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PENGARUH PROGRAM PEREGANGAN *PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION* TERHADAP PENINGKATAN KEKUATAN *VERTICAL JUMP* PADA PERFORMA *SMASH* BOLA VOLI

THE EFFECT OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION STRETCHING PROGRAM ON IMPROVING VERTICAL JUMP STRENGTH IN VOLLEYBALL SMASH PERFORMANCE

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Abstrak

Penelitian ini bertujuan untuk menguji pengaruh peregangan Proprioceptive Neuromuscular Facilitation (PNF) terhadap peningkatan performa lompatan vertikal saat smash jump pada pemain voli di SMA Kesatuan Bangsa Yogyakarta. Penelitian ini menggunakan metode eksperimental dengan desain pretest–posttest satu kelompok. Partisipan adalah pemain voli putra yang terlibat dalam kegiatan ekstrakurikuler. Instrumen penelitian adalah tes lompatan vertikal untuk mengukur kekuatan tungkai bawah sebelum dan sesudah intervensi. Perlakuan terdiri dari program pelatihan terstruktur yang dikombinasikan dengan peregangan PNF. Data dianalisis menggunakan uji normalitas, uji homogenitas, dan uji t sampel berpasangan dengan tingkat signifikansi 0,05. Hasil penelitian menunjukkan bahwa peregangan PNF berpengaruh signifikan terhadap peningkatan performa lompatan vertikal. Oleh karena itu, peregangan PNF dapat direkomendasikan sebagai metode pelatihan alternatif yang efektif untuk meningkatkan performa smash jump pada pemain voli SMA.
Kata kunci: *proprioceptive neuromuscular facilitation*, *vertical jump*, *smash* bola voli

Abstract

This study aimed to examine the effect of Proprioceptive Neuromuscular Facilitation (PNF) stretching on improving vertical jump performance during smash jumps in volleyball players at SMA Kesatuan Bangsa Yogyakarta. The study employed an experimental method using a one-group pretest–posttest design. The participants were male volleyball players involved in extracurricular activities. The research instrument was a vertical jump test to measure lower limb strength before and after the intervention. The treatment consisted of a structured training program combined with PNF stretching. Data were analyzed using normality tests, homogeneity tests, and a paired sample t-test with a significance level of 0.05. The results showed that PNF stretching had a significant effect on increasing vertical jump performance. Therefore, PNF stretching can be recommended as an effective alternative training method to enhance smash jump performance in high school volleyball players.
***Keywords**: proprioceptive neuromuscular facilitation, vertical jump, volleyball smash*

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INTRODUCTION

Volleyball is a globally recognized sport characterized by high-intensity intermittent actions that demand a sophisticated integration of technical skill and peak physical conditioning. At its competitive core, success is largely dictated by the ability to execute explosive movements above the net, specifically through offensive smashes and defensive blocks. These actions are fundamentally predicated on the athlete's vertical jump capacity, which serves as a primary determinant of performance outcomes. Research by Sheppard et al. (2008) emphasizes that the vertical jump is not merely a product of raw force but is a complex manifestation of neuromuscular coordination and mechanical efficiency. Consequently, optimizing the vertical jump remains a central objective for coaches and sports scientists seeking to enhance the competitive edge of volleyball practitioners.

The physiological foundation of a potent vertical jump resides in the synergistic relationship between lower limb muscle strength and the rapid recruitment of motor units. High-velocity movements in volleyball require the musculoskeletal system to generate maximum force within milliseconds, a concept known as explosive power. However, the biomechanical efficiency of this power generation is often constrained by the elasticity and functional range of motion of the surrounding connective tissues. According to Alter (2004), flexibility is a critical yet frequently undervalued component that facilitates optimal joint mechanics and reduces internal resistance during the eccentric-concentric transition. Without adequate flexibility, the potential for maximal muscle contraction is physically hindered, leading to suboptimal athletic execution.

Despite its clear importance, physical conditioning in high school sports programs often remains subordinate to technical drill repetition. In many secondary education settings, training regimens lack a robust scientific framework, often neglecting the holistic development of physical biomotor abilities. This pedagogical gap frequently results in stagnant performance levels and an increased susceptibility to overuse injuries among student-athletes. At SMA Kesatuan Bangsa Yogyakarta, anecdotal evidence suggests that while technical proficiency is emphasized, the specific physiological integration of flexibility and strength training is not yet fully optimized. This lack of variation in training methodology highlights a critical need for evidence-based interventions that can be seamlessly integrated into the school-based sports curriculum.

