The effects of loaded plyometrics and short sprints in U19 male soccer players in Tunisia

Aloui, Ghaith; Souhail, Hermassi; Hayes, Lawrence D.; Bouhafs, El Ghali; Chelly, Mohamed Souhaiel; Schwesig, René

Published in:
Applied Sciences

DOI:
10.3390/app11167621

Published: 19/08/2021

applied sciences

MDPI

Article

The Effects of Loaded Plyometrics and Short Sprints in U19 Male Soccer Players in Tunisia

Ghaith Aloui [1], Hermassi Souhail [2,*], Lawrence D. Hayes [3], El Ghali Bouhafs [4], Mohamed Souhaiel Chelly [1,†] and René Schwesig [5,†]

[1] Research Unit (UR17JS01) Sport Performance, Health & Society, Higher Institute of Sport and Physical Education, Ksar-Saîd, University of "La Manouba", Tunis 2010, Tunisia; gaithaloui@hotmail.fr (G.A.); mohamedsouhaiel.chelly@issep.uma.tn (M.S.C.)
[2] Physical Education Department, College of Education, Qatar University, Doha 2713, Qatar
[3] School of Health and Life Sciences, University of the West of Scotland, Glasgow G72 0LH, UK; Lawrence.Hayes@uws.ac.uk
[4] Department of Sports Science, Martin-Luther-University Halle-Wittenberg, von-Seckendorff-Platz 2, 06120 Halle, Germany; bouhafs.elghali@gmail.com
[5] Department of Orthopaedic and Trauma Surgery, Martin-Luther-University Halle-Wittenberg, Ernst-Grube-Str. 40, 06120 Halle, Germany; rene.schwesig@uk-halle.de
* Correspondence: shermassi@qu.edu.qa
† The last two authors are co-last authors.

Featured Application: The investigation examined adding 8 weeks of bi-weekly loaded plyometric and short sprints training into standard training for U19 soccer players. We report that including bi-weekly loaded plyometric and short sprints training in standard training during the coronavirus-19 (COVID-19) pandemic improved the physical fitness of young soccer players. Particularly, the ability to repeatedly change direction benefited most from the intervention.

Abstract: We investigated adding 8 weeks of bi-weekly loaded plyometric and short sprints (LPaSS) training into training for under 19 (U19) soccer players. An experimental group (EG, n = 18, age: 17.5 ± 0.58 years, body mass: 67.4 ± 4.37 kg, height: 1.76 ± 0.05 m, body fat: 11.4 ± 1.55%), and a control group (CG, n = 16, age: 17.5 ± 0.58 years, body mass: 68.7 ± 3.65 kg, height: 1.78 ± 0.03 m, body fat: 11.6 ± 1.14%) participated. The pre- and postintervention measures were: the squat-jump (SJ); the countermovement-jump with arm swing (CMJA); the five jump test (5JT); 10 m and 30 m sprint; the ability to change direction (sprint with 90° turns (S90°) and sprinting 9–3–6–3–9 m ,involving running both backwards and forwards (SBF); repeated sprint ability (RSA), and balance (Y-balance test). The EG experienced superior jump ($p < 0.001$; d_{range}: 1.69–1.89), sprint ($p < 0.001$; d_{range}: 1.82–2.56), S90° ($p < 0.001$; d_{range}: 1.64–2.25), RSA ($p < 0.001$; d_{range}: 3.90–4.17), and balance ($p < 0.001$; d_{range}: 1.11–2.54) improvement. Comparatively, the pre- to postchanges in the CG ranged from d = 0.36 (dynamic balance) to d = 1.00 (10 m sprint). Therefore, bi-weekly LPaSS training improves athletic performance in young soccer players, particularly RSA.

Keywords: stretch-shortening cycle; sprint training; plyometric training; additional load; soccer training; periodization

Citation: Aloui, G.; Souhail, H.; Hayes, L.D.; Bouhafs, E.G.; Chelly, M.S.; Schwesig, R. The Effects of Loaded Plyometrics and Short Sprints in U19 Male Soccer Players in Tunisia. *Appl. Sci.* **2021**, *11*, 7621. https://doi.org/10.3390/app11167621

Academic Editor: Mark King

Received: 24 June 2021
Accepted: 16 August 2021
Published: 19 August 2021

1. Introduction

Soccer is a sport with many important characteristics comprising technical, tactical, and physical aspects [1], combining cyclic and acyclic movements [2,3]. In youth soccer teams, endurance, speed, and muscular strength are valued physical skills [4], so youth athletes have a greater change of selection when they demonstrate excellence in these abilities [5]. Therefore, applicable fitness traits are generally assessed and monitored, and typically include maximum speed, strength, change-of-direction (CoD) ability, balance, and flexibility [6]. Therefore, fitness training in young soccer players is imperative to achieve success in their soccer careers [7].

Conceiving appropriate training programs for soccer players requires a detailed understanding of the physiological load placed on players of particular age groups and positions [8]. In high level soccer matches, particularly at the elite level, there is a well described requirement to produce high speed intermittently, and repeatedly [9,10]—this ability to recover between each sprint, and maintain performance in subsequence sprints is known as repeated sprint ability (RSA). RSA is therefore considered a specific fitness requirement of soccer [8]. Time and motion analyses indicate youth soccer players cover an average of 8448 m during a match, 501 m at 16–19 km·h^{-1} and 428 m at >19.1 km·h^{-1} [11].

Plyometric and sprint exercises have been used as training methods for increasing abilities such as jumping, sprinting, and change of direction performance [12–15]. Several researchers have discussed the use of plyometric [16–19] and sprint [20–22] training with additional external loading. Recently, it has come to light that a combination of training methods may be more efficacious than standalone approaches [23]. Indeed, some recent studies have reported improved fitness parameters after loaded combined plyometric and short sprints (LPaSS) training in soccer players [24]. Recently, Hammami et al. [24] studied effects of LPaSS training in male U17 soccer players and reported improved sprint performance, jumping, CoD ability, RSA, and balance performance.

To our knowledge, there is a dearth of studies examining the effects of LPaSS training in under 19 (U19) soccer players. As such, the primary aim of the present investigation was to determine the effects of replacing some proportion of habitual soccer training with LPaSS on jumping, sprinting, agility, CoD ability, RSA, and balance in male U19 soccer players. We hypothesized that replacing some of regular training with 8 weeks of LPaSS training twice per week would improve both horizontal and vertical jump performance, sprint performance, and CoD ability when compared with the control group, who maintained habitual training. Specifically, we examined vertical and horizontal jump performance (i.e., squat jump (SJ), countermovement jump with arm swing (CMJA), and the five jump test (5JT)), sprint performance (i.e., 10 m and 30 m sprint), CoD ability (sprint with 90° turns (S90°) and sprint 9–3–6–3–9 m with backward and forward running (SBF)), RSA, and dynamic balance performance (Y-balance test).

2. Materials and Methods

2.1. Participants

This study was completed during the 2020/2021 soccer season. During the study, Government guidelines were altered as a response to the pandemic in early April 2020, and citizens were prohibited from leaving their homes to visit coastal areas, children's playgrounds, parks, sporting areas, recreation areas, and squares. Moreover, seeing more than two people was prohibited. The government prohibited citizens from leaving their homes and being on the streets without documents evidencing the purpose for their being outside. Police was entrusted to oversee and monitor citizens and ensure citizens followed self-isolation regulations. Breaking these regulations was penalized with a fine or imprisonment. Procedures were granted approval by the national university institutional review board (approval number: KS00000-KS2021) for human subjects and complied with the requirements of the Declaration of Helsinki. Participants (and their guardians, in the case of minors) gave written informed consent (and assent where necessary).

