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Research article

# Effects of different strength and velocity training programs on physical performance in youth futsal players

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ABSTRACT

Futsal is a high intensity team sport with intermittent actions of short duration, so it is necessary to include different training strategies to improve explosive actions. There is a gap in the scientific literature regarding training programs that improve the performance of young futsal players. The aim of this study was to determine the effects of different strength and velocity training programs on lower body physical performance in youth futsal players. Forty-two youth futsal players were divided into control group (CG, n = 14) and a strength intervention group (SG, n = 14), which included a weekly session for 8 weeks of eccentric strength training, plyometrics and core strengthening, and a velocity intervention group (VG, n = 14), which included a weekly session during 8 weeks of training with linear speed exercises and with change of direction, accelerations with resistance bands and core strengthening. SG significantly improved horizontal jump (HJ) (p:0.02), V-CUT (p:0.91) and change of direction deficit (CODD) (p:0.01). VG showed significant improvements in HJ (p:0.01), in 25 m sprint (p:0.01), in total repeated sprint ability time (p:0.01), in V-CUT (p:0.01) and in CODD (p:0.01). SG showed significant intergroup differences (p:0.01) in COD variables with respect to CG and VG. In conclusion, SG and VG showed significant improvements in lower body performance variables in youth futsal players. In addition, the SG has substantial changes in COD compared to the other two groups, so it has a greater effect.

## 1. Introduction

Futsal is a team sport composed of five players (a goalkeeper and four field players), characterized by its dynamism and the rapid succession of plays that generate multiple scoring opportunities. A competitive match consists of two 20-min halves, with a 10-min interval between each half [1]. Futsal players need to have intermittent endurance capacity, the ability to perform repeated sprints and muscular power in the lower body [2]. The duration of the actions in futsal matches are of short duration, since 95 % of the actions that occur have a duration of less than 20 s [3]. Futsal is distinguished by being a sport that involves a greater number of sprints than other intermittent sports such as soccer [4].

In futsal training, it is important to manage and set training loads appropriately in order to stimulate adaptations in performance

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[5]. It is essential to understand, plan and implement the training load of futsal sessions, by establishing an interrelation between performance factors such as strength and velocity [6]. Training methodologies have been developed that focus on improving performance in futsal, including strength training. This approach is particulary beneficial for sports that require explosive strength and speed [7]. A 6 week preventive strength circuit performed showed significant improvements in the physical abilities of futsal players [8]. A 12-week study of functional training led to significant improvements in speed testing in highly competitive youth soccer players [9]. A 6-week study of low-volume, low-load power combined with COD (Change of Direction) was sufficient to simultaneously improve RSA (Repeated Sprint Ability) and strength performance in futsal players [10]. This information can be adapted for use jn training programs for youth players and is necessary to improve the physical performance of futsal players.

The relationship between strength and velocity provides information about mechanical capabilities of the musculoskeletal system in terms of force production, power and speed [11]. In the field of sports performance, the height reached in a jump is considered to be good indicator of muscle power, which is why different types of vertical jumps have been used as standardized tests [12]. Among these tests, the Counter Movement Jump (CMJ) has been highlighted as a reliable tool for assessing explosive strength in soccer players of different ages and levels [13]. In addition, a correlation has been established between horizontal jump power and sprint speed, making it an indirect test of explosive strength for the lower body [14]. This type of jump has proven to be highly reproducible and valid in comparison with other vertical jump tests [15].

The results of a study showed that sprints with a maximum recovery time of 15–20 s were significantly more frequent than other repeated sprints in futsal matches, so it seems appropriate to perform the RSA test to assess repeated sprinting ability in futsal players [16]. The ability to change direction and agility, known as COD, plays a crucial role in futsal due to the rapid transitions between actions during the game. A commonly used test to evaluate and measure this ability is the "V-CUT test" [17]. The calculation of the "COD deficit" has been proposed as a variable that indicates the amount of additional time required to complete a COD task compared to the time required to cover the same distance in a straight run [18].

Futsal is developing in terms of practice and popularity. In a comparison between elite and sub-elite futsal players, the findings revealed that elite players presented better results in intermittent endurance and performance time tests compared to sub-elite players [2,19]. Therefore, incorporating different training programs for both strength and velocity in youth players can be an opportunity to improve their performance and be able to reach the elite level.

In the scientific literature, the impact of strength and velocity training in different sports has been widely investigated, with soccer being the main focus of research. The research gap that exists in the scientific literature on training protocols for youth futsal players makes researchers call for further research in this field. This lack of research limits the ability of physical trainers and coaches to design

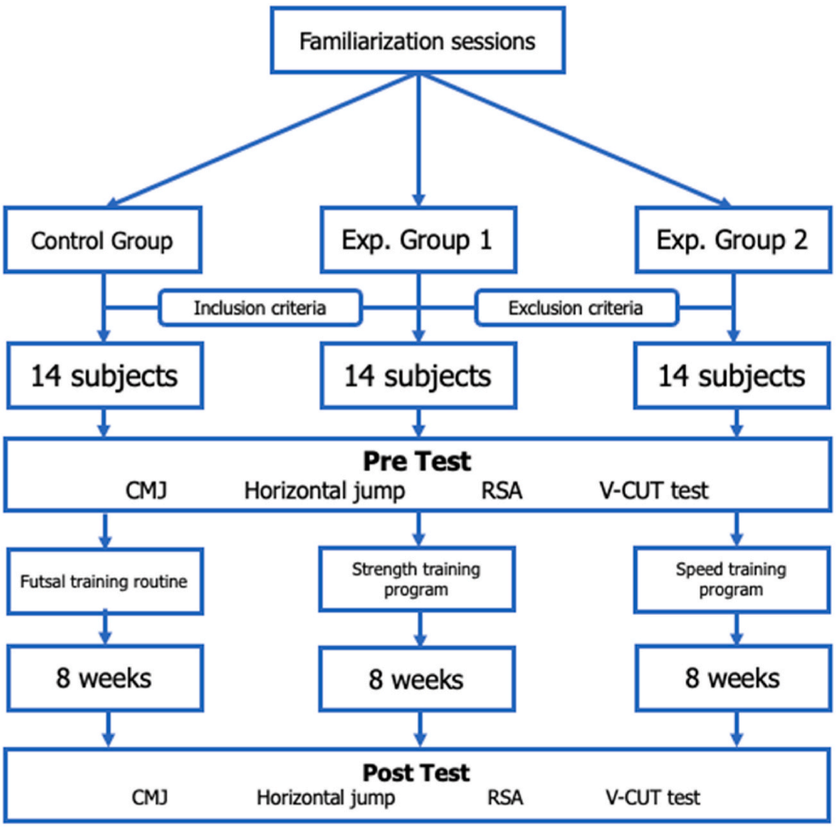


**Fig. 1.** Project timeline.

effective and specific training protocols for these players. The research question guiding this study is: “What are the effects of strength and velocity training programs on lower body physical performance in youth futsal players?”. The findings of this study have the potential to provide valuable information for the design and optimization of specific training protocols aimed at improving the physical performance of youth futsal players.