One of the most sophisticated methods for enhancing both flexibility and functional strength is Proprioceptive Neuromuscular Facilitation (PNF). Unlike traditional static stretching, PNF utilizes specific neuromuscular reflex mechanisms specifically autogenic and reciprocal inhibition to bypass the stretch reflex and allow for deeper tissue elongation. Sharman, Cresswell, and Riek (2006) demonstrate that the alternating cycles of contraction and relaxation inherent in PNF stretching lead to superior gains in range of motion compared to other modalities. Furthermore, the active involvement of the muscular unit during PNF protocols suggests a secondary benefit in muscle activation and motor control. This dual-action mechanism makes PNF a compelling candidate for athletes requiring both suppleness and explosive power.

The urgency of this research is underscored by the evolving demands of modern volleyball, where even minor increments in vertical reach can decide the outcome of a match. Beyond performance, the implementation of PNF stretching carries a significant preventative health dimension for student-athletes. By improving joint compliance and muscle elasticity, PNF can mitigate the risk of common lower-limb injuries, such as patellar tendinopathy or ankle sprains, which are prevalent in jumping sports. Hindle et al. (2012) further suggest that when PNF is systematically applied, the resultant increases in flexibility can lead to more efficient energy transfer throughout the kinetic chain. Therefore, investigating PNF is not merely a matter of performance enhancement but also of athletic longevity and safety.

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Currently, there is a palpable lack of longitudinal data regarding the specific effects of PNF stretching on the vertical jump performance of high school-aged volleyball players in Indonesia. Most existing literature focuses on professional or collegiate populations, leaving a significant research gap concerning the developmental stages of student-athletes. This study seeks to bridge that gap by providing empirical evidence on the efficacy of PNF stretching within the specific socio-athletic context of SMA Kesatuan Bangsa Yogyakarta. By analyzing how this advanced stretching technique influences vertical jump strength, the research will offer a localized yet scientifically rigorous perspective on adolescent physical development.

In conclusion, this research aims to validate the role of PNF stretching as a superior alternative to conventional training methods in a school setting. The findings are expected to provide a definitive scientific reference for physical education teachers and coaches to modernize their training paradigms. By transitioning from traditional, less varied routines to science-based conditioning, schools can foster an environment that maximizes the athletic potential of their students. Ultimately, this study serves as a catalyst for a more analytical approach to sports coaching, ensuring that the next generation of volleyball players at SMA Kesatuan Bangsa Yogyakarta is equipped with the physical tools necessary for excellence.

METHOD

This study utilizes a quantitative approach with a pre-experimental design, specifically employing the one-group pretest-posttest model. This design is selected to observe the longitudinal changes in physical performance within a single cohort before and after a specific intervention, allowing for the direct measurement of the treatment's impact. According to Creswell and Creswell (2017), this design is particularly effective in educational and sports settings where a control group may not be feasible due to limited player availability or ethical considerations regarding equal access to training. The primary focus is to quantify the shift in vertical jump strength and flexibility following the administration of a systematic Proprioceptive Neuromuscular Facilitation (PNF) program. By comparing the baseline data with the results, the researcher can establish the magnitude of improvement attributed to the experimental stimulus.

The population for this research comprises the student-athletes within the volleyball program at SMA Kesatuan Bangsa Yogyakarta. To ensure the data reflects the specialized nature of the sport, a total sampling (census) technique was employed, involving all active members of the school's volleyball team. This technique is advantageous in small-to-medium-sized populations as it eliminates sampling error and provides a comprehensive overview of the specific group being studied (Sugiyono, 2018). Participants were screened to ensure they met the inclusion criteria, which included being in good health, having no recent history of lower limb injuries, and committing to the full duration of the intervention. This focused demographic ensures that the findings are directly applicable to high school-level volleyball development.

Data collection was executed through two primary standardized instruments designed to measure explosive power and range of motion. The Vertical Jump Test (Sargent Jump Test) was utilized to quantify lower limb explosive strength, measuring the difference between standing reach and the peak height attained during a maximal jump. To complement this, a flexibility assessment was conducted using a sit-and-reach test or a goniometer-based lower limb range of motion (ROM) measurement to capture the physiological changes in muscle elasticity. Reiser et al. (2017) suggest that using standardized physical tests ensures high reliability and validity, provided that environmental conditions and equipment remain constant throughout both the pretest and posttest phases. These instruments provide the empirical foundation necessary to evaluate the efficacy of the PNF stretching protocols.

