Research Paper

Effects of a 6-week High-intensity Resistance and Stretching Program on Football Performance in Novice Players: A Randomized Controlled Trial

Hussein Ziab[1*], Hani Deeb[1], Hassan Deeb[1], Rami Mazbouh[2]

1. Department of Physical Education, Faculty of Education, University of Sciences and Arts in Lebanon, Beirut, Lebanon.
2. Department of Physiotherapy, Faculty of Public Health, Lebanese University, Beirut, Lebanon.

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ABSTRACT

Purpose: This study aimed to assess the effects of a 6-week training program that combined stretching and strength exercises on the performance of novice football players aged 15 to 18 years.

Methods: A double-blind randomized controlled trial (RCT) was conducted with 46 participants divided into four groups: A) dynamic high-intensity resistance training (DHIRT) (n=12), B) static stretching (n=13), AB) Combined DHIRT+stretching (n=11), and C) control (n=10). Performance outcomes included vertical and horizontal jump (VJ and HJ) distances, running speed (RS), acceleration (ACC), endurance (VO_2 max), shooting speed (SS), and heart rate (HR). Repeated-measures analysis of variance (ANOVA) and post-hoc analyses were used to assess group differences and time effects.

Results: A repeated-measures ANOVA showed a significant effect of time (η^2=0.827) and a significant time-by-group interaction (η^2=0.418), indicating substantial intervention effects. Pairwise comparisons revealed that the combined training group (AB) demonstrated statistically significant improvements over the control group (C) in HJ (P=0.003), RS (P=0.003), VO_2 max (P=0.000), endurance (P=0.000), SS (P=0.018), and ACC (P=0.000). Vertical jump (VJ) improved by 2.97%, HJ by 6.85%, and VO_2 max by 5.83% in the combined Group. No significant intergroup differences were observed in HR (P>0.05).

Conclusion: Combining DHIRT and static stretching is more effective than either intervention alone for improving football-related physical attributes in novice players.

*** Corresponding Author:**
Hussein Ziab
Address: *Department of Physical Education, Faculty of Education, University of Sciences and Arts in Lebanon, Beirut, Lebanon.*
Phone: *+96 (17) 0804130*
E-mail: *houssein.ziab@gmail.com*

Highlights

- Combined DHIRT and static stretching significantly improved jump height and distance.
- VO_2 max increased most in the combined training group after 6 weeks.
- ACC and RS showed the greatest improvement in the combined Group.
- SS did not significantly improve in any of the Group.

Plain Language Summary

Young football players often need to improve their strength, speed, and flexibility. This study evaluated a 6-week training program to determine the most effective approach: Resistance training, stretching, or a combination of both. Forty-six male participants aged 15-18 were divided into four groups. One group received only strength training, another only stretching, one Group received both, and the last Group received no intervention. At the end of the program, the players who performed both strength training and stretching exercises showed the most improvement. They jumped higher, ran faster, had better endurance, and performed better overall. This indicates that combining the two training methods is more effective than using either one alone. The players' shooting speed (SS) and heart rate (HR) did not change significantly, regardless of the program they followed. Why does this matter? Many football coaches and physical educators wonder how to develop more effective training plans for young athletes. This study provides a clear answer: A mix of strength and stretching exercises can lead to faster, stronger, and more agile players without the need for complicated or expensive equipment.

Introduction

Several studies have evaluated the impact of various training protocols on football players' performance and injury risk. Stretching and resistance training are two vital techniques that have been widely studied and recommended as key components of a training session, either before competition or after a sports injury, due to their impact on speed and force generation, which are crucial issues in competitive sports [1, 2].

Static stretching exercises (SSE) are commonly used in many warm-up protocols [3, 4], especially in sports that require flexibility. Static stretching involves positioning the joints or limbs so that the muscles and connective tissues are stretched to their maximum length. Stretching should last 15-30 seconds [5]. However, no agreement exists in the literature on the true effect of SSE; several authors have recommended using SSE to lightly increase flexibility joints range of motion (ROM) (studies reported minimal increase in the ROM after SSE) [6, 7] and reduce the risk of injuries [8, 9], as well as influencing several performance variables, such as sprinting [10, 11], jumps [12, 13], football skills (e.g. kicking and striking) [14], balance, and reaction time [15, 16]. SSE, on the other hand, has been shown in recent studies to hurt athlete performance by reducing strength [17–19], force [17, 18, 20], and speed [21]; however, it does not reduce the risk of injury [8, 22, 23]. Therefore, it should be avoided during warm-up routines [17, 18]. Deficits in muscle force have usually been attributed to delayed onset muscle soreness and damage to contractile proteins in skeletal muscles [24].

Strength exercises, on the other hand, have been shown in several studies to improve the performance of football players [25–27]. In a highly competitive sport, the primary goal of strength training is to improve players' specific and relevant athletic performance inherent to their sport. In this context, different variables must be considered when designing a resistance training protocol; one of the vital factors that has been extensively studied is the load. Research indicates that lower extremity strength training protocols, either low-load with high repetition and high velocity training (10-30% one-repetition maximum [1RM]) [28, 29] or maximal or supramaximal loads (120-150% 1RM) [30, 31], are effective in improving football players' sports abilities. Accordingly, the authors of the current study used dynamic high-intensity resistance training (DHIRT), which involves applying loads between 60-80% of an individual's 1RM, and has been linked to significant neuromuscular adaptations [32]. These include increased rate of force development, improved motor unit synchronization, and enhanced muscle fiber recruitment, particularly in type II (fast-twitch) fibers [33].

The selection of 60–80% 1RM in this study was deliberate: This range is known to be effective in enhancing both muscular strength and power without posing excessive risk to adolescent participants [32]. It also distinguishes the protocol from low-load endurance training or hypertrophy-focused programs, making it more relevant to football-specific skills, such as sprinting, jumping, and directional changes.

The authors suggest that when combined, DHIRT and SSE offer both structural and functional benefits, potentially leading to enhanced power output, endurance, and mobility in young athletes. However, to the best of our knowledge, no previous studies have addressed the combination of SSE with DHIRT in the training of novice football players.

Against this backdrop, this study aims to bridge the critical gap in the literature by investigating the combined effects of SSE and DHIRT on the performance of novice football players. In our study, novice players are defined as male adolescents aged 15-18 years who had participated in structured football training for less than three months, with no previous engagement in strength training or competitive-level football. Additionally, these participants did not exceed two football sessions per week in the six months preceding the study. This definition aligns with the criteria used in developmental training research [34].

The novelty of this study lies in its exploration of the synergistic impact of these two training modalities, shedding light on potential benefits or drawbacks that may emerge when employed concurrently. This study aims to contribute valuable insights into the field of sports science by informing training protocols tailored specifically to the unique needs of novice football players. Through an in-depth analysis over a 6-week training cycle, we aimed to elucidate the complex impact of stretching and strength exercises on key performance variables of football players.

