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FUNCTIONAL PERFORMANCE TESTING TO EVALUATE STRETCHING PROGRAMS FOR SPRINTERS AND JUMPERS

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Abstract. *Flexibility is a crucial element for success in various sports, notably in athletics, especially for runners and jumpers. Inadequate flexibility heightens the risk of strains, sprains, and other musculoskeletal issues. This article forms part of a project aimed at devising warm-up and cool-down stretching routines. The study population is adolescent athletes. The following assessment methods are used: Trunk Power Test (Backward Overhead Medicine Ball Throw); Lower Extremity Power Tests (Vertical Jump; Standing Long Jump); Upper Extremity Power Test (Seated Shot-Put Medicine Ball Throw); Sprint Test (30 Meter Flying Start).*
Conclusion. The warm-up program is designed to facilitate dynamic muscle engagement and prepare the body for activity. Meanwhile, the relaxation program focuses on enhancing muscle and tendon flexibility; thereby decreasing the risk of overuse injuries and improving overall lower extremity resilience. Determining the influence of various stretching programs on speed-power metrics will aid in adjusting training protocols and enhancing competitive performances.

Key words: *Adolescent track and field athletes, power and sprint tests.*

1. Introduction

Stretching holds paramount importance in the training regimen of sprinters and jumpers, pivotal for enhancing performance and reducing the risk of injuries. These athletes heavily rely on explosive power, speed, and flexibility, all optimized through a comprehensive stretching routine.

Additionally, stretching serves as an integral component of warm-up and cool-down routines, preparing the body for vigorous activity and aiding in recovery post-exercise. It enhances blood circulation, delivering oxygen and nutrients to muscles, while also flushing out metabolic waste products, thus reducing muscle soreness and promoting faster recovery times [5].

According to Opplert, J., & Babault, N. (2018) [4] if the objective of a warm-up is to enhance joint range of motion (ROM) and muscle force or power, dynamic stretching emerges as a viable alternative to static stretching. The authors

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emphasize the presence of conflicting findings from numerous studies, some indicating no change or even performance decline, suggesting potential influencing factors such as stretch duration, amplitude, or velocity. Consequently, ballistic stretching, a dynamic form with higher velocities, may offer less benefit compared to controlled dynamic stretching. Nevertheless, inconsistent descriptions of stretching procedures have hindered consensus in the literature. Research done by the authors underscores the necessity for future studies to adopt uniform, clearly outlined stretching protocols and proposes a standardized stretching terminology and methodology [4].

2. Utilizing Functional Performance Testing to Evaluate Stretching Programs

Functional performance testing plays a crucial role in adolescent track and field athlete training programs by ensuring their readiness for competition and minimizing the risk of injuries. By evaluating biomechanical efficiency, muscle strength, flexibility, and agility, this testing provides insights into areas needing improvement and helps tailor individualized training regimens. It identifies weaknesses that may predispose athletes to injury during strenuous activities like sprinting, jumping, and throwing. Through targeted interventions and adjustments, coaches can optimize athletes' performance potential while reducing the likelihood of overuse injuries. Ultimately, functional performance testing promotes safe and effective training strategies, facilitating the development of young track and field athletes. For the purposes of this study, we have selected tests for strength and speed, namely: Trunk Power Test (Backward Overhead Medicine Ball Throw); Lower Extremity Power Tests (Vertical Jump; Standing Long Jump); Upper Extremity Power Test (Seated Shot-Put Medicine Ball Throw); Sprint Test (30 Meter Flying Start).

3. Research Methodology

The study aimed to achieve the following objectives: (1) identify trends in current research concerning stretching in athletes, (2) develop a test battery for assessing stretching programs, and (3) perform initial testing of adolescent athletes using strength and speed tests.

Fifty athletes aged between 9 and 16 were examined, and they were divided into two groups: under 14 (21 girls;17 boys) and under 16 (21 girls;17 boys). Eighty-six percent of the children were at a healthy weight, 4% were overweight, and 10% were underweight.

3.1 Functional performance testing for power

Trunk Power Test

Backward Overhead Medicine Ball Throw (BOMBT)

The athlete begins by holding a medicine ball (2 kg) with arms extended straight in front of the body. Then, they initiate a countermovement by flexing at the hips and knees. After this preparatory motion, they forcefully extend their hips and knees backward, propelling the medicine ball over their head. This movement involves a coordinated sequence of flexion and extension, generating power from the lower body to propel the ball upward. The action is dynamic, utilizing the body's momentum to maximize the distance and height of the throw. By effectively engaging the muscles of the lower body and core, the athlete achieves a powerful and efficient release of the medicine ball, enabling them to perform the exercise effectively and achieve optimal results.