Before recruitment, a power calculation (nQuery Advisor 4.0; Statistical Solutions, Saugus, MA, USA) was performed using previous data [25], which suggested a sample size of 13 participants in each group would provide the study with 80% power to detect a mean difference of 2.90 cm in CMJ height using a two-sided t-test with an alpha level of 0.05 under the assumption of a pooled standard deviation of 2.50 cm [26]. Therefore, to allow for participant drop out, thirty-four males from one soccer team in the first National division participated. Participants had 7.6 ± 0.8 years playing experience prior to enrollment, and before participating they were examined by the team doctor. Participants were randomized between the experimental group (EG, n = 18, age: 17.5 ± 0.6 years, body mass: 67.4 ± 4.4 kg, height: 1.76 ± 0.05 m, body fat: 11.4 ± 1.6%), and control group (CG, n = 16, age: 17.5 ± 0.6 years, body mass: 68.7 ± 3.7 kg, height: 1.78 ± 0.03 m, body fat: 11.6 ± 1.1%). No baseline between-group differences existed in age ($p = 0.926$, $\eta_p^2 = 0.000$) or anthropometric characteristics ($p \geq 0.269$).

Participants were included on the bases they were over 18 years of age, were without cognitive impairment, had no current injuries, had >3 years of soccer experience, and did not present with coronovirus-19 (COVID-19) symptoms. Asymptomatic COVID-19 cases or discharged cases were considered eligible. Participants abstained from alcohol and pharmaceuticals for ≥24 h before testing and maintained their habitual diet according to self-reporting.

Before the study, participants had completed a training period of 8 weeks (5–6 sessions per week) which included resistance training targeting hypertrophy and muscle strength. In the final three of eight weeks, muscle power was targeted by reducing load and increasing speed of execution. Each weekend, participants took part in a non-competitive training match. Participants maintained participation in five training sessions per week when the league season started.

2.2. Experimental Design

Only training with the soccer team was permitted during the experiment. Both the EG and CG trained five times per week for ~90 min per session, with a competitive game each weekend. During the first three training sessions of each week, 60% of the total session time was focused on developing technical and tactical skills, and 40% of the time was focused on developing physical abilities. In addition, during the last two training sessions of each week, 75% of the total session time was focused on technical and tactical skills development, and 25% of the time was focused on physical ability development. All participants also participated in weekly 60 min school physical education sessions. The planning of training time (technical–tactical and physical) is frequently used in research that has studied the effects of one type of training program on the athletic performance of participants [27,28]. Strength and conditioning training was performed twice a week. Indeed, the first session of training of the week was focused on the development of aerobic capacity through skill drills/circuit training with low intensity and medium volume (8 to 10 min). The second training session was focused on the development of maximum aerobic power through high intensity interval training (HIIT) and small-sided games [29]. The third second training session focused on developing maximum anaerobic power through resistance training, including dynamic exercises based on bodyweight only and jump exercises and sprinting exercises. The remaining training sessions focused primarily on tactical and technical skills (Table 1). The soccer players performed the training with the team and under the supervision of a coach.

Table 1. Details of habitual training routine performed by both control and experimental groups over the 8-week study.

Days	Objectives
Monday	Rest
Tuesday	Aerobic conditioning/defensive tactics
Wednesday	Maximum aerobic power conditioning/defensive tactics
Thursday	Anaerobic power training/defensive and offensive tactics
Friday	Technical training/offensive tactics
Saturday	Technical training/offensive tactics
Sunday	Official games

The control group maintained their normal training schedule throughout the 8-week intervention, while each Tuesday and Thursday the experimental group replaced the technical–tactical part of their standard training program with loaded combined plyometric and short sprints training. The loaded combined plyometric and short sprints training program consisted of 4 principal workshops, twice per week (Figure 1).

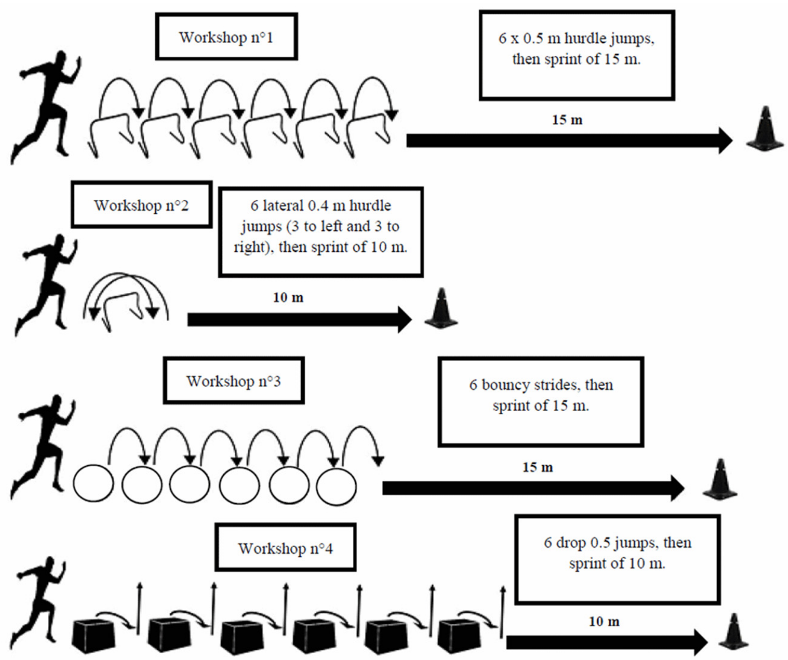

Figure 1. Exercise used in loaded combined plyometric and short sprint training group.

For the EG, each LPaSS workshop began with plyometric exercises (hurdle jumps, lateral hurdle jumps, bouncy strides, and drop jumps) and finished with short sprints. Details are given in Table 2. The EG executed all workshops with a weighted vest (8% body mass) [18,19]. Plyometric training design was based on from Bedoya et al. [30] and the sprint training protocol was based on recommendations for CoD ability [31,32].

Table 2. Plyometric components in the program of the experimental group.

Week	Workshop 1	Workshop 2	Workshop 3	Workshop 4	Total (Contact)
1	3 Repetitions	3 Repetitions	3 Repetitions	3 Repetitions	72
2	3 Repetitions	3 Repetitions	3 Repetitions	3 Repetitions	72
3	4 Repetitions	4 Repetitions	4 Repetitions	4 Repetitions	96
4	4 Repetitions	4 Repetitions	4 Repetitions	4 Repetitions	96
5	5 Repetitions	5 Repetitions	5 Repetitions	5 Repetitions	120
6	5 Repetitions	5 Repetitions	5 Repetitions	5 Repetitions	120
7	6 Repetitions	6 Repetitions	6 Repetitions	6 Repetitions	144
8	6 Repetitions	6 Repetitions	6 Repetitions	6 Repetitions	144

The EG executed all workshops with a weighted vest (8% body mass) [18,19]. Plyometric training design was based on from Bedoya et al. [30] and the sprint training protocol was based on recommendations for sprint distances [31,32].

2.3. Testing Schedule

Two weeks before testing commenced (2 months into the soccer season), both the EG and CG underwent familiarization with testing procedures. Tests were conducted at least 3 days after the last competitive match and 5–9 days after the previous training session. All performance tests were conducted on a tartan surface and were integrated into the weekly training schedule, and a standardized warm-up preceded each test. Fitness tests were conducted over three days in an identical order to facilitate similar fatigue or learning or order effects. Anthropometric assessment, SJ, CMJ, and S90° were conducted on day 1. The Y-balance test, 10 and 30 m sprint, and SBF were conducted on day 2. The 5JT and RSA test were completed on day 3. Fitness tests have been previously described in detail [18,24,33] and are therefore not detailed here to avoid self-plagiarism, but also for brevity.