Materials and Methods

Design

This single-blinded RCT was conducted to evaluate the effects of DHIRT, SSE, and their combination (DHIRT+SSE) on football-related performance metrics in novice male football players. The assessors were blinded to group allocation to reduce bias. This study adhered to the CONSORT guidelines for reporting clinical trials and was conducted between November and December 2023.

Participants

A Google Form, in which the aims and methods of this study were described, was sent via WhatsApp and email to young male teenagers between the ages of 15-18 years in different football academies across Beirut [35]. To determine whether the applicant was qualified to participate, demographic characteristics (age, weight, height) and specific information about their sports performance (i.e. duration of football practice and strength training bodybuilding) were collected.

Participants were selected according to the following criteria:

1) Novice male football players who had been training for less than 3 months [34]. 2) No history of musculoskeletal injury in the last 6 months. 3) No other health-related problems (i.e. cardiorespiratory or systemic problems) that might affect their sports performance.

Participants who were unable to attend the whole protocol, missed more than two consecutive sessions, or refused to sign the informed consent form were excluded.

To ensure baseline equivalence across groups, independent sample t-tests were conducted for all performance variables before the intervention, confirming no statistically significant differences ($P>0.05$) between groups at baseline.

Sampling and allocation concealment strategies

A priori power analysis was conducted using G*Power software, version 3.1.9.7 to determine the required sample size for this RCT. A pilot study involving five novice football players in each Group (SSE and DHIRT) provided initial data on multiple performance metrics. For each variable, we calculated the mean difference, pooled standard deviation, and Cohen's d to estimate effect sizes (ES). Using a significance level of $\alpha=0.05$ and power of 0.80, the required sample size for each outcome was determined.

To ensure adequate statistical power across all outcomes, we adopted a conservative approach using the largest sample size estimate among all calculated metrics (12 participants per group) as the basis for recruitment. This decision was made to ensure that the study was sufficiently powered to detect meaningful differences, particularly for variables with small ESs. For full details of the power analysis and calculations, please refer to Appendix 1.

Subsequently, all eligible participants were randomly assigned to groups using a concealed allocation process. Group assignments were determined using a computer-generated randomization list and concealed in sealed, opaque, sequentially numbered envelopes prepared by an independent researcher who was not involved in recruitment or assessment. Envelopes were opened only after participants were confirmed eligible, ensuring unbiased group allocation. The groups were as follows: A (DHIRT), B (SSE), AB (combined DHIRT and SSE), and C (control) (Figure 1).

Outcome measures

The football-related skills refer to the ability to perform a motor task with maximum accuracy and minimum energy or time [36]. Accordingly, different variables were assessed in this study, including jump abilities (vertical and horizontal), running abilities (speed, endurance, and acceleration [ACC]), shooting speed (SS), joint mobility, and physiological parameters after effort (maximum oxygen volume [VO_2max] and heart rate [HR]).

To reduce the risk of injury, each participant received a 10 to 15-minute warm-up session before the evaluation. The training included jogging, running with and without the ball, as well as stretching exercises for the hamstrings, quadriceps, and triceps muscles. It is worth noting that the tests were conducted outdoors on artificial grass under dry and warm conditions.

Shoot speed test

Shooting refers to the attempt to score a goal by striking the ball with speed, strength, or accuracy. With sneakers suitable for soccer and using Gabonese football (Conti, circumference of 69.0 cm and mass of 440 g), the assessors asked the participants to shoot the ball at the center of the goal, which was 11 m away, using the foot that they felt was most suitable to successfully complete the task. The test was repeated thrice, and the time of the fastest kick was recorded. Each player was given a minute break between the kicks (Figure 2). A video camera (Sony^{TM}, HDR-PJ20, Japan) with a maximum resolution of 1920 x 1080 px was placed near the imaging area (VC, Figure 2), and time was counted from the moment the participant's foot touched the ball until it reached the goal line [37]. Using the free online "Kapwing" program, the video of each shoot was slowed to a minimum speed, and the first time the player's foot reached the ball was logged, as well as the time the ball crossed the goal line. The total time spent between the two times was then computed. The time displayed on the screen was used as a guide for the measurements. The speed was then measured using the Equation 1:

$$1.\ Velocity(m\backslash s) = \frac{Distance(m)}{Time\ (s)} = \frac{11}{Time\ (s)}$$

where velocity is measured in m/s, and time is extracted from videos in seconds, and the distance is constant for all trials (11 m) [38].

It is worth noting that, according to Murray et al. this method of evaluating RS using 2D video-camera analysis is a reliable technique for measuring speed, with an intraclass correlation coefficient (ICC) of 0.98 [39].

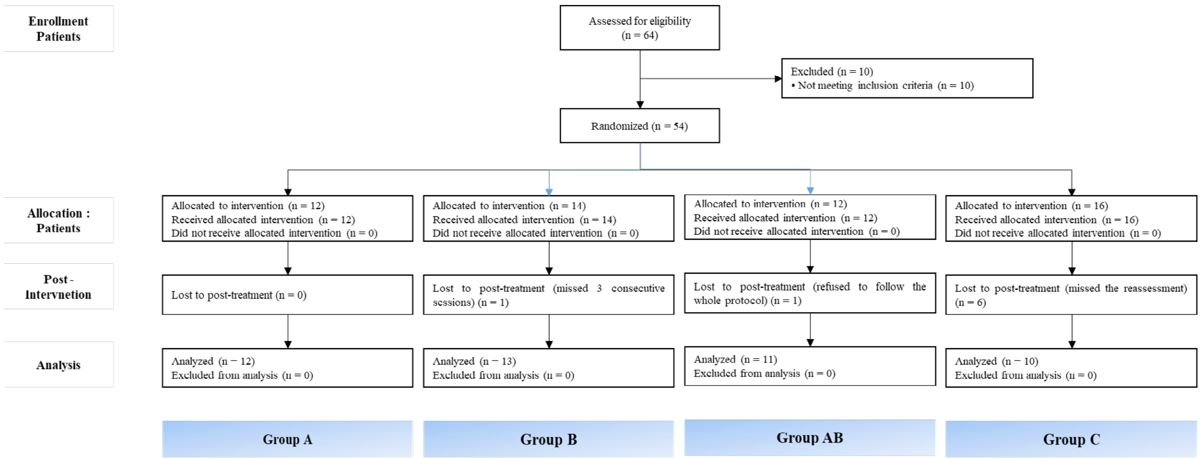

Figure 1. CONSORT flowchart of the study

PHYSICAL TREATMENTS

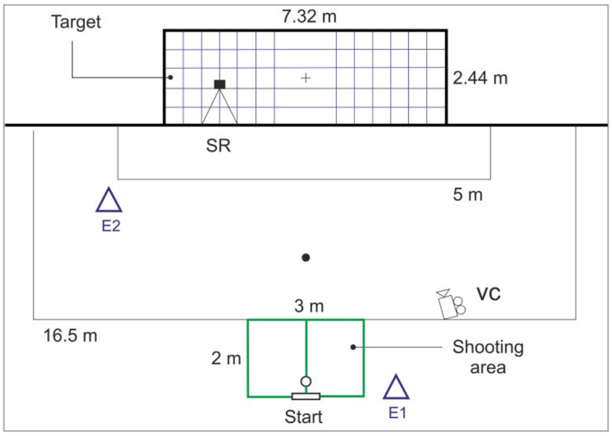

Figure 2. Shot speed test

PHYSICAL TREATMENTS

Endurance

Athlete endurance refers to the ability of an athlete to perform work over an extended period. The "multistage fitness beep test" is a reliable measure of endurance in sports activities; it is a multistage fitness test (MSFT) commonly used as a maximum aerobic fitness test [40] (Figure 3).