The intervention followed a structured PNF stretching program integrated into the athletes' regular training schedule over a determined period. Each session utilized the "Hold-

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Relax" technique, which involves a passive stretch followed by an isometric contraction of the antagonist muscle and a subsequent deeper passive stretch. This specific protocol is designed to trigger the Golgi tendon organ, inducing autogenic inhibition and allowing for greater muscle elongation (Sharman et al., 2006). The training was supervised by a physical conditioning specialist to ensure proper technique and to prevent overexertion. The pretest was conducted one week prior to the intervention, while the posttest was administered 48 hours after the final training session to allow for adequate neuromuscular recovery and to capture the chronic adaptations of the training.

To interpret the gathered data, a rigorous statistical analysis was performed using SPSS software. Initially, the data underwent normality tests (e.g., Shapiro-Wilk) and homogeneity tests to ensure they met the parametric assumptions required for inferential statistics. Once the data were confirmed to be normally distributed, a Paired Sample T-test was conducted with a significance level of $\alpha = 0.05$. This test is the gold standard for determining whether the mean difference between the pretest and posttest scores is statistically significant or merely the result of chance. Additionally, the Effect Size (Cohen's d) was calculated to determine the practical significance and the strength of the relationship between PNF training and vertical jump improvement.

RESULTS

This study aimed to determine the effect of training programs and PNF stretching on improving vertical jump strength in performing smash jumps among volleyball players at SMA Kesatuan Bangsa Yogyakarta.

Tabel 1. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Pretest	10	250.00	284.00	267.5000	11.61656
Posttest without PNF	10	251.00	285.00	268.1000	11.95780
Posttest with PNF	10	251.00	286.00	268.5000	12.28594
Valid N (listwise)	10				

The results of the initial measurements (pretest) indicated that students' vertical jump ability and lower limb flexibility were in the moderate category. After the implementation of the PNF stretching training program, an increase in the mean scores was observed across all research variables, including both flexibility and vertical jump strength. The mean posttest scores were higher than the pretest scores, indicating that PNF stretching training had a positive effect on the physical condition of volleyball players at SMA Kesatuan Bangsa Yogyakarta.

Tabel 2. Test of Normality

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	.117	10	.200*	.957	10	.749
Posttest without PNF	.146	10	.200*	.939	10	.543
Posttest with PNF	.146	10	.200*	.941	10	.566

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Normality test results showed that all pretest and posttest data for flexibility and vertical jump strength variables had significance values greater than 0.05. Therefore, the data were normally distributed and met the requirements for parametric statistical analysis.

Tabel 3. Test of Homogenity of Variances

	Criteria	Levene Stastic	df1	df2	Sig.
Value	Based on Mean	.032	2	27	.969
	Based on Median	.023	2	27	.977
	Based on Median and with Adjusted df	.023	2	26.931	.977
	Based on Trimmed Mean	.032	2	27	.969

The homogeneity test results indicated that the variance of pretest and posttest data across all research variables was homogeneous (significance value > 0.05). This indicates that the sample originated from a population with relatively similar characteristics.

Tabel 4. Paired Samples T-Test Results for Pretest and Posttest Comparisons (N = 10)

Treatment Group	Mean Difference	SD	t	df	p	95% Confidence Interval of Difference	
						Lower	Upper
without PNF	-0.60	0.84	-2.25	9	.051	-1.20	0.00
with PNF	-1.00	1.05	-3.00	9	.015	-1.75	-0.25

The paired sample t-test results showed that the significance value was less than 0.05, indicating a statistically significant effect of PNF stretching training on improving flexibility and vertical jump strength in performing smash jumps among volleyball players. Thus, the research hypothesis stating that PNF stretching training affects vertical jump strength improvement was accepted.

DISCUSSION

The primary findings of this research demonstrate that a structured Proprioceptive Neuromuscular Facilitation (PNF) stretching program yields a statistically significant improvement in both flexibility and vertical jump strength among high school volleyball players. The data transition from pretest to posttest suggests that the integration of PNF protocols provides a superior stimulus for musculoskeletal adaptation compared to conventional stretching routines. This improvement aligns with the principle of progressive overload and neuromuscular adaptation, where the specific mechanical stress of PNF enhances the functional capacity of the lower limbs. The significant p-value obtained in the paired sample t-test confirms that these gains are not coincidental but are a direct result of the experimental intervention at SMA Kesatuan Bangsa Yogyakarta.