2.4. Statistical Analysis

Statistical analysis was performed on SPSS version 25.0 for Windows (SPSS Inc., IBM, Armonk, NY, USA). Data were tested for normality with a Shapiro–Wilk Test and homogeneity of variance with Levene's Test. Differences in outcome variables between groups (EG vs. CG) and time (preintervention vs. postintervention) were examined using a univariate, two-factors (group $^{\times}$ time) general linear model [26]. Differences were considered meaningful if $p < 0.05$ and partial eta-squared (η_p^2) > 0.15 [34]. Effect size (d) (the mean difference of scores divided by the pooled SD) was calculated for each parameter [35], as is interpreted as trivial (<0.20), small (≥0.20–0.49), moderate (≥0.50–0.79), and large (≥0.80) [36]. Pearson product–moment correlation coefficients (r) tested for relationships between variables and r was interpreted thusly: <0.1, trivial; 0.1–0.3, small; 0.3–05, moderate; 0.5–0.7, large; 0.7–0.9, very large; 0.9–1.0, almost perfect [36]. Therefore, $r^2 > 0.5$ was defined as meaningful and is shown in bold type in the results section. The critical value for the product–moment correlation based on a two-sided t-test and $\alpha = 5\%$ is r = 0.325 [37]. Reliability was assessed using intraclass correlation coefficients [38] and the coefficients of variation (CV) over consecutive pairs of intraparticipant trials [39]. The interpretation of the reliability values was based on several references [36–42]. The intraclass correlation coefficient (ICC) was considered to show excellent relative reliability if >0.75, 0.40–0.75 was considered fair to good, and <0.40 was considered poor. A CV <10% can be defined as 'good' [43].

3. Results

3.1. Reliability

All investigated performance parameters showed an excellent relative reliability (ICC ≥ 0.75). The ICC ranged from 0.90 (SBF) to 0.98 (Y-balance test, right leg, ad; Table 3). The absolute reliability measured by CV was also on a comparable high level. All CVs were below 10% (Table 1) and ranged from 1.5% (S90°) to 4.8% (Y-balance test, left leg, pl; Table 3).

Table 3. Interclass correlation coefficient (ICC, 95% confidence intervals (95% CI)) and coefficient of variation (CV) showing excellent reliability for all performance parameters.

	ICC (95% CI)	CV (95%CI) [%]
	Sprint times	
10 m (s)	0.95 (0.92–0.98)	1.7 (1.3–2.2)
30 m (s)	0.94 (0.91–0.97)	1.8 (1.5–2.3)
	Change of direction test	
S90° (s)	0.92 (0.90–0.95)	1.5 (1.2–1.9)
SBF (s)	0.90 (0.88–0.94)	1.8 (1.5–2.2)
	Vertical jump	

SJ (cm)	0.95 (0.91–0.98)	1.9 (1.5–2.3)
CMJA (cm)	0.94 (0.91–0.97)	2.1 (1.8–2.6)
	Horizontal jump	
5JT (m)	0.86 (0.82–0.90)	3.9 (3.7–4.3)
	Y-balance test	
Right support leg		
Anterior direction (cm)	0.98 (0.92–0.99)	4.3 (4.0–4.8)
Posteromedial direction (cm)	0.97 (0.91–0.99)	4.4 (4.0–4.7)
Posterolateral direction (cm)	0.95 (0.92–0.98)	4.7 (4.2–5.1)
Left support leg		
Anterior direction (cm)	0.97 (0.93–0.99)	4.5 (4.1–5.0)
Posteromedial direction (cm)	0.97 (0.92–0.99)	4.5 (4.0–4.8)
Posterolateral direction (cm)	0.94 (0.90–0.98)	4.8 (4.4–5.3)

3.2. Normal Distribution and Variance Homogeneity

The variables age (p = 0.024), postintervention 10 m sprint (p = 0.002), postintervention RSA_{best} (p = 0.007), postintervention RSA_{mean} (p = 0.004), right leg pl (p = 0.016), postintervention right leg pm (p = 0.04), left leg pm (p = 0.009), left leg pl (p = 0.016) and postintervention left leg pl (p = 0.014) were not normally distributed. Regarding variance homogeneity, three parameters (10 m sprint: $p < 0.002$; right leg pd: $p < 0.036$; left leg ad: $p < 0.007$) were consistently (both times) heterogeneous in variance.

3.3. Effect of Training on Jump and Sprint Performance

For vertical and horizontal jump performance, intervention effects (group × time interaction) were significant for all parameters and ranged from $\eta_p^2 = 0.94$ (5JT) to $\eta_p^2 = 0.99$ (SJ). The interaction effects for the sprint parameters were of a similar magnitude (from $\eta_p^2 = 0.94$ (10 m sprint) to $\eta_p^2 = 0.95$ (30 m sprint) (Table 4)).

Table 4. Jump and sprint test performances depending on groups (EG vs. CG) before and after 8-week intervention. Meaningful effects (criteria: $p < 0.05$ and $\eta_p^2 > 0.15$ and d > 0.80) are highlighted in bold.

	EG (n = 18)			**CG (n = 16)**			**Variance Analysis p (η_p^2)**		
	Test	**Retest**	**d**	**Test**	**Retest**	**d**	**Group**	**Time**	**Group × Time**
				Vertical jump					
SJ (cm)	29.6 ± 3.19	35.7 ± 3.28	1.89	29.7 ± 2.48	30.7 ± 2.45	0.41	0.020 (0.16)	<0.001 (1.00)	<0.001(0.99)
CMJA (cm)	36.0 ± 3.83	43.4 ± 4.05	1.88	35.5 ± 2.33	36.6 ± 2.28	0.48	0.003 (0.25)	<0.001 (0.99)	<0.001 (0.98)
				Horizontal jump					
5JT (m)	11.3 ± 0.87	12.7 ± 0.79	1.69	11.3 ± 0.49	11.7 ± 0.40	0.90	0.029 (0.14)	<0.001 (0.98)	<0.001 (0.94)
				Sprint					
10 m (s)	1.70 ± 0.12	1.50 ± 0.10	1.82	1.72 ± 0.04	1.68 ± 0.04	1.00	0.001 (0.28)	<0.001 (0.97)	<0.001 (0.94)
30 m (s)	4.42 ± 0.18	4.01 ± 0.14	2.56	4.43 ± 0.15	4.36 ± 0.15	0.44	0.001 (0.28)	<0.001 (0.98)	<0.001 (0.95)

The effect sizes (d) for EG were consistently higher than for CG. The improvements of performance in EG ranged from d = 1.69 (5JT) to d = 2.56 (30 m sprint), whereas the effect sizes for CG were markedly lower (d_{range}: 0.41 to 1.00). No difference between groups was observed for 5JT ($\eta_p^2 = 0.14$).

3.4. Effect of Training on Change of Direction Ability

The S90°, SBF, and RSA improved in the EG ($d_{range} = 1.64–4.17$), more than in the CG (d = 0.41–0.60) (Table 5). The improvements regarding RSA parameters ($d_{fastest\ time} = 3.90$, $d_{mean\ time} = 4.17$) were the largest for any parameter and were almost twice as large as S90° (d = 2.25) and SBF (d = 1.64) improvements. Equal preintervention values were observed for SBF (group effect: $\eta_p^2 = 0.08$).

Table 5. Change of direction ability and Repeated Sprint Ability test performances depending on groups (EG vs. CG) before and after 8-week intervention. Meaningful effects (criteria: $p < 0.05$ and $\eta_p^2 > 0.15$ and d > 0.80) and the largest effect sizes for each parameter are highlighted in bold.

