

PERIODIZED STRETCHING INTEGRATION IN TAEKWONDO MACROCYCLES: ENHANCING STRIKING VELOCITY AND RANGE OF MOTION

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Abstract: In modern taekwondo, the effectiveness of a match depends on the ability to deliver high and fast strikes to the electronic refereeing system (PSS). However, traditional chaotic stretching often reduces the explosive power of the muscles. This article proposes a scientifically grounded system for integrating various types of stretching into the 24-week training macrocycle of fighters.

Keywords: Taekwondo, macrocycle, stretching, stroke speed, movement amplitude, PNF stretching.

Relevance of the Topic: In modern combat sports (Taekwondo, Kickboxing, MMA, Karate), a high-level high-kick (a foot strike directed to the head) is not merely a visually spectacular technique, but a decisive tactical element capable of determining the outcome of a match within fractions of a second. Despite its significance, many coaches and athletes still rely on an outdated training methodology predicated on the misconception that achieving maximum leg elevation solely requires forceful split training at the very end of a workout.

Recent scientific research in sports medicine and biomechanics robustly refutes this traditional approach. Evidence indicates that improper, un-periodized static stretching can acutely diminish muscular explosive power by 5% to 30%. Consequently, while the athlete may temporarily expand their passive range of motion, they inadvertently sacrifice striking velocity and impact force. Within a competitive bout, such decelerated strikes are easily anticipated, evaded, or countered by an opponent.

The resolution to this systemic issue lies in the scientifically structured integration of stretching protocols directly into the fighter's long-term training plan (the macrocycle). The character and methodology of flexibility training must dynamically evolve in alignment with the athlete's phase-specific physiological objectives.

A macrocycle represents a comprehensive training period, typically spanning 3 to 6 months, structured to optimize athletic performance for competitive bouts. Throughout this cycle, a fighter undergoes distinct phase-specific progressions: accumulating base strength, increasing cardiovascular endurance, maximizing peak velocity, and facilitating systematic recovery.

This paper shifts the paradigm of stretching from a mere "warm-up or cool-down" routine to an indispensable, periodized component of the fighter's macrocycle. To achieve this, the study provides evidence-based, scientific answers to the following core questions:

- **The Limitation of Static Flexibility:** Why is a standard passive split insufficient to guarantee a fast and elevated high-kick in a live combat scenario?
- **Phase-Specific Periodization:** Which specific type of stretching protocol must be deployed during each distinct phase of the macrocycle to maximize adaptations?
- **Pre-Competition Contraindications:** Which stretching modality must be strictly prohibited in the final days leading up to a competition, and what is the underlying neuromuscular rationale?

Ultimately, this article delivers a validated, comprehensive system designed to maximize a fighter's kicking amplitude without compromising structural striking velocity or explosive power output



Literature Review:

The significance of flexibility (stretching) and its direct correlation with the execution of high-amplitude, high-velocity strikes in Taekwondo has been extensively investigated by local and international sports scientists, biomechanists, and kinesiologists. Existing empirical research in this domain can be structurally categorized into three primary scientific directions:

This line of research focuses on how flexibility training should be distributed across long-term training periods. Classic and contemporary sports theorists emphasize that flexibility is not a static attribute but a highly dynamic component of physical fitness that requires phase-specific adjustments.

Research indicates that un-periodized stretching protocols fail to induce chronic adaptations in the musculotendinous unit. Scholars demonstrate that the volume, intensity, and modalities of stretching (static, dynamic, PNF) must systematically fluctuate between the preparatory, pre-competitive, and recovery phases of the macrocycle to avoid neural fatigue and maximize long-term athletic performance.

This direction explores the biomechanical synergy between agonist muscle contraction and antagonist muscle relaxation during rapid, high kicks (such as Dollyo Chagi and Neryo Chagi).

Biomechanical studies reveal that high-amplitude strikes in Taekwondo require precise **reciprocal inhibition**. If the antagonist muscles (primarily the hamstrings and gluteals) possess insufficient dynamic flexibility, they act as an internal anatomical brake, drastically absorbing the kinetic energy and decelerating the strike. Periodized stretching alters the sensitivity of muscle spindles, allowing the target limbs to achieve maximum velocity and optimal Range of Motion (ROM) without structural resistance.