The main objective of this project was to determine the effects of different strength and velocity training programs on the physical performance of the lower body in youth futsal players. The main hypothesis of the study was that players performing the strength and velocity training programs would achieve an improvement in lower body physical performance tests by increasing their horizontal and vertical jump capacity, as well as their linear speed and COD abilities.

## 2. Materials and methods

### 2.1. Study design

The study design was longitudinal experimental cohort and prospective. Study participants were assigned to three non-randomized groups, ensuring that each group had similar characteristics. However, the assignment of the training programs and the control group was randomized, according to the CONSORT guidelines. Randomization lists were generated using an Excel spreadsheet. Each group participating in the study was assigned to one of the groups (control group, strength group or velocity group) on a completely random basis. The methodology used to carry out the project was a of 3 pre-test and post-test groups. The control group (CG) (n = 14) continued with their futsal training routines for 8 weeks, experimental group 1 (n = 14) performed a training program based on the strength submanifestation (SG) for 8 weeks and experimental group 2 (n = 14) performed a training program based on the velocity submanifestation (VG) for 8 weeks. Participants in each group were blinded to the details of the intervention. All participants belonged to the maximum national U-19 category of futsal (Youth Honor Division). The players performed 3 weekly field sessions of 90 min composed of warm-up, technical actions, reduced games and tactical tasks, in addition to competing a 40-min match at a stopped clock every weekend. Before and after the interventions, the participants performed the following battery of tests: vertical jump test (CMJ), horizontal jump test, 25 m linear speed test, sprint repetition ability test (RSA test) and COD test (i.e. “V-CUT” test). A total of 4 familiarization sessions were performed in the experimental groups, 2 sessions were to ensure correct execution of the exercise technique during the intervention, while another 2 sessions were for familiarization with the performance tests, in which the control group was included (Fig. 1).

### 2.2. Participants

Forty-two futsal players [(Age 17.47 years ± 0.64; Height 175 cm ± 4.41; Weight 69.63 kg ± 6.7; Body mass index (BMI) 22.46 kg*m2 ± 1.68)] were recruited to participate in the study. The sample size was calculated post hoc in G*power (version 3.1.9.2; Kiel University, Kiel, Germany) Effect size f = 0.4; α err prob = 0,05; Power (1-β err prob) = 0.72. Table 1 shows the descriptive data of the participants. All participants belonged to the highest U-19 national futsal category and had performed weekly training structured in volume and methodology (3 futsal-specific training sessions of 90 min duration and 1 match per week). The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of the European Atlantic University Ethics Committee (CEI-08/2023).

The inclusion criteria were as follows: (i) Players between 16 and 19 years of age, (ii) Players without previous injury during the month prior to any assessment. While the exclusion criteria were as follows: (i) Failure to complete any assessment test, (ii) Players who at the time of testing may have had any type of injury or illness that could impair their abilities, (iii) Players who for any reason have not been able to perform at least 80 % of the sessions.

### 2.3. Procedure

The main variable analysed was the level of strength of youth futsal players in the lower extremities. This main variable was monitored through the secondary variables of vertical jump (CMJ), horizontal jump (HJ), linear velocity, RSA total, RSA deficit, V-CUT test and COD deficit. For the assessment of the different tests, the assessment instruments of the APP “My Jump Lab” were used [20–22], scientifically validated to measure performance, through an IPhone 12 electronic device. These assessment tests are used as fundamental tools to measure and evaluate different aspects of physical performance, such as speed, strength and agility [23]. The observers and assessors were blinded when it came to performance testing the players.

Interventions were performed in the middle of the competitive period of the season. Experimental group 1 performed a training

**Table 1**
Descriptive data of the subjects (mean and SD).

| | Age (years) | Height (cm) | Weight (kg) | BMI (kg*m$^2$) |
|---|---|---|---|---|
| **Control Group (CG)** | 17.50 ± 0.65 | 175 ± 3.85 | 71.47 ± 4.22 | 23.22 ± 1.19 |
| **Exp. Group 1 (SG)** | 17.71 ± 0.61 | 176 ± 3.20 | 69.57 ± 6.53 | 22.29 ± 1.48 |
| **Exp. Group 2 (VG)** | 17.47 ± 0.57 | 176 ± 5.92 | 67.85 ± 8.72 | 21.88 ± 2.02 |

SD = Standard Deviation; BMI = Body Mass Index.

protocol for 8 weeks based on strength manifestation on MD-4 (four days before match day) of the structured microcycle, adequate time is allowed for muscle recovery and rest before the match, while experimental group 2 performed a training protocol for 8 weeks based on velocity manifestation on MD-2 (two days before match day) of the structured microcycle, promotes blood circulation and fatigue accumulation is reduced, preparing players for optimal performance on match day [24]. All sessions were performed at the same time in the evening (19:00 h).

The training load was periodized as follows: weeks 1 and 2, 3 sets of 6 repetitions; weeks 3 and 4, 3 sets of 8 repetitions; weeks 5 and 6, 4 sets of 6 repetitions; and weeks 7 and 8, 4 sets of 8 repetitions. Load periodization was similar in both training programs, with a biweekly progression of linear load increase (Table 2).

Before each session of both training programs, as well as the pre- and post-intervention evaluation tests, a standardized warm-up protocol was performed for 10 min. This warm-up was structured as follows: (i) 3 min of continuous running at a moderate pace (60 % of maximum heart rate); (ii) dynamic stretching of quadriceps, psoas, and calf muscles; (iii) frontal and lateral ballistic stretching; (iv) lateral steps (monster walk) with the use of "mini-bands" at ankle level; (v) running at a moderate pace (60 % of maximum heart rate); (vi) running at a moderate pace (60 % of maximum heart rate); (vii) running at a moderate pace (60 % of maximum heart rate); and (viii) dynamic stretching of quadriceps, psoas, and calf muscles [1,25]. A 3-min hydration break was taken between the warm-up and the beginning of the sessions. The sessions were carried out in an futsal pavilion with a parquet surface. The players wore specific futsal shoes for the sessions. Testing was performed one week before the start of training and one week after the last session of the intervention program. Participants were asked to refrain from intense exercise for at least 48 h prior to any performance evaluation.

#### 2.3.1. Counter movement jump test

The vertical jump tests with countermovement were performed to measure the explosive force in the vertical plane of youth futsal players. They were analysed using an iPhone 12 electronic device with the "MyJump2″ APP (this application have been scientifically validated and reliability-tested), where the height of the jump is determined indirectly by measuring the time of flight [20,21]. The evaluation protocol for each test was performed 3 times with 45 s of recovery and the best jump was recorded [26]. To certify the correct technical execution of the vertical jumps, the instructors observed the subjects, checking that the flight phase was performed without leg flexion and that the arms remained attached to the hips throughout the execution of the jump. The evaluation protocol was performed 3 times, with a 45-s recovery pause. The best jump was selected for subsequent statistical analysis.

