Acute effects of repeated isoinertial lunges on jump and sprint parameters

Mehmet Kale1ABCDE, Emre Çelik1B, Ezgi Uyar2BE, Esen Kızıldağ Kale2BCDE

1 Department of Coach Training in Sport, Faculty of Sports Sciences, Eskişehir Technical University, Turkey
2 Department of Coach Training, School of Physical Education and Sports, İstanbul Nişantaşı University, Turkey

Authors’ Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Background and Study Aim
Understanding the relationship between repeated isoinertial lunges and jump and sprint parameters is an important factor in achieving success in sports requiring explosive strength and speed. The aim of this study was to examine the acute effects of repeated isoinertial lunges on jump and sprint parameters.

Material and Methods
Volunteered 42 students from Sports Sciences Faculty were participated to the study. They were randomly divided into experimental group (EG) (n=22, age=22.8±1.1year, height=180.6±7.1cm, body weight=77.5±8.8kg) and control group (CG) (n=20, age=23.0±2.1year, height=173.1±5.6 cm, body weight=71.3±8.4 kg). As pre- and post-tests, each participant performed squat jump (SJ), countermovement jump (CMJ), and 30m sprint on a non-motorized treadmill. Isoinertial lunges were included in 8 reps with dominant leg (DL), 1 min rest, and 8 reps with non-dominant leg (NDL). As a statistical analysis, pre- and post-test differences were analyzed with independent t test between groups and paired t test within groups. The level of significance was taken as p≤0.05.

Results
There were pre-test and also post-test differences between groups in SJ (p<0.05) but there were no differences within groups. Both groups had significant pre- and post-test time, velocity, and power differences [for EG: p<0.01, p<0.001, p<0.01; for CG: p<0.001, p<0.001, p<0.01, respectively]. EG had significant pre- and post-test differences in stride frequency (SF) (p<0.01). There was a post-test SF difference between two groups (p<0.05). There were no statistically significant pre-test differences between the groups in 30m sprint parameters of NDL and DL. There were only significant post-test differences between the groups in SFDL (p<0.005) and NDL horizontal force (HFNDL) (p<0.01). EG had only significant pre- and post-test differences in SFDL and PNDL (p<0.005 and p<0.05).

Conclusions
Detailed studies in SF and SFDL increases result by repeated isoinertial lunges should be beneficial focus on DL neuromuscular activation. Furthermore, incorporating repeated isoinertial lunges into training regimens could be a valuable strategy for enhancing specific aspects of athletic performance in sports that demand high levels of speed and explosive power.

Keywords: stride frequency, dominant leg, isoinertial lunge, horizontal force

Introduction
Strength training produces muscle adaptations at both structural and functional levels [1]. Strength training with an isoinertial resistance has become one of the popular training methods. It is a technology that improves proprioception, neuromuscular efficiency and motor coordination based on postural control by improving neuromuscular activity. It elicits an equal amount of eccentric force against the isoinertial force (concentric force) applied by athletes [2]. The supramaximal weight generated during isoinertial eccentric strength exercises leads to a muscle-lengthening contraction, greater muscle strength gains, muscle hypertrophy. It provides greater improvements in muscle coordination compared to concentric strength training [3]. Compared to other traditional strength training methods, isoinertial resistance training method has positive effects on muscle architecture and cross-sectional area. The reason is that it achieves the same goals in less time [4]. Movements performed with isoinertial systems resulted in the same or greater strength development than the traditional weight training [5]. Isoinertial eccentric strength provides greater muscle activation on eccentric muscle contraction compared to traditional strength training [6]. Therefore, isoinertial eccentric training increases muscle strength by providing the opportunity to work on strength and speed in the muscle [7]. As a post-activity performance enhancement (PAPE), isoinertial squat and deadlift increased hamstring’ eccentric strength but didn’t affect the concentric strength [8]. Isoinertial system has a preventive effect against muscle tissue lesion by developing eccentric strength. It also allows gaining extensor strength [9]. It compares power/ strength and balance in eccentric/concentric phases during exercise in real-time. This supports
that isoinertial training is effective in improving vertical and horizontal strength during sprinting, squat jump (SJ) and countermovement jump (CMJ). In optimal strength training, half-squat and squat jump movements are used in preventing strength and speed reductions [10]. In addition, CMJ is a commonly used movement for the assessment of isoinertial leg strength due to its simplicity and explosiveness [11]. Relationships among isoinertial strength, speed and power help to identify the mechanism responsible for maximal power and training adaptations [12]. However, Beato et al. [13] noted very few studies have investigated the acute neuromuscular mechanisms induced by isoinertial training. These studies were associated acute musculoskeletal adaptations and acute effects on PAPE. Isoinertial systems have become widespread and started to be used in different fields and purposes because of their beneficial effects.