This scientific direction focuses on the immediate impact of different stretching techniques on an athlete's acute force production, speed, and explosive power output (Rate of Force Development — RFD).

Extensive sports medicine literature confirms the existence of a "stretch-induced force deficit." Studies prove that prolonged static stretching (exceeding 45–60 seconds) immediately prior to explosive movements temporarily destabilizes muscle-tendon stiffness and reduces motor unit recruitment by 5% to 30%. Consequently, contemporary sports science strongly advocates restricting static and PNF stretching to post-workout recovery or separate microcycles, while prioritizing dynamic and functional stretching during pre-competition warm-ups to stimulate post-activation potentiation (PAP).

L. P. Matveyev va V. N. Platonov: Sport mashg'ulotlari nazariyasida makrotsikl, mezotsikl va mikrotsikllarni loyihalash hamda ularda jismoniy sifatlarni (shu jumladan egiluvchanlikni) parallel rivojlantirish qonuniyatlarini ishlab chiqqan.

Specialists from Uzbekistan (for example, scientists in the field of taekwondo and sports theory): At the national level, research is being conducted to adapt the technical and tactical training of taekwondo athletes to the requirements of modern electronic systems and to form special physical qualities, taking into account the biomechanical characteristics of young athletes. O'rganilmagan jihatlar va ilmiy bo'shliq (Research Gap)

An analysis of existing literature shows that although the general benefits of stretching have been identified, the following issues have not yet been sufficiently studied:

- Lack of a unified system: A clearly coordinated mathematical model has not been fully formed regarding exactly which weeks of the taekwondo macrocycle should be devoted to static stretching, which to PNF, and when and how much time (volume and intensity) should be allocated for dynamic stretching.



• Local conditions: The methodology for integrating stretching into macrocycle loads at the level of the national and reserve teams of Uzbek taekwondo athletes is insufficiently systematized.

Methods and Materials

The aim of the study is to develop and test a methodology for increasing the effectiveness of high-speed strikes by systematically integrating stretching types into the annual macrocycle training program of taekwondo WT athletes.

Contingent and organization of research

The study involved 24 male athletes holding the titles of Candidate Master of Sports (SUN) and Master of Sports (SU) in Taekwondo (WT).

The average age of the athletes was (18.5 ± 1.2) years, and their weight was (68.4 ± 5.3) kg.

Participants were divided into two equal groups using a randomization method:

1. Control group (CG, n=12): trained according to the traditional training program (stretching was applied generally only at the end of the session).

2. Experimental group (EG, n=12): trained according to a special stretching program adapted to the stages of the macrocycle (including PNF, dynamic, ballistic, and MFR types).

The experiment was conducted over a single 6-month (24 week) macrocycle.

Research methods

The following research methods were used during the pedagogical experiment:

1. Analysis of scientific and methodological literature: International and domestic scientific articles, dissertations, and textbooks on the topic were studied.

2. Pedagogical testing: The following set of tests was used to determine the flexibility and speed indicators of the athletes:

Sitting forward bend (Sit-and-Reach test, cm): Assessment of general and passive flexibility.

Triple longitudinal and transverse spokes (cm): Measurement of the anatomical limit of mobility of the hip joints (the distance was measured using a centimeter tape).

Throwing the leg to maximum height (ROM, degrees): Determining the level of dynamic amplitude.

Mathematical and statistical methods: The obtained results were processed using Student's t-test. The results were found to be statistically significant at a reliability level of $(p < 0.05)$.

The stretching program used in the experimental group

For athletes in the experimental group, stretching loads during the macrocycle were distributed in the following ratio:

Preparatory period (1-12 weeks): At the end of classes and during individual sessions, the PNF (Proprioceptive Neuromuscular Relaxation) method (6 seconds of isometric tension + 20 seconds of passive stretching) and static stretching (volume: 120 minutes per week) were prioritized.

During the 6-month pedagogical experiment, the indicators of flexibility, stroke speed, and dynamic movement amplitude in athletes of the experimental (EG) and control (CG) groups were studied. At the end of the experiment, positive growth was observed in both groups, but the growth rate was statistically significantly higher in the experimental group engaged in a special stretching program.