#### 2.3.2. Horizontal jump test

The horizontal jump tests were performed with the purpose of evaluating the explosive strength of the lower extremities in the horizontal force application of youth futsal players. It was determined with a standard tape measure [27]. The evaluation protocol was performed 3 times with 45 s of recovery, and the best jump was recorded [26]. To certify the correct technical execution of the horizontal jumps, the instructor observed the subjects, controlling the landing phase, so that the subjects maintained their balance at the moment of landing for 2 s. The evaluation protocol was performed 3 times, with a 45-s rest pause. The best jump was selected for subsequent statistical analysis.

#### 2.3.3. 25 m sprint test

The 25 m sprint test was performed to evaluate the maximum sprint speed of futsal players. They were analysed using an IPhone 12 electronic device with the "Runmatic" APP (this application have been scientifically validated and reliability-tested) [22], where the time of each sprint was determined through video analysis. Each player was positioned behind the first mark at 0.5 m and started the test when he/she considered appropriate, without receiving any signal, completing the test by crossing the next mark at 25 m distance. The evaluation protocol was performed 3 times with 2 min of recovery. The best sprint was selected for subsequent statistical analysis.

#### 2.3.4. Repeated sprint ability test

The RSA tests were analysed using an electronic device IPhone 12 with the "Runmatic" APP (this application have been scientifically validated and reliability-tested) [22], where the time of each sprint was determined through video analysis. Each player performed an RSA test consisting of eight 25-m sprints, with a 20-s active rest period between each repetition. Each player received a 5-s warning before starting the next sprint and moved into the starting position. This protocol has been used previously for the evaluation of soccer players who share similar characteristics [28]. In the RSA test, the times of each sprint were analysed, obtaining the variables of best sprint, difference between the best and worst sprint (i.e., decrease in performance) and the sum of the time taken in all sprint.

#### 2.3.5. "V-CUT" test and COD déficit

The "V-CUT" tests were analysed using an Iphone 12 electronic device with the "COD Timer" APP (this application have been scientifically validated and reliability-tested) [22,29], where the time of each sprint was determined through video analysis. The

**Table 2**
Periodization of the training load in the interventions.

| | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 | Week 7 | Week 8 |
|---|---|---|---|---|---|---|---|---|
| Sets | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 |
| Repetitions | 8 | 8 | 10 | 10 | 8 | 8 | 10 | 10 |

players performed a sprint of 25 m distance, in which there were 4 COD every 5 m with an exit angle of 45° (Fig. 2) [30]. Each player was positioned behind the first mark at 0.5 m and started the test when he/she considered appropriate, without receiving any signal, completing the test by crossing the last mark. The evaluation protocol was performed 3 times with 2 min of recovery. The best mark was selected for subsequent statistical analysis.

The COD deficit was calculated from the difference between the times of the first part of the linear sprint (i.e., the time recorded in 25 m) and the COD test (i.e., the V-CUT test) [18].

#### 2.3.6. Strength training program

The training program based on the submanifestation of strength was structured with a weekly session on MD-4 for 8 weeks. All the sessions to be performed started with the standardized warm-up protocol. The training program applied included exercises with eccentric load, plyometric exercises and exercises for strengthening the lumbo-pelvic musculature (Table 3). The distribution of the exercises was through triseries. The first triseries included eccentric quadriceps on Russian belt as the main exercise, vertical jump as a complementary exercise and front plank as a compensatory exercise. The second triseries included as main exercise "nordic hamstring", as complementary exercise horizontal jump and as compensatory exercise lateral plank Copenhagen. The third triserie included as main exercise front stride with resistance rubber, as complementary exercise unilateral "L" jumps including landing, lateral jump, horizontal jump and vertical jump and as compensatory exercise hip abductions and adductions resisted by a partner.

#### 2.3.7. Velocity training program

The velocity training program was structured with a weekly session on MD-2 for 8 weeks. All sessions were started with the standardized warm-up protocol. The training program applied included exercises with linear speed load and with DC, accelerations with resistance bands and exercises for strengthening the lumbo-pelvic musculature (Table 3). The distribution of the exercises was through triseries. The first triseries included as the main exercise a 25 m linear sprint with parachute resistance, as a complementary exercise a 2 m frontal exit with rubber resistance and as a compensatory exercise a frontal plank. The second triserie included as the main exercise a 6 m acceleration with a 7 kg ballast (10 % of the body weight), as a complementary exercise a 2 m cross exit with rubber resistance and as a compensatory exercise a lateral plank Copenhagen. The third triserie included as the main exercise a 25 m sprint at maximum speed with 4 COD (V-CUT test), as a complementary exercise a 2 m lateral exit with a resistance band and as a compensatory exercise hip abductions and adductions resisted by a partner.

### 2.4. Statistical analyses

The data analysis of the present study was carried out both descriptively and inferentially. Before performing any statistical analysis, the Shapiro-Wilk statistical test was performed to verify that the data of all variables follow a normal distribution.

After verifying normality, a descriptive analysis of the groups was performed. The measure of central tendency as mean and the measure of dispersion as standard deviation (SD) were calculated for the subjects. Relative reliability analysis was examined by the intraclass correlation coefficient (ICC). To examine absolute reliability, the standard error of measurement (STEM) was used. The Hopkins spreadsheet ((Reliability from consecutive pair of trials, xrely.xls)) [31]] was used to determine both the ICC and the STEM, expressed as the coefficient of variation (CV).

To determine if there were significant differences between groups, within-group comparisons (paired Student's t-test) were performed to detect significant differences between pre-test and post-test for all variables in both groups Data were first analysed using a 3 $\times$ 2 factorial ANOVA with repeated measures using an interfactor (CG vs. SG vs. VG) and an intrafactor (Pre vs. Post-training) with Bonferroni post-hoc comparisons (CG vs. SG vs. VG) to clarify the interaction. Percent change (%) was calculated for each all variables analysed in the study [(post - pre/pre) $\times$ 100]. The 95 % confidence interval was calculated to determine the magnitude of the pairwise comparisons for the pretest and posttest. Finally, the effect size (ES) was calculated to assess statistical significance and to be able to determine the magnitude of differences between groups using Cohen's d statistic. Quantitative values for Cohen's d ES were >0.2

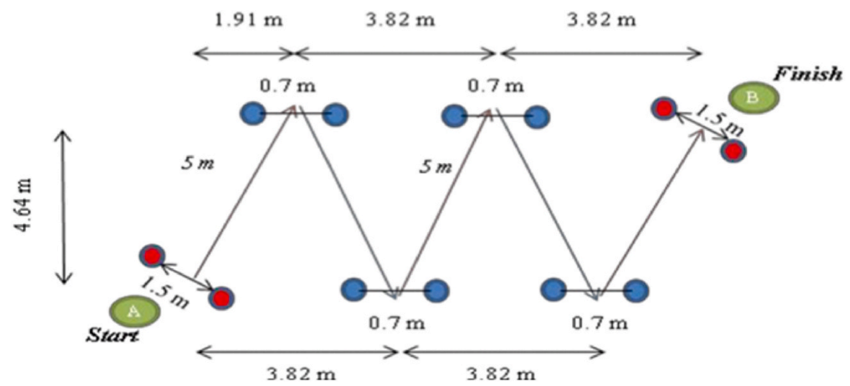


**Fig. 2.** "V-CUT" test.

**Table 3**
Overview of training programs.

| | Main | Complementary | Compensatory |
|---|---|---|---|
| **Strength training program** | Eccentric quadriceps on Russian belt as Nordic hamstring | Vertical jump | Front plank |
| | | Horizontal jump | Lateral plank Copenhagen |
| | Front stride with resistance rubber | Unilateral "L" jumps | Hip abductions and adductions resisted |
| **Velocity training program** | 25 m linear sprint with parachute resistance | 2 m frontal exit with rubber resistance | Front plank |
| | 6 m acceleration with a 7 kg ballast | 2 m cross exit with rubber resistance | Lateral plank Copenhagen |
| | 25 m sprint at maximum speed with 4 COD (V-CUT test) | 2 m lateral exit | Hip abductions and adductions resisted |

(small), >0.6 (moderate) and >1.2 (large) [32,33].

