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FUNCTIONAL ASSESSMENTS OF TRACK AND FIELD ATHLETES FOR RELATIVE SHORTNESS IN PARTICULAR MUSCLES

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Abstract *This article contributes to a project focused on crafting stretching exercise regimens tailored for runners and jumpers. The aim is to enhance the extensibility of muscles prone to shortening, particularly targeting specific muscles in the lower limbs, as well as the trapezius and paravertebral muscles. The program targets specialists in sports training and kinesiotherapy, benefiting from its application. The study cohort comprises adolescent track and field athletes. Subjects undergo testing to identify muscle shortening in various muscle groups, including the lower extremities (such as "m.iliopsoas", "m.soleus, m. rectus femoris", and biceps femoris, semitendinosus and semimembranosus muscle group), as well as the paravertebral muscles and "m. trapezius". Identifying muscle shortening among adolescent track and field athletes will enhance the development of stretching programs for warm-up and cool-down routines specifically tailored to runners and jumpers in track and field events.*

Key words: *Adolescent track and field athletes, Physiotherapy tests for shortness of muscles.*

1. Introduction

Stretching is paramount in the training regimen of sprinters and jumpers, and it is pivotal for enhancing performance and reducing the risk of injuries. These athletes rely heavily on explosive power, speed, and flexibility, 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.

According to Opplert, J., & Babault, N. (2018). 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 emphasize the presence of conflicting findings from

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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 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 [9].

2. Research Methodology

The objective of this study is to enhance the extensibility of muscles prone to shortening, particularly targeting specific muscles in the lower limbs, as well as the trapezius and paravertebral muscles. The study cohort comprises adolescent track and field athletes. Subjects undergo testing to identify muscle shortening in various muscle groups including the lower extremities such as m iliopsoas triceps surae *m. soleus m. rectus femoris* and biceps femoris semitendinosus and semimembranosus muscle group), as well as the paravertebral muscles and *m. trapezius.*

We have utilized the following assessments to evaluate the specified muscles.

The soleus muscle shortening test evaluates flexibility in the soleus, which is essential for proper ankle dorsiflexion during movements like squatting. Here's how the test is performed:

Starting Position: The test subject stands barefoot, with feet hip-width apart and parallel, ensuring the heels (posterior portion of the foot) are flat on the floor.

Movement: The subject is instructed to squat down slowly, keeping their torso upright and maintaining the heels fully in contact with the floor throughout the movement.

Assessment: The goal is to reach a deep squat position (knees bent to at least 90 degrees) while keeping the heels on the ground.

The soleus is considered shortened if: The test subject cannot perform the squat without their heels lifting off the ground. The inability to keep the heels down suggests limited ankle dorsiflexion, indicating tightness or shortening in the soleus muscle.

A shortened soleus limits deep squatting and restricts smooth ankle movement during activities that require bending.

2.1. *M. rectus femoris* shortness test

The rectus femoris shortening test assesses flexibility in the rectus femoris, part of the quadriceps muscle group that crosses both the hip and knee joints. Here's how the test is performed:

Starting Position: The subject stands upright or lies prone (face down) with the legs extended.

Movement: The subject bends one knee, aiming to bring the heel as close to the buttock as possible. This movement stretches the rectus femoris, which is responsible for both hip flexion and knee extension.

Assessment: The range of motion at the knee is observed, specifically how close the heel comes to the buttock without compensatory movements like arching the back or shifting the pelvis.

The rectus femoris is considered shortened if: Knee flexion is limited, and the subject cannot bring the heel close to or in contact with the buttock. The subject experiences tightness or resistance during the movement, which prevents full knee flexion. Compensation, such as an anterior pelvic tilt or arching of the lower back, occurs as they try to reach the buttock.

2.2. ***Hamstring*** shortness test

The hamstring shortening test assesses the flexibility of the hamstrings, which include the biceps femoris, semimembranosus, and semitendinosus muscles. Here's how the test is performed:

Starting Position: The subject lies on their back (supine position) with legs extended and arms relaxed by their sides.

Movement: The subject actively flexes one hip joint (lifts the leg upward) while keeping the knee fully extended (straight) and the opposite leg flat on the ground. The goal is to raise the leg as high as possible without bending the knee.

