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RESEARCH ARTICLE

Acute Effects of Passive and Proprioceptive Neuromuscular Facilitation (PNF) Stretching Techniques on Speed, Agility, and Explosive Strength in Youth Basketball Players: A Randomized Controlled Trial

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Abstract
Objective: The aim of this study was to examine the acute effects of static passive and proprioceptive neuromuscular facilitation (PNF) stretching techniques on agility, speed, and lower-extremity explosive power in youth basketball players. **Methods**: Twenty male basketball players were randomized as passive and PNF groups. A single session of passive or PNF stretching techniques was applied to each group on the hamstring, quadriceps and calf group muscles. Outcome measurements consisted of the T Agility Test for agility, the 30-Meter Sprint Test for speed, the Standing Long Jump Test and the Lateral Jump Test for lower-extremity explosive power. **Results**: In within-group comparisons, statistically significant improvements were found in the passive group in all tests ($p<0.05$) except the 30-meter sprint test ($p>0.05$). In the PNF group, a significant improvement was found only in the T Agility Test in within-group comparisons ($p=0.05$). In the between-group comparison, no statistical difference was found between the two groups ($p>0.05$). **Conclusion**: In conclusion, static passive stretching before activity may have a greater effect on lower-extremity explosive power compared to PNF stretching. Additionally, PNF stretching improved agility, and did not cause any negative acute effects on speed and explosive strength. In the future, we think that conducting studies on how long the positive or negative acute effects of stretching techniques continue will be important for warm-up programs.

Keywords
Basketball, Passive Stretching, PNF Stretching, Athletic Performance

INTRODUCTION

Stretching techniques can play an important role in preventing musculoskeletal injuries, relieving muscle pain, increasing muscle strength capacity, and improving activities of daily living or athletic performance. There are various stretching techniques available, including dynamic, static, ballistic, and proprioceptive neuromuscular facilitation (PNF). Static and PNF stretching are two commonly used techniques (Lim et al., 2014).

Despite many studies conducted, debates about the most effective approach and technique for stretching still continue in clinical practice and literature (Lempke et al., 2018; Reid et al., 2018). It is known that static stretching can affect subsequent performance, and perceptions of the benefits of static stretching in a pre-activity routine vary considerably (Kay & Blazevich, 2012). While most current research suggests that static stretching negatively impacts performance, there are also studies that show no decrease in performance (Chaouachi et al., 2010; Hayes & Walker, 2007; Power et al., 2004). Altered afferent feedback from the proprioceptors of the stretched muscle has been advocated as a possible underlying mechanism by

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which passive static stretching reduces the capacity to produce muscle force (Cè et al., 2020; Trajano et al., 2017). However, a review by Rubini et al. showed that static, ballistic, and PNF stretching methods produced similar effects on maximal force production (Rubini et al., 2007). The effects of stretching techniques are studied in a wide range due to various factors such as acute and chronic effects, different stretching methods and durations. It has been emphasized that this wide scope is one of the main reasons why stretching effects are unclear (Kay & Blazevich, 2012).

Another type of stretching that is widely used is PNF stretching. Although studies on PNF are limited, there are controversial results on the benefits of PNF stretching. It has been reported that PNF stretching should not be prescribed in specific warm-up programs because it impairs muscle performance (Gomes et al., 2011; Sá et al., 2016). Another study reported that none of the stretching protocols (static, dynamic, and PNF) caused decline in muscle performance (Manoel et al., 2008). Additionally, the effects of PNF stretching on jumping performance are also controversial (Christensen & Nordstrom, 2008; Church et al., 2001).

The effects of static passive and PNF stretching on muscle performance are contradictory in the literature. We also did not encounter any study examining the acute effects of PNF stretching on basketball players. We believe that we will contribute to the literature on the selection of stretching techniques in warm-up programs. The aim of this study was to examine the acute effects of static passive and PNF stretching techniques on agility, speed, and lower-extremity explosive power in youth basketball players.

MATERIALS AND METHODS

Trial Design

A randomised controlled trial followed the CONSORT statement guidelines. The study was approved by the Halic University Non-Interventional Clinical Research Ethics Committee (04.07.2024/156) and was registered on the Clinical Trials (number:NCT06591052).

