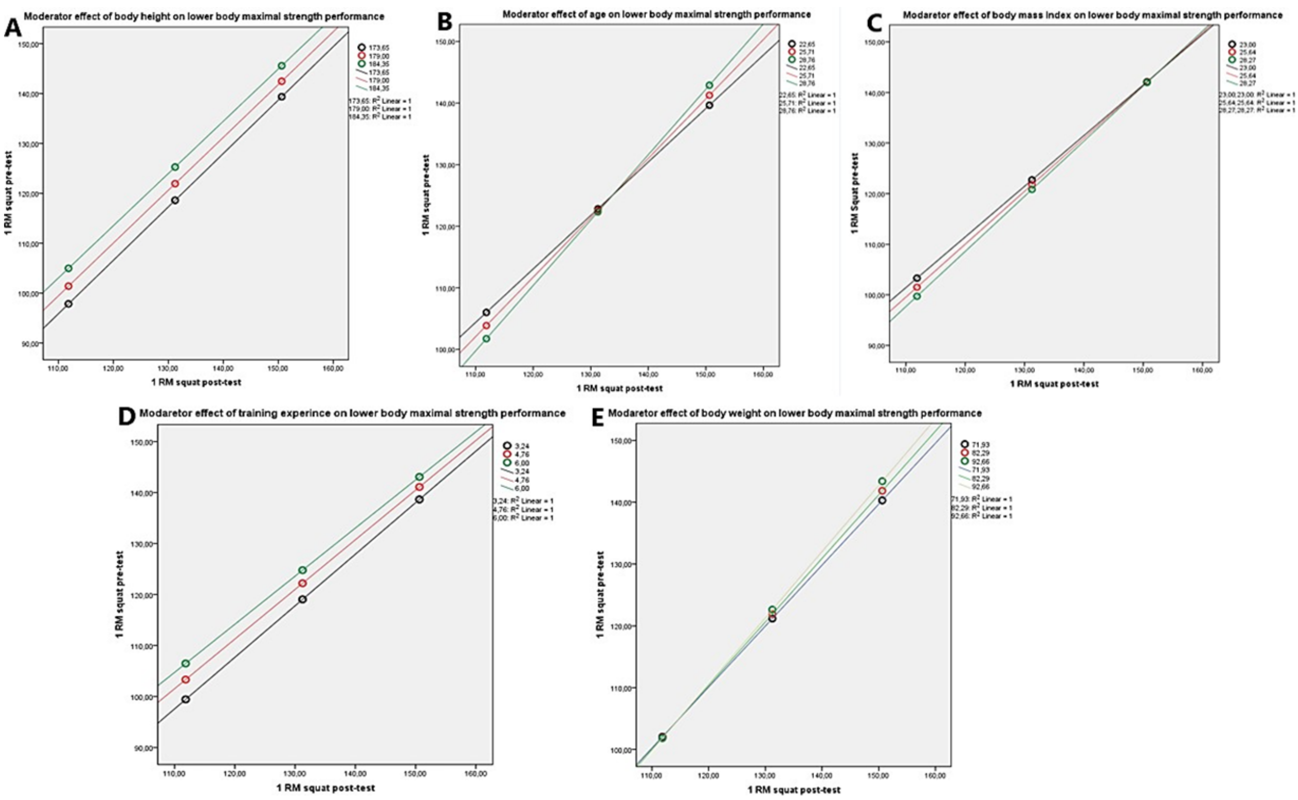

Figure 3. Moderator analysis results of the study. The red line represents the mean value, the green line the value one standard deviation above the mean, and the black line the value one standard deviation below the mean. A (Body height): Green line (184.35 cm), red line (179.00 cm), black line (173.65); B (Age): Green line (28.76 years), red line (25.71 years), black line (22.65 years); C (Body mass index): Green line (28.27), red line (25.64), black line (23.00); D (Training experience): Green line (6 years), red line (4.76 years), black line (3.24 years); E (Body weight): Green line (92.66 kg), red line (82.29 kg), black line (71.93 kg).

4. Discussion

This study aimed to evaluate the acute effect of joint distraction exercises applied with an elastic band on lower-body maximal strength performance. Study findings showed that this warm-up method could have a moderate effect on lower-body maximal strength performance acutely (p = 0.00; d = 0.45, 95% CI = 0.30 - 0.60).

From our knowledge, only one study examined the effect of joint distraction exercises on athletic performance (Guillot et al., 2019). This study investigated the effect of joint distraction exercises with elastic band and foam roller on range of motion performance. Researchers stated that joint distraction exercises between 5-7 weeks could improve the range of motion performance of male rugby players by 2-20% (Guillot et al., 2019). Similar to the positive results obtained in the previous study on range of motion (ROM) performance, it was determined that joint distraction exercises using elastic bands improved strength performance in this study. Since joint distraction exercises using elastic bands can enhance the range of motion (ROM), increasing maximal strength performance may be linked to the development of ROM (Krzysztofik et al., 2022).