Lower Extremity Power Tests

Vertical Jump (VJ). The vertical jump test evaluates explosive anaerobic power, a crucial athletic attribute. The athlete starts by standing evenly on both legs while reaching upward as high as they can with one arm. Subsequently, the athlete performs a jump or hop, aiming to achieve maximum height. This test assesses the athlete's ability to generate power through a quick, explosive movement, primarily utilizing the lower body muscles. By measuring how high the athlete can jump, it provides insights into their explosive strength and speed capabilities. The test is widely used in various sports to gauge athletes' vertical leap performance, which is integral for activities such as basketball, volleyball, and track and field events.

Standing Long Jump (SLJ). The standing long jump is a physical test designed to measure an individual's lower body power and explosive strength. In this test, the participant begins by standing behind a marked line on the ground with their feet shoulder-width apart. They then prepare themselves by bending their knees slightly and swinging their arms back. With explosive force, the participant jumps forward as far as possible, aiming to land with both feet together and maintain balance upon landing.

The distance from the starting line to the back of the heel closest to the starting line is measured to determine the length of the jump. This test evaluates the athlete's ability to generate power solely from a stationary position, without the aid of a running start or momentum. It assesses the muscles involved in the jump, including the quadriceps, glutes, and calf muscles, as well as coordination and technique.

Upper Extremity Power Test

Seated Shot-Put Medicine Ball Throw (SSPMBT). In the seated shot-put Medicine Ball (2 kg) throw, the athlete aims to focus solely on the upper body's strength and technique. To achieve this, the athlete positions themselves on the floor with their back resting against a wall. By sitting in this manner, the lower body is immobilized, ensuring that the force generated comes predominantly from the upper extremities. This setup isolates the muscles of the arms, shoulders, and chest, allowing for a concentrated and controlled release of the shot-put Medicine Ball. By eliminating the influence of lower body movement, the athlete can refine their throwing technique and maximize the power generated through the upper body. The seated shot-put throw is often utilized in training and testing scenarios to assess an athlete's upper body strength and throwing proficiency without the interference of lower body mechanics.

In all strength tests modified by us following Manske, R., and Reiman, M. (2013) [3], two trials are conducted, and the superior result is considered.

3.2 Functional performance testing for speed

Sprint Test (30 Meter Flying Start). The Sprint Test, specifically the 30 Meter

Flying Start, is a commonly used method to assess an athlete's speed and acceleration capabilities. In this test, the athlete begins by standing still a short distance before the starting line, known as the “flying start” position. Upon the start signal, the athlete accelerates rapidly, reaching maximum speed by the time they cross the starting line.

The Sprint Test (30 Meter Flying Start) provides valuable insights into an athlete's performance potential and can inform training strategies aimed at improving sprinting ability.

4. Data Analysis and Interpretation

Fifty athletes aged between 9 and 16 were examined, and they were divided into two groups: under 14 (21 girls; 17 boys) and 16 (21 girls; 17 boys). Eighty-six percent of the children were at a healthy weight, 4% were overweight, and 10% were underweight.

A variational analysis was conducted on the output data to monitor the impact of implementing stretching programs for runners and jumpers (Table 1,2).

Thirty-eight of the athletes fall into the under-14 age group. The results achieved are as follows SLJ = 1.80 ± 0.28 m; VJ = 31.87 ± 6.04 cm; 30 m = 4.5 ± 0.54 sec., BOMBT = 2.01 ± 0.54 m; SSPMBT = 1.71 ± 0.51 m; mean ± SD, respectively.

For the group of athletes under 16 (n=12), the results are as follows SLJ = 2.35 ± 0.21 m; VJ = 42.42 ± 8.58 cm; 30 m = 3.79 ± 0.34 sec., BOMBT = 3.09 ± 0.74 m; SSPMBT = 2.95 ± 0.11 m; mean ± SD, respectively.