Participants and Study Setting

Individuals on the Bahçeşehir College Sports Club basketball team were included in the study between July and August 2024. Informed consent was obtained from eligible participants and their families who agreed to participate voluntarily. Twenty participants who met the inclusion criteria were randomized into two different groups (passive group and PNF group) using a sealed envelope method.

The inclusion criteria were as follows: being (a) male; (b) between 14-18 years of age; having (c) at least 2 years of basketball experience; (d) participated in regular team training for at least 2 months; (e) a body mass index of < 29.9 kg/m^2. The exclusion criteria were as follows: (a) presence of pain and/or history of injury in the lower extremity within the last 6 months; (b) history of orthopedic surgery of the lower extremity.

Study Groups and Interventions

All participants performed agility, speed, and lower-extremity explosive strength tests after the same warm-up program. All participants had experience with the tests (having previously performed these tests during team training). After the initial assessments, participants underwent passive stretching or PNF stretching by the same physiotherapist. The tests were repeated immediately after the stretching interventions.

The passive stretching was applied to the hamstring, quadriceps, and calf group muscles by the same physiotherapist to the participants in the passive group. The muscle to be stretched was brought to the most lengthened position by the physiotherapist, and this position was maintained for 30 seconds. Three stretches were applied, and a 30-second rest period was given between each muscle group (O'Sullivan et al., 2009; Prentice, 2021).

The “hold-relax” technique, which is one of the special techniques of PNF, was applied to the hamstring, quadriceps, and calf group muscles by the same physiotherapist to the participants in the PNF group (Adler et al., 2007). The muscle to be stretched was brought to the most extended position by the physiotherapist (These positions are the same as those used in passive stretching). In this extended position, a maximum isometric contraction was performed in the antagonist direction for 5-8 seconds (Rowlands et al., 2003). After isometric contraction, the participant was asked for active relaxation (5 seconds were waited after complete relaxation was achieved), then the increase in the direction of movement was passively controlled. The end point of the advanced range of motion was maintained for 30 seconds. Three stretches were applied and a 30-second rest period was given between each muscle group.

Outcome Measurements

Agility was assessed with a T-test. Four 38 cm cones forming a T shape were placed as markers for the turning points. The athlete starts at cone A and sprints to cone B. Then, they shuffle to the right to cone D, shuffle to the left to cone C, and return to cone B. Finally, they sprint back to the starting point at cone A to complete the test. Each participant performed three trials with at least two minutes of rest in between. If necessary, participants were given a longer rest period. The duration of the test was recorded in seconds using a stopwatch by an experienced researcher. The best time was kept for analysis (França et al., 2022).

Speed was measured using a 30-meter (m) sprint test conducted on a straight track. For the test, the start and finish lines were marked and the distance between them was measured as 30 meters. During the test, participants took a ready position at the start line and started running with the whistle of the physiotherapist. At the finish line, the time was recorded with a stopwatch to the nearest 0.01 seconds. Each participant performed two trials with at least two minutes of rest in between. If necessary, participants were given a longer rest period. The 30-m sprint test performance was determined as the best time obtained in both trials (Xiong et al., 2022).

Lower-body explosive power was assessed with the Standing Long Jump Test (SLJT) and Lateral Jump Test (LJT). For the SLJT, participants were asked to jump forward as much as possible from a standing position with both legs and arms accelerating. The test was performed twice, and for analysis, the highest score (the distance between the test starting line and the heel closest to this line) was recorded in centimeters. If subjects fell back or touched the ground with another part of the body, another attempt was allowed (Marin-Jimenez et al., 2024). In LJT, the participant aligned the lateral edge of his primary (dominant) foot sideways to the starting line, then came to a squat position and performed a maximum jump to the side. The test was performed twice, the distance between the medial part of the primary foot and the starting line in the position reached after the jump was recorded (Trzaskoma et al., 2015).

The tests were conducted in the order of agility, speed, and explosive strength. A minimum of two minutes of rest was given between tests. If necessary, participants were given a longer rest period.

Statistical Analysis

"Statistical Package for Social Sciences Version 24" (SPSS, Chicago, IL, USA) statistical program was used to data analysis. Numerical data were given as mean±standard deviation; qualitative variables were given as number and percentage (%). The normality of data were examined with skewness and kurtosis values. To compare within-group differences, "Paired-samples T-Tests" for normally distributed numerical variables and "Wilcoxon signed rank test" for non-normally distributed variables. In between-group comparisons, "Independent Samples T-Test" was used, taking into account the normal distribution of the data. The level of statistical significance was set at $p<0.05$.