In an isoinertial system, a resistance is exhibited in proportion to the concentric contraction exhibited during the eccentric contraction [14]. Previous studies have used isoinertial interventions for physical fitness [15] and rehabilitation [16]. Some of them found positive effects on different populations such as the elderly [17], athletes [18], athletes undergoing rehabilitation [19]. It is known that the acute and chronic increase in various performance parameters with isoinertial training varies. They depend on the type of movement in training method, volume, intensity and protocol as well as characteristics of participants. However, there are no studies on acute effects of repetitive isoinertial lunges on sprint and jump performances. The aim of this study was to investigate the acute effects of repetitive isoinertial lunges on jump and sprint parameters.

Materials and Methods

Participants
The study included 50 male volunteers who were studying at Eskisehir Technical University, Faculty of Sport Sciences aged between 18-22 years. They had not participated in an application with the isoinertial training system before, and had no health problems. The study was completed with 42 participants due to the problems in the data. The targeted number of participants was determined by G*Power 3.1.9.7 analysis. It was based on the data entered with a power size (1-β) of 0.80, α=0.05, and an effect size (d) of 0.80. They were randomly divided into experimental group (EG) (n=22, age=22.8±1.1year, height=180.6±7.1cm, body weight=77.5±8.8kg) and control group (CG) (n=20, age=23.0±2.1year, height=173.1±5.6 cm, body weight=71.5±8.4 kg). They avoided high intensity exercise for 48 hours before the study. They were asked not to change their normal diet, smoke, drink alcohol or consume caffeine for 24 hours before tests. Participants were informed in detail about the purpose, content, importance, application, and possible risks. They could freely discontinue the study at any time before starting the measurements and tests according to the procedures of the Declaration of Helsinki, trial measurements and tests. Each participant signed an informed consent. Istanbul Nisantası University Ethics Committee approval (2022/24) was obtained for the study. Participants were assigned to the test protocols by simple randomization.

Research Design
After the device calibration, trial measurements and tests were performed for participants to adapt to laboratory conditions, measurements, and tests. They had a 10 min warm-up consisting of light-paced jogging, stretching and exercise movements. Participants performed 2x30m sprint tests with 3 min intervals. They had a 90 sec passive rest as stated by Kacoglu and Kale [20]. Then, they were taken to the vertical jump tests consisting of 2xSJ and 2xCMJ and the pre-tests were completed. SJ and CMJ tests were performed with 30 sec of passive rest between reps and 60 sec of passive rest between tests. The best of the 2 attempts in the jump tests was included in the statistical analysis. Before the post-tests, EG performed 16reps maximum (RM) lunges (8RM with DL in front, 1min rest, 8RM with NDL in front). CG performed repetitive lunges in the same way without isoinertial force.

Isoinertial Lunge Procedure
Each participant first performed a 10-minute warm-up consisting of light jogging, flexibility and calisthenic movements individually. Afterwards, the participant was shoeless, hands on the waist and torso upright, front foot on the phalanges on the isoinertial training system (Desmotec D11 Version Sport Pro, Italy). An adjustable rope was attached to the waist with a special belt from the bottom to the flywheel. Knees were in the flexion position between approximately 110-130°. When the participant felt ready, he performed extension until the knees reached 180° and returned to the starting position. He performed 16RM isoinertial lunges with 8RM of DL in front, 1 min rest, 8RM of NDL in front.

