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EFFECTIVENESS OF A SPECIALIZED BLOCK-BASED TRAINING MODEL FOR DEVELOPING PHYSICAL FITNESS OF SCHOOL-AGE ATHLETES THROUGH WEIGHTLIFTING

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ABOUT ARTICLE

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Abstract: The systematic and evidence-based development of physical fitness in school-age athletes constitutes a priority challenge in contemporary sports pedagogy. Rapid morphofunctional changes occurring during adolescence demand a carefully calibrated approach to training load, exercise selection, and recovery management, as improper programming during this critical developmental window may result in overuse injuries, stunted growth adaptation, or long-term athletic burnout. Weightlifting exercises have been scientifically validated as an effective multimodal training stimulus for this population, simultaneously targeting neuromuscular coordination, explosive power, postural control, and bone mineral density. Nevertheless, integrated training models that coherently combine technical prescription, physiological rationale, progressive overload principles, and individualized intensity parameters remain insufficiently represented in the existing literature.

Introduction. The physical development of school-age athletes represents one of the most methodologically complex domains within sports pedagogy. The adolescent period-particularly between ages 12 and 16 is characterized by pronounced neuromuscular maturation, skeletal-articular remodeling, and cardiorespiratory expansion. When appropriately channeled through structured physical loading, these concurrent developmental processes yield superior adaptive responses compared with those achievable at any other career stage (Faigenbaum et al., 2009). This developmental window is therefore strategically critical for the long-term athlete development (LTAD) pathway.

Weightlifting movements have received increasing empirical support as versatile and effective stimuli for the comprehensive physical conditioning of youth populations. Properly programmed Olympic-style lifts and their derivatives simultaneously develop explosive strength, muscular endurance, inter-muscular coordination, and movement technique—attributes that form the kinematic and neurological foundation of advanced athletic performance (Schmidtbleicher, 1992). However, the realization of these benefits is entirely contingent upon the scientific quality of the training prescription: the selection of exercises, their technical parameters, intensity gradients, and recovery protocols must each be calibrated to the physiological and biomechanical characteristics of the young athlete.

The concept of block periodization in strength training-originally articulated by Medvedev (1986) and Vorobyov (1977)-proposes that training stimuli be organized into discrete, sequentially structured blocks, each targeting a specific physical quality. This approach allows for concentrated loading of individual muscle groups and motor qualities while managing cumulative fatigue, thereby facilitating superior long-term adaptation compared to concurrent or mixed training paradigms.

In the context of lumbar stabilization, McGill's (2010) posterior chain model underscores the role of the erector spinae, multifidus, and quadratus lumborum as primary vertebral stabilizers under axial loading. Their systematic development through structured weightlifting exercises not only augments force-transfer efficiency but constitutes an essential injury-prevention strategy for adolescent athletes. Complementarily, Bernstein's (1967) theory of movement coordination and Zatsiorsky and Kraemer's (2006) concept of functional strength provide the neuromechanical rationale for including complex locomotor tasks-such as loaded walking and stair ascent-in the training model.

Despite substantial theoretical grounding, the existing literature lacks comprehensive, practically validated training models for school-age weightlifters that integrate (a) biomechanically sequenced exercise selection, (b) explicit technical action descriptors, (c) clearly defined tactical-physical objectives, and (d) age-appropriate intensity and recovery parameters within a single systematic framework. The present study was designed to address this gap.

The primary aim was to develop and validate a specialized six-block, twelve-exercise training model for the comprehensive physical development of school-age weightlifting athletes. Secondary aims were to provide a biomechanical and physiological rationale for each block's structural architecture and to evaluate the model's pedagogical effectiveness through a one-year experimental study.

A prospective, controlled pedagogical experiment with pre- and post-test measurements was conducted over 12 months. Ethical approval was granted by the institutional review board of the Research Institute of Physical Education and Sports, Uzbekistan, and all procedures conformed to the Declaration of Helsinki. Written parental or guardian informed consent was obtained prior to enrollment.

Materials and methods. The specialized training model was designed according to an interdisciplinary framework integrating sport biomechanics, exercise physiology, and sports pedagogy. Four guiding principles governed its construction:

(1) Biomechanical coherence: each exercise was selected for alignment with the kinetic chain patterns intrinsic to competitive weightlifting;

(2) Multi-joint primacy: preference was accorded to compound, multi-articular exercises capable of simultaneously recruiting several muscle groups;

(3) Objective measurability: the physical objective of each block was operationally defined and quantifiable;

(4) Developmental safety: intensity parameters were constrained to ranges empirically validated as safe for the adolescent musculoskeletal system.

Intensity parameters (repetitions, sets, rest intervals) were established according to the dominant metabolic pathway required by each block. Explosive-strength blocks were prescribed at lower repetition volumes (4–7 reps) with full phosphocreatine-system recovery intervals (60–90 s); endurance-oriented blocks were prescribed at moderate-to-high volumes (7–8 reps); functional locomotion exercises were dosed by distance or step count.