	EG (n = 18)			CG (n = 16)			Variance Analysis p (η_p^2)		
	Test	Retest	d	Test	Retest	d	Group	Time	Group × Time
Change of direction Performance									
S90° (s)	7.05 ± 0.31	6.42 ± 0.25	**2.25**	7.06 ± 0.28	6.89 ± 0.29	0.60	**0.019 (0.16)**	**<0.001 (0.98)**	**<0.001 (0.94)**
SBF (s)	8.16 ± 0.49	7.42 ± 0.41	**1.64**	8.13 ± 0.42	7.94 ± 0.36	0.41	0.102 (0.08)	**<0.001 (0.97)**	**<0.001 (0.92)**
Repeated Sprint Ability parameters (RSA test)									
Fastest time (s)	7.29 ± 0.20	6.55 ± 0.18	**3.90**	7.28 ± 0.25	7.17 ± 0.24	0.45	**<0.001 (0.35)**	**<0.001 (0.98)**	**<0.001 (0.97)**
Mean time (s)	7.38 ± 0.19	6.63 ± 0.17	**4.17**	7.39 ± 0.24	7.27 ± 0.24	0.50	**<0.001 (0.38)**	**<0.001 (0.98)**	**<0.001 (0.96)**

3.5. Effect of Training on Balance

For all balance parameters significant interaction effects were observed as an indication of the effectiveness of the intervention (Table 6). Partial eta squared (η_p^2) consistently moved on a very high level (from 0.78 to 0.95).

Y-balance test right leg pld ($p = 0.034$, $\eta_p^2 = 0.13$), left leg ad ($p = 0.094$, $\eta_p^2 = 0.09$) and pmd ($p = 0.488$, $\eta_p^2 = 0.02$), were not different between groups preintervention. The effect sizes in for improvement in EG ranged from d = 1.11 (right leg pld) to d = 2.54 (left leg pmd) and were greater than in the CG ($d_{max} = 0.64$, left leg pmd).

Relationships between Anthropometric and Performance Parameters

Meaningful correlations (r ≥ 0.5) were not observed between anthropometric and performance parameters. The largest relevant relationship was detected for height and right leg pl (r = 0.475).

Relevant relationships between performance parameters (sprint, jump, change of direction, balance) were observed, however:

- 5JT/right leg pl: r = 0.553,
- sprint 10 m/RSA_{best}: r = 0.547,
- sprint 10 m/RSA_{mean}: r = 0.541.

Table 6. Y-Balance test performances depending on groups (EG vs. CG) before and after 8-week intervention. Anterior direction = ad; Posteromedial direction = pmd; Posterolateral direction = pld; Meaningful effects (criteria: $p < 0.05$ and $\eta_p^2 > 0.15$ and d > 0.80) and the largest effect sizes for each parameter are highlighted in bold.

		EG (n = 18)			CG (n = 16)			Variance Analysis p (η_p^2)		
		Test	Retest	d	Test	Retest	d	Group	Time	Group × Time
Right support leg	ad (cm)	95.5 ± 5.26	107 ± 6.16	**2.01**	92.5 ± 5.49	94.4 ± 4.98	0.36	**<0.001 (0.36)**	**<0.001 (0.96)**	**<0.001 (0.92)**
	pmd (cm)	115 ± 5.45	127 ± 4.02	**2.53**	114 ± 5.27	117 ± 5.40	0.56	0.003 **(0.24)**	**<0.001 (0.96)**	**<0.001 (0.91)**
	pld (cm)	80.4 ± 7.99	89.6 ± 8.62	**1.11**	79.2 ± 3.99	80.9 ± 3.82	0.44	0.034 (0.13)	**<0.001 (0.88)**	**<0.001 (0.78)**
Left support leg	ad (cm)	95.2 ± 8.09	107 ± 7.95	**1.47**	95.7 ± 5.39	98.0 ± 5.35	0.43	0.094 (0.09)	**<0.001 (0.97)**	**<0.001 (0.94)**
	pmd (cm)	115 ± 4.70	126 ± 3.96	**2.54**	119 ± 3.35	121 ± 2.86	0.64	0.488 (0.02)	**<0.001 (0.97)**	**<0.001 (0.92)**
	pld (cm)	79.7 ± 4.95	89.9 ± 4.87	**2.08**	74.2 ± 5.29	76.5 ± 5.11	0.44	**<0.001 (0.48)**	**<0.001 (0.98)**	**<0.001 (0.95)**

4. Discussion

In this experiment we investigated the effects of LPaSS training in U19 soccer players. We accept our hypothesis that replacing some habitual soccer training with LPaSS twice a week for 8 weeks improved horizontal and vertical jump performance, sprint performance, and agility. The data presented here demonstrate LPaSS resulted in significant fitness gains (e.g., RSA, balance, power performance) in the EG, but not in the CG.

4.1. Effect of Training on Jump Performance

Explosive strength in the form of jumping is perceived as important to optimize football performance and is generally considered when testing for fitness and talent screening in soccer players [44]. Arnason et al. [45] observed that competitive higher level soccer players exhibit superior jumping ability than lower performance level players. Furthermore, vertical jump performance is reportedly associated with lower leg strength and sprint performance in soccer players [46]. The EG experienced improved performance compared to control in both vertical and horizontal jump performance. This corroborates findings of Hammami et al. [24] who studied the effects of a combination of a 10-week LPaSS training in male soccer players (U17s) and noted improved vertical and horizontal jump performance. Moreover, Gil et al. [21] observed increased vertical jump performance following loaded sprints training, in elite senior soccer players. Moreover, both Negra et al. [18] and Rosas et al. [19] reported significantly improved vertical and horizontal jump performance following loaded plyometrics in prepubertal male soccer players. To explicate improved performance with the addition of external load during plyometrics and/or jump training, Kobal et al. [17] reported adding load during jump training increased ground reaction force (GRF) in both vertical or horizontal axes, and ensured the GRF was applied over more time. As instantaneous GRF was greater, and GRF was applied over a longer time, this resulted in increased impulse during jumps [47], thus producing superior adaptations in jumping with additional external load [17].

4.2. Effect of Training on Sprint Performance

Elite players demonstrate superior ability in sprint distances over 5 to 10 m [48]. Powerful muscular contractions are required in both attacking and defending situations when goals typically occur [49]. During in-game situations, 500 to 600 m is covered during sprints [2], which occur every 90 s [50]. Data from this study showed LPaSS improved sprint performance over 10 and 30 m (Table 4). Our findings are in accordance with existing literature, which has reported improved sprint performance after several programs, including LPaSS training [24], loaded plyometric training [17,18,28], and loaded sprint training [20,21,47]. Recently, Hammami et al. [24] examined the effects of 10-week LPaSS training in male U17 soccer players and noted improved sprint performance over 5, 10, 20, 30, and 40 m. Moreover, Kargarfard et al. [28] observed improved 30 m sprint times following unloaded plyometric and short sprints training in U19 male soccer players. Indeed, gains in sprint performance as a result of unloaded plyometric and short sprints training in male U15 soccer players have previously been observed [27]. Research has shown that loaded sprint training can increase the eccentric force of the extensor muscles during the ground contact braking phase and increase leg stiffness, increasing the ability of muscles to store elastic energy and enhance power output [51,52].