Height and Body Weight Measurements
Height was measured with a wall-mounted stadiometer (Holtain, UK) with an accuracy of 0.1mm. The accuracy was checked by measuring the height between the ground and the head table of the stadiometer. A 60cm standard aluminum flat bar was provided for this height. Body weight was measured using an electronic laboratory scale (Seka, Vogel & Halke, Hamburg) with an accuracy of 0.1kg. The measurements were done as recommended by Lohman et al. [21].
Sprint Test
Each participant had a 10-min warm-up consisting of light jogging, flexibility and calisthenic movements. He participated in 2x30m sprint tests with a 3-min interval on a non-motorized computer-assisted treadmill (Woodway Force 3.0, Woodway Inc., Waukesha, USA). Before the test, the horizontal force strain gauge attached to the waist was adjusted to be parallel to the treadmill. The best performance in 30m sprint tests was included in the statistical analyses. The best 30m sprint speed was calculated in m/sec from the formula \( V = \frac{d}{t} \). Horizontal force (HF) and vertical force (VF) data during 30m sprint were recorded on a computer at 200Hz. Means of SL and SF were determined in the best 30m sprint. The best 30m sprint HF= 30m sprint total HF (ΣHF) / 30m sprint total stride number (ΣSN) was calculated in Newton (N). The best 30m sprint VF= 30m sprint total vertical force (ΣVF) / 30m sprint total stride number (ΣSN) was calculated in N.

Jump Tests
Two different jump tests (SJ and CMJ) were applied on a jump mat that acts as an electronic on-off switch. As explained by Kale et al. [22], SJ and CMJ time was transferred to the computer. ESC 2XXX Series Data Acquisition computer software at 1000Hz [23] was used for each data transfer. Participants rested for 60sec after each jump test. Two trials were performed with 50 sec rest. Jumps were calculated with the formula \( h = \frac{g t^2}{2} \). Therefore, the highest jump height was taken into statistical analysis. SJ was performed on the mat with feet shoulder-width apart and hands on the waist. Eyes focused across and standing in a ~90° fixed squat position for 2-3 sec were followed by a vertical jump. CMJ was performed on the same mat with feet shoulder-width apart and hands on the waist. Eyes focused across and standing position, knees ~90° squat position as soon as possible were followed by a vertical jump.

Statistical Analysis
Data obtained from the study were analyzed using Jamovi statistical program (2.3.28.0, Stats Open Now). Skewness-Kurtosis test showed that all pre-test parameters of both groups were normally distributed. Independent sample t-test was used for between-group pre- and post-test comparisons. Paired sample t-test was used for within-group pre- and post-test comparisons. The significance level was based on p<0.05. Effect sizes (ES) were analyzed through means and standard deviations as stated by Wasserrthell and Cohen [25]. <0.2 was considered as trivial, 0.2-0.5 as small, 0.5-0.8 as moderate and >0.8 as large inference.

Results
Each parameter in the pre-tests was normally distributed (p > 0.05). Participants were divided into EG and CG. All results are presented in Table 1-4.

Table 1 demonstrated that there were no significant SJ differences in pre- and post-test comparisons within two groups. A statistically significant SJ difference was found between groups in pre-test [ES: 0.72 (moderate), 95% CI: [0.07, 1.36], p<0.05]. A statistically significant SJ difference also was found between groups in post-test [ES: 0.78 (moderate), 95% CI: [0.13, 1.42], p<0.05]. There were no statistically significant CMJ differences between-group and within-group comparisons in both pre-tests and post-tests.

Table 2. showed that no statistically significant differences in 30m sprint pre- and post-test peak parameters were found between EG and CG. There was a statistically significant difference in EG between the pre- and post-test \( V_{peak} \) [ES: -0.61 (moderate), 95% CI: [-1.06, -0.15], p<0.01]. CG had also a significant difference between the pre- and post-test \( V_{peak} \) [ES: -0.63 (moderate), 95% CI: [-1.11, -0.14], p<0.01]. In addition, CG had a significant pre- and post-test \( P_{peak} \) difference [ES: -0.87 (large), 95% CI: [-1.38, -0.35], p<0.001]. There were no significant differences between pre- and post-test results of the other 30m sprint peak parameters within the group.