Mean change (Δ) was used in between-groups comparisons. Δ were calculated using the formula: Δ = After test value – Before test value

RESULTS

Table 1 shows the comparison of the demographical characteristics of the participants. There was no statistically significant difference between the groups ($p>0.05$).

The within-group and between-group comparisons, along with effect sizes, are presented in Table 2. In within-group comparisons, a significant difference was found in the T agility test *(p=0.002)*, SLJT *(p=0.049)*, and LJT *(p=0.034)* parameters in the passive group, whereas no statistically significant difference was found in the 30-m sprint test (*p=0.087*). In the PNF group, no statistically significant difference was found in all tests except the T Agility Test *(p=0.005)* in the within-group comparisons. No statistical difference was found between the two groups in the comparison of the mean change (Δ) variables of the outcome measures between the groups *(p>0.05)*.

Table 1. Comparison of demographic characteristics between groups

	Passive Group (n=10) X̄±SD (min-max)	PNF Group (n=10) X̄±SD (min-max)	t	p[a] value
Age (years)	15.50 ± 0.70 (14-16)	15.30 ± 0.82 (14-16)	0.582	0.567
Height (cm)	187.70 ± 4.76 (178-194)	186.40 ± 8.55 (173-196)	0.419	0.679
Weight (kg)	80.80 ± 6.89 (70-93)	82.70 ± 8.26 (70-96)	-0.558	0.583
Body Mass Index (kg/m²)	22.91 ± 1.38 (20.80-24.84)	23.79 ± 1.64 (21.60-26.49)	-1.287	0.214
Basketball Experience (years)	6.30 ± 1.41 (3-8)	5.30 ± 0.94 (4-7)	1.853	0.080

[a] = Independent Samples T-test; X̄±SD = mean ± standard deviation

Table 2. Effects of the interventions on outcome measures

	Passive Group (n=10)				PNF Group (n=10)				Between groups (Before-test)	Difference Between Groups	
	Before	After	Δ	p value	Before	After	Δ	p value	p value	p value	Cohen's d
T Agility Test (s)	10.17±0.50	9.88±0.42	-0.28±0.21	**0.002**[a]*	10.03±0.43	9.78±0.39	-0.25±0.19	**0.005**[b]*	0.534[c]	0.747[c]	-0.146
30-Meter Sprint Test (s)	5.31±0.39	5.23±0.32	-0.08±0.14	0.087[a]	5.27±0.43	5.21±0.39	-0.06±0.10	0.069[a]	0.839[c]	0.747[c]	-0.146
Standing Long Jump Test (cm)	220.50±9.39	223.60±7.30	3.10±4.33	**0.049**[a]*	221.50±13.31	221.10±14.27	-0.40±6.20	0.842[a]	0.848[c]	0.160[c]	0.654
Lateral Jump Test (cm)	205.10±8.94	211.00±7.03	5.90±7.48	**0.034**[a]*	207.00±13.17	215.30±16.13	8.30±11.85	0.054[a]	0.710[c]	0.594[c]	-0.242

Data are expressed as mean ± standard deviation
Δ: difference between after and before the interventions
*p<0.05
a Comparison between before and after the intervention using Paired Samples T-test
b Comparison between before and after the intervention using Wilcoxon signed-rank test
c Comparison between passive and PNFgroups using the Independent Samples T-test

DISCUSSION

This study investigated the acute effects of static passive and PNF stretching on agility, speed, and lower-extremity explosive strength in youth basketball players. It was found that static passive stretching improved agility and explosive strength, but PNF stretching only provided significant differences in agility. Neither stretching technique had any effect on speed. No difference was found between the two groups in the comparison of the difference variables between the groups.