This test entails running continuously between two cones 20 m apart at an appropriate time. Participants began by running at a pace that allowed them to cross 20 meters in five seconds, and then they switched directions when instructed by the assessor. If a participant did not reach the line within 5 s, they received a warning and were required to continue running to the line. Following the second warning, the data were recorded by the number of times the participants successfully crossed the line [41].

The RSs

The time taken to run 60 m was computed using an adequate chronometer (Ociodual Chronomètre XL-013) (Figure 4). The RS was then determined using the Equation 2 [38, 42]:

$$2.\ Velocity(m\backslash s) = \frac{Distance(m)}{Time\ (s)} = \frac{60}{Time\ (s)}$$

ACC

ACC performance is critical for athletes in sports that require a high level of repeat sprint ability [43], such as football. The rate of change in velocity is defined as ACC. In practice, however, ACC ability is often referred to as sprint performance over shorter distances, such as 5 m or 10 m. It is measured using sprint time or velocity, particularly among applied sports scientists and coaches.

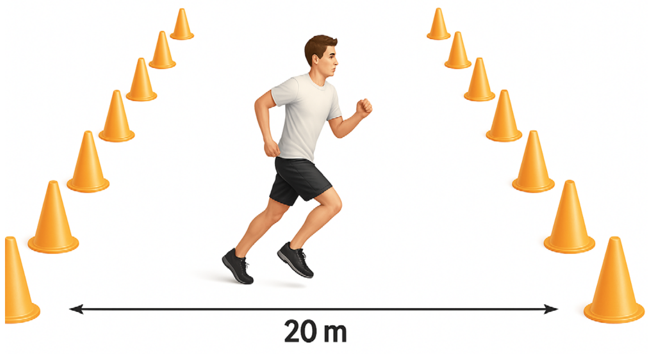

Figure 3. Multistage fitness beep test

PHYSICAL TREATMENTS

Figure 4. Ociodual chronometer XL-013

PHYSICAL TREATMENTS

In the current study, the time spent running 5 m was measured using a digital camera (Sony, HDR. -PJ260, Japan) positioned in the middle of two cones; the first cone was placed at the starting point, and the second cone was placed 5 m away on a 60-m running track. The time was extracted from the video recording using "Kapwing" software. Due to the stability before starting the run, the initial time and speed were considered zero [34]. The ACC was then calculated using the Equations 3, 4 and 5:

$$3.\ Acceleration\left(\frac{m}{s^2}\right) = \frac{Change\ in\ Speed\ \left(\frac{m}{s}\right)}{Change\ in\ Time\ (s)} =$$

$$4.\ = \frac{\Delta v}{\Delta t} = = \frac{v(t_2) - v(t_1)}{t_2 - t_1}$$

With t_1=0, v_1=0.34

Then

$$5. Acceleration\left(\frac{m}{s^2}\right) = \frac{v(t_2) - 0}{t_2 - 0} = \frac{\frac{v(t_2)}{t_2}}{t_2} = \frac{\frac{d}{t_2}}{t_2} = \frac{5}{t_2^2}$$

ACC was measured using video-based timing, which has been validated in previous studies with ICCs exceeding 0.90 when the camera position and frame analysis were standardized [44] (Figure 5).

Vertical and horizontal jumps (HJ)

The vertical jump (VJ) is a test of lower-body strength. Sargent's jump test was performed using a measuring tape attached to the wall. The participant stood close to the wall, with the shoulder fixed at 180° and the elbow fully extended. The athlete jumps vertically at the highest possible level and marks the tape. The distance between the athlete's standing reach height and jumping reach height was recorded. The test was repeated three times and the highest jump was considered [45, 46].

The HJ or long jump is a common and easily managed test used to assess explosive leg strength. A measuring tape was used to measure the distance travelled, and a two-foot take-off and landing was used, with arms swinging and knees folding to provide forward oscillation. The participants were instructed to jump as far as possible and land on both feet together. They were asked to make three attempts to choose the most far-reaching distance [46].

These methods have shown high reliability in adolescent populations, with reported ICC of 0.91–0.97 [47].

Maximum oxygen rate

Maximal oxygen uptake is considered the best indicator of aerobic capacity and maximal cardiorespiratory function [48]. It refers to oxygen consumption during stress tests or when exercising hard [42].

It is a measure of fitness in terms of an individual's ability to tolerate long periods of moderate-to-vigorous physical activity. As a result, a 12-minute Cooper race test was used as a valid and reliable measure of maximum aerobic fitness, with a minimal standard error of estimate (SEE=0.193 mL/kg/min) [49]. It entails asking participants to move as far as they can in 12 minutes and then to record the total distance traveled [50, 51]. Consequently, VO_2max is measured using the Equation 6:

$$6.\ VO2_{max} = (22.35 \times distance\ in\ km) - 11.29$$

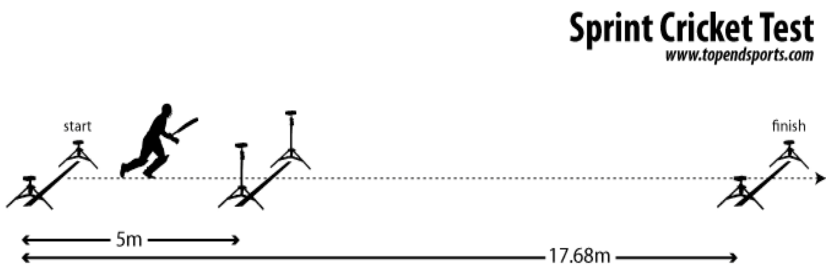

Figure 5. ACC test track

PHYSICAL TREATMENTS

Procedures

Following randomization, participants completed 24 supervised training sessions between November 8 and December 15, 2021. Certified strength and conditioning specialists conducted all sessions, each holding at least a bachelor's degree in physical education and prior experience working with adolescent athletes. To ensure methodological consistency, all trainers were thoroughly briefed and adhered to a standardized intervention protocol, covering exercise technique, load progression, session timing, and instructional delivery. To minimize variability, each trainer was assigned to the same Group throughout the intervention. The final group allocation was as follows:

Group A

The term "high intensity" in this study refers to resistance loads prescribed at 60–80% of the estimated one-repetition maximum. 1RM was estimated using the Brzycki formula [52], a submaximal prediction method validated for use in adolescent populations. This intensity range is consistent with the recommendations of the National Strength and Conditioning Association and the American College of Sports Medicine for high-intensity resistance training in youth [34, 53].