<p>| Table 1. Mean ± SD values and comparisons of jump parameters of pre- and post-tests for EG and CG |</p>
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group</th>
<th>Pre</th>
<th>Post</th>
<th>ES [95% CI]</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>SJ (cm)</td>
<td>EG</td>
<td>35.0 ± 5.12</td>
<td>35.9 ± 5.57</td>
<td>0.39 [-0.82, 0.05]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>30.9 ± 6.00</td>
<td>31.6 ± 5.57</td>
<td>0.21 [-0.65, 0.24]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.72 [0.07, 1.36]</td>
<td>0.78 [0.13, 1.42]</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>CMJ (cm)</td>
<td>EG</td>
<td>36.5 ± 4.77</td>
<td>37.4 ± 6.49</td>
<td>0.30 [-0.75, 0.15]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>33.9 ± 6.39</td>
<td>34.3 ± 6.03</td>
<td>0.22 [-0.66, 0.25]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.43 [-0.19, 1.05]</td>
<td>0.49 [-0.14, 1.11]</td>
<td>Moderate</td>
<td></td>
</tr>
</tbody>
</table>

Data are Mean ± SD. EG: Experimental group; CG: Control group; ES: Effect size; 95% CI: 95% Confidence interval; SJ: Squat jump; CMJ: Counter movement jump; *: p<0.05, between groups; ¥: p<0.05, within groups.
Table 2. Mean ± SD values and comparisons of peak parameters of 30m sprint pre- and post-tests for EG and CG

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group</th>
<th>Pre</th>
<th>Post</th>
<th>ES [95% CI]</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{\text{peak}}$ (m.sec$^{-1}$)</td>
<td>EG</td>
<td>4.98 ± 0.73</td>
<td>5.26 ± 0.57**</td>
<td>-0.61 [-1.06, -0.15]</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>4.89 ± 0.50</td>
<td>5.13 ± 0.39**</td>
<td>-0.63 [-1.11, -0.14]</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.14 [-0.47, 0.74]</td>
<td>0.28 [-0.54, 0.89]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Trivial</td>
<td>Small</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$H_{\text{peak}}$ (N)</td>
<td>EG</td>
<td>400 ± 198</td>
<td>381 ± 143</td>
<td>0.20 [-0.22, 0.62]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>368 ± 151</td>
<td>369 ± 140</td>
<td>-0.01 [-0.45, 0.43]</td>
<td>Trivial</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.18 [-0.43, 0.79]</td>
<td>0.08 [-0.53, 0.69]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Trivial</td>
<td>Trivial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{\text{peak}}$ (N)</td>
<td>EG</td>
<td>1626 ± 484</td>
<td>1687 ± 455</td>
<td>-0.23 [-0.66, 0.19]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>1611 ± 454</td>
<td>1594 ± 412</td>
<td>0.10 [-0.34, 0.54]</td>
<td>Trivial</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.03 [-0.57, 0.64]</td>
<td>0.21 [-0.40, 0.82]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Trivial</td>
<td>Small</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{\text{peak}}$ (W)</td>
<td>EG</td>
<td>1625 ± 873</td>
<td>1654 ± 636</td>
<td>-0.02 [-0.44, 0.40]</td>
<td>Trivial</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>1349 ± 491</td>
<td>1489 ± 525***</td>
<td>-0.87 [-1.58, -0.55]</td>
<td>Large</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.39 [-0.24, 0.10]</td>
<td>0.25 [-0.37, 0.86]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Trivial</td>
<td>Small</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data are Mean ± SD. EG: Experimental group; CG: Control group; ES: Effect size; 95% CI: 95% Confidence interval; $V_{\text{peak}}$: Peak velocity; $H_{\text{peak}}$: Peak horizontal force; $V_{\text{peak}}$: Peak vertical force; $P_{\text{peak}}$: Peak power; **: p<0.01, within groups; ***: p<0.001, within groups.