Assessment: The test measures how far the leg can be lifted while maintaining a straight knee. Normally, the leg should reach a hip flexion angle of 70-80 degrees (close to vertical).

The hamstrings (biceps femoris, semimembranosus, and semitendinosus) are considered shortened if: The subject is unable to achieve at least 70-80 degrees of hip flexion while keeping the knee straight. The movement is restricted by tightness or discomfort in the back of the thigh, limiting the ability to lift the leg fully. Compensatory movements, such as bending the knee or tilting the pelvis, occur during the test.

Shortened hamstrings restrict hip flexion and can cause issues with posture, flexibility, and movements requiring a full range of motion, such as bending or squatting.

2.3. ***Hip adductors*** shortness test

The hip adductor shortening test, performed in a dorsal supine position, assesses the flexibility of the adductor muscles. Here's a step-by-step description:

Positioning: The patient lies flat on their back (dorsal supine position) with their hips and knees bent.

Movement. One leg is kept stationary, while the other knee can drop outwards (adducted) to the side, moving towards the table or floor.

Assessment. As the leg is moved outward, the range of motion and resistance are observed. Normally, the knee should drop towards the surface without significant restrictions or tightness.

The hip adductors are considered shortened if There is a limited range of motion, and the knee cannot drop near the surface or stay elevated; the movement is restricted or resisted early, indicating tightness in the adductor muscles.

2.4. ***Upper trapezius*** shortness test

Positioning: The patient is seated while the practitioner stands behind.

Movement. The practitioner compares which side-bending maneuver yields a greater range and checks if the neck can easily achieve 45° of side flexion in each direction, as it should.

Assessment. If neither side can achieve this degree of side-bending, it suggests that both trapezius muscles are likely short. The practitioner then assesses the relative shortness of one trapezius muscle compared to the other.

3. Data analysis and Interpretation

Fifty athletes aged between 9 and 16 were examined. After testing all 50 athletes, it was determined that there was no observed shortening of the paravertebral muscle group and the iliopsoas muscle.

3.1. Shortening testing of m. soleus

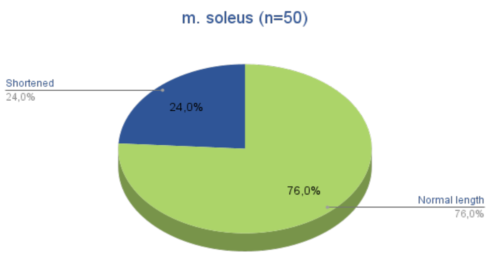

Fig 1. *Shortening testing of “m. soleus”*

Nearly a quarter (24%) of the studies in our group show a shortening of the soleus muscle. This percentage is concerning, especially given the muscle's crucial role in jumping-related activities.

While running, the soleus muscle, being the primary plantar flexor, produces most of the mechanical work by actively shortening. On average, the soleus, gastrocnemius medialis, and gastrocnemius lateralis comprise approximately 52±3%, 32±2%, and 16±2% of the total triceps surae (TS) muscle volume, respectively. Additionally, they account for 62±5%, 26±3%, and 12±2% of the total triceps surae physiological cross-sectional area (PCSA), respectively [1].

3.2. Hamstring shortness test

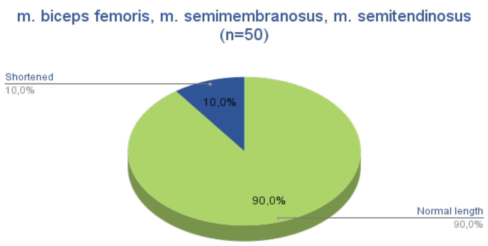

Fig 2. *Hamstring shortness test (“m. biceps femoris”, “m. semimembranosus”, m. semitendinosus”*)

Ten percent of the research group showed shortening of the hamstring muscles. However, this rate is lower than the prevalence of soleus muscle shortening, though muscle shortening increases the risk of injury to the hamstring muscles. Biceps femoris injuries are particularly common among runners and jumpers. Therefore, maintaining normal hamstring length is essential for athletes to prevent such injuries.