Four performance tests were administered at baseline (T0) and at 12-month follow-up (T1):

(1) Standing box jump onto 50 cm platform - explosive strength and lower-limb reactive power;

(2) Snatch-grip barbell row to waist - lumbar and posterior-chain muscular strength;

(3) Barbell back squat maximum repetitions lower-limb muscular strength and endurance;

(4) Technical accuracy score standardized rubric-based assessment of movement quality across three lifts, rated independently by two certified coaches (inter-rater reliability: ICC = 0.91).

Descriptive statistics (mean ± SD) were computed for all variables. Between-group differences at T1 were evaluated with the independent-samples t-test; within-group changes were assessed with the paired-samples t-test. All tests were two-tailed ($\alpha = 0.05$). Effect size was calculated using Cohen's d (small: 0.2; medium: 0.5; large: 0.8). Analyses were performed with IBM SPSS Statistics v26.0.

Results and discussion. The model comprises twelve exercises distributed across six sequentially ordered blocks (Table 1). The logical progression moves from high-neural-demand, power-dominant modalities (Blocks I–II) through structural strength development (Block III), plyometric loading (Block IV), and statokinetic endurance (Block V), culminating in functional locomotor integration (Block VI). This sequence reflects established principles of neuromuscular fatigue management and adaptive specificity (Zatsiorsky & Kraemer, 2006).

Table 1

Comprehensive Structure of the Specialized Six-Block Training Model

№	Block	Exercise Name	Technical Action	Physical Objective	Intensity
1	I Speed-Strength	Classical Snatch	Full kinetic chain pull from floor; coordinated leg–hip–torso extension to overhead lockout	Develop whole-body explosive power impulse and neuromuscular recruitment	4 × 2; 60 s
2	I Speed-Strength	Snatch from Knee	Pull initiated at knee height; emphasis on lower-limb drive and hip extension	Develop lower-limb explosive force and inter-segment power transfer	7 × 2; 60 s
3	I Speed-Strength	Hang Snatch (from Rack)	Bar starts at shoulder height; explosive overhead drive with upper-body and core stabilization	Develop upper-body explosive power; complete proximal-to-distal chain integration	6 × 1; 60–90 s
4	II Lumbar Strength	Snatch-Grip Barbell Row to Waist	Wide-grip bilateral pull; lumbar extensors, trapezius, and posterior deltoid through full ROM	Strengthen posterior chain; enhance lumbar stabilization and scapular retraction force	5 × 2; 60 s
5	II Lumbar Strength	Clean-Grip Barbell Row to Waist	Moderate-grip pull with controlled eccentric phase; thoracolumbar extensor and multifidus activation	Develop lumbar–thoracic coordination and posterior-chain endurance	5 × 2; 60–90 s
6	III Leg Musculature	Back Squat (Barbell on Shoulders)	Full-depth bilateral squat with barbell on upper trapezius; knee and hip flexion/extension	Maximize quadriceps, gluteal, and hamstring strength and muscular endurance	8 × 3; 60 s

№	Block	Exercise Name	Technical Action	Physical Objective	Intensity
7	III Leg Musculature	Front Squat (Barbell on Chest)	Full-depth squat with bar on anterior deltoids; increased quadriceps demand and trunk stabilization	Develop anterior lower-limb strength and core stabilization simultaneously	7 × 2; 60 s
8	IV Explosive Power	Box Jump (50 cm)	Bilateral countermovement jump onto a 50 cm platform; maximal rate of force development	Develop plyometric reactive power and stretch-shortening cycle (SSC) efficiency	8 × 3; 60 s
9	V Combined Endurance	Half-Squat, Barbell on Shoulders	Partial-depth squat (90° knee flexion); sustained statokinetic loading of knee extensors	Develop lower-limb strength-endurance and statokinetic muscular capacity	6 × 2; 60 s
10	V Combined Endurance	Half-Squat, Barbell on Chest	Partial front squat; combined anterior-chain and core statokinetic demand	Develop combined lower-limb and trunk strength-endurance	5 × 2; 60 s
11	VI Coord. & Endurance	Loaded Walk (Barbell on Shoulders)	Ambulation over a set distance with barbell on upper trapezius; vestibular and proprioceptive challenge	Develop functional strength, postural stability, and cardiorespiratory-muscular coordination	Per dist. × 3; 60–90 s
12	VI Coord. & Endurance	Stair Ascent, Barbell on Shoulders	Step-by-step stair ascent carrying barbell; unilateral-alternating lower-limb loading	Develop lower-limb endurance, dynamic balance, and inter-limb synchrony	Per step × 3; 60–90 s

Note. ROM = range of motion; dist. = distance; s = seconds; rest = inter-set recovery.