As can be seen in Table 3., there was no statistically significant difference between groups in all 30m sprint pre-test parameters. A statistically significant difference was found only in SF [ES: 0.74 (moderate), 95% CI: (-0.09, 1.58), p<0.05]. EG had statistically significant t, V, SF and P differences (p<0.01, p<0.005, p<0.01 and p<0.01, respectively) between pre- and post-tests. The inferences were moderates (ES: 0.70, -0.79, -0.59 and -0.65, respectively). CG had significant differences in t and V [p<0.001, ES: 0.83 (large) and p<0.001, ES: -0.86 (large), HF and P [p<0.05, ES: -0.51 (moderate) and p<0.01, ES: -0.81 (large)].

In Table 4., there were no statistically significant differences between groups in 30m sprint pre-test parameters based on DL and NDL. In the post-test comparisons between groups in 30m sprint pre-test parameters, no statistically significant differences were found in all other parameters except for SF$_{DL}$ [ES: 0.91 (large), 95% CI: [0.24, 1.57], p<0.005] and HF$_{NDL}$ [ES: 0.78 (medium), 95% CI: [0.12, 1.42], p<0.01]. DG had a significant pre- and post-test difference in $F_{DL}$ [ES: -0.74 (moderate), 95% CI: [-1.21, -0.26], p<0.005]. DG also had a significant pre- and post-test difference in $P_{NDL}$ [ES: -0.56 (moderate), 95% CI: [-1.00, -0.10], p<0.05].

There were statistically significant pre- and post-test differences in CG for $F_{DL}$ [ES: -0.48 small, 95% CI: [-0.94, -0.01], p<0.05]. It was observed that CG had a significant pre- and post-test $F_{DL}$ difference [ES: 0.48 (small), 95% CI: [0.01, 0.94], p<0.05].

Discussion

The aim of this study was to investigate acute effects of isoinertial lunges on SJ, CMJ and 30 m sprint. In literature, there were no studies demonstrating acute effects of isoinertial lunges performed with DL and NDL on sprint and jump parameters. SJ had a statistically significant pre- and post-test difference (p<0.05) between groups while no differences were found within groups. Both groups had statistically significant pre- and post-test differences in t, V, P (p<0.01, p<0.001, and p<0.01, respectively for EG; p<0.001, p<0.001, and p<0.01, respectively for CG). EG had a statistically significant SF difference between pre- and post-tests (p<0.01). There is a statistically significant difference between groups in SF post-tests (p<0.05). There were no differences between groups in pre-test DL and NDL 30m sprint parameters. There were statistically significant SF$_{DL}$ and SF$_{NDL}$ differences between groups in post-tests (p<0.005 and p<0.01). Statistically significant differences (p<0.005 and p<0.05) was found between pre- and post-tests in SF$_{DL}$ and $P_{NDL}$ in EG.

Eccentric strength training activated large motor units in hamstring muscle group and increased eccentric strength-related performance such as vertical jump [26]. Timon et al. [27] compared the
post-activation performance enhancement effect of traditional strength and isoinertial resistance different preload protocols. They found that vertical jump performance increased after the isoinertial preload protocol. Pre- and post-test results of this study between and within groups were compared. Isoinertial lunges performed 8RM of DL, 1min rest, 8RM of NDL didn’t have acute effects on SJ and CMJ after 90sec. Therefore, SJ and CMJ results of current study were not considered to support Timon et al. [27]' study results. This may be due to the fact that in the study of Timon et al. [27]. Their jump tests were performed after 4min and 8min, while in the present study, jump tests were performed after 90sec.

Beato et al. [28] tested jumping and change of direction running after 4sets of 6reps isoinertial eccentric strength protocols. The results showed that soccer players had no statistical differences among 3 different leg movements (cross-cutting step, leg extension and squat). It was determined that 5m chance of direction performed 4min after 3 exercises showed statistically positive acute increases. Beato et al. [13] compared eccentric overloading with isoinertial strength and traditional strength with Olympic bar. Both of them increased vertical jump acutely in a statistically significant manner, but did not affect 5m sprint. In their another study, Beato et al. [29] determined that moderate isoinertial loads on athletes statistically significantly increased vertical jump. They also stated significant differences in chance of direction running performances at 30s, 5min and 6min after this loading.