Chatzopoulos et al., (2014) reported that static stretching had a negative acute effect on balance and agility performance compared to dynamic stretching in high school female athletes. Fletcher & Monte-Colombo (2010) found that pre-activity static stretching negatively affected both 20-m sprint and Balsom agility test. However, according to research by Amiri-Khorasani et al., (2010) static stretching did not show any effect on professional football players' performance on the Illinois agility test. The acute effects of static passive stretching protocols on athletes were studied and found to result in a significant increase in 20-m sprint test time (Nelson et al., 2005). Another study showed that short-term static stretching protocols provided acute improvement in

10 and 20-m sprint and T agility test performance, while longer-term static stretching protocols had neither positive nor negative effects (Avloniti et al., 2016). In the study conducted by Favero et al., subjects with low baseline flexibility scores were observed to have increased performance after static stretching and improved 40-m sprint times. In contrast, subjects with high baseline flexibility scores were found to be negatively affected after static stretching and their sprint times slowed down. In the current study, T agility test time was shortened after static passive stretching, but no change was found in the 30-m sprint test time (Favero et al., 2009). The results of our study reflect the differences in the literature. Further studies are needed to standardize the outcome measures and stretching protocols used.

We found only two studies examining the acute effects of PNF stretching on agility. In elite youth soccer players, no significant effects were found on Balsom agility test performance after static or PNF stretching (Jordan et al., 2012). Another study noted that PNF stretching had no significant acute effects on agility or sprint times in active men (Burgess et al., 2019). Our study was conducted on basketball players and agility performance increased after PNF stretching. This difference in our study may be due to the use of different PNF special techniques and/or the fact that our sample consisted of youth basketball players and/or the use of different agility tests, and/or a variety of stretching protocols.

Malek et al., (2024) compared dynamic stretching, PNF stretching, and a no-stretching control group in terms of jumping and sprint performance in their study on recreationally active men and found that the PNF stretching group increased vertical jumping and 20-m sprint performance compared to the control group. However, Alemdaroğlu et al., (2017) compared the acute effects of static, ballistic, PNF stretching in their study on taekwondo practitioners and stated that all three stretching techniques may negatively affect 10 and 20-m sprint performance. In our current study, no significant change was found on 30-m sprint performance after PNF stretching. These different results reflect the uncertainty of the acute effect of PNF stretching on speed tests.

Melocchi et al., (2021) promoted dynamic stretching instead of static stretching to improve vertical jump performance in young female artistic gymnasts. However, Oliveira et al., (2016) reported in their study on trained healthy athletes that jumping and running ability did not change after static stretching. Similarly, Gesel et al., (2022) reported that static and ballistic stretching had no effect on isometric strength and vertical jump testing. The many studies have shown that static stretching before activity has no effect on strength and power (Kingsley et al., 2013). However, a 2021 review reported that static stretching negatively affects jumping performance in runners (Ullman et al., 2021). Pacheco et al., (2011) demonstrated that static stretching in warm-up programs can be recommended to improve activities requiring explosive power. In our study, similar to this study, explosive strength evaluated with standing long jump and lateral jump tests improved after static passive stretching. We believe that the variations in the literature regarding the acute effects of static stretching are related to the variety of samples, stretching protocols, outcome measures, and flexibility levels.

To prevent a possible decrease in performance after longer stretching periods (>60 seconds), dynamic activities can be performed after stretching. However, it remains unclear whether this strategy is suitable for isolated PNF stretching applications for different muscle groups. Konrad et al. recommended avoiding dynamic or PNF stretching during warm-up, especially to optimize explosive or reactive muscle contractions (Konrad et al., 2022). Malek et al., (2024) compared dynamic stretching, PNF stretching and a no-stretching control group in terms of jumping and sprint performance in their study on recreationally active men and found that the PNF stretching group increased vertical jumping and 20-m sprint performance compared to the control group. Church et al., (2001) reported that PNF interventions would negatively affect vertical jump performance. Christensen & Nordstrom (2008) showed that PNF and dynamic stretching had no significant effect on vertical jump. The results of our study were that PNF stretching had no acute effects on jumping performance. However, all of the studies evaluated vertical jumping, and our study differs from the studies in the literature because it always included both the standing long jump and lateral jump tests.

Limitations of the Study

The limitations of our study include the small number of participants. In addition, although it is known that using photocells timing system is more accurate in measuring results for more sensitive results, we used a stopwatch due to lack of equipment. Another limitation may be the absence of a dynamic stretching group and a control group and. Finally, dividing our participants into groups according to their flexibility levels using the block randomization method could have made the results of our study more reliable.