Participants in the DHIRT group followed a push–pull–legs split program, performed four times per week for six weeks. A progressive linear loading model was used, beginning at 60% of estimated 1RM in the first week and increasing gradually by approximately 5% each week, reaching 80% of the 1RM by the final training phase. Load adjustments were made based on weekly performance reassessments and participant feedback, ensuring both progressive overload and safety. The 1RM estimates were updated mid-protocol to accommodate strength gains. All training loads were individualized by muscle group based on the initial strength assessment [33] (Table 1).

Each session began with a 5-minute general warm-up, consisting of running on a treadmill, followed by a very light free-weight warm-up (<20% of RM). Subsequently, one hour of DHIRT was applied.

Group B

Group B consisted of a protocol of SSE of the gross muscles of the whole body with a higher focus on the muscles of the lower extremities (Table 2).

It is worth noting that each exercise was applied for 15 to 30 s, with three repetitions per session. The athlete was instructed to lean on his back in a relaxed position and avoid unnecessary contraction or any risk of injury. In case the athlete felt any pain or unsupported tension, he was instructed to raise his hand, and the trainer immediately stopped the exercise [54].

Group AB

Given that multiple studies have demonstrated the need to design a holistic protocol that improves all aspects of training for athletes to enhance their performance, rather than focusing solely on specific approaches, such as stretching or strength training, the authors combined both protocols in group AB to examine their effect on participants, with the hypothesis that better improvement in fitness-related outcome measures will be recorded when compared to other groups.

Accordingly, the same DHIRT program used in group A was used in this group, with the same intensity and frequency for each exercise. In addition, a global muscle SSE program with a greater focus on muscle strengthening was introduced. Stretching exercises were applied immediately after the strengthening exercises in each session. Each exercise was performed twice.

It is worth noting that if any participants in groups A, B or AB missed a training session, a makeup session was held on Saturdays.

Table 1. The DHIRT protocols [77]

Days	Categories	Muscle groups	Exercises	Sets	Repetitions	Descriptions
Day 1 (Monday)	Push	Pectorals	Barbell bench press	3	10	The athlete grasps the bar with a 1.5 shoulder-width grip, with their thumbs wrapped under the bar, and uses a rack for added safety. He then uncracks the bar and starts with his shoulder blades slightly drawn back and the bar over his mid-chest. When lowering the bar to the chest, keep the elbows out to approximately an inch from the sternum. The forearms should be nearly vertical at this point. The athlete should then drive the bar back to the starting position while keeping elbows loose.
		Deltoids anterior and posterior	Front raise, lateral raise	3	10	Front raise: The athlete stands with their feet hip-distance apart, holding dumbbells in their hands. Then, he must extend his arms straight up and out in front, palms facing behind, until they reach shoulder height, and then slowly return to the starting position. Lateral raise: The athlete stands with his feet hip-distance apart, holding dumbbells in his hands, palms facing inward. Then, with arms bent out to the sides, up and away from the body to about shoulder height, slowly return to the beginning position.
		Triceps brachialis	Cable push-down	2	10	The athlete stands in front of a high pulley, palms down, and grasps the cable attachment with hands slightly wider than shoulder-width. He should maintain a straight back and firm abdominal muscles. He then exhales and lowers the cable with his elbow. He then holds for a second, squeezes, inhales, and returns to the beginning position.
Day 2 (Tuesday)	Legs and Abdominals	Quadriceps	Seated dumbbell leg extensions	3	10	The athlete sits on a quadriceps bench with their back straight and a dumbbell between their feet. The knees were extended to a 90-degree angle; therefore, they were straight and parallel to the ground. The rest of the body should remain stable. He held it a second before gradually lowering the weight back to its original position.
		Hamstring	Lying leg curl	1	10	The trainer adjusts the leg curl machine lever to fit the athlete, who is lying face down on the bench, with the pad of the lever only a few inches under his calves. Then, he grasps the side grips of the machine and flexes his knees as possible while exhaling.
		Ilio-Psoas	Romanian chair leg raises	1	10	The athlete stands straight in the Roman chair, with the lower back firmly pressed against the backrest and forearms resting on the pad. He raises his legs untill they are parallel to the floor by flexing his hips and keeping his knees straight. Return slowly to the starting position and repeat.
		Calf (Triceps Surae)	Seated calf raise with toes pointed outward/inward	2	10	He holds the contraction for three seconds before breathing in and returning the legs to their starting position.
		Abdominals	Crunches	2	10	The athlete lies supine, knees bent and feet flat on the ground. He places his hands behind his head and curls his torso up towards his knees, keeping his back pressed firmly against the ground.
Day 3 (Thursday)	Pull	Back extensors	Reverse grip incline bench cable row	3	10	The athlete lies prone on an inclined bench at a 35–45-degree angle. With his feet on the floor, he grasps a straight bar attached to the lower pulley facing the bench. Then, with his palms, he pulls the bar as far as he can toward his lower chest while exhaling, holds the contraction for 3 seconds, inhales, and lowers the barbell as far as he can.
		Trapezius	Barbell shrugs	2	10	The athlete grips the barbell with a shoulder-width apart stance. He stands straight, exhales, and raises his shoulders toward his ears. Then he squeezes on top for contraction, takes a deep breath, and carefully lowers the barbell back to the beginning position.
		Biceps Brachialis	Ez bar preacher curl	3	10	The athlete sits on the preacher's bench, holding the E-Z Curl Bar at shoulder length and pressing the chest on the preacher's bench. He slowly exhales and raises the weight toward his shoulders. Then he squeezes his bicep on top, takes a deep breath, and lowers the weight back to its initial position.