Significance of the statistical analysis was used at the $p < 0.05$ level. All statistical calculations were analysed with SPSS software (version 28.0, IBM SPSS Inc., Chicago, IL, USA).

## 3. Results

The intraclass correlation coefficient and CV scores for this study were 0.80–0.97 and ranged from 2.00 % to 4.80 %. Therefore, each test had acceptable consistency between each attempt with a CV <10 % and a good or excellent ICC (Table 4) [34].

The descriptive characteristics of the players in both groups are shown in Table 1. The results of the analysis revealed that there were no significant differences between the two groups in these variables. The results of all the CG, SG and VG tests are shown in Table 5.

Table 5 shows the mean and SD of the changes in the lower body performance variables. Significant differences were found in SG between pre-test and post-test measurement in horizontal jump (*p*:0.02; ES:7.98; %:2.59), V-CUT (*p*:0.91; ES:0.45; %:10.19) and COD deficit (*p*:0.01; ES:0.40; %: 18.32), as well as in VG in horizontal jump (p:0.01; ES:5.26; %:3.71), in 25 m sprint (*p*:0.01; ES:0.12; %: 5.52), in total RSA time (*p*:0.01; ES:0.47; %:1.66), in V-CUT (*p*:0.01; ES:0.21; %:0.21) and in COD deficit (*p*:0.01; ES:0.20; %:5.35).

Figs. 3 and 4 show the inter-group effects. In the CMJ test, there were no significant main effects of time (*p*:0.15; F:4.71; $np^2$:0.05), nor a significant group by time interaction (*p*:0.24; F:1.49; $np^2$:0.07).

In the horizontal jump test there were significant main effects of time (*p*:0.01; F:30.50; $np^2$:0.43) with a significant group by time interaction (*p*:0.01; F:6.20; $np^2$:0.24). In the post hoc analysis, significant intergroup differences were found between the CG and SG (*p*:0.04; ES; 0.38) and between the CG and VG (*p*:0.01; ES:0.37).

In the 25-m sprint test there were significant main effects of time (*p*:0.01; F:18.90; $np^2$:0.33) with a significant group-by-time interaction (*p*:0.01; F:7.98; $np^2$:0.29). In the post hoc analysis, no significant intergroup differences were found.

In the RSA total time test there were significant main effects of time (*p*:0.01; F:12.34; $np^2$:0.99) with a significant group by time interaction (*p*:0.01; F:5.03; $np^2$:0.21). In the post hoc analysis, no significant intergroup differences were found.

In the RSA difference test there were no significant main effects of time (*p*:0.38; F:0.79; $np^2$:0.02) with a significant group by time interaction (*p*:0.30; F:1.25; $np^2$:0.06).

In the V-CUT meter test there were significant main effects of time (*p*:0.01; F:12.34; $np^2$:0.24) with a significant group by time interaction (*p*:0.01; F:5.04; $np^2$:0.21). In the post hoc analysis, significant differences were found between CG and SG (*p*:0.01; ES:1.64) and between VG and SG (*p*:0.01; ES:0.90).

In the deficit COD test there were significant main effects of time (*p*:0.01; F:46.42; $np^2$:0.54) with a significant group-by-time interaction (*p*:0.01; F:25.45; $np^2$:0.57). In the post hoc analysis, significant differences were found between CG and SG (*p*:0.01; ES:1.35) and between VG and SG (*p*:0.01; ES:1.24).

**Table 4**
Relative and absolute reliability measures of the variables evaluated.

| Variables | ICC | CV (STEM) |
|---|---|---|
| CMJ (cm) | 0,85 | 4,21 |
| HJ (cm) | 0,97 | 4,75 |
| S25 m (s) | 0,80 | 4,80 |
| RSA t. (s) | 0,86 | 3,20 |
| RSA d. (s) | 0,88 | 2,82 |
| V-CUT (s) | 0,94 | 2,00 |
| COD def. (s) | 0,84 | 4,48 |

CMJ = Counter Movement Jump; HJ = Horizontal jump; S25 m = 25 m linear sprint; RSA t. = total time in the RSA test; RSA d. = difference between the best and worst sprint in the RSA test; V-CUT = time of the V-CUT test; COD def. = time difference between the 25 m linear sprint and the V-CUT test; ICC = intraclass correlation coefficient; STEM = standard error of measurement.