Sabido et al. [30] studied chronic effects of

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group</th>
<th>Pre</th>
<th>Post</th>
<th>ES [95% CI]</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>t (sec)</td>
<td>EG</td>
<td>7.58 ± 1.51</td>
<td>6.95 ± 1.12 **</td>
<td>0.70 [0.23, 1.17]</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>7.71 ± 1.47</td>
<td>7.22 ± 1.08 ***</td>
<td>0.83 [0.31, 1.33]</td>
<td>Large</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>-0.22 [-0.83, 0.39]</td>
<td>-0.25 [-0.86, 0.36]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Small</td>
<td>Small</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V (m.sec⁻¹)</td>
<td>EG</td>
<td>4.23 ± 0.82</td>
<td>4.42 ± 0.70 ***</td>
<td>-0.79 [-1.26, -0.30]</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>4.02 ± 0.70</td>
<td>4.24 ± 0.60 ***</td>
<td>-0.86 [-1.56, -0.33]</td>
<td>Large</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.27 [-0.34, 0.88]</td>
<td>0.28 [-0.35, 0.89]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Small</td>
<td>Small</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF (Hz)</td>
<td>EG</td>
<td>5.97 ± 1.07</td>
<td>6.43 ± 1.21 **</td>
<td>-0.59 [-1.04, -0.13]</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>5.60 ± 0.82</td>
<td>5.71 ± 0.77 **</td>
<td>-0.24 [-0.68, 0.21]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.38 [-0.24, 0.10]</td>
<td>0.74 [-0.09, 1.38]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Small</td>
<td>Moderate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SL (m)</td>
<td>EG</td>
<td>0.82 ± 0.11</td>
<td>0.81 ± 0.12</td>
<td>0.11 [-0.31, 0.53]</td>
<td>Trivial</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>0.83 ± 0.10</td>
<td>0.85 ± 0.10</td>
<td>-0.26 [-0.70, 0.19]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>-0.01 [-0.62, 0.59]</td>
<td>-0.32 [-0.93, 0.29]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Trivial</td>
<td>Small</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HF (N)</td>
<td>EG</td>
<td>152 ± 12</td>
<td>191 ± 161</td>
<td>-0.24 [-0.67, 0.18]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>146 ± 111</td>
<td>151 ± 147 **</td>
<td>-0.51 [-0.97, -0.03]</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.53 [-0.10, 1.15]</td>
<td>0.34 [-0.28, 0.95]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Moderate</td>
<td>Small</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VF (N)</td>
<td>EG</td>
<td>779 ± 148</td>
<td>767 ± 171</td>
<td>0.09 [-0.33, 0.51]</td>
<td>Trivial</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>776 ± 128</td>
<td>772 ± 132</td>
<td>0.31 [-0.14, 0.76]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.02 [-0.58, 0.63]</td>
<td>0.03 [-0.64, 0.58]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Trivial</td>
<td>Trivial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P (W)</td>
<td>EG</td>
<td>691 ± 151</td>
<td>732 ± 161 **</td>
<td>-0.65 [-1.08, -0.16]</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>612 ± 120</td>
<td>681 ± 112 **</td>
<td>-0.81 [-1.31, -0.30]</td>
<td>Large</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.57 [-0.06, 1.20]</td>
<td>0.37 [-0.64, 0.58]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Moderate</td>
<td>Small</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data are Mean ± SD. EG: Experimental group; CG: Control group; ES: Effect size; 95% CI: 95% Confidence interval; t: time; V: Velocity; SF: Stride frequency; SL: Stride length; HF: Horizontal force; VF: Vertical force; P: Power; *: p<0.05, within groups; **: p<0.01, within groups; ***: p<0.001, within groups; ¥: p<0.05.
Tablo 4. Mean ± SD values and comparisons of NDL and DL parameters of 30m sprint pre- and post-tests for EG and CG