Days	Categories	Muscle groups	Exercises	Sets	Repetitions	Descriptions
Day 4 (Friday)	Legs and Abdominals	Quadriceps	Seated dumbbell leg extensions	3	10	The athlete sits on a quadriceps bench with his back straight and a dumbbell between his feet. The knees were extended to a 90-degree angle; therefore, they were straight and parallel to the ground. The rest of the body should stay stable. He held it for a second before gradually lowering the weight back to its original position.
		Hamstring	Lying leg curl	1	10	The trainer adjusts the leg curl machine lever to fit the athlete, who is lying face down on the bench, with the pad of the lever only a few inches under his calves. Then, he grasps the side grips of the machine and flexes his knees as much as possible while exhaling.
		Gluteus maximus	Barbell glute bridge	1	10	The athlete is in a supine position, hips and knees flexed, feet hip-width apart, and a few inches in front of the buttocks. The trainer adjusted the bar just above the hip crease. He strongly grips the bar with both hands, exhales slowly, and drives his hips up until he forms a bridge (straight line with the body between the shoulders and knees). Then he squeezes the glutes at the top and holds the contraction for 3 seconds. He then takes a deep breath and lowers himself with control.
		Calf (triceps surae)	Seated calf raise with toes pointed outward/inward	2	10	The athlete sits on the calf bench and places the heels of his feet on the floor, toes pointing outward-inward. Then, he slid his lower thighs under the lever pad of the bench and adjusted it to his thigh height. He then extends his ankles (plantarflexion) and releases his grip from the safety bar. Then, he holds a second on top to contract the calf's muscle efficiently. He then lowers his heels until his calves are fully stretched.
		Abdominals	Crunches	2	10	The athlete lies supine, knees bent and feet flat on the ground. He places his hands behind his head and curls his torso up towards his knees, keeping his back pressed firmly against the ground.

Group C

The control group was included to isolate the effects of the training interventions by providing a reference with no structured physical conditioning. The participants in this Group did not participate in any supervised training or structured exercise sessions during the study. However, they were permitted to continue their usual informal football and physical activity routines, which they had been practicing regularly before the study. This ensured that their activity levels reflected their natural baseline behavior, without introducing new training effects that could influence the outcome measures.

Statistical analysis

Statistical analyses were conducted using SPSS software, version 26 (SPSS Inc., Chicago, Illinois, USA). The normal distribution of data was examined using the Shapiro-Wilk test and Q-Q plot. In addition, an analysis of variance (ANOVA) test was used to compare participants and detect any significant differences at baseline. Moreover, descriptive statistics were calculated for the demographic data using Means±SD.

An independent t-test was used to compare pre and post-tests concerning group allocation. Moreover, comparisons between groups were performed using repeated-measures ANOVA. The level of significance was set at $P<0.05$. Moreover, post-hoc pairwise comparisons were conducted using the Bonferroni correction to adjust for multiple testing and reduce the risk of Type I error

ES was calculated using Partial Eta Squared (η^2). The magnitude of the ESs was classified as small (0.01), medium (0.06), or large (>0.14). A $P<0.05$ was used to detect significance [55, 56].

Results

Descriptive analysis

Initially, 64 participants were enrolled in the study. Ten were excluded because they did not meet the inclusion criteria. Eight participants dropped out during the intervention. The analysis followed a per-protocol

Table 2. SSE protocol [54]

Muscles	Position of Athlete	Exercise	Muscles	Position of Athlete	Exercise
	Day 1			Day 2	
Pectoralis: Clavicular, sternal and pectoral	Supine	Shoulder: ABD, ER Elbow: Ext. Wrist: Ext.	Quadriceps (rectus femurs)	Quadriceps muscle stretch in prone position	Hip: Ext (0-20) Knee: Full flexion
Deltoid: anterior and posterior	Supine	Anterior deltoid: Shoulder: Ext (30) Elbow: semi-flexion (30) Posterior deltoid: Shoulder: Flexion (160) Elbow: semi-flexion (30)	Hamstring	Supine, contralateral limb on bed (extension)	Hip: Flexion (up to 90) with ER, Knee: Ext (up to zero)
Triceps brachialis (long head)	Supine	Shoulder: Flexion, IR Elbow: Flexion	Gluteus maximus	Supine, contralateral limb on bed (extension)	Hip: Fully flexed, ER, adduction, Knee flexion, pelvis stabilized to bed
Adductors of hips	Lying on back with hands wrapped around contralateral knee over the edge of the table	Hip: ABD (40) Ext (10) and ER (10), knee: Flex (10-20)	Ilio-Psoas	Lying on back with hands wrapped around contralateral knee over the edge of the table	Hip: Ext. (20) Knee: Flexion
Gluteus medius	Contralateral side lying on the edge of the table, contralateral knee in flexion for support	Hip in flexion (20) with adduction (45) and knee in extension	Triceps Surae	Prone	Knee and hip: ext., Ankle, dorsiflexion
Tensor Fascia Latae	Lying on back with hands wrapped around contralateral knee over the edge of the table	Lower limb outside the table, hip: ER, Ext to zero, knee: Flexion	External oblique abdominis	Contralateral side lying position on specific cushion under pelvis	Upper arm above head, bottom leg flexed to give support and top leg hangs out over the back the cushion
Obturators	Prone, contralateral limb in extension (neutral position)	Hip: Extension (up to 0) and IR (up to limit of support), knee: Flexion (90)	Intercostals	Lying on back with arm above the head and elbow flexed 90°. The trainer supports the patient's forearm against their body with the aid of their forearm.	Inhalation, exhalation supports stretching
	Day 3			Day 4	
Spinal muscles	Sitting	Spine stretch forward	Quadriceps (rectus femurs)	Quadriceps muscle stretch in prone position	Hip: Ext (0-20) Knee: Full flexion
Superior trapezius	Supine	Neck: Flexion, homolateral rotation and contralateral side bending	Hamstring	Supine, contralateral limb on bed (extension)	Hip: flexion (up to 90) with ER, Knee: Ext (up to zero)
Long head of biceps brachialis	Supine	Shoulder: Ext (40), IR elbow: Ext.	Gluteus maximus	Supine, contralateral limb on bed (extension)	Hip: Fully flexed, ER, adduction, Knee flexion, pelvis stabilized to bed
Adductors of hips	Lying on back with hands wrapped around the contralateral knee over the edge of the table Homolateral limb outside the table (ABD)	Hip: ABD (40) Ext (10) and ER (10), knee: Flex (10-20),	Ilio-Psoas	Lying on back with hands wrapped around contralateral knee over the edge of the table	Hip: Ext. (20) Knee: Flexion

Muscles	Position of Athlete	Exercise	Muscles	Position of Athlete	Exercise
Gluteus Medius	Contralateral side-lying on the edge of the table, contralateral knee in flexion for support	Hip in flexion (20) with adduction (45) and knee in extension	Triceps surae	Prone	Knee and hip: Ext., Ankle, dorsiflexion
Internal rotators	Lying on back with hands wrapped around contralateral knee over the edge of the table Homolateral limb outside the table	Hip: ER, Ext to zero, knee: Flexion	External oblique abdominis	Contralateral side lying position on specific cushion under pelvis	upper arm above head, bottom leg flexed to give support and top leg hangs out over the back of the cushion
External rotators	Prone, contralateral limb in extension (neutral position)	Hip: extension (up to 0) and IR (up to limit of support), knee: Flexion (90)	Intercostalis	The patient was lying on the back with the arm above the head and the elbow flexed at 90°. Trainer supports patient's forearm against own body with the aid of own forearm.	Inhalation, and exhalation support stretching

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design, including only participants who completed the full intervention protocol and attended at least 90% of the training sessions. Dropouts were excluded from the final analysis to preserve the integrity of intervention effect estimates Finally, the outcomes of 46 participants were analyzed. The mean age, weight, and height of the participants were 16.54 years, 69.1 kg, and 174.7 cm, respectively (Table 3). Figure 1 shows the CONSORT flowchart of this study.