**Table 5**
Results of the tests performed in the control and experimental groups, mean ± SD.

| Variable | Pre-test | Post-test | CI (95 %) | p | % | ES (95 CI) |
|---|---|---|---|---|---|---|
| **Control Group (CG)** | | | | | | |
| **CMJ (cm)** | 37,85 ± 3,76 | 37,69 ± 3,55 | (-0,4; 0,71) | 0,56 | −0,42 | 0,97 (−0,37; 0,69) |
| **HJ (cm)** | 205,79 ± 10,95 | 206,57 ± 10,51 | (-2,6; 1,03) | 0,37 | 0,38 | 3,14 (−0,78; 0,29) |
| **25m (s)** | 3,95 ± 0,20 | 3,97 ± 0,20 | (-0,06; 0,05) | 0,83 | −0,51 | 0,10 (−0,58; 0,47) |
| **RSA t. (s)** | 35,60 ± 1,02 | 35,79 ± 1,05 | (-0,49; 0,10) | 0,19 | −0,53 | 0,52 (−0,91; 0,18) |
| **RSA d. (s)** | 0,45 ± 0,13 | 0,44 ± 0,12 | (-0,08; 0,08) | 0,98 | −2,22 | 0,15 (−0,53; 0,53) |
| **V-CUT (s)** | 6,93 ± 0,26 | 6,94 ± 0,19 | (-0,09; 0,69) | 0,76 | −0,14 | 0,14 (−0,61; 0,44) |
| **COD def. (s)** | 2,96 ± 0,27 | 2,97 ± 0,25 | (-0,11; 0,10) | 0,91 | −0,34 | 0,49 (−0,56; 0,45) |
| **Strength Group (SG)** | | | | | | |
| **CMJ (cm)** | 37,98 ± 5,00 | 38,35 ± 5,04 | (-2,10; 1,35) | 0,64 | 0,97 | 2,98 (0,65; 0,40) |
| **HJ (cm)** | 217,93 ± 17,65 | 223,57 ± 17,17 | −10,25;-1,03) | 0,02* | 2,59 | 7,98 (−1,29;-0,11) |
| **25m (s)** | 3,92 ± 0,24 | 3,83 ± 0,21 | (-0,03,0,20) | 0,27 | 2,30 | 0,20 (−0,13; 0,97) |
| **RSA t. (s)** | 35,98 ± 1,46 | 35,83 ± 1,42 | (-0,12; 0,40) | 0,81 | 0,41 | 0,45 (−0,23; 0,84) |
| **RSA d. (s)** | 0,40 ± 0,14 | 0,41 ± 0,13 | (-0,08; 0,07) | 0,40 | −2,5 | 0,13 (−0,59; 0,46) |
| **V-CUT (s)** | 7,85 ± 0,37 | 7,05 ± 0,33 | (0,54; 1,06) | <0,01* | 10,19 | 0,45 (0,91; 2,62) |
| **COD def. (s)** | 3,93 ± 0,29 | 3,21 ± 0,34 | (0,48; 0,94) | <0,01* | 18,32 | 0,40 (0,93; 2,65) |
| **Velocity Group (VG)** | | | | | | |
| **CMJ (cm)** | 39,52 ± 5,25 | 40,73 ± 4,81 | (-2,29;-0,12) | 0,32 | 3,06 | 1,87 (−1,21;-0,06) |
| **HJ (cm)** | 227,50 ± 15,60 | 235,93 ± 17,94 | (-11,47;-5,40) | <0,01* | 3,71 | 5,26 (−2,39;-0,79) |
| **25m (s)** | 3,98 ± 0,15 | 3,76 ± 0,12 | (0,14; 0,28) | <0,01* | 5,52 | 0,12 (0,93; 2,65) |
| **RSA t. (s)** | 36,59 ± 1,71 | 35,98 ± 1,64 | (0,33; 0,88) | <0,01* | 1,66 | 0,48 (0,54; 1,96) |
| **RSA d. (s)** | 0,42 ± 0,12 | 0,36 ± 0,10 | (0,01; 0,11) | 0,22 | 14,29 | 0,86 (0,10; 1,27) |
| **V-CUT (s)** | 7,16 ± 0,25 | 6,78 ± 0,18 | (0,26; 0,50) | <0,01* | 5,31 | 0,21 (0,93; 2,65) |
| **COD def. (s)** | 3,18 ± 0,20 | 3,01 ± 0,13 | (0,05; 0,29) | <0,01* | 5,35 | 0,20 (0,21; 1,43) |

CMJ = countermovement jump; SH = horizontal jump; S25 m = 25 m linear sprint; RSA t. = total time in the RSA test; RSA d. = difference between the best and worst sprint in the RSA test; V-CUT = time of the V-CUT test; COD def. = difference in time between the 25-m linear sprint and the V-CUT test; SD: standard deviation; cm: centimeters; s: seconds; CI: confidence interval; ES: effect size. 0.2 (small), >0.6 (moderate) and >1.2 (large). * Significant difference between pre-test and post-test ($p < 0.05$).

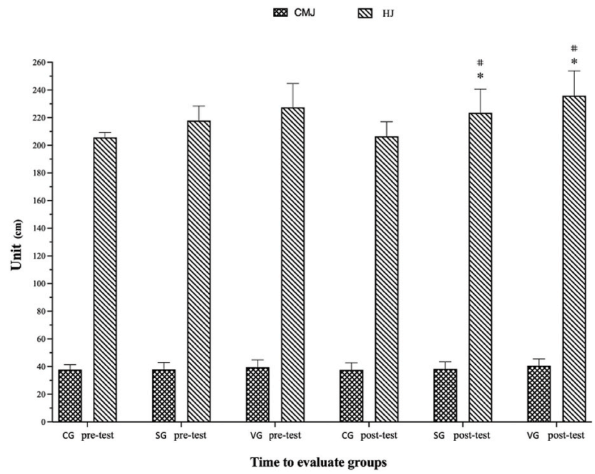


**Fig. 3.** Variation of the strength variables in each group and evaluation phase. *Represents a statistically significant difference ($p < 0.05$) compared to the pre-test. #Represents a statistically significant difference ($p < 0.05$) between groups. CG = Control group; SG = Strength group; VG: Velocity group.

## 4. Discussion

The aim of this study was to determine the effects of different strength and velocity training programs on the physical performance of the lower body in youth futsal players. It was hypothesized that players performing the strength and velocity training programs would achieve an improvement in post-intervention test values, thus improving their physical performance. The main findings found in the project were: (i) 8 weeks with the strength-based intervention protocol significantly improved horizontal jump (*p*:0.02; ES:7.98; %:2.59), V-CUT (*p*:0.01; ES:0.45; %:10.19) and COD deficit (*p*:0.01; ES:0.40; %:18.32). (ii) 8 weeks of intervention with the velocity-based training protocol showed significant improvements in horizontal jump (*p*:0.01; ES:5.26; %:3.71), 25 m sprint (*p*: 0.01; ES:0.12; %:5.52), in total RSA time (*p*:0.01; ES:0.47; %:1.66), in V-CUT (*p*:0.01; ES:0.21; %:0.21) and in COD deficit (*p*:0.01; ES:0.20; %:5.35). (iii) The control group showed no significant differences after 8 weeks of futsal training.

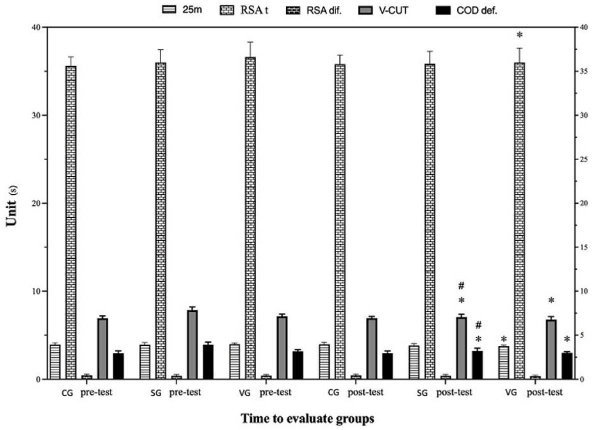


**Fig. 4.** Variation of velocity variables in each group and evaluation phase. *Represents a statistically significant difference ($p < 0.05$) compared to the pre-test. #Represents a statistically significant difference ($p < 0.05$) between groups. CG = Control group; SG = Strength group; VG: Velocity group.