4.3. Effect of Training on Change of Direction Ability

Although linear sprinting is an important ability in soccer, the ability to accelerate, decelerate, and CoD is probably more determinant of soccer ability, and more relevant to in-game situations [53,54]. Match analysis has demonstrated the importance of CoD ability in soccer since an average sprint time of 2.3 s (10 to 12 m sprint) [55] and an average of 50 directional changes per match have been recorded [56]. The data presented herein demonstrated that the EG improved CoD ability more than the CG. This is the first investigation of the effects of LPaSS on CoD ability in male U19 soccer players. We reported improved CoD ability, which corroborates the results of previous recent studies [24,29,30] following LPaSS training [24], loaded plyometric training [16,18], and loaded sprint training [21,22] in male soccer players. Recently, Negra el al. [18] demonstrated significant improvements in CoD ability following 10 weeks of loaded and unloaded combined plyometric and short sprints training in youth soccer players (U17). However, our results contrast with the results of De Hoyo et al. [57] who reported no gain in change of direction ability after loaded sprint training in U19 soccer players. Differences in training protocol, intervention period, tests used, and participant characteristics could contribute to the divergence between studies. The mechanism responsible for CoD ability improvements in our study may be associated with neural adaptations and improved motor unit recruitments [58]. Improved CoD ability after plyometric training may also occur as a result of neuromuscular adaptations such as increased neural drive and inter- and intra-muscular coordination. These neuromuscular adaptations may be responsible for, or occur independently but simultaneously with, altered gait parameters (e.g., modified stride length, stride frequency, contact time and horizontal GRF) [59,60], ultimately improving change-of-direction performance [22].

4.4. Effect of Training on Repeated Sprint Ability

Soccer players perform many high-intensity runs during an average match [61], with short intervals of recovery between bouts, repeatedly throughout the competition [62]. Thus, recovery ability and RSA is a critical component of soccer player performance [51,63] and is associated with high aerobic power (VO_{2max}) [1]. RSA is a significant factor in determining success in soccer [64,65]. Rampinini et al. [65] reported significant correlations between distances covered during competitive matches and RSA test performance in professional soccer players. Our results suggest LPaSS improved RSA; our study, to the best of our knowledge, is the first to have examined the effects of LPaSS on RSA in young soccer players. Our results are confirmed by Hammami et al. [24] who observed improvement in repeated change of direction (RCoD) ability following LPaSS training in male U17 soccer players. Additionally, Rey et al. [66] reported significant improvement in all repeated sprint ability parameters except the fatigue index following loaded sprints training in male senior soccer players. In contrast, our results contradict those of Kargarfard et al. [33] who reported no improvement in RSA following combined unloaded plyometric and short sprints training in U19 male soccer players. The divergent results between our data and previous investigations may result from various experimental design factors such as the competition level of the participants, gender or sex, or differences in the external load applied. The improvement in RSA performance following a plyometric training program is probably related to the improvement in explosive performance, improving the ability to change-of-direction when pivoting during the RSA test [67], or running economy [68], increased efficiency in running [69], and or an enhanced degree of tendon stiffness [70].

4.5. Effect of Training on Balance Performance

In a soccer match, players perform multiple actions (primarily with the lower limbs), which include passing, dribbling, and shooting, all with football boots and commonly on a grass playing field [71]. Balance ability is important as it permits players to maintain postural control whilst running, spring, kicking, and changing direction [72]. Moreover, players must exert postural control when they are blocked by opposition [73]. In addition to the stand-alone benefits of balance ability for maintaining postural control, balance performance is associated with other components of fitness. In this context, Pant et al. [74] noted correlations between balance performance and muscular strength around the ankle joint. To the best of our knowledge, only one previous study has investigated the effects of LPaSS training on balance performance in young soccer players [24]. Hammami et al.

[24] examined the effects of 10-week LPaSS training on dynamic and static balance performance in male soccer players (U17) whereby balance improved as a result of LPaSS, corroborating the results of the present study. Makhlouf et al. [75] confirmed observations made herein by reporting improved static and dynamic balance following combined plyometric and short sprint with CoD training in young soccer players. EG improvements were likely resultant from enhanced neuromuscular control of the lower limb musculature [76].

In terms of diet in relation to exercise and COVID-19, Ammar et al. [77] suggested that the quarantine itself can be considered a risk factor for the consumption of poor-quality foods, such as ultraprocessed foods, when compared to the standard living condition. Combined with the potential for lower levels of physical activity, impaired nutritional habits could lead to a positive energy balance (i.e., weight gain). There is limited evidence to evaluate the effect of confinement on loaded plyometrics and short sprints and dietary behaviors. Investigating how physical activity and eating behaviors are affected by lengthy restrictions is important to establish appropriate recommendations for lifestyle modifications during this time [78].

4.6. Limitations

The results of this study may not be ubiquitously observed in all age groups and all competition levels (i.e., outside of 17–19 year olds, or outside of soccer players) so LPaSS cannot be uniformly prescribed to all soccer teams regardless of age, gender, or competition level. Moreover, sexual maturation and dietary assessment were not evaluated within the present investigation, which may have hampered internal validity. As such, future studies should include an assessment of sexual maturation when examining LPaSS (or any training type) in young soccer players as the level of sexual maturation may influence the adaptive response. Moreover, the addition of laboratory-based tests (i.e., VO_{2max} tests) could confirm the field-based tests utilized in the present study, although this may not be as ecologically valid. The extension of the present study into other invasion games, genders, and competition levels may provide confirmatory evidence of the effects noted in this study. It is also necessary to compare the gains in test performance with the analysis of performance during competitions to determine whether better fitness translates into improved gaming performance. Otherwise, neuromuscular mechanisms that underlie the improvements reported here can also be an area of future research. Finally, future studies should extend to compare the effects of LPaSS training on the fitness and body composition of young and adult soccer players.

4.7. Practical Applications

This investigation demonstrated the efficacy of substituting some typical usual soccer training with twice weekly LPaSS training in male adolescent soccer players. Thus, it appears pragmatic to incorporate LPaSS training into traditional in-season technical and tactical adolescent training sessions to improve performance. Finally, the weighted vests used in this study as additional load are inexpensive and unsophisticated, thereby making them simple for all clubs to access and easy for both coaches and athletes to handle during strength and conditioning exercises.

5. Conclusions

To conclude, incorporating LPaSS training into standard training improved jump performance, sprinting, CoD ability, RSA, and balance. Therefore, soccer coaches and practitioners should incorporate combined plyometric and short sprints training into soccer training to enhance fitness. Most of the gains associated with LPaSS training seem to be of significant magnitude, so should be of interest for both soccer players and their coaches. Further investigation is warranted to fully optimize LPaSS, including variables such as quantity of external load, and training volume.

Author Contributions: Conceptualization, G.A.; methodology, G.A.; software, G.A.; validation, H.S., M.S.C. and G.A.; formal analysis, E.G.B.; investigation, G.A.; resources, M.S.C.; data curation, G.A.; writing—original draft preparation, G.A.; writing—review and editing, L.D.H. and H.S.; visualization, R.S.; supervision, M.S.C.; project administration, G.A.; funding acquisition, R.S. All authors have read and agreed to the published version of the manuscript.

Funding: The authors thank the Ministry of Higher Education and Scientific Research, Tunis, Tunisia for financial support.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board of Research Unit (UR17JS01) Sport Performance, Health and Society, Higher Institute of Sport and Physical Education, Ksar-Saîd, University (approval number: KS00000-KS2021).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors without undue reservation.