To validate statistical assumptions, the Shapiro–Wilk test showed that all performance variables at baseline were normally distributed (P>0.05) (Appendix 2). This was further supported by visual inspection of histograms and Q–Q plots, which indicated approximate normality across variables. Although the P for endurance at baseline was at the threshold (P=0.050), the sample size (n=46) provided sufficient robustness through the Central Limit Theorem, supporting the use of parametric tests.

Baseline comparability among groups was also confirmed: No significant differences were found in demographic variables (age, height, and weight) across the four groups (P>0.05) as assessed by one-way ANOVA (Tables 4 and 5, Appendix 3).

The repeated measures ANOVA multivariate analysis revealed significant differences between and within groups (P<0.05). Accordingly, the univariate tests revealed significant changes in all variables except SS in the within-group analysis (time comparison) and HR in the between-group analysis.

Additionally, a significant time * group interaction was observed in the within-group analysis of different variables (i.e. HJ, VJ, RS, and hip ROM), indicating the superiority of one Group over the others across time (Table 6).

Table 3. Demographic variables of the participants

Groups	No.	Mean±SD		
		Age (y)	Height (cm)	Weight (kg)
A	12	17.08±0.95	176.25±9.85	68.41±12.77
B	13	16.38±1.19	172.3±4.99	69.23±13.4
AB	11	16.91±0.94	175.67±5.16	67.83±7.2
C	10	15.75±1.03	173.25±6.5	66.75±8.5
Total	46	16.54±1.1	174.7±6.9	69.1±10.67

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Table 4. Multivariate analysis using repeated measures ANOVA

Effect	Wilks' Lambda	F	Sig.	Partial Eta Squared
Between Subjects – Group	0.214	2.501	.001	0.402
Within Subjects – Time	0.173	17.585[b]	.000	0.827
Time × Group Interaction	0.198	2.667	.000	0.418

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Wilks' Lambda is a multivariate test statistic. Lower values indicate a greater group effect across multiple dependent variables. Partial eta squared values indicate large effects per conventional thresholds (>0.14).

Furthermore, as shown in Table 6, large ESs were reported, revealing the great impact of the three interventions on all participants in all groups (0.402 $\leq\eta^2\leq$ 0.827).

A comparison between groups is presented in the abovementioned graphs using post-hoc testing for all variables. Group comparisons are represented by the horizontal axis (x-axis), and the P is represented by the vertical axis (y-axis).

The pairwise comparison between groups, on the other hand, revealed that the participants in Group AB improved more significantly than those in the other groups. Table 2 shows that Group AB differed significantly from Group C in the HJ, RS, SS, endurance VO_2max, and ACC variables (P<0.05). Similarly, for endurance and VO_2max, Group AB outperformed Groups A and B. Moreover, Group A outperformed Group C in terms of RS and VO_2max, and Group B outperformed Group C in ACC. These findings were confirmed using a post-hoc test (Table 5, Figure 6).

Table 5. Comparing the mean values of variables before and after training

Groups	Mean±SD					
	VJ (cm)		Horizontal Jump (cm)		Speed of running 60 m (m/s)	
	Before	After	Before	After	Before	After
A	261.46±13.03	269.00±13.46	209.25±27.04	222.42±36.37	6.65±0.54	6.86±0.52
AB	266.27±8.17	274.18±8.89	233.64±29.71	249.64±30.16	6.99±0.67	7.33±0.59
C	261.00±16.49	260.25±17.29	189.80±30.91	189.60±32.14	6.06±0.93	5.91±0.80
B	256.35±10.50	262.69±12.98	201.54±31.45	219.38±31.34	6.51±0.73	6.65±0.66
Total	261.07±12.38	266.55±13.98	208.67±32.80	220.93±37.62	6.56±0.77	6.70±0.79

Groups	Mean±SD							
	Speed of Shoot (m/s)		Endurance (reps)		VO_2max (mL/kg/min)		ACC (m/s²)	
	Before	After	Before	After	Before	After	Before	After
A	18.40±2.79	18.25±3.17	8.83±3.01	9.58±4.19	29.62±7.24	32.39±6.71	2.35±0.92	2.46±0.76
AB	21.10±3.43	21.46±3.18	14.82±7.29	16.18±6.48	38.6110.12	40.86±8.75	2.94±0.57	3.05±0.58
C	16.85±2.84	16.63±2.58	6.00±2.54	6.40±3.41	19.12±10.00	20.18±8.93	1.70±0.45	1.69±0.42
B	19.67±3.85	20.59±4.22	8.00±3.51	10.15±3.83	23.82±8.94	24.49±9.80	2.58±0.83	2.67±0.83
Total	19.02±3.51	19.28±3.78	9.41±5.39	10.63±5.63	27.85±11.30	29.53±11.40	2.42±0.83	2.49±0.82

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Table 6. Pairwise comparisons of repeated ANOVA results (Bonferroni-adjusted P)

Measure	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.	Post-hoc Test
VJ	A	B	5.71	5.095	1	0.679
		AB	-4.346	5.449	1	0.855
		C	4.604	5.449	1	0.833
	B	AB	-10.056	5.353	0.405	0.253
		C	-1.106	5.353	1	0.997
	AB	C	8.95	5.692	0.741	0.405
HJ	A	B	5.372	12.439	1	0.973
		AB	-25.167	13.304	0.394	0.247
		C	26.133	13.304	0.338	0.218
	B	AB	-30.538	13.069	0.147	0.106
		C	20.762	13.069	0.719	0.396
	AB	C	51.300*	13.896	0.004	0.003
SR	A	B	0.174	0.27	1	0.917
		AB	-0.363	0.289	1	0.595
		C	0.762	0.289	0.07	0.055
	B	AB	-0.537	0.284	0.393	0.247
		C	0.588	0.284	0.266	0.179
	AB	C	1.125*	0.301	0.003	0.003
SS	A	B	-1.808	1.312	1	0.52
		AB	-2.956	1.404	0.248	0.168
		C	1.584	1.404	1	0.674
	B	AB	-1.148	1.379	1	0.839
		C	3.393	1.379	0.109	0.082
	AB	C	4.541*	1.466	0.021	0.018
EN	A	B	0.131	1.806	1	1
		AB	-6.392*	1.932	0.012	0.01
		C	3.008	1.932	0.763	0.414
	B	AB	-6.523*	1.898	0.008	0.007
		C	2.877	1.898	0.823	0.438
	AB	C	9.400*	2.018	0.000	0.000

Measure	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.	Post-hoc Test
VO_2max	A	B	6.849	3.554	0.365	0.233
		AB	-9.052	3.801	0.132	0.097
		C	11.354*	3.801	0.028	0.024
	B	AB	-15.901*	3.734	0.001	0.001
		C	4.504	3.734	1	0.626
	AB	C	20.405*	3.97	0.000	0.000
ACC	A	B	-0.219	0.282	1	0.864
		AB	-0.659	0.302	0.208	0.145
		C	0.716	0.302	0.135	0.099
	B	AB	-0.44	0.296	0.874	0.457
		C	0.935*	0.296	0.018	0.015
	AB	C	1.375*	0.315	0.001	0.000

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Abbreviations: ACC: Acceleration; EN: Endurance test; HJ: Horizontal jump; HR: Heart rate; ROM: Range of motion; SR: Speed of running; SS: Speed of shoot; VJ: Vertical jumps; VO_2max: Maximum volume of oxygen.