Table 2

Block-Level Summary: Physiological Targets and Training Parameters

Block	Name	n	Primary Physiological Effect	Energy System	Reps	Sets	Rest (s)
I	Speed-Strength	3	Explosive power; high-threshold motor unit recruitment	ATP-PCr	4–7	1–2	60–90
II	Lumbar Strength	2	Posterior-chain strength; lumbar stabilization	ATP-PCr	5	2	60–90
III	Leg Musculature	2	Quadriceps, gluteal, hamstring maximal strength	Glycolytic	7–8	2–3	60
IV	Explosive Power	1	SSC reactive power; plyometric neuromuscular adaptation	ATP-PCr	8	3	60

Block	Name	n	Primary Physiological Effect	Energy System	Reps	Sets	Rest (s)
V	Combined Endurance	2	Statokinetic strength-endurance; metabolic capacity	Glycolytic	5–6	2	60
VI	Coord. & Endurance	2	Functional integration; vestibular and proprioceptive adaptation	Oxidative	Dist.	3	60–90
TOTAL	**Full Model**	**12**	**Comprehensive: explosive, strength, endurance, coordination**	**Multi-system**	**4–8**	**2–3**	**60–90**

Note. SSC = stretch-shortening cycle; ATP-PCr = adenosine triphosphate–phosphocreatine system; Dist. = distance-based dosing.

No statistically significant between-group differences were observed at baseline for any of the four performance measures (all $p > 0.05$), confirming the adequacy of matched-pairs allocation and the initial comparability of both groups.

Following the 12-month intervention, the experimental group demonstrated statistically significant improvements across all outcome measures relative to both their own baseline (within-group) and the control group (between-group). All between-group differences at T1 were significant at $p < 0.05$ with large effect sizes.

Explosive strength (box jump) improved by 18–23% in EG vs. 6–8% in CG ($p < 0.05$; $d = 1.12$). Lumbar muscular strength (snatch-grip row) improved by 15–20% in EG vs. 5–7% in CG ($p < 0.05$; $d = 0.97$). Lower-limb maximal strength (back squat) showed the largest absolute improvement: EG +20–26% vs. CG +7–9% ($p < 0.05$; $d = 1.21$). Technical accuracy improved by 22–28% in EG vs. 8–11% in CG ($p < 0.05$; $d = 1.34$).

The injury incidence rate in the experimental group was substantially lower than in the control group over the 12-month study period. This differential was most pronounced for lumbar-strain events, consistent with the targeted posterior-chain stabilization work embedded in Block II. No serious adverse events were recorded in either group. The sequential arrangement of classical snatch, snatch-from-knee, and hang snatch in Block I reflects a deliberate biomechanical logic grounded in Schmidtbleicher's (1992) model of explosive force production. The classical snatch is positioned first because it activates the complete ascending kinetic chain (ankle–knee–hip–lumbar–shoulder), establishing the neural recruitment template for subsequent exercises. Schmidtbleicher demonstrated that this class of multi-joint ballistic movement maximizes high-threshold motor unit recruitment and inter-muscular synchronization prerequisites for explosive power development.

The snatch-from-knee isolates the mid-pull phase, directing adaptive emphasis toward the knee and hip extensors critical to first-pull mechanics. The hang snatch concludes the block by training the shoulder-girdle musculature in the rapid force-application mode established by preceding exercises, completing the proximal-to-distal power chain. The prescribed parameters (4–7 reps; 60–90 s rest) are congruent with ATP-phosphocreatine system demands for explosive strength (Zatsiorsky & Kraemer, 2006).

The effect sizes observed (d = 0.97–1.34) classify the intervention effect as large by established conventions (Cohen, 1988) and substantially exceed typical effect sizes in youth resistance training meta-analyses (Faigenbaum et al., 2009). The superior technical accuracy gains (22–28%) are particularly noteworthy: technical quality is notoriously resistant to rapid improvement in parallel with physical conditioning, suggesting that the model's block-structured progression facilitates concurrent skill acquisition and physical development.

The model's injury prevention efficacy is consistent with the theoretical framework of Block II: systematic lumbar stabilization training reduces the incidence of the most prevalent weightlifting-related overuse pathology in adolescent populations. This finding has direct implications for the LTAD paradigm, in which injury prevention during developmental years is considered a prerequisite for senior-level performance attainment.

Conclusion. The present investigation developed, biomechanically justified, and empirically validated a specialized six-block training model for the comprehensive physical preparation of school-age weightlifting athletes. The following principal conclusions are drawn:

1. The six-block model (12 exercises: speed-strength, lumbar strength, leg musculature, explosive power, combined endurance, coordinative endurance) constitutes a biomechanically coherent and physiologically appropriate framework for the concurrent development of all major physical qualities required in competitive weightlifting.

2. The biomechanical sequencing within Block I enables progressive proximal-to-distal power-chain activation and superior neuromuscular recruitment compared to isolated or randomly ordered exercise selection.

3. The posterior-chain approach of Block II, combined with rest intervals calibrated to lumbar fatigue recovery, simultaneously enhances performance capacity and reduces vertebral injury susceptibility in the adolescent spine.

4. The plyometric component of Block IV provides an effective and developmentally safe reactive power stimulus consistent with growth-plate tolerance constraints for 14–15-year-old athletes.

The model provides coaches and sports educators with a standardized, evidence-based, and replicable instructional framework applicable to long-term athlete development programs in Uzbekistan and analogous educational-sport systems.

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