The strength intervention protocol had substantial changes in the CMJ (*p*:0.64; ES:3.14; %:0.97) and horizontal jump (*p*:0.02; ES:7.98; %:2.59) variables, in addition to having significant improvements in the V-CUT test (*p*:0.01; ES:0.45; %:10.19) and COD deficit (*p*:0.01; ES:0.40; %:18.32). These results are consistent with previous research in youth futsal players showing similar results regarding the effects of similar prevention programs [35–37]. These programs, which include eccentric, plyometric and stability exercises in the lumbo-pelvic region, can be effectively implemented as a form of training to improve both the physical fitness and technical performance of youth futsal players. In addition, lower body eccentric loading exercises have the potential to be a valuable addition to intervention protocols designed especially for intermittent sports players, as they can have a positive impact on key performance variables, such as speed in non-linear movements such as COD [38]. One study demonstrated that 6 weeks of strength-based exercise training once or twice a week which incorporated exercises similar to the strength training produced significant improvements in jumping, sprinting and RSA performances [39], so one strength session per week seems to be sufficient. According to the systematic review carried out by Ramírez-Campillo in 2022 [40], it was found that the intervention of plyometric training programs is suitable for an optimal dose of training. Based on this evidence, it can be confirmed that the inclusion of training involving strength exercises once a week is shown as a relevant recommendation to improve the physical level of U-19 futsal teams.

The velocity training program showed substantial changes in the CMJ (ES:1.87) and horizontal jump (ES:5.26) variables, in addition to having significant improvements in the 25 m test (*p*: 0.01; ES:0.12; %:5.52), in the total time of the RSA test (*p*:0.01; ES:0.47; %:1.66), in the V-CUT test (*p*:0.01; ES:0.21; %:0.21) and in the COD deficit (*p*:0.01; ES:0.20; %:5.35). According to a study on the impact of a repeated sprint skill test on muscle contractile properties, it shows that initial muscle contractile parameters can play a significant role in the physical abilities of players during high-intensity intermittent activities [41]. A combined program of plyometric exercises and linear speed for 6 weeks obtained significant improvements (*p*:0.01; ES:0.27) in CMJ and substantial changes in 10–20 m sprint time (*p*:0.65; ES,0.77) in youth futsal players [42], these differences may be related to the fact that incorporating plyometric training into a velocity program has a direct relationship with improvement in the CMJ test.

When performing the intergroup post hoc analysis, significant differences were found in the horizontal jump test between the control group and experimental groups (*p*:0.01; ES:0.37 to 0.38), so that incorporating specific velocity or strength training sessions to the futsal training routines may improve this variable. In addition, significant intergroup differences (*p*:0.01; ES:0.90 to 1.64) were found in the variables of COD (V-CUT test and COD deficit) between the strength training group and the control group and velocity training group. Post hoc analysis is conducted to identify specifically which of these groups differ from each other, providing a more detailed understanding of the nature of these differences. These findings seem to indicate the importance of the eccentric component in COD performance. These indications seem to be related to the current scientific literature, since in different studies with training programs with an eccentric component showed significant improvements in the COD tests [43,44]. According to current research focusing on athletes from different disciplines and with different levels of competition, it has been found that those athletes who exhibit high levels of velocity and strength may experience lower efficiency when carrying out COD movements [45,46]. This research seems to indicate that eccentric training, trunk stabilization and unilateral strength work can improve COD and thereby reduce the COD deficit.

Although both training programs significantly improved different lower body performance variables in futsal players, the principle of training adaptation specificity prevailed. The strength group showed greater adaptations (i.e., higher % improvement) in tests that predominantly emphasized strength (CMJ and SH), while the best results in the velocity training group were found in tests related to linear speed (25 m, RSA). The results indicate that both training paradigms induced remarkable adaptations in COD performance. However, the strength group obtained greater adaptations (i.e., higher % improvement) in the V-CUT (10.19 %) and COD deficit (18.32 %) tests, leading to better COD performance.

The main limitation that can be found in this study is the sample size. The target population would be youth U-19 players of the highest national category, currently between 1000 and 1200 players, so a sample of 42 subjects is limiting when it comes to obtaining external validity, which allows us to have statistical representativeness, being able to extrapolate the results to the general population. A bias that appears in our study is not performing the training on the same day of the microcycle in both training groups, since it can alter the results of the study. The principal investigator of the study assumes this bias, with a contingency plan according to the scientific literature, the strength submanifestation is worked mainly on MD - 4 and the velocity submanifestation is worked on MD – 2 [24,47].

As a future lines of research, the first would be to implement strength and velocity training programs in youth futsal players at an international level with a significant sample size to support the results of this study. In addition, it would be interesting to carry out an intervention combining both training programs to find the optimal effective dose that develops maximum player performance while simultaneously preventing injuries. The need to incorporate strength and speed training protocols in futsal is increasing, so scientific researchers should provide coaches and physical trainers with access to intuitive and effective intervention protocols.

## 5. Conclusions

Strength and velocity training programs of 8 weeks duration have significant positive effects on the physical performance of the lower body in youth futsal players. These improvements are reflected in performance variables such as strength, jumping ability, linear velocity and COD. In addition, it is observed that the strength-based training protocol has a significantly greater effect on CODs compared to the velocity training program. This relationship could be linked to the importance of the eccentric phase during the landing of the COD. Therefore, the incorporation of these training protocols in the physical preparation of youth futsal players is recommended, with the aim of optimising their performance and preventing future injuries.

## Ethics statement

This study was reviewed and approved by the Ethics Committee of the European Atlantic University Ethics Committee, with the approval number CEI-08/2023 All participants (or their proxies/legal guardians) provided informed consent to participate in the study. The study was conducted according to the guidelines of the Declaration of Helsinki.

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## Data availability statement

The datasets generated and/or analysed during the current study are publicly available on Zenodo (DOI: 10.5281/zenodo.10790976) Upon request, the corresponding author will share the dataset.

## CRediT authorship contribution statement

**Oscar Villanueva-Guerrero:** Writing – original draft, Validation, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Conceptualization. **Demetrio Lozano:** Writing – original draft, Validation, Project administration, Investigation, Conceptualization. **Alberto Roso-Moliner:** Writing – original draft, Supervision, Software, Methodology, Data curation. **Hadi Nobari:** Software, Investigation, Formal analysis, Conceptualization. **Carlos Lago-Fuentes:** Validation, Resources, Methodology, Investigation, Data curation. **Elena Mainer-Pardos:** Writing – review & editing, Validation, Supervision, Investigation, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## References

[1] J. Alvarez Medina, San Jose J. Ramirez, V. Murillo Lorente, El gol como unidad de medida de rendimiento en futsal (Goal as a performance measurement unit in futsal), Retos 36 (0) (2019) 251–258, https://doi.org/10.47197/retos.v36i36.67633.
[2] N. Naser, A. Ali, P. Macadam, Physical and physiological demands of futsal, J Exerc Sci Fit 15 (2) (2017) 76–80, https://doi.org/10.1016/j.jesf.2017.09.001.
[3] J.C. Alvarez, S. D'Ottavio, J.G. Vera, C. Castagna, Aerobic fitness in futsal players of different competitive level, J. Strength Condit Res. 23 (7) (2009) 2163–2166, https://doi.org/10.1519/JSC.0b013e3181b7f8ad.

[4] J.C. Barbero-Alvarez, V.M. Soto, V. Barbero-Alvarez, J. Granda-Vera, Match analysis and heart rate of futsal players during competition, eng, J. Sports Sci. 26 (1) (2008) 63–73, https://doi.org/10.1080/02640410701287289. Cited in: Pubmed; PMID 17899472.