Post-hoc tests were performed using the Bonferroni correction; Reported P are adjusted for multiple comparisons; Values shown as P=1 indicate that the Bonferroni-adjusted P exceeded 1.0 and was truncated by the software; *significant P<0.05

The independent t-test, which was used to assess the significance of the improvement in all variables in all groups by time effect (before and after), revealed that the SS and HR variables did not change significantly in any of the intervention groups. In contrast, all other variables improved significantly in the post-intervention assessment (P<0.05) (Table 7).

Discussion

To avoid any negative impact of sports injuries on players' health and future [57], the training protocol of football players must be a comprehensive strategy that considers all patterns of sports performance. Accordingly, the use of strengthening and stretching exercises has been widely studied and is widely recommended for football players before and after injuries, as well as in competition preparation. The primary objective of this study was to assess the effects of combining static stretching with dynamic high-intensity resistance exercises on the performance of novice football players. This was verified by comparing it with DHIRT alone and SSE alone.

The findings of the current study show that using DHIRT alone (Group A), SSE alone (Group B), or the combination of both techniques (Group AB) had a positive impact on the jumping performance and running capacity (speed, ACC, and endurance) of novice football players, with a preference for Group toward the others. The small, non-significant difference in the effects of both protocols (A and B), with a preference for Group A, seems to be attributed to an increase in lower extremity explosive forces, which improves the ability to perform higher and longer jumps, as well as better running practice. Similarly, the non-significant superiority of Group AB over the other intervention groups (A and B) could be attributed to the number of exercises received by participants in each session, as well as the fact that adding SSE to the protocol may increase elasticity and decrease expected muscle stiffness after strengthening and prepare the muscle to generate a higher rate of force at a very specific moment.

Previous studies reported a positive impact of maximal and submaximal dynamic resistance training [2, 58] and SSE of lower limb muscles improve jumping performance [59–61], and running abilities (speed, endurance and ACC) [1, 20, 62, 63]. The authors of the current study attribute the improvement in jumping and running abilities in groups A and AB to the role of muscle strength in increasing maximum propulsion force while running.

Figure 6. The pairwise comparisons of repeated measures ANOVA test

This effect can be explained by the increased activity of fast-twitch fibers, the selective intensive activation of motor units, increased stiffness, and an increased stretch reflex of lower limb muscles [2], all of which improve the rate of force development. This is particular crucial in sports that require high jumping and explosive force abilities. Additionally, Alikhajeh et al. stated that warm-up stretching could improve the ACC of novice soccer players [64], which the current study found in groups B and AB. The authors proposed that static stretching may improve muscle contractility and reduce the risk of stiffness-related injuries; however, previous studies have failed to provide a consensus on the optimal stretching protocol (i.e. duration and placement in the session).

Moreover, despite various studies emphasizing the superiority of dynamic stretching over static stretching in terms of jump performance, several authors have reported that muscular performance was unaffected after static stretching [65–67]. Our findings are consistent with those of previous studies showing that SSE improves jump performance and running ability. The decrease in VJ performance after SS was attributed by Hough et al. to a possible change in the viscoelastic properties of the muscular tendon unit (MTU) [68]. Similarly, Gelen et al. and Young and Behm reported the negative impact of SSE on vertical and HJs, respectively [20, 69]. Thus, the authors highlight the need for further studies to emphasize the real impact of static and dynamic stretching on football players' performance.

Table 7. Results of the independent t-test

Groups		Paired Differences				t	df	Sig. (2-tailed)
		Mean±SD	SEM	95% CI of the Difference				
				Lower	Upper			
VJ	A	-7.54167±5.79756	1.67361	-11.22526	-3.85807	-4.506	11	0.001
	B	-6.34615±3.69901	1.02592	-8.58144	-4.11086	-6.186	12	0.000
	AB	-7.90909±4.36931	1.3174	-10.84444	-4.97375	-6.004	10	0.000
	C	0.75±3.71371	1.17438	-1.90663	3.40663	0.639	9	0.539
HJ	A	-13.16667±12.71244	3.66976	-21.24376	-5.08957	-3.588	11	0.004
	B	-17.84615±10.80776	2.99753	-24.37722	-11.31509	-5.954	12	0.000
	AB	-16±14.60822	4.40454	-25.81393	-6.18607	-3.633	10	0.005
	C	0.2±6.05163	1.91369	-4.12908	4.52908	0.105	9	0.919
SR	A	-0.20937±0.20398	0.05889	-0.33897	-0.07976	-3.555	11	0.005
	B	-0.13998±0.26126	0.07246	-0.29786	0.0179	-1.932	12	0.077
	AB	-0.33556±0.27885	0.08407	-0.52289	-0.14823	-3.991	10	0.003
	C	0.15106±0.34217	0.1082	-0.09371	0.39583	1.396	9	0.196
SS	A	0.14148±1.76787	0.51034	-0.98177	1.26473	0.277	11	0.787
	B	0.21894±1.41037	0.446	-0.78998	1.22785	0.491	9	0.635
	AB	-0.36185±0.72354	0.2288	-0.87944	0.15575	-1.581	9	0.148
	C	-0.92333±1.06894	0.29647	-1.56929	-0.27737	-3.114	12	0.009
EN	A	-0.75±2.00567	0.57899	-2.02434	0.52434	-1.295	11	0.222
	B	-2.15385±1.51911	0.42133	-3.07183	-1.23586	-5.112	12	0.000
	AB	-1.36364±1.62928	0.49125	-2.4582	-0.26907	-2.776	10	0.02
	C	-0.4±1.42984	0.45216	-1.42285	0.62285	-0.885	9	0.399
VO_2max	A	-2.77525±2.42099	0.69888	-4.31347	-1.23703	-3.971	11	0.002
	B	-0.67569±1.65669	0.45948	-1.67682	0.32544	-1.471	12	0.167
	AB	-2.25339±1.65943	0.50034	-3.36821	-1.13857	-4.504	10	0.001
	C	-1.05497±3.0856	0.97575	-3.26228	1.15234	-1.081	9	0.308
ACC	A	-0.10607±0.24269	0.07006	-0.26027	0.04813	-1.514	11	0.158
	B	-0.0873±0.08908	0.02471	-0.14113	-0.03347	-3.533	12	0.004
	AB	-0.11053±0.09068	0.02734	-0.17144	-0.04961	-4.043	10	0.002
	C	0.00811±0.0411	0.013	-0.0213	0.03751	0.624	9	0.548

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Abbreviations: ACC: Acceleration; EN: Endurance test; HJ: Horizontal jump; HR: Heart rate; ROM: Range of motion; SR: Speed of running; SS: Speed of shoot; VJ: Vertical jumps; VO_2max: Maximum volume of oxygen; CI: Confidence interval.