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group</th>
<th>Pre</th>
<th>Post</th>
<th>ES [95% CI]</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EG</td>
<td>5.96 ± 1.05</td>
<td>6.58 ± 1.14***</td>
<td>-0.74 [-1.21, -0.26]</td>
<td>Moderate</td>
</tr>
<tr>
<td>SF&lt;sub&gt;DL&lt;/sub&gt; (Hz)</td>
<td>CG</td>
<td>5.57 ± 0.92</td>
<td>5.69 ± 0.75**</td>
<td>-0.23 [-0.67, 0.22]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.40 [-0.22, 1.01]</td>
<td>0.91 [0.24, 1.57]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Small</td>
<td>Large</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF&lt;sub&gt;NDL&lt;/sub&gt; (Hz)</td>
<td>EG</td>
<td>5.98 ± 1.16</td>
<td>6.29 ± 1.18</td>
<td>-0.33 [-0.75, 0.11]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>5.64 ± 0.82</td>
<td>5.73 ± 0.86</td>
<td>-0.14 [-0.58, 0.31]</td>
<td>Trivial</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.34 [-0.28, 0.95]</td>
<td>0.54 [-0.10, 1.16]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Trivial</td>
<td>Small</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SL&lt;sub&gt;DL&lt;/sub&gt; (N)</td>
<td>EG</td>
<td>0.80 ± 0.10</td>
<td>0.78 ± 0.12</td>
<td>0.23 [-0.20, 0.65]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>0.80 ± 0.09</td>
<td>0.83 ± 0.09</td>
<td>-0.32 [-0.76, 0.14]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>-0.02 [-0.63, 0.58]</td>
<td>-0.50 [-1.12, 1.15]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Small</td>
<td>Small</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SL&lt;sub&gt;NDL&lt;/sub&gt; (N)</td>
<td>EG</td>
<td>0.82 ± 0.12</td>
<td>0.81 ± 0.13</td>
<td>0.10 [-0.32, 0.52]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>0.82 ± 0.11</td>
<td>0.85 ± 0.12</td>
<td>-0.37 [-0.81, -0.09]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.05 [-0.56, 0.65]</td>
<td>-0.35 [-0.96, 0.27]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Trivial</td>
<td>Small</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HF&lt;sub&gt;DL&lt;/sub&gt; (N)</td>
<td>EG</td>
<td>156 ± 22</td>
<td>156 ± 17</td>
<td>0.004 [-0.41, 0.42]</td>
<td>Trivial</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>147 ± 16</td>
<td>153 ± 12*</td>
<td>-0.48 [-0.94, -0.01]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.48 [-0.15, 1.09]</td>
<td>0.18 [-0.44, 0.78]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Small</td>
<td>Trivial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HF&lt;sub&gt;NDL&lt;/sub&gt; (N)</td>
<td>EG</td>
<td>147 ± 15</td>
<td>157 ± 16</td>
<td>-0.40 [-0.83, 0.04]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>145 ± 11</td>
<td>146 ± 15*</td>
<td>0.14 [-0.30, 0.58]</td>
<td>Trivial</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.15 [-0.46, 0.76]</td>
<td>0.78 [0.12, 1.42]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Trivial</td>
<td>Small</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VF&lt;sub&gt;DL&lt;/sub&gt; (N)</td>
<td>EG</td>
<td>755 ± 200</td>
<td>805 ± 174</td>
<td>-0.23 [-0.65, 0.20]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>801 ± 119</td>
<td>768 ± 157*</td>
<td>0.48 [0.01, 0.94]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>-0.28 [-0.88, 0.34]</td>
<td>0.22 [-0.39, 0.83]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Trivial</td>
<td>Small</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VF&lt;sub&gt;NDL&lt;/sub&gt; (N)</td>
<td>EG</td>
<td>805 ± 180</td>
<td>734 ± 227</td>
<td>0.34 [-0.09, 0.77]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>753 ± 155</td>
<td>779 ± 142</td>
<td>-0.40 [-0.85, 0.06]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.51 [-0.31, 0.92]</td>
<td>-0.24 [-0.84, 0.38]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Small</td>
<td>Small</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P&lt;sub&gt;DL&lt;/sub&gt; (W)</td>
<td>EG</td>
<td>713 ± 187</td>
<td>720 ± 169</td>
<td>-0.06 [0.47, 0.36]</td>
<td>Trivial</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>615 ± 121</td>
<td>678 ± 97***</td>
<td>-0.84 [-1.55, -0.32]</td>
<td>Large</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.62 [-0.03, 1.24]</td>
<td>0.30 [-0.32, 0.91]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Moderate</td>
<td>Small</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P&lt;sub&gt;NDL&lt;/sub&gt; (W)</td>
<td>EG</td>
<td>678 ± 127</td>
<td>745 ± 173*</td>
<td>-0.56 [-1.00, -0.10]</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>CG</td>
<td>629 ± 110</td>
<td>679 ± 151</td>
<td>-0.44 [-0.89, 0.03]</td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>ES [95% CI]</td>
<td>0.41 [-0.21, 1.02]</td>
<td>0.42 [-0.20, 1.04]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inference</td>
<td>Small</td>
<td>Small</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data are Mean ± SD. EG: Experimental group; CG: Control group; ES: Effect size; 95% CI: 95% Confidence interval; SF<sub>NDL</sub>: Non-dominant leg stride frequency; SF<sub>DL</sub>: Dominant leg stride frequency; SL<sub>NDL</sub>: Non-dominant leg stride length; SL<sub>DL</sub>: Dominant leg stride length; HF<sub>NDL</sub>: Non-dominant leg horizontal force; HF<sub>DL</sub>: Dominant leg horizontal force; VF<sub>NDL</sub>: Non-dominant leg vertical force; VF<sub>DL</sub>: Dominant leg vertical force; P<sub>NDL</sub>: Non-dominant leg power; P<sub>DL</sub>: Dominant leg power; *: p<0.05, within groups; ¥: p<0.05, between groups; ¥¥: p<0.01, between groups.
iso inertial bilateral squat or unilateral lunges applied to athletes. Training protocols were 7 weeks, ones a week, 4 sets of 8 reps of isoinertial bilateral squat and unilateral lunges. Both protocols significantly increased in CMJ and 20m sprint. Nunez et al. [31] studied isoinertial squat and lunges for 6 weeks, 2 times a-week, 4 sets of 7 reps. They provided statistically significant improvement in lower body muscle volume, strength, CMJ, 90° change of direction. They also stated that isoinertial lunges improved 90° change of direction time and deceleration percentage of both DL and NDL. Isoinertial squats improved only the 90° change of direction time and deceleration percentage of DL. In addition, Kale et al. [32] explained that isoinertial half squats performed 4RM can support sprints by tolerating SL imbalance between DL and NDL.