Conclusions

For basketball players, stretching and warming up are critical to enhancing performance and reducing the risk of injury. In particular, this study found that incorporating static passive stretching before activity in youth basketball players may be more beneficial for improving lower-extremity explosive power compared to PNF stretching. Improvements in agility and lower-extremity explosive power were found after static stretching, except speed. Additionally, PNF stretching improved agility, and did not cause any negative acute effects on speed and explosive strength. In the future, we think that conducting studies on how long the positive or negative acute effects of stretching techniques continue will be important for warm-up programs. In addition, more studies are needed to determine which stretching techniques have a positive or negative acute effect on which muscle group. EMG measurements performed during activities performed after different stretching techniques may be important in determining the mechanical effects of the interventions.

Conflict of Interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethics Statement

The study was approved by the Halic University Non-Interventional Clinical Research Ethics Committee (04.07.2024/156).

Author Contributions

Study Design: AÇ, NC; Data Collection: NC; Statistical Analysis: AÇ; Data Interpretation: AÇ, NC, DŞA, MYK; Manuscript Preparation: AÇ, DŞA, MYK; Literature Search: AÇ, NC, DŞA, MYK. All authors have read and agreed to the published version of the manuscript.

REFERENCES

Adler, S.S., Beckers, D., & Buck, M. (**2007**). *PNF in Practice: An Illustrated Guide*. Springer Berlin Heidelberg. [**CrossRef**]

Alemdaroğlu, U., Köklü, Y., & Koz, M. (**2017**). The acute effect of different stretching methods on sprint performance in taekwondo practitioners. *J Sports Med Phys Fitness*, *57*(9), 1104-1110. [**CrossRef**]

Amiri-Khorasani, M., Sahebozamani, M., Tabrizi, K.G., & Yusof, A.B. (**2010**). Acute effect of different stretching methods on Illinois agility test in soccer players. *J Strength Cond Res*, *24*(10), 2698-2704. [**CrossRef**]

Avloniti, A., Chatzinikolaou, A., Fatouros, I.G., Avloniti, C., Protopapa, M., Draganidis, D., et al., (**2016**). The Acute Effects of Static Stretching on Speed and Agility Performance Depend on Stretch Duration and Conditioning Level. *J Strength Cond Res*, *30*(10), 2767-2773. [**CrossRef**]

Burgess, T., Vadachalam, T., Buchholtz, K., & Jelsma, J. (**2019**). The effect of the contract-relax-agonist-contract (CRAC) stretch of hamstrings on range of motion, sprint and agility performance in moderately active males: A randomised control trial. *S Afr J Sports Med*, *31*(1), v31i31a6091. [**CrossRef**]

Cè, E., Coratella, G., Bisconti, A.V., Venturelli, M., Limonta, E., Doria, C., Rampichini, S., Longo, S., & Esposito, F. (**2020**). Neuromuscular versus Mechanical Stretch-induced Changes in Contralateral versus Ipsilateral Muscle. *Med Sci Sports Exerc*, *52*(6), 1294-1306. [**CrossRef**]

Chaouachi, A., Castagna, C., Chtara, M., Brughelli, M., Turki, O., Galy, O., et al., (**2010**). Effect of warm-ups involving static or dynamic stretching on agility, sprinting, and jumping performance in trained individuals. *J Strength Cond Res*, *24*(8), 2001-2011. [**CrossRef**]

Chatzopoulos, D., Galazoulas, C., Patikas, D., & Kotzamanidis, C. (**2014**). Acute effects of static and dynamic stretching on balance, agility, reaction time and movement time. *J Sports Sci Med*, *13*(2), 403-409. [**PubMed**]

Christensen, B.K., & Nordstrom, B.J. (**2008**). The effects of proprioceptive neuromuscular facilitation and dynamic stretching techniques on vertical jump performance. *J Strength Cond Res*, *22*(6), 1826-1831. [**CrossRef**]

Church, J.B., Wiggins, M.S., Moode, F.M., & Crist, R. (**2001**). Effect of warm-up and flexibility treatments on vertical jump performance. *J Strength Cond Res*, *15*(3), 332-336. [**PubMed**]

de Oliveira, F.C., & Rama, L.M. (**2016**). Static stretching does not reduce variability, jump and speed performance. *Int J Sports Phys Ther*, *11*(2), 237-246. [**PubMed**]