Variational analysis – athletes under 14 (n=38) Table 1

	n	X min	Xmax	R	X	S	V	As	Ex
SLJ	38	1,45	2,57	1,12	1,8015789	0,28	15,35	0,956 *	0,522
VJ	38	25	46	21	31,868421	6,04	18,94	1,153*	0,278
30m	38	3,41	5,4	1,99	4,5002632	0,54	11,91	-0,331	-0,652
BOMBT	38	1,2	3,5	2,3	2,0128947	0,54	26,63	0,959*	1,442
SSPMBT	38	0,91	3,4	2,49	1,7060526	0,51	29,76	1,149*	1,94 *

Variational analysis – athletes under 16 (n=12) Table 2

	n	X min	Xmax	R	X	S	V	As	Ex
SLJ	12	2	2,7	0,7	2,3508333	0,21	8,79	0,156	-0,138
VJ	12	32	60	28	42,416667	8,58	20,22	0,629	-0,093
30 m	12	3,25	4,38	1,13	3,7891667	0,34	8,85	0,051	-0,617
BOMBT	12	2	4,6	2,6	3,0875	0,74	23,92	0,426	0,26
SSPMBT	12	1,8	4,1	2,3	2,9458333	0,71	24,21	0,334	-0,512

Correlation analysis – athletes under 14 (n=38) Table 3

	SLJ	VJ	30m	BOMBT	SSPMBT
SLJ	1				
VJ	0,925**	1			
30m	-0,882**	-0,858**	1		
BOMBT	0,785**	0,717**	-0,706**	1	
SSPMBT	0,777**	0,767**	-0,662**	0,856**	1

Correlation analysis – athletes under 16 (n=12) Table 4

	SLJ	VJ	30 m	BOMBT	SSPMBT
SLJ	1				
VJ	0,753**	1			
30 m	-0,906**	-0,758**	1		
BOMBT	0,004	0,023	-0,058	1	
SSPMBT	-0,177	0,099	0,048	0,651*	1

Tables 3 and 4 show a correlation analysis between the studied indicators. There are notable correlational dependencies among the studied indicators, with particularly significant associations observed between jumps and sprints.

5. Discussion

Researchers have explored the effects of dynamic versus static stretching across various domains [2],[7],[9].

López et al. (2021) [2] conducted a study with thirteen healthy female athletes handball players, who trained three times per week. At the beginning of the competitive season, they underwent an assessment following eight weeks of conditioning. During stretching exercises, participants experienced one of three conditions in random order: 1.) Control (CON), where they sat and rested for 6 minutes. 2.) Static stretching (SS), which involved a 6-minute static stretching protocol. 3.) Dynamic stretching (DS), where participants engaged in dynamic stretching exercises for 6 minutes. Each experimental trial, regardless of the condition, lasted approximately 11 minutes in total.

The study by López et al. findings endorses the effectiveness of dynamic stretching (DS) in a warm-up routine to prevent a decline in power output during repeated cycling sprints. In contrast, an equivalent period of static stretching (SS) did not offer the same advantages. The research suggests that a concise and properly structured warm-up regimen can enhance repeated sprint ability (RSA) in proficient female athletes [2].

A meta-analysis conducted by Takeuchi, K. et al. (2023) [7] examined the impact of both acute and long-term static stretching on muscle-tendon unit stiffness (MTS) in young, healthy individuals. The analysis included 17 papers retrieved from PubMed, Web of Science, and EBSCO databases up to January 6, 2023.

The findings revealed that acute static stretching led to a moderate decrease in MTS, indicating an increased range of motion for joints (effect size = -0.772, Z = -2.374, 95% confidence interval = -1.409 - -0.325, p = 0.018, I2 = 79.098). However, long-term static stretching did not result in a significant change in MTS (effect size = -0.608, Z = -1.761, 95% CI = -1.284 - 0.069, p = 0.078, I2 = 83.061).

Furthermore, the analysis found a correlation between total stretching duration and MTS in acute static stretching (p = 0.011, R2 = 0.28), suggesting that longer stretching durations were associated with greater decreases in MTS. However, such a relationship was not observed in long-term stretching (p = 0.085, R2 < 0.01). Overall, while acute static stretching led to a decrease in MTS and increased joint flexibility, long-term static stretching showed only a tendency towards decreasing MTS [7].

Thomas, E. et al. (2024) manuscript aims to explore whether the order in which stretching exercises are administered affects outcomes related to range of movement (ROM).

A total of 108 participants were divided into five groups. Each group underwent eight sets of unilateral static stretching (SS), with each set lasting 30 seconds followed by a 30-second rest period, focusing on either the knee extensors (KE) or knee flexors (KF). The groups were divided based on the order of stretching: KE first, KF first, KE followed by KF, KF followed by KE, and a control group (CG) without stretching. ROM measurements were taken for both lower limbs before (T0), immediately after (T1), and 15 minutes after the intervention (T2) using passive hip extension (PHE) for KE motion and passive straight leg raise (PSLR) for KF motion.