Conclusions
The limited training time for coaches and athletes provides research opportunities on efficient training programs and methods. The study results showed acute effects of isoinertial lunges on SF and SF_DL parameters. In future studies, it would be beneficial to focus on DL neuromuscular activation for optimal training in repetitive isoinertial lunges.

Acknowledgement
This present paper was supported by Istanbul Nisantası University Scientific Research Projects by Project 2022/14.

Conflict of interest
The authors declare no conflicts of interest.


Information about the authors:

Mehmet Kale; (Corresponding author); https://orcid.org/0000-0002-1960-2234; mkale@eskisehir.edu.tr; Department of Coach Training in Sport, Faculty of Sport Sciences, Eskişehir Technical University; Eskişehir, Turkey.

Emre Çelik; https://orcid.org/0009-0002-6479-7234; celikemmre@outlook.com; Department of Coach Training in Sport, Faculty of Sport Sciences, Eskişehir Technical University; Eskişehir, Turkey.

Ezgi Ayaz; https://orcid.org/0000-0002-5696-201X; ezgi.ayaz@nisantasi.edu.tr; School of Physical Education and Sports, Department of Coaching Education, İstanbul Nişantaşı University; İstanbul, Turkey.

Esen Kızıldağ Kale; https://orcid.org/0000-0002-4927-8682; ekizildag@nisantasi.edu.tr; School of Physical Education and Sports, Department of Coaching Education, İstanbul Nişantaşı University; İstanbul, Turkey.

Cite this article as:
https://doi.org/10.15561/20755279.2023.0604

This is an Open Access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited
http://creativecommons.org/licenses/by/4.0/deed.en

Received: 20.10.2023

Accepted: 21.11.2023; Published: 30.12.2023