Favero, J.P., Midgley, A.W., & Bentley, D.J. (**2009**). Effects of an acute bout of static stretching on 40 m sprint performance: influence of baseline flexibility. *Res Sports Med*, *17*(1), 50-60. [**CrossRef**]

Fletcher, I.M., & Monte-Colombo, M.M. (**2010**). An investigation into the effects of different warm-up modalities on specific motor skills related to soccer performance. *J Strength Cond Res*, *24*(8), 2096-2101. [**CrossRef**]

França, C., Gouveia, É., Caldeira, R., Marques, A., Martins, J., Lopes, H., Henriques, R., & Ihle, A. (**2022**). Speed and Agility Predictors among Adolescent Male Football Players. *Int J Environ Res Public Health*, *19*(5). [**CrossRef**]

Gesel, F.J., Morenz, E.K., Cleary, C.J., & LaRoche, D.P. (**2022**). Acute Effects of Static and Ballistic Stretching on Muscle-Tendon Unit Stiffness, Work Absorption, Strength, Power, and Vertical Jump Performance. *J Strength Cond Res*, *36*(8), 2147-2155. [**CrossRef**]

Gomes, T.M., Simão, R., Marques, M.C., Costa, P.B., & da Silva Novaes, J. (**2011**). Acute effects of two different stretching methods on local muscular endurance performance. *J Strength Cond Res*, *25*(3), 745-752. [**CrossRef**]

Hayes, P.R., & Walker, A. (**2007**). Pre-exercise stretching does not impact upon running economy. *J Strength Cond Res*, *21*(4), 1227-1232. [**CrossRef**]

Jordan, J.B., Korgaokar, A.D., Farley, R.S., & Caputo, J.L. (**2012**). Acute effects of static and proprioceptive neuromuscular facilitation stretching on agility performance in elite youth soccer players. *International journal of exercise science*, *5*(2), 2. [**CrossRef**]

Kay, A.D., & Blazevich, A.J. (**2012**). Effect of acute static stretch on maximal muscle performance: a systematic review. *Med Sci Sports Exerc*, *44*(1), 154-164. [**CrossRef**]

Kingsley, J.D., Zakrajsek, R.A., Nesser, T.W., & Gage, M.J. (**2013**). The effect of motor imagery and static stretching on anaerobic performance in trained cyclists. *J Strength Cond Res*, *27*(1), 265-269. [**CrossRef**]

Konrad, A., Seiberl, W., Tilp, M., Holzer, D., & Paternoster, F.K. (**2022**). What to stretch? - Isolated proprioceptive neuromuscular facilitation stretching of either quadriceps or triceps surae followed by post-stretching activities alters tissue stiffness and jump performance. *Sports Biomech*, 1-18. [**CrossRef**]

Lempke, L., Wilkinson, R., Murray, C., & Stanek, J. (**2018**). The Effectiveness of PNF Versus Static Stretching on Increasing Hip-Flexion Range of Motion. *J Sport Rehabil*, *27*(3), 289-294. [**CrossRef**]

Lim, K.I., Nam, H.C., & Jung, K.S. (**2014**). Effects on hamstring muscle extensibility, muscle activity, and balance of different stretching techniques. *J Phys Ther Sci*, *26*(2), 209-213. [**CrossRef**]

Malek, N.F.A., Nadzalan, A.M., Tan, K., Nor Azmi, A.M., Krishnan Vasanthi, R., Pavlović, R., Badau, D., & Badau, A. (**2024**). The Acute Effect of Dynamic vs. Proprioceptive Neuromuscular Facilitation Stretching on Sprint and Jump Performance. *J Funct Morphol Kinesiol*, *9*(1). [**CrossRef**]

Manoel, M.E., Harris-Love, M.O., Danoff, J.V., & Miller, T. A. (**2008**). Acute effects of static, dynamic, and proprioceptive neuromuscular facilitation stretching on muscle power in women. *J Strength Cond Res*, *22*(5), 1528-1534. [**CrossRef**]