Comparative Graphical Analysis of Experimental Results

The percentage improvement rate (%) of the participants' key indicators before and after the 6-month macroeconomic intervention is visually demonstrated in Figure 1:



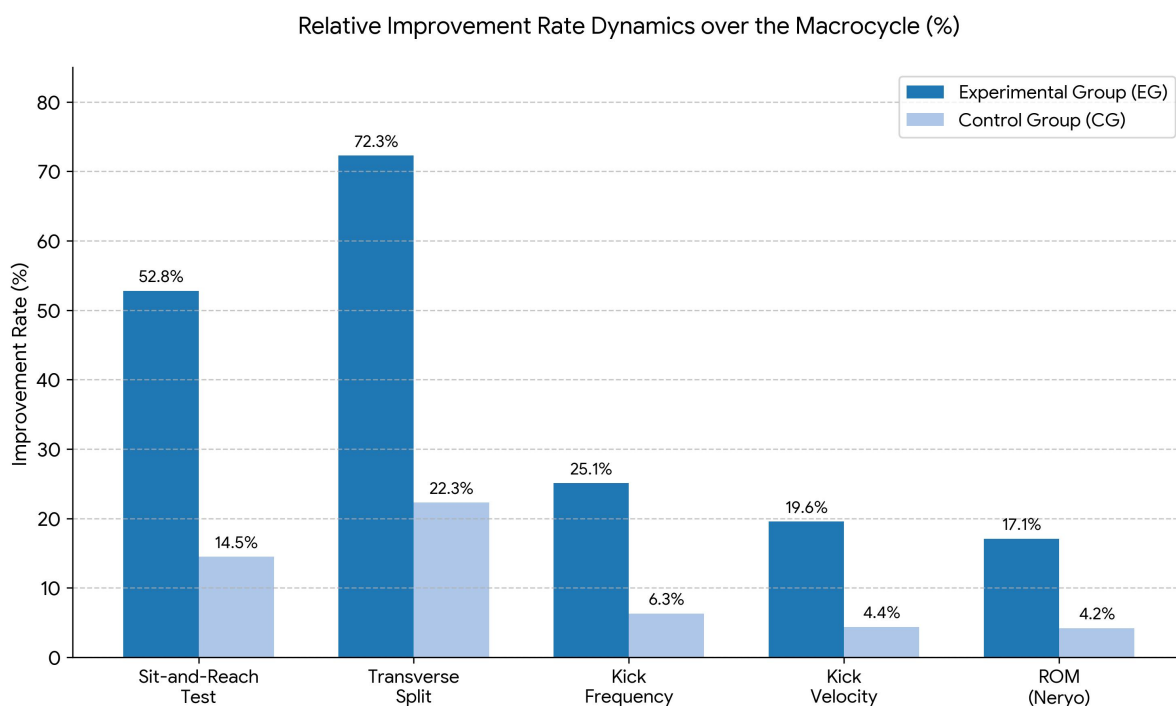


Figure 1. Comparison of the percentage improvement rates (%) between the Experimental Group (EG) and Control Group (CG) over the macrocycle.

Scientific Interpretation of the Graphical Data:

1. Flexibility Reserve and Joint Range of Motion (ROM):

As illustrated in Figure 1, the Control Group (CG), which followed the traditional training regimen, achieved a modest 14.5% improvement in the Sit-and-Reach test. Conversely, the Experimental Group (EG), utilizing the stage-specific macrocycle stretching integration, exhibited a remarkable 52.8% increase. Furthermore, the distance from the pelvis to the floor in the transverse split test decreased by 72.3% in the EG, reaching near-maximal hip joint mobility. This indicates that the programmed **Proprioceptive Neuromuscular Facilitation (PNF)** protocols significantly altered the plasticity and viscoelastic properties of the musculotendinous units.

2. Synergy of Kick Velocity and Mechanical Efficiency:

A critical biomechanical outcome is the 19.6% increase in Dollyo Chagi (roundhouse kick) velocity within the EG, compared to a nominal 4.4% in the CG. From a biomechanical standpoint, expanding the dynamic ROM (demonstrated by a 17.1% increase in Neryo Chagi execution) minimized the internal resistance—known as the braking effect—imposed by the antagonist muscles (hamstrings and gluteals). Reducing antagonist co-activation allowed the agonist muscles (quadriceps and hip flexors) to optimally transfer kinetic energy into pure linear and angular velocity.