Acknowledgments: The authors thank the Ministry of Higher Education and Scientific Research, Tunis, Tunisia for financial support.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Reilly, T.; Bangsbo, J.; Franks, A. Anthropometric and Physiological Predispositions for Elite Soccer. *J. Sports Sci*. **2000**, *18*, 669–683.
2. Slimani, M.; Bragazzi, N.L.; Tod, D.; Dellal, A.; Hue, O.; Cheour, F.; Taylor, L.; Chamari, K. Do Cognitive Training Strate-gies Improve Motor and Positive Psychological Skills Development in Soccer Players? Insights from a Systematic Re-view. *J. Sports Sci.* **2016**, *34*, 2338–2349, doi:10.1080/02640414.2016.1254809.
3. Stølen, T.; Chamari, K.; Castagna, C.; Wisløff, U. Physiology of Soccer: An Update. *Sports Med*. **2005**, *35*, 501–536, doi:10.2165/00007256-200535060-00004.
4. Reilly, T.; Williams, A.; D., R. Identifying Talented Players. In *Science and Soccer*; Reilly, T., Williams A.M., Eds.; Routledge: London, UK, 2003; pp. 307–326.
5. Malina, R.M.; Bouchard, C.; Oded, B.-O. *Growth, Maturation, and Physical Activity*; Human Kinetics: Champaign, IL, USA, 2004.
6. Carling, C. Interpreting Physical Performance in Professional Soccer Matchplay: Should We Be More Pragmatic in Our Approach? *Sports Med.* **2013**, *43*, 655–663, doi:10.1007/s40279-013-0055-8.
7. Negra, Y.; Chaabene, H.; Fernandez-Fernandez, J.; Sammoud, S.; Bouguezzi, R.; Prieske, O.; Granacher, U. Short-Term Plyometric Jump Training Improves Repeated-Sprint Ability in Prepuberal Male Soccer Players. *J. Strength Cond. Res.* **2020**, *34*, 3241–3249, doi:10.1519/JSC.0000000000002703.
8. Buchheit, M.; Mendez-Villanueva, A.; Simpson, B.M.; Bourdon, P.C. Repeated-Sprint Sequences During Youth Soccer Matches. *Int. J. Sports Med*. **2010**, *31*, 709–716, doi:10.1055/s-0030-1261897.
9. Bradley, P.S.; Di Mascio, M.; Peart, D.; Olsen, P.; Sheldon, B. High-Intensity Activity Profiles of Elite Soccer Players at Dif-ferent Performance Levels. *J. Strength Cond. Res.* **2010**, *24*, 2343–2351, doi:10.1519/JSC.0b013e3181aeb1b3.
10. Bradley, P.S.; Sheldon, W.; Wooster, B.; Olsen, P.; Boanas, P.; Krustrup, P. High-Intensity Running in English FA Premier League Soccer Matches. *J. Sports Sci*. **2009**, *27*, 159–168, doi:10.1080/02640410802512775.
11. Buchheit, M.; Mendez-Villanueva, A.; Simpson, B.M.; Bourdon, P.C. Match Running Performance and Fitness in Youth Soccer. *Int. J. Sports Med*. **2010**, *31*, 818–825, doi:10.1055/s-0030-1262838.
12. Sánchez, M.; Sanchez-Sanchez, J.; Nakamura, F.Y.; Clemente, F.M.; Romero-Moraleda, B.; Ramirez-Campillo, R. Effects of Plyometric Jump Training in Female Soccer Player's Physical Fitness: A Systematic Review with Meta-Analysis. *Int. J. En-viron. Res. Public Health*. **2020**, *17*, 8911, doi:10.3390/ijerph17238911.
13. Ramirez-Campillo, R.; Castillo, D.; Raya-González, J.; Moran, J.; de Villarreal, E.S.; Lloyd, R.S. Effects of Plyometric Jump Training on Jump and Sprint Performance in Young Male Soccer Players: A Systematic Review and Meta-Analysis. *Sports Med*. **2020**, *50*, 2125–2143, doi:10.1007/s40279-020-01337-1.
14. Rumpf, M.C.; Lockie, R.G.; Cronin, J.B.; Jalilvand, F. Effect of Different Sprint Training Methods on Sprint Performance Over Various Distances: A Brief Review. *J. Strength Cond. Res.* **2016**, *30*, 1767–1785, doi:10.1519/JSC.0000000000001245.
15. Mujika, I.; Santisteban, J.; Castagna, C. In-Season Effect of Short-Term Sprint and Power Training Programs on Elite Junior Soccer Players. *J. Strength Cond. Res.* **2009**, *23*, 2581–2587, doi:10.1519/JSC.0b013e3181bc1aac.
16. Coratella, G.; Beato, M.; Milanese, C.; Longo, S.; Limonta, E.; Rampichini, S.; Ce, E.; Bisconti, A.V.; Schena, F.; Esposito, F. Specific Adaptations in Performance and Muscle Architecture after Weighted Jump-Squat vs. Body Mass Squat Jump Training in Recreational Soccer Players. *J. Strength Cond. Res.* **2018**, *32*, 921–929, doi:10.1519/JSC.0000000000002463.