Various mechanisms can explain the increase in maximal power performance observed in bodybuilders. The first of these mechanisms is the joint range of motion. According to the researchers, increasing joint ROM can positively impact strength performance (Kim et al., 2015; Liebler et al., 2013). Thus, the joint distraction exercises may have acutely increased the ROM of the lower-body, which can lead to improved maximal strength performance (Ottinger et al., 2022). Previous studies support the hypothesis that increasing the range of motion can improve muscle strength (Chen & SL Delp, 2016; Liebler et al., 2013; Maeo et al., 2021). Liebler et al. (2013) found that increasing ROM led to a 6% improvement in muscle strength while Chen and Delp (2016) and Maeo et al. (2021) also reported that lower extremity muscles need greater ranges of motion to produce more strength (Chen & SL Delp, 2016; Maeo et al., 2021). In another study, researchers found that lower-body mobilization exercises can increase ROM in ankle dorsiflexion and hip flexion (Guillot et al., 2019). Several physiological mechanisms can explain these improvements. First, increasing joint ROM can change the pennation angel of the muscles, which subsequently will affect force transmission to the tendons and bones ROM (Tillin & Bishop, 2009); secondly, the elastic band creates a lever, which diminishes the friction between articular surfaces; this means that the movement is produced with less effort; third, elastic bands increase proprioception and balance, which indirectly increase strength (Choi, 2019). The study findings expressed are supported by many systematic review and meta-analysis in the literature (Pallarés et al., 2021; Wilke et al., 2020).

Another mechanism that enhances maximal strength performance may be related to post-activation performance improvement (Trybulski et al., 2022). Elastic band resistance training was reported to positively affect physical performance and muscle strength (Lopes et al., 2019). Studies found that using elastic bands in warm-up activity may positively affect post-activation potentiation (PAP) (Galpin et al., 2015; Peng et al., 2021). Researchers identified that using elastic bands in 3RM and 5RM resistance squatting as a warm-up activity might positively affect PAP to improve explosiveness ability with the 4-minute recovery (Peng et al., 2021). A similar study protocol evaluated the acute effect of elastic band used as additional resistance in the warm-up on lower body power performance (Buttifant & Hrysomallis, 2015). The study results indicated that have a moderate effect on lower body power performance of the elastic band squat group (d = 0.59 - 0.67) (Buttifant & Hrysomallis, 2015). Other researchers supported the findings of studies, and using elastic bands for additional resistance decreased the time to peak force, and greater resistance from bands resulted in more significant peak and relative power when lifting at 85% 1 RM (Galpin et al., 2015).

On the other hand, results of the study showed that other factors such as height, body weight, BMI, and training experience did not have a significant effect on strength performance ($p > 0.05$). These results caused contradiction with the result of the previous studies (Harbo et al., 2012; Samson et al., 2000). The researchers stated that strength performance might decrease by 19 - 24% with the maturity level increases (Samson et al., 2000), and that age, height, and body mass have an effect of 20 - 29% in the prediction of strength performance (Harbo et al., 2012). Moreover, researchers observed a strong correlation ($p < 0.05$, $r > 0.70$) between anthropometric characteristics and strength performance (Potteiger et al., 2010).

In our study, the sample size required to evaluate the effect of the training method on maximal strength performance was determined. However, this sample size may need more statistical power for moderator variables. It is stated that the study findings may be statistically insignificant when enough sample size is not determined for the study's dependent variables (Akobeng, 2016).

5. Practical Applications.

The practical application of the current study is that using joint distraction exercices, we can reduce the articular compression, especially while working with heavy weights. Also, if the athlets have an injury, by using these type of exercices, we can facilitate exercices without pain.

The present study includes some limitations, in addition to the positive study outcomes. Studies with different groups of athletes are needed to interpret the effect of joint distraction exercises on sport performance. Since this study evaluates strength performance acutely, the chronic effect of joint distraction exercises on strength performance should be evaluated. In addition, the joint range of motion of the participants was not measured. Moreover, the scope of this study was restricted to male athletes. Therefore, the effect of joint distraction exercises on the strength performance of female athletes has yet to be discovered. With the studies to be carried out on the current limitations, the effect of joint distraction exercises on sportive performance can be questioned with more robust hypotheses.

6. Conclusions

The main findings revealed that joint distraction exercises with an elastic band added to the warm-up phase could improve maximal strength performance acutely. Practitioners, fitness trainer can apply joint distraction exercises with elastic bands to improve the performance of athletes and increase the gain from strength training. The joint distraction exercise routines can be added to the final part of the warm-up phase. Depending on the range of motion and strength levels of the athletes, the density of the elastic band used for the exercise routine may differ.

Authors' contribution: Conceptualization: E.T.Ç. and H.Ş.U.; Methodology: H.Ş.U ve E.T.Ç.; Statistical Analysis: H.Ş.U.; Investigation: M.D. and S.K.; Resources: M.D. and S.K.; Writing—Original Draft Preparation: H.Ş.U. and E.T.Ç.; Writing—Review and Editing: M.D., A.B. and H.Ş.U.; Supervision: S.K. and A.B.; Project Administration: E.T.Ç., M.D., H.Ş.U., A.B. and S.K.

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