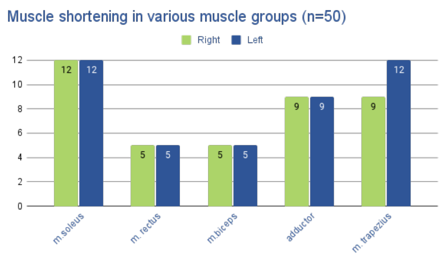

Fig 3. *Muscle shortening in various muscle groups*

Figure 3 illustrates the prevalence of muscle group shortening among the studied contingent (n=50). The highest number of athletes examined—12 (24%)—had shortening of the soleus muscle, followed by the trapezius muscle (18-24%), hip adductors (18%), and both the anterior and posterior thigh muscle groups (each 10%).

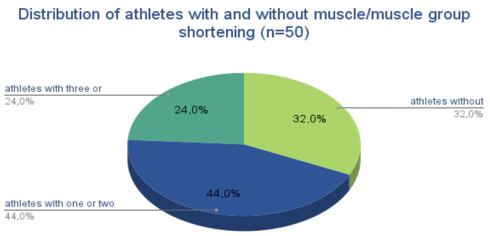

Fig 4. *Distribution of athletes with and without muscle/muscle group shortening in various muscle groups*

Figure 4 shows the distribution of athletes with and without muscle shortening. In 32% of cases, no muscle shortening was observed in the muscle groups studied. Meanwhile, 44% of the athletes had shortening in one or two muscle groups, and 24% had shortening in three or more muscle groups.

The results highlight the need for a comprehensive stretching program to prevent and address existing muscle length deficits in athletes, ensuring the maintenance of normal length in specific muscle groups.

4. Discussion

Overall, the issue of injuries in adolescent athletes is not thoroughly addressed in the scientific literature.

Zemper E. (2005) aims to study the existing literature on injuries to youth (< or =18 years old) in track and field or athletics.

Only nine prospective or retrospective studies were identified that focused on track and field injuries in children and reported injury rates or enough data to estimate them. Variations in study design and inconsistencies in defining a reportable injury made it challenging to compare or combine findings. However, available data suggest that most injuries involve lower extremities, with muscle strains and ligament sprains being the most common types. Although many injuries occur during training due to higher exposure, the risk of injury during competitions is approximately four times greater. The conclusion is that effective injury prevention in youth track and field relies on the quality of foundational epidemiological data, which is currently lacking. Given the large number of participants and diverse activities in track and field, conducting well-designed epidemiological studies is challenging [10].

Running is a bouncing gait in which the body's center of mass slows and lowers during the first half of the stance phase, then accelerates forward and upward into flight in the second half. Muscle-driven simulations can help analyze how muscle forces contribute to these accelerations. However, such simulations for different running speeds had not been developed before, making it unclear how muscles adjust to varying speeds. Hamner, S. R., & Delp, S. L. (2013) aimed to study this by creating three-dimensional muscle simulations of ten subjects running at speeds of 2.0, 3.0, 4.0, and 5.0 m/s, using acceleration analysis to determine how each muscle influences center-of-mass accelerations. The analysis of the simulations showed that the soleus muscle provides the most significant upward acceleration of the body's center of mass at all running speeds. At 5.0 m/s, the soleus generates a peak upward acceleration of 19.8 m/s^2, equivalent to about 2.0 times bodyweight in ground reaction force. It also contributes the most to forward acceleration, increasing from 2.5 m/s^2 at 2.0 m/s to 4.0 m/s^2 at 5.0 m/s. [7].

A study by Malliaropoulos *et al.* [8] explored the hypothesis that a previous inversion ankle injury significantly increases the likelihood of an athlete sustaining a subsequent hamstring injury on the same side, and vice versa. In a 17-year observational cohort study (1998-2015) involving 367 elite track and field athletes, participants were categorized based on their initial isolated ankle or hamstring injury. Among them, fifty athletes sustained both types of injuries. The results indicate that athletes with a prior ankle injury had a statistically higher likelihood of later sustaining a hamstring injury compared to those whose first injury was to the hamstring ($\chi^2 = 4.245$, $p = 0.039$). The rates of ankle and hamstring injuries were similar between female (18%) and male (11%) athletes, with age and injury severity showing no effect on the likelihood of these injuries occurring. The study concludes that elite track and field athletes with a prior ankle ligament injury have a significantly higher frequency of hamstring injuries [8]. Our study revealed a tendency for soleus and hamstring shortening to occur together.