17. Kobal, R.; Pereira, L.A.; Zanetti, V.; Ramirez-Campillo, R.; Loturco, I. Effects of Unloaded vs. Loaded Plyometrics on Speed and Power Performance of Elite Young Soccer Players. *Front. Physiol*. **2017**, *8*, 742, doi:10.3389/fphys.2017.00742.
18. Negra, Y.; Chaabene, H.; Sammoud, S.; Prieske, O.; Moran, J.; Ramirez-Campillo, R.; Nejmaoui, A.; Granacher, U. The In-creased Effectiveness of Loaded Versus Unloaded Plyometric-Jump Training in Improving Muscle Power, Speed, Change-of-Direction, and Kicking-Distance Performance in Prepubertal Male Soccer Players. *Int. J. Sports Physiol. Perform*. **2019**, *15*, 1–25, doi:10.1123/ijspp.2018-0866.
19. Rosas, F.; Ramirez-Campillo, R.; Diaz, D.; Abad-Colil, F.; Martinez-Salazar, C.; Caniuqueo, A.; Canas-Jamet, R.; Loturco, I.; Nakamura, F.Y.; McKenzie, C.; et al. Jump Training in Youth Soccer Players: Effects of Haltere Type Handheld Loading. *Int. J. Sports Med.* **2016**, *37*, 1060–1065, doi:10.1055/s-0042-111046.
20. Alcaraz, P.E.; Carlos-Vivas, J.; Oponjuru, B.O.; Martínez-Rodríguez, A. The Effectiveness of Resisted Sled Training (RST) for Sprint Performance: A Systematic Review and Meta-Analysis. *Sports Med*. **2018**, *48*, 2143–2165, doi:10.1007/s40279-018-0947-8.
21. Gil, S.; Barroso, R.; Crivoi do Carmo, E.; Loturco, I.; Kobal, R.; Tricoli, V.; Ugrinowitsch, C.; Roschel, H. Effects of Resisted Sprint Training on Sprinting Ability and Change of Direction Speed in Professional Soccer Players. *J. Sports Sci*. **2018**, *36*, 1923–1929, doi:10.1080/02640414.2018.1426346.
22. McMorrow, B.J.; Ditroilo, M.; Egan, B. Effect of Heavy Resisted Sled Sprint Training During the Competitive Season on Sprint and Change-of-Direction Performance in Professional Soccer Players. *Int. J. Sports Physiol. Perform*. **2019**, *14*, 1066–1073, doi:10.1123/ijspp.2018-0592.
23. Adams, K.; O'Shea, J.; O'Shea, K.; Climstein, M. The Effects of Six Weeks of Squat, Plyometric and Squat-Plyometric Train-ing on Power Development. *J. Appl. Sports Sci. Res*. **1992**, *6*, 36–41.
24. Hammami, M.; Gaamouri, N.; Suzuki, K.; Aouadi, R.; Shephard, R.J.; Chelly, M.S. Effects of Unloaded vs. Ankle-Loaded Plyometric Training on the Physical Fitness of U-17 Male Soccer Players. *Int. J. Environ. Res. Public Health* **2020**, *17*, 7877, doi:10.3390/ijerph17217877.
25. Hermassi, S.; Hayes, L.D.; Bragazzi, N.L.; Schwesig, R. Physical Fitness and Academic Performance in Normal Weight, Overweight, and Obese Schoolchild Handball Players in Qatar: A Pilot Study. *Front. Psychol*. **2020**, *11*, 616671, doi:10.3389/fpsyg.2020.616671.
26. Bortz, J. Basic Principle of One-Factorial Analysis of Variance. In *Statistics for Social Scientists*; Bortz, J., Ed.; Springer: Berlin/Heidelberg, Germany; New York, NY, USA, 1999; pp. 237–249.
27. Aloui, G.; Hammami, M.; Fathloun, S.; Hermassi, N.; Gaamouri, R.J.; Shephard, R.; Chelly, M.S. Effects of an 8-Week In-Season Elastic Band Training Program on Explosive Muscle Performance, Change of Direction, and Repeated Changes of Direction in the Lower Limbs of Junior Male Handball Players. *J. Strength Cond. Res.* **2019**, *33*, 1804–1815, doi:10.1519/jsc.0000000000002786.
28. Aloui, G.; Hermassi, S.; Hammami, M.; Cherni, Y.; Gaamouri, N.; Shephard, R.J.; van den Tillaar, R.; Chelly, M.S. Effects of Elastic Band Based Plyometric Exercise on Explosive Muscular Performance and Change of Direction Abilities of Male Team Handball Players. *Front. Physiol*. **2020**, *11*, 604983, doi:10.3389/fphys.2020.604983.
29. Dello Iacono, A.; Beato, M.; Unnithan, V. Comparative Effects of Game Profile-Based Training and Small-Sided Games on Physical Performance of Elite Young Soccer Players. *J. Strength Cond. Res.* **2019**, online ahead of print, doi:10.1519/JSC.0000000000003225.
30. Bedoya, A.; Miltenberger, M.; Lopez, R. Plyometric Training Effects on Athletic Performance in Youth Soccer Athletes: A Systematic Review. *J. Strength Cond. Res.* **2015**, *29*, 2351–2360, doi:10.1519/JSC.0000000000000877.
31. Sáez de Villarreal, E.; Suarez-Arrones, L.; Requena, B.; Haff, G.G.; Ferrete, C. Effects of Plyometric and Sprint Training on Physical and Technical Skill Performance in Adolescent Soccer Players. *J. Strength Cond. Res.* **2015**, *29*, 1894–1903, doi:10.1519/JSC.0000000000000838.
32. Kargarfard, M.; Tajvand, S.; Rabbani, A.; Clemente, F.; Jalilvand, F. Effects of Combined Plyometric and Speed Training on Change of Direction, Linear Speed, and Repeated Sprint Ability in Young Soccer Players: A Pilot Study. *Kinesiology* **2020**, *52*, 85–93, doi:10.26582/k.52.1.11.
33. Sporis, G.; Jukic, I.; Milanovic, L.; Vucetic, V. Reliability and Factorial Validity of Agility Tests for Soccer Players. *J. Strength Cond. Res.* **2010**, *24*, 679–686, doi:10.1519/JSC.0b013e3181c4d324.
34. Richardson, J.T.E. Eta Squared and Partial Eta Squared as Measures of Effect Size in Educational Research. *Educ. Res. Rev*. **2011**, *6*, 135–147, doi:10.1016/j.edurev.2010.12.001.
35. Hartmann, A.; Herzog, T.; Drinkmann, A. Psychotherapy of Bulimia Nervosa: What Is Effective? A Meta-Analysis. *J. Psychosom. Res*. **1992**, *36*, 159–167, doi:10.1016/0022-3999(92)90024-v.
36. Cohen, J. *Statistical Power Analysis for the Behavioural Sciences*, 2nd ed.; Lawrance Erlbaum Associates: Hillsdale, NJ, USA, 1988.
37. Willimczik, K. *Statistik im Sport: Grundlagen, Verfahren, Anwendungen*, 3rd ed.; Czwalina: Hamburg, Germany, 1997; p. 259.
38. Vincent, W. *Statistics in Kinesiology*; Human Kinetics: Champaign, IL, USA, 1995.
39. Schabort, E.J.; Hopkins, W.G.; Hawley, J.A. Reproducibility of Self-Paced Treadmill Performance of Trained Endurance Runners. *Int. J. Sports Med*. **1998**, *19*, 48–51, doi:10.1055/s-2007-971879.
40. Shrout, P.E.; Fleiss, J.L. Intraclass Correlations: Uses in Assessing Rater Reliability. *Psychol. Bull*. **1979**, *86*, 420–428, doi:10.1037//0033-2909.86.2.420.
41. Hopkins, W.G. Measures of Reliability in Sports Medicine and Science. *Sports Med*. **2000**, *30*, 1–15, doi:10.2165/00007256-200030010-00001.