[5] F.Y. Nakamura, L.A. Pereira, C.C. Cal Abad, R. Kobal, K. Kitamura, H. Roschel, F. Rabelo, W.A. Souza Jr., I. Loturco, Differences in physical performance between U-20 and senior top-level Brazilian futsal players, J. Sports Med. Phys. Fit. 56 (11) (2016) 1289–1297, eng. Epub 20150529. Cited in: Pubmed; PMID 26022747.

[6] J.C. Barbero-Alvarez, J.V. Subiela, J. Granda-Vera, C. Castagna, M. Gómez, J. Del Coso, Aerobic fitness and performance in elite female futsal players, eng. Epub 20151229, Biol. Sport 32 (4) (2015) 339–344, https://doi.org/10.5604/20831862.1189200. Cited in: Pubmed; PMID 28479664.

[7] A. Sander, M. Keiner, K. Wirth, D. Schmidtbleicher, Influence of a 2-year strength training programme on power performance in elite youth soccer players, eng. Epub 20121113, Eur. J. Sport Sci. 13 (5) (2013) 445–451, https://doi.org/10.1080/17461391.2012.742572. Cited in: Pubmed; PMID 24050460.

[8] S. Saryono, A. Irawan, S. Nopembri, A. Wiharja, M.I. Zein, The effects of the FIVE futsal injury prevention program on lower limb muscle strength among young futsal players, eng. Epub 20220325, J. Sports Med. Phys. Fit. 62 (12) (2022) 1685–1692, https://doi.org/10.23736/s0022-4707.22.13498-5. Cited in: Pubmed; PMID 35333027.

[9] J. Baron, A. Bieniec, A.S. Swinarew, T. Gabryś, A. Stanula, Effect of 12-week functional training intervention on the speed of young footballers, Epub 20191224, Int. J. Environ. Res. Publ. Health 17 (1) (2019), https://doi.org/10.3390/ijerph17010160. Cited in: Pubmed; PMID 31878326.

[10] J. Torres-Torrelo, D. Rodríguez-Rosell, R. Mora-Custodio, F. Pareja-Blanco, J.M. Yañez-García, J.J. González-Badillo, Effects of resistance training and combined training program on repeated sprint ability in futsal players, Epub 20180516, Int. J. Sports Med. 39 (7) (2018) 517–526, https://doi.org/10.1055/a-0596-7497. Cited in: Pubmed; PMID 29768643.

[11] P. Jiménez-Reyes, P. Samozino, M. Brughelli, J. Morin, Effectiveness of an individualized training based on force-velocity profiling during jumping, Front. Physiol. 7 (2017) 677.

[12] P. Jiménez-Reyes, V. Cuadrado-Peñafiel, J.J. González-Badillo, Analysis of variables measured in vertical jump related to athletic performance and its application to training, CCyD 6 (17) (2011) 113–119.

[13] D. Rodríguez-Rosell, R. Mora-Custodio, F. Franco-Márquez, J.M. Yáñez-García, J.J. González-Badillo, Traditional vs. sport-specific vertical jump tests: reliability, validity, and relationship with the legs strength and sprint performance in adult and teen soccer and basketball players, J. Strength Condit Res. 31 (1) (2017) 196–206.

[14] P. Jiménez-Reyes, J.J. González-Badillo, Monitoring training load through the CMJ in sprints and jump events for optimizing performance in athletics, CCyD 7 (18) (2011) 207–217.

[15] K. Maćkała, M. Fostiak, K. Kowalski, Selected determinants of acceleration in the 100m sprint, J. Hum. Kinet. 45 (1) (2015) 135–148.

[16] F.G. Caetano, M.J. de Oliveira Bueno, A.L. Marche, F.Y. Nakamura, S.A. Cunha, F.A. Moura, Characterization of the sprint and repeated-sprint sequences performed by professional futsal players, according to playing position, during official matches, J. Appl. Biomech. 31 (6) (2015) 423–429, https://doi.org/10.1123/jab.2014-0159. Cited in: Pubmed; PMID 26155741.

[17] A. Baena-Raya, D. García-Ortega, S. Sánchez-López, A. Soriano-Maldonado, P.J. Reyes, M.A. Rodríguez-Pérez, The influence of sprint mechanical properties on change of direction in female futsal players, J. Hum. Kinet. 79 (2021) 221–228, https://doi.org/10.2478/hukin-2021-0075.

[18] S. Nimphius, S.J. Callaghan, T. Spiteri, R.G. Lockie, Change of direction deficit: a more isolated measure of change of direction performance than total 505 time, J. Strength Condit Res. 30 (11) (2016) 3024–3032, https://doi.org/10.1519/jsc.0000000000001421.

[19] F. Farhani, H. Rajabi, R. Negaresh, A. Ali, S. Amani Shalamzari, J.S. Baker, Reliability and validity of a novel futsal special performance test designed to measure skills and anaerobic performance, Int. J. Sports Physiol. Perform. 14 (8) (2019) 1096–1102, https://doi.org/10.1123/ijspp.2018-0850.

[20] C. Bishop, P. Jarvis, A. Turner, C. Balsalobre-Fernandez, Validity and reliability of strategy metrics to assess countermovement jump performance using the newly developed my jump Lab smartphone application, J. Hum. Kinet. 83 (2022) 185–195, https://doi.org/10.2478/hukin-2022-0098.

[21] C. Balsalobre-Fernández, M. Glaister, R.A. Lockey, The validity and reliability of an iPhone app for measuring vertical jump performance, J. Sports Sci. 33 (15) (2015) 1574–1579.

[22] C. Balsalobre-Fernández, H. Agopyan, J.B. Morin, The validity and reliability of an iPhone app for measuring running mechanics, eng. Epub 20170626, J. Appl. Biomech. 33 (3) (2017) 222–226, https://doi.org/10.1123/jab.2016-0104. Cited in: Pubmed; PMID 27918692.

[23] D.J. Paul, G.P.J.T.S. Nassis, C. Research, Testing strength and power in soccer players: the application of conventional and traditional methods of assessment 29 (6) (2015) 1748–1758.

[24] A. Martín-García, A. Gómez Díaz, P.S. Bradley, F. Morera, D. Casamichana, Quantification of a professional football team's external load using a microcycle structure, eng, J. Strength Condit Res. 32 (12) (2018) 3511–3518, https://doi.org/10.1519/jsc.0000000000002816. Cited in: Pubmed; PMID 30199452.

[25] E.D. Cambridge, N. Sidorkewicz, D.M. Ikeda, S.M. McGill, Progressive hip rehabilitation: the effects of resistance band placement on gluteal activation during two common exercises, eng. Epub 20120330, Clin. Biomech. 27 (7) (2012) 719–724, https://doi.org/10.1016/j.clinbiomech.2012.03.002. Cited in: Pubmed; PMID 22464817.

[26] S. Emmonds, T. Sawczuk, S. Scantlebury, K. Till, B.J.T.S. Jones, C. Research, Seasonal changes in the physical performance of elite youth female soccer players 34 (9) (2020) 2636–2643.