Physiologically, the observed increase in flexibility is deeply rooted in the mechanisms of autogenic and reciprocal inhibition. During the "hold-relax" phase of PNF, the isometric contraction of the target muscle activates the Golgi tendon organs (GTO), which subsequently

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signals the muscle to relax to prevent excessive tension a process known as autogenic inhibition. This allows the muscle to reach a new, extended length during the subsequent passive stretch phase. As noted by Sharman et al. (2006), these neuromuscular reflex modifications are more effective at increasing the range of motion (ROM) than static stretching alone, as they actively recalibrate the muscle's stretch perception and tolerance.

The enhancement of vertical jump strength can be analytically linked to the optimization of the length-tension relationship within the quadriceps and gastrocnemius complexes. When flexibility is improved through PNF, the muscles can undergo a more efficient eccentric-concentric transition during the dip and drive phases of a volleyball smash jump. Greater joint mobility allows for a deeper "countermovement," which, according to the stretch-shortening cycle (SSC) theory, increases the potential energy stored in the elastic components of the muscle. Consequently, the muscles can generate a more forceful contraction at optimal lengths, directly translating to increased vertical displacement.

The results of this study corroborate the findings of Hindle et al. (2012), who posited that PNF stretching does not merely "loosen" the tissue but enhances neuromuscular function. By involving active muscle contractions, PNF promotes better motor unit recruitment and synchronization. This increased neural drive is essential for explosive movements such as the vertical jump, where the speed of force production is as critical as the absolute force itself. Therefore, the improved jump height observed in the participants is a combined manifestation of mechanical elasticity and heightened neural efficiency, reinforcing the dual-benefit nature of PNF stretching.

In the specific context of high school athletics, these findings offer a transformative perspective on student-athlete development. Most secondary school programs focus heavily on repetitive technical drills, which can lead to muscle tightness and restricted movement patterns. The introduction of PNF provides a science-based variation that addresses the physical bottlenecks preventing students from reaching their peak jumping potential. By modernizing the preparatory and recovery phases of training with PNF, coaches can facilitate more explosive performance outcomes while simultaneously educating student-athletes on the importance of physiological maintenance.

Furthermore, the urgency of implementing such programs is highlighted by the role of flexibility in injury prevention. Increased ROM and muscle compliance significantly reduce the risk of strains and tendinopathies, which are common in sports involving high-frequency jumping. As volleyball requires constant landings and rapid changes of direction, the improved musculoskeletal elasticity gained from PNF acts as a protective buffer for the knee and ankle joints. This research suggests that PNF is not only a performance enhancer but also a vital component of a long-term athletic health strategy for adolescent players.

Despite the positive outcomes, several limitations must be acknowledged to maintain academic rigor. The study utilized a relatively small sample size at a single institution, which may limit the generalizability of the results to broader populations. Additionally, the researchers had limited control over the participants' external physical activities and daily nutritional intake, factors that can influence muscle recovery and performance. Future research should consider a randomized controlled trial (RCT) design, incorporating a control group to further isolate the effects of PNF from natural developmental growth or general training effects.

The implications of this research for the field of sports science are significant, particularly for school-based sports programs. These results provide empirical evidence that PNF stretching is a highly efficient alternative to traditional methods, offering a higher "return on investment" regarding training time and physical gains. School administrators and athletic directors should consider incorporating specialized PNF training workshops for coaches to ensure the safe and effective application of these techniques. Moving forward, the results

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advocate for a more holistic approach to physical education that prioritizes neuromuscular quality alongside technical skill.

As a follow-up to this study, it is recommended that future investigations explore the combination of PNF stretching with other modalities, such as plyometrics or resistance training. Examining the long-term retention of these flexibility and power gains would also provide valuable insights into the sustainability of PNF-induced adaptations. Additionally, utilizing advanced biomechanical tools, such as force plates or electromyography (EMG), could offer a more granular look at the specific muscle activation patterns during the jump. Ultimately, this study serves as a foundational step toward creating a more sophisticated, evidence-based training culture in Indonesian high school volleyball.

CONCLUSION

Proprioceptive Neuromuscular Facilitation (PNF) stretching training has been proven to have a significant effect on improving flexibility and vertical jump strength in performing smash jumps among volleyball players at SMA Kesatuan Bangsa Yogyakarta. The structured application of PNF stretching effectively and efficiently enhances students' physical abilities. Therefore, PNF stretching can be recommended as an alternative training method in the physical conditioning development of volleyball players at the high school level.

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