Marin-Jimenez, N., Perez-Bey, A., Cruz-Leon, C., Conde-Caveda, J., Segura-Jimenez, V., Castro-Piñero, J., & Cuenca-Garcia, M. (**2024**). Criterion-related validity and reliability of the standing long jump test in adults: The Adult-Fit project. *Eur J Sport Sci*, *24*(9), 1379-1392. [**CrossRef**]

Melocchi, I., Filipas, L., Lovecchio, N.,M, D.E.N., A,L. A.T., & Codella, R. (**2021**). Effects of different stretching methods on vertical jump ability and range of motion in young female artistic gymnastics athletes. *J Sports Med Phys Fitness*, *61*(4), 527-533. [**CrossRef**]

Nelson, A.G., Driscoll, N.M., Landin, D.K., Young, M.A., & Schexnayder, I. C. (**2005**). Acute effects of passive muscle stretching on sprint performance. *J Sports Sci*, *23*(5), 449-454. [**CrossRef**]

O'Sullivan, K., Murray, E., & Sainsbury, D. (**2009**). The effect of warm-up, static stretching and dynamic stretching on hamstring flexibility in previously injured subjects. *BMC Musculoskelet Disord*, *10*, 37. [**CrossRef**]

Pacheco, L., Balius, R., Aliste, L., Pujol, M., & Pedret, C. (**2011**). The acute effects of different stretching exercises on jump performance. *J Strength Cond Res*, *25*(11), 2991-2998. [**CrossRef**]

Power, K., Behm, D., Cahill, F., Carroll, M., & Young, W. (**2004**). An acute bout of static stretching: effects on force and jumping performance. *Med Sci Sports Exerc*, *36*(8), 1389-1396. [**CrossRef**]

Prentice, W.E. (**2021**). *Principles of Athletic Training: A Guide to Evidence-based Clinical Practice*. McGraw Hill Higher Education. [**CrossRef**]

Reid, J.C., Greene, R., Young, J.D., Hodgson, D.D., Blazevich, A.J., & Behm, D.G. (**2018**). The effects of different durations of static stretching within a comprehensive warm-up on voluntary and evoked contractile properties. *Eur J Appl Physiol*, *118*(7), 1427-1445. [**CrossRef**]

Rowlands, A.V., Marginson, V.F., & Lee, J. (**2003**). Chronic flexibility gains: effect of isometric contraction duration during proprioceptive neuromuscular facilitation stretching techniques. *Res Q Exerc Sport*, *74*(1), 47-51. [**CrossRef**]

Rubini, E.C., Costa, A.L., & Gomes, P.S. (**2007**). The effects of stretching on strength performance. *Sports Med*, *37*(3), 213-224. [**CrossRef**]

Sá, M.A., Matta, T.T., Carneiro, S.P., Araujo, C.O., Novaes, J.S., & Oliveira, L.F. (**2016**). Acute Effects of Different Methods of Stretching and Specific Warm-ups on Muscle Architecture and Strength Performance. *J Strength Cond Res*, *30*(8), 2324-2329. [**CrossRef**]

Sarıca, O. & Gencer, Y. G. (2024). The Effect of Resistance Band Exercises on The Speed, Agility, Balance and Strength Required for Hit Shooting in MountedJavelinAthletes. Int. J. Sports Eng. Biotech,2(1),27-34. [**CrossRef**]

Trajano, G.S., Nosaka, K., & Blazevich, A.J. (**2017**). Neurophysiological Mechanisms Underpinning Stretch-Induced Force Loss. *Sports Med*, *47*(8), 1531-1541. [**CrossRef**]

Trzaskoma, Z., Ilnicka, L., Wiszomirska, I., Wit, A., & Wychowański, M. (**2015**). Laterality versus jumping performance in men and women. *Acta Bioeng Biomech*, *17*(1), 103-110. [**PubMed**]

Ullman, Z. J., Fernandez, M.B., & Klein, M. (**2021**). Effects of Isometric Exercises versus Static Stretching in Warm-up Regimens for Running Sport Athletes: A Systematic Review. *Int J Exerc Sci*, *14*(6), 1204-1218. [**PubMed**]

Xiong, J., Li, S., Cao, A., Qian, L., Peng, B., & Xiao, D. (**2022**). Effects of integrative neuromuscular training intervention on physical performance in elite female table tennis players: A randomized controlled trial. *PLoS One*, *17*(1), e0262775. [**CrossRef**]