However, the results showed a significant difference over time only between the AB and C groups in shot speed. These findings are consistent with those of Skoufas, who reported that shot speed is dependent not only on muscle force but also on kicking technique [70].Additionally, Workman reported that stretching exercises did not affect football players' SS [71]. The authors of the current study suggest that combining SSE and DHIRT may lead to better improvements in the speed of 15-meter shot by triggering the active ROM and the strength of hip flexors and knee extensors.

Moreover, consistent with previous research [72–74], a marginally significant improvement was observed in VO_2max in groups A and AB. Hepple et al. suggested that the increase in VO_2max after resistance training can be attributed to the growth of small vessels, which leads to the ACC of oxygen circulation in the blood and its transport to body cells [75], raising the myoglobin concentration and activating various enzymes in the muscles [76]. Furthermore, our results confirm that stretching does not increase the maximum oxygen consumption, as previously stated by Mojock et al. [74].

Beyond statistical significance, the observed improvements have substantial practical implications for football performance and injury prevention, particularly in novice players. For example, a 7.9 cm increase in VJ height may enhance a player's ability to win aerial duels, execute powerful headers, and improve explosive movements, such as take-offs and rapid direction changes. Similarly, even small gains in ACC and sprint speed, on the order of tenths of a second, can provide a competitive advantage in high-speed, short-distance actions that frequently occur during matches. A 5.83% increase in VO_2 max suggests better aerobic fitness, which may help players maintain intensity throughout the game and recover more efficiently between efforts. Additionally, the 16 cm improvement in HJ distance reflected a significant gain in horizontal power and neuromuscular control, which are essential for sprinting, lateral movements, and quick stops or starts. Improved HJ performance is also linked to a reduced risk of injury, particularly for non-contact lower-limb injuries such as ACL tears, due to enhanced eccentric control and improved landing stability. Together, these functional outcomes indicate that the combined training intervention not only boosts performance but may also contribute to increased resilience and reduced injury risk in adolescent football players.

Conclusion

Six weeks of DHIRT combined with SSE, performed four times per week, led to significant improvements in several football-related performance variables, including vertical and HJs, RS, and VO_2 max, indicating enhanced athletic readiness in novice players. These findings support the use of a moderate-to-high intensity resistance training protocol (60–80% of 1RM) in combination with static stretching; however, further research is needed to determine the most effective intensity thresholds within this range.

From a practical standpoint, coaches working with adolescent football players should consider incorporating these combined protocols into their regular training schedules. A feasible implementation could involve two to four sessions per week, with resistance training performed at 60%–80% 1RM and 15–30 minutes of static stretching targeting major lower-limb muscle groups, scheduled either before or after resistance exercises based on logistical preference.

This study has some methodological limitations that offer valuable avenues for future investigations. Comparative trials examining diverse combinations of stretching and resistance training protocols are warranted to delineate their specific effects on athletic performance and the risk of injury. Although the current sample size was adequate for preliminary analysis, a larger and more heterogeneous cohort would improve the generalizability of the results. Additionally, the timing and duration of static stretching within combined interventions, such as pre-versus post-exercise application and variations in stretching length, should be systematically evaluated. Future research should also address potential selection bias inherent in digital recruitment, standardize control group activity levels, and employ more precise assessment tools (e.g. electronic sprint timing). Finally, although the proposed mechanisms, such as fast-twitch fiber recruitment and muscle-tendon elasticity, are theoretically grounded, they were not directly assessed due to logistical constraints. Incorporating neuromuscular and biomechanical measurements (e.g. electromyography, motion capture) is essential for validating the underlying physiological adaptations.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of University of Sciences and Arts in Lebanon, Beirut, Lebanon, and written informed consent was obtained from the participants and their guardians.

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Authors' contributions

Conceptualization, supervision and data analysis: Hussein Ziab; Data collection: Hani Deeb and Hassan Deeb; Funding acquisition and resources: Rami Mazbouh Methodology, investigation, writing the original draft, review & editing: All authors.

Conflict of interest

The authors declared no conflict of interest.

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Appendix

Appendix 1. Sample size calculation

Variables	Mean±SD		Mean Difference	SD Pooled	Cohen's d	Critical Value		Estimated Sample Size
	Before	After				Zα/2	Zβ	
VJ (cm)	238.3±11.4	245.3±15.3	7.0	13.5	0.519	2.0	-0.8	10
Horizontal Jump (cm)	208.3±13.1	215.1±10.3	6.8	11.8	0.577	2.0	-0.8	8
Speed of running 60 m (m/s)	5.9±0.8	6.3±0.8	0.4	0.8	0.507	2.0	-0.8	10
Endurance (reps)	8.5±3.0	10.3±3.1	1.8	3.1	0.59	2.0	-0.8	8
VO_2max (ml/kg/min)	28.1±6.3	31.2±7.0	3.1	6.7	0.466	2.0	-0.8	12
ACC (m/s^2)	2.1±0.9	2.5±0.8	0.4	0.8	0.477	2.0	-0.8	11

PHYSICAL TREATMENTS

Appendix 2. Shapiro-Wilk test of normality

Variables	Shapiro-Wilk		
	Statistic	df	Sig.
VJ (cm) before	0.978	45	0.545
VJ (cm) after	0.969	45	0.276
Horizontal jump (cm) before	0.979	45	0.571
Horizontal jump (cm) after	0.970	45	0.287
Speed of running 60 m (m/s) before	0.933	45	0.062
Speed of running 60 m (m/s) after	0.930	45	0.069
Endurance (reps) before	0.844	45	0.050
Endurance (reps) after	0.920	45	0.074
VO_2max (mL/kg/min) before	0.982	45	0.704
VO_2max (mL/kg/min) after	0.967	45	0.217
ACC (m/s^2) before	0.970	45	0.301
ACC (m/s^2) after	0.953	45	0.067

PHYSICAL TREATMENTS

Annex 3. ANOVA test at baseline

Variables	Sig.
Age	0.05
Height	0.424
Weight	0.995

PHYSICAL TREATMENTS