The results received by Thomas, E. et al. (2024) [9] indicate that the order of exercise administration influences ROM outcomes. ROM significantly increased only for the last stretched muscle in each intervention group. There was no observed crossover effect in the contralateral limb [8].

In a randomized crossover study conducted by Zmijewski, P., et al. (2020), [10] the impact of conventional static and dynamic stretching warm-up routines on repeated-sprint performance was investigated. Thirteen young female handball players engaged in a 5-minute aerobic warm-up session, followed by one of three lower limb stretching protocols: (1) static stretching, (2) dynamic-ballistic stretching, or (3) no stretching, before completing five maximal-effort sprints on a cycle ergometer. The key discovery of this study was that dynamic stretching (DS) incorporated into the warm-up routine significantly improved repeated sprint performance in female handball players. This improvement was achieved through a warm-up regimen consisting of 5 minutes of aerobic exercise followed by 6 minutes of dynamic stretching. This combination provided a more advantageous stimulus for repeated sprint performance compared to alternatives such as 5 minutes of aerobic exercise supplemented with 6 minutes of static stretching (SS) or a 6-minute passive rest period. Although the observed effects were modest, they were still noteworthy, with improvements of 3.3% and 3.0% respectively.

The findings of this study endorse the incorporation of dynamic stretching (DS) into warm-up routines as an effective strategy to prevent a decline in power output during repeated cycling sprints. Conversely, an equivalent duration of static stretching (SS) did not yield similar benefits. These results offer compelling evidence that a concise and appropriately structured warm-up can enhance repeated sprint ability (RSA) in highly trained female athletes.

And while some authors report a lack of effect on athletic performance with various types of stretching, others categorically report a deterioration in athletic performance with passive stretching that reaches the point of discomfort. Behm and Kibele (2007) [1] conducted research involving ten participants who underwent pre-testing, performing two repetitions of three different stretches to assess range of motion (ROM), and two repetitions each of five different types of jumps. After pre-testing, participants underwent stretching, being stretched four times for 30 seconds each with 30 seconds of recovery for the quadriceps, hamstrings, and plantar flexors at 100%, 75%, and 50% of their perceived onset of discomfort (POD), or a control condition. Five minutes after the stretching or control conditions, they were retested with the same stretches and jumps as the pre-test. The results showed that all three stretching intensities adversely affected jump heights [10].

We are particularly interested in studies examining the relationship between stretching and muscle strength. Thomas, E. et al. (2023) [9], conducted research aimed at reviewing articles that examined the effects of stretching training on muscular strength. Studies were included if they compared the effects of stretching training versus a non-training control group, or stretching training combined with resistance training (RT) versus an RT-only group, after at least 4 weeks of intervention. A total of 35 studies (with 1,179 subjects) were included, with interventions lasting an average of 8 weeks (ranging from 4 to 24 weeks), conducted 3-4 days per week, with approximately 4 sets of stretching lasting around 1 minute each.

The meta-analysis comparing stretching versus a non-training control group revealed a significant small effect in improving dynamic strength ($k = 14$; $ES = 0.33$; $p = 0.007$), but not isometric strength ($k = 8$; $ES = 0.10$; $p = 0.377$), with static stretching programs ($k = 17$; $ES = 0.28$; $p = 0.006$). When stretching was added to RT interventions, the main analysis indicated no significant effect ($k = 17$; $ES = -0.15$; $p = 0.136$).

Nonetheless, moderator analysis indicated that engaging in stretching prior to resistance training sessions resulted in a slight adverse impact ($k = 7$; $ES = -0.43$; $p = 0.014$), with meta-regression revealing a notable negative correlation with study duration ($\beta = -0.100$; $p = 0.004$). Chronic static stretching protocols marginally enhanced dynamic muscular strength. However, performing stretching before RT and for an extended period (>8 weeks) could moderately blunt strength gains. Stretching sessions separated from RT sessions might be a strategy to avoid hindering strength development [8].

For us as researchers and specialists, the study of the effectiveness of different stretching methods in the warm-up and cool-down of jumpers and runners is of interest. The present article is part of the study of the accumulation of the effect of the application of the methodologies expressed in the functional tests commented on above.

6. Conclusions

Incorporating dynamic stretching before workouts and static stretching during cool-downs helps maintain optimal muscle length-tension relationships, ensuring sprinters and jumpers are primed for peak performance while mitigating the risk of overuse injuries. Overall, stretching is indispensable for sprinters and jumpers, contributing to their success on the track and in the field while safeguarding their long-term athletic well-being.

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