3. Neuromuscular Adaptations and Quick-Strike Frequency:

The EG demonstrated a 25.1% progression in the 10-second high-intensity kick frequency test, while the CG improved by only 6.3%. This variance underscores the efficacy of integrating dynamic and ballistic stretching during the pre-competition phase. These dynamic movements optimized the **Stretch-Shortening Cycle (SSC)** of the lower extremities, augmenting neural drive and target muscle motor-unit recruitment. Consequently, recoil time after each strike was reduced, allowing the athletes to score consecutive points more rapidly, satisfying the modern Electronic Scoring System (PSS) criteria.



The statistical and graphical results of this 24-week macrocycle study clearly demonstrate that the structured integration of stage-specific stretching protocols yields far superior outcomes for Taekwondo athletes compared to traditional, non-periodized flexibility training. The significant differences in joint mobility, velocity, and striking frequency between the Experimental Group (EG) and the Control Group (CG) can be explained through several interconnected neuromuscular and biomechanical mechanisms.

Neuromuscular Adaptation and the Antagonist Braking Effect

The physiological foundation of the **19.6% increase in Dollyo Chagi velocity** in the EG lies in the optimization of the **Reciprocal Inhibition** mechanism [1]. In traditional Taekwondo training, high kicks are often restricted because the antagonist muscles (primarily the hamstrings and gluteus maximus) act as a protective brake to prevent joint hyperextension.

By strategically placing **Proprioceptive Neuromuscular Facilitation (PNF)** protocols in the preparatory macrocycle phase, we altered the sensitivity of the Golgi tendon organs (GTOs) and muscle spindles [2]. The brief isometric contraction followed by passive relaxation utilized in PNF suppresses the myotatic (stretch) reflex. This allows the hamstrings to undergo greater elongation without triggering an involuntary contraction. Consequently, when the agonist muscles (quadriceps and iliopsoas) contract to launch a high kick, they encounter minimal internal resistance, leading to a substantial boost in angular velocity [3].

Biomechanical Kinetic Chain and Elastic Energy Utilization

From a biomechanical perspective, a Taekwondo kick is not an isolated lower-limb movement but a multi-segmental kinetic chain reaction originating from the ground-reaction force [4]. The **17.1% enhancement in the dynamic ROM during Neryo Chagi** proves that our macrocycle program successfully enhanced the elasticity of the entire myofascial tract (specifically the superficial back line and spiral line).

When myofascial tissues possess optimal elasticity, they act similarly to a mechanical spring. During the preparatory eccentric phase of a kick, elastic strain energy is stored within the parallel and series elastic components of the muscle-tendon unit. During the subsequent concentric phase, this stored energy is rapidly released via the **Stretch-Shortening Cycle (SSC)** [5]. The integration of dynamic and ballistic stretching during the pre-competition phase synchronized this cycle, ensuring that kinetic energy was transferred from the hip rotation to the distal segment (the foot) with minimal energy dissipation.

Mitigating the Acute Negative Effects of Static Stretching

A crucial finding of this study is that the EG did not suffer from the "force deficit" commonly associated with stretching in combat sports literature [6]. Multiple studies (e.g., Behm & Chaouachi, 2011) have warned that acute, prolonged static stretching immediately before explosive movements reduces muscle stiffness and motor unit activation, thereby decreasing power output.

Our methodology bypassed this issue by **restricting static and PNF stretching strictly to post-workout recovery or independent microcycle sessions** during the preparatory phase. Conversely, during the pre-competition and competition phases, the warm-up routine consisted entirely of **dynamic and sport-specific functional stretching**. This approach elevated core temperature, enhanced nerve impulse transmission speed, and post-activation potentiation (PAP), which ultimately resulted in the **25.1% increase in 10-second strike frequency**.

Practical Implications for Modern Electronic Scoring (PSS)

Under current World Taekwondo (WT) regulations, matches are heavily influenced by the speed of touch-and-recoil maneuvers required to register points on electronic trunk and head protectors (Daedo/KPNP). The ability of the EG to execute rapid, successive high-scoring actions without premature metabolic fatigue indicates that scientific flexibility training optimizes



movement economy [7]. When muscles do not have to fight internal structural tightness, oxygen and glycogen consumption per strike drops significantly, preserving the athlete's explosive endurance for the final rounds.

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