Gervasi, M., et al. (2022) examined the relationship between muscle-tendon stiffness and drop jump performance in young male basketball players.

The relationship between stiffness and drop jump performance across different stages of athlete development remains largely unexplored. This study aimed to assess the association between the stiffness of the patellar and quadriceps tendons (PT, QT), gastrocnemius-Achilles tendon unit (GAT), and rectus femoris (RF) with drop jump (DJ) performance in young basketball players. In a study of 73 male basketball players aged 12 to 18, stiffness levels of the gastrocnemius-Achilles tendon (GAT), patellar tendon (PT), quadriceps tendon (QT), and rectus femoris (RF) were measured in both limbs. Pearson correlation analysis revealed a significant association between drop jump (DJ) performance and the dynamic stiffness of PT, QT, GAT, and RF. Younger participants had lower stiffness values compared to older ones, indicating that muscle and tendon stiffness, which influences the stretch-shortening cycle, increases with maturation. Further research could explore how training impacts muscle and tendon stiffness in developing athletes [5].

Allam, N. M. *et al*. [2] investigated the relationship between hamstring muscle tightness and the occurrence of low back pain among female students at Jouf University in Saudi Arabia. The study included 100 female participants with hamstring tightness of at least 15 degrees. Hamstring shortening was assessed using the Active Knee Extension (AKE) test and the Straight Leg Raising (SLR) test, while the level of functional disability was measured using the Oswestry Disability Index (ODI).

The Straight Leg Raising (SLR) test and Active Knee Extension (AKE) of the dominant leg showed significantly greater flexibility compared to the non-dominant leg. There was a weak, non-significant positive correlation between the Oswestry Disability Index (ODI) and AKE on both the dominant ($r = 0.162$, $p = 0.1$) and non-dominant sides ($r = 0.071$, $p = 0.48$). Additionally, a weak, non-significant negative correlation was found between ODI and SLR for both the dominant ($r = -0.29$, $p = 0.77$) and non-dominant sides ($r = -0.53$, $p = 0.6$). The study found no relationship between the degree of hamstring tightness and low back pain (LBP) in female students at Jouf University [2].

The study by Joźwiak, M., et al. (1997) is significant for its investigation into age-related characteristics of the foot and hamstrings in adolescents.

A study conducted with a population of 920 healthy children sought to assess the incidence of tightness in the hamstring muscles and plantar flexors, as well as to examine the correlation of these symptoms with gait, posture, and low back discomfort or pain. The researchers focused on the popliteal angle and dorsal foot flexion in their assessments. The researchers paid special attention to the popliteal angle and dorsal foot flexion. The borderline values for the popliteal angle were as follows: for boys, 40 degrees for ages 3 to 5, 50 degrees for ages 6 to 15, and 40 degrees for ages 16 to 19; for girls, 30 degrees for ages 3 to 5, 45 degrees for ages 6 to 14, and 30 degrees for ages 15 to 19. The borderline values for dorsal foot flexion were 7 degrees for ages 3 to 4, 10 degrees for ages 5 to 13, and 5 degrees for ages 14 to 19. The findings indicated a natural increase in hamstring tightness, especially just before the pubertal growth spurt, which appears to be associated with the normal development of lumbar lordosis and pelvic tilt. When hamstring tightness exceeded the borderline values, it led to decreased dorsiflexion and lumbar lordosis, resulting in postural deformities, forward bending deficits, discomfort while sitting, and a shuffling gait [5]. When interpreting the results, it is important to consider the measurement methodology to ensure comparability of the findings.

Our literature review found insufficient research on the prevalence of muscle tears in adolescent athletes. Additionally, the impact of these injuries on sports performance and the underlying risk factors for trauma remain understudied.

5. Conclusions

Only 24% of the tested athletes showed no signs of muscle or muscle group shortening, while 32% exhibited shortening in three or more muscles/muscle groups. Identifying muscle shortening among adolescent track and field athletes will facilitate the design of stretching programs for warm-up and cool-down routines customized for runners and jumpers in track and field events.

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