[27] E. Pardos-Mainer, J.A. Casajús, O. Gonzalo-Skok, Reliability and sensitivity of jumping, linear sprinting and change of direction ability tests in adolescent female football players, Science and Medicine in Football 3 (3) (2019) 183–190.

[28] T. Reilly, A.M. Williams, A. Nevill, A. Franks, A multidisciplinary approach to talent identification in soccer, eng, J. Sports Sci. 18 (9) (2000) 695–702, https://doi.org/10.1080/02640410050120078. Cited in: Pubmed; PMID 11043895.

[29] Z. Chen, C. Bian, K. Liao, C. Bishop, Y. Li, Validity and reliability of a phone app and stopwatch for the measurement of 505 change of direction performance: a test-retest study design, Epub 20210924, Front. Physiol. 12 (2021) 743800, https://doi.org/10.3389/fphys.2021.743800. Cited in: Pubmed; PMID 34630164.

[30] O. Gonzalo-Skok, J. Tous-Fajardo, L. Suarez-Arrones, J.L. Arjol-Serrano, J.A. Casajús, A. Mendez-Villanueva, Validity of the V-cut test for young basketball players, eng. Epub 20150702, Int. J. Sports Med. 36 (11) (2015) 893–899, https://doi.org/10.1055/s-0035-1554635. Cited in: Pubmed; PMID 26134663.

[31] W.G. Hopkins, Measures of reliability in sports medicine and science, Sports Med. 30 (1) (2000) 1–15, https://doi.org/10.2165/00007256-200030010-00001. PMID: 10907753.

[32] A.M. Batterham, W.G. Hopkins, Making meaningful inferences about magnitudes 1 (1) (2006) 50–57.

[33] W.G. Hopkins, S. Marshall, A. Batterham, J. Hanin, Progressive statistics for studies in sports medicine and exercise, science 41 (1) (2009) 3.

[34] E. Bradshaw, P. Hume, M. Calton, B. Aisbett, Reliability and variability of day-to-day vault training measures in artistic gymnastics, Sports BioMech. 9 (2) (2010) 79–97.

[35] V.F. Neves da Silva, S.D.S. Aguiar, C.V. Sousa, R.D.C. Sotero, J.M.S. Filho, I. Oliveira, M.R. Mota, H.G. Simões, M.M. Sales, Effects of short-term plyometric training on physical fitness parameters in female futsal athletes, eng. Epub 20170516, J. Phys. Ther. Sci. 29 (5) (2017) 783–788, https://doi.org/10.1589/jpts.29.783. Cited in: Pubmed; PMID 28603345.

[36] O. Faude, R. Rössler, E.J. Petushek, R. Roth, L. Zahner, L. Donath, Neuromuscular adaptations to multimodal injury prevention programs in youth sports: a systematic review with meta-analysis of randomized controlled trials, Front. Physiol. 8 (2017) 791.

[37] I. Reis, A. Rebelo, P. Krustrup, J. Brito, Performance enhancement effects of Federation Internationale de Football Association's "The 11+" injury prevention training program in youth futsal players, Clin. J. Sport Med. 23 (4) (2013) 318–320.

[38] J. Sánchez-Sánchez, J.G. Rodríguez, D.M. García, D.R. Martín, J.B. García, A.B. Cerezal, Efectos de un entrenamiento con cargas excéntricas sobre el rendimiento en jugadores de fútbol sala, SPORT TK-Revista EuroAmericana de Ciencias del Deporte. 6 (1) (2017) 57–66.

[39] A. Paz-Franco, E. Rey, R. Barcala-Furelos, Effects of 3 different resistance training frequencies on jump, sprint, and repeated sprint ability performances in professional futsal players, eng, J. Strength Condit Res. 31 (12) (2017) 3343–3350, https://doi.org/10.1519/jsc.0000000000001766. Cited in: Pubmed; PMID 28225522.

[40] R. Ramirez-Campillo, J. Moran, J.L. Oliver, J.S. Pedley, R.S. Lloyd, U. Granacher, Programming plyometric-jump training in soccer: a review. Sports (Basel), Epub 20220610 10 (6) (2022), https://doi.org/10.3390/sports10060094. Cited in: Pubmed; PMID 35736834.

[41] J. Sánchez-Sánchez, D. Bishop, J. García-Unanue, E. Ubago-Guisado, E. Hernando, J. López-Fernández, E. Colino, L. Gallardo, Effect of a Repeated Sprint Ability test on the muscle contractile properties in elite futsal players, Epub 20181123, Sci. Rep. 8 (1) (2018) 17284, https://doi.org/10.1038/s41598-018-35345-z. Cited in: Pubmed; PMID 30470816.

[42] D.L. Marques, B. Travassos, A.C. Sousa, M.H. Gil, J.N. Ribeiro, M.C. Marques, Effects of low-moderate load high-velocity resistance training on physical performance of under-20 futsal players, Epub 20190318, Sports (Basel) 7 (3) (2019), https://doi.org/10.3390/sports7030069. Cited in: Pubmed; PMID 30889811.

[43] O. Gonzalo-Skok, J. Tous-Fajardo, C. Valero-Campo, C. Berzosa, A.V. Bataller, J.L. Arjol-Serrano, G. Moras, A. Mendez-Villanueva, Eccentric-overload training in team-sport functional performance: constant bilateral vertical versus variable unilateral multidirectional movements, eng. Epub 20161214, Int. J. Sports Physiol. Perform. 12 (7) (2017) 951–958, https://doi.org/10.1123/ijspp.2016-0251. Cited in: Pubmed; PMID 27967273.

[44] J. Tous-Fajardo, O. Gonzalo-Skok, J.L. Arjol-Serrano, P. Tesch, Enhancing change-of-direction speed in soccer players by functional inertial eccentric overload and vibration training, eng. Epub 20150501, Int. J. Sports Physiol. Perform. 11 (1) (2016) 66–73, https://doi.org/10.1123/ijspp.2015-0010. Cited in: Pubmed; PMID 25942419.

[45] T.T. Freitas, P.E. Alcaraz, C. Bishop, J. Calleja-González, A.F.S. Arruda, A. Guerriero, V.P. Reis, L.A. Pereira, I. Loturco, Change of direction deficit in national team Rugby union players: is there an influence of playing position? Sports (Basel), Epub 20181221 7 (1) (2018), https://doi.org/10.3390/sports7010002. Cited in: Pubmed; PMID 30577602.

[46] I. Loturco, A.P. L, T.F. T, E.A. P, V. Zanetti, C. Bishop, I. Jeffreys, Maximum acceleration performance of professional soccer players in linear sprints: is there a direct connection with change-of-direction ability?, Epub 20190514, PLoS One 14 (5) (2019) e0216806, https://doi.org/10.1371/journal.pone.0216806. Cited in: Pubmed; PMID 31086386.

[47] J. Illa, D. Fernandez, X. Reche, G. Carmona, J.R. Tarragó, Quantification of an elite futsal team's microcycle external load by using the repetition of high and very high demanding scenarios, eng. Epub 20201015, Front. Psychol. 11 (2020) 577624, https://doi.org/10.3389/fpsyg.2020.577624. Cited in: Pubmed; PMID 33178080.