42. Portney, L.G.; Watkins, M.P. *Foundations of Clinical Research: Applications to Practice*, 3rd ed.; Pearson Prentice Hall: Upper Saddle River, NJ, USA, 2009.
43. Brughelli, M.; Van Leemputte, M. Reliability of Power Output During Eccentric Sprint Cycling. *J. Strength Cond. Res.* **2013**, *27*, 76–82, doi:10.1519/JSC.0b013e31824f2055.
44. Castagna, C.; Castellini, E. Vertical Jump Performance in Italian Male and Female National Team Soccer Players. *J. Strength Cond. Res.* **2013**, *27*, 1156–1161, doi:10.1519/JSC.0b013e3182610999.
45. Arnason, A.; Sigurdsson, S.B.; Gudmundsson, A.; Holme, I.; Engebretsen, L.; Bahr, R. Physical Fitness, Injuries, and Team Performance in Soccer. *Med. Sci. Sports Exerc*. **2004**, *36*, 278–285, doi:10.1249/01.MSS.0000113478.92945.CA.
46. Wisløff, U.; Castagna, C.; Helgerud, J.; Jones, R.; Hoff, J. Strong Correlation of Maximal Squat Strength with Sprint Per-formance and Vertical Jump Height in Elite Soccer Players. *Br. J. Sports Med*. **2004**, *38*, 285–288, doi:10.1136/bjsm.2002.002071.
47. Cronin, J.B.; Brughelli, M.; Gamble, P.; Brown, S.R.; McKenzie, C. Acute Kinematic and Kinetic Augmentation in Hori-zontal Jump Performance Using Haltere Type Handheld Loading. *J. Strength Cond. Res.* **2014**, *28*, 1559–1564, doi:10.1519/JSC.0000000000000312.
48. Sporis, G.; Jukic, I.; Ostojic, S.M.; Milanovic, D. Fitness Profiling in Soccer: Physical and Physiologic Characteristics of Elite Players. *J. Strength Cond. Res.* **2009**, *23*, 1947–1953, doi:10.1519/JSC.0b013e3181b3e141.
49. Jovanovic, M.; Sporis, G.; Omrcen, D.; Fiorentini, F. Effects of Speed, Agility, Quickness Training Method on Power Per-formance in Elite Soccer Players. *J. Strength Cond. Res.* **2011**, *25*, 1285–1292, doi:10.1519/JSC.0b013e3181d67c65.
50. Strøyer, J.; Hansen, L.; Klausen, K. Physiological Profile and Activity Pattern of Young Soccer Players During Match Play. *Med. Sci. Sports Exerc.* **2004**, *36*, 168–174, doi:10.1249/01.MSS.0000106187.05259.96.
51. Cronin, J.; Hansen, K. Resisted Sprint Training for the Acceleration Phase of Sprinting. *Strength Cond. J.* **2006**, *28*, 42–51.
52. Clark, K.P.; Stearne, D.J.; Walts, C.T.; Miller, A.D. The Longitudinal Effects of Resisted Sprint Training Using Weighted Sleds vs. Weighted Vests. *J. Strength Cond. Res*. **2010**, *24*, 3287–3295, doi:10.1519/JSC.0b013e3181b62c0a.
53. Little, T.; Williams, A.G. Specificity of Acceleration, Maximum Speed, and Agility in Professional Soccer Players. *J. Strength Cond. Res.* **2005**, *19*, 76–78, doi:10.1519/14253.1.
54. Chaouachi, A.; Manzi, V.; Chaalali, A.; Wong del, P.; Chamari, K.; Castagna, C. Determinants Analysis of Change-of-Direction Ability in Elite Soccer Players. *J. Strength Cond. Res.* **2012**, *26*, 2667–2676, doi:10.1519/JSC.0b013e318242f97a.
55. Castagna, C.; D'Ottavio, S.; Abt, G. Activity Profile of Young Soccer Players During Actual Match Play. *J. Strength Cond. Res*. **2003**, *17*, 775–780, doi:10.1519/1533-4287(2003)017<0775:apoysp>2.0.co;2.
56. Withers, R.; Maricic, Z.; Wasilewski, S.; Kelly, L. Match Analysis of Australian Soccer Players. *J. Hum. Mov. Stud*. **1982**, *8*, 159–176.
57. de Hoyo, M.; Gonzalo-Skok, O.; Sañudo, B.; Carrascal, C.; Plaza-Armas, J.R.; Camacho-Candil, F.; Otero-Esquina, C. Com-parative Effects of In-Season Full-Back Squat, Resisted Sprint Training, and Plyometric Training on Explosive Performance in U-19 Elite Soccer Players. *J. Strength Cond. Res*. **2016**, *30*, 368–377, doi:10.1519/JSC.0000000000001094.
58. Aagaard, P.; Simonsen, E.B.; Andersen, J.L.; Magnusson, P.; Dyhre-Poulsen, P. Increased Rate of Force Development and Neural Drive of Human Skeletal Muscle Following Resistance Training. *J. Appl. Physiol*. **2002**, *93*, 1318–1326, doi:10.1152/japplphysiol.00283.2002.
59. Morin, J.B.; Petrakos, G.; Jiménez-Reyes, P.; Brown, S.R.; Samozino, P.; Cross, M.R. Very-Heavy Sled Training for Improv-ing Horizontal-Force Output in Soccer Players. *Int. J. Sports Physiol. Perform*. **2017**, *12*, 840–844, doi:10.1123/ijspp.2016-0444.
60. West, D.J.; Cunningham, D.J.; Bracken, R.M.; Bevan, H.R.; Crewther, B.T.; Cook, C.J.; Kilduff, L.P. Effects of Resisted Sprint Training on Acceleration in Professional Rugby Union Players. *J. Strength Cond. Res*. **2013**, *27*, 1014–1018, doi:10.1519/JSC.0b013e3182606cff.
61. Carling, C.; Dupont, G. Are Declines in Physical Performance Associated with a Reduction in Skill-Related Performance During Professional Soccer Match-Play? *J. Sports Sci*. **2011**, *29*, 63–71, doi:10.1080/02640414.2010.521945.
62. Carling, C.; Le Gall, F.; Dupont, G. Analysis of Repeated High-Intensity Running Performance in Professional Soccer. *J. Sports Sci*. **2012**, *30*, 325–336, doi:10.1080/02640414.2011.652655.
63. Gabbett, T.J. The Development of a Test of Repeated-Sprint Ability for Elite Women's Soccer Players. *J. Strength Cond. Res*. **2010**, *24*, 1191–1194, doi:10.1519/JSC.0b013e3181d1568c.
64. Impellizzeri, F.M.; Rampinini, E.; Castagna, C.; Bishop, D.; Ferrari Bravo, D.; Tibaudi, A.; Wisloff, U. Validity of a Repeat-ed-Sprint Test for Football. *Int. J. Sports Med*. **2008**, *29*, 899–905, doi:10.1055/s-2008-1038491.
65. Rampinini, E.; Bishop, D.; Marcora, S.M.; Ferrari Bravo, D.; Sassi, R.; Impellizzeri, F.M. Validity of Simple Field Tests as Indicators of Match-Related Physical Performance in Top-Level Professional Soccer Players. *Int. J. Sports Med*. **2007**, *28*, 228–235, doi:10.1055/s-2006-924340.
66. Rey, E.; Padrón-Cabo, A.; Fernández-Penedo, D. Effects of Sprint Training with and without Weighted Vest on Speed and Repeated Sprint Ability in Male Soccer Players. *J. Strength Cond. Res*. **2017**, *31*, 2659–2666, doi:10.1519/JSC.0000000000001726.
67. Buchheit, M.; Mendez-Villanueva, A.; Delhomel, G.; Brughelli, M.; Ahmaidi, S. Improving Repeated Sprint Ability in Young Elite Soccer Players: Repeated Shuttle Sprints vs. Explosive Strength Training. *J. Strength Cond. Res*. **2010**, *24*, 2715–2722, doi:10.1519/JSC.0b013e3181bf0223.
68. Marta, C.; Marinho, D.A.; Barbosa, T.M.; Izquierdo, M.; Marques, M.C. Effects of Concurrent Training on Explosive Strength and VO(2max) in Prepubescent Children. *Int. J. Sports Med*. **2013**, *34*, 888–896, doi:10.1055/s-0033-1333695.

69. Balsalobre-Fernández, C.; Santos-Concejero, J.; Grivas, G.V. Effects of Strength Training on Running Economy in Highly Trained Runners: A Systematic Review with Meta-Analysis of Controlled Trials. *J. Strength Cond. Res.* **2016**, *30*, 2361–2368, doi:10.1519/JSC.0000000000001316.
70. Markovic, G.; Mikulic, P. Neuro-Musculoskeletal and Performance Adaptations to Lower-Extremity Plyometric Training. *Sports Med.* **2010**, *40*, 859–895, doi:10.2165/11318370-000000000-00000.
71. Orchard, J. Is There a Relationship Between Ground and Climatic Conditions and Injuries in Football? *Sports Med.* **2002**, *32*, 419–432, doi:10.2165/00007256-200232070-00002.
72. Luedke, L.E.; Geisthardt, T.W.; Rauh, M.J. Y-Balance Test Performance Does Not Determine Non-Contact Lower Quadrant Injury in Collegiate American Football Players. *Sports* **2020**, *8*, 27, doi:10.3390/sports8030027.
73. Gerbino, P.G.; Griffin, E.D.; Zurakowski, D. Comparison of Standing Balance Between Female Collegiate Dancers and Soccer Players. *Gait Posture* **2007**, *26*, 501–507, doi:10.1016/j.gaitpost.2006.11.205.
74. Pant, H.; Sukumar, K.; Sharma, H.; Pandey, A.; Goel, S.; Roorkee, I. Correlation Between Muscles Strength in Relation to Dorsiflextion, Planterflextion, Eversion and Inversion Strength with Body Balance. *J. Biomech.* **2006**, *39*, 557, doi:10.2478/v10078-010-0044-z.
75. Makhlouf, I.; Chaouachi, A.; Chaouachi, M.; Ben Othman, A.; Granacher, U.; Behm, D.G. Combination of Agility and Plyometric Training Provides Similar Training Benefits as Combined Balance and Plyometric Training in Young Soccer Players. *Front. Physiol.* **2018**, *9*, 1611, doi:10.3389/fphys.2018.01611.
76. Ozer, D.; Duzgun, I.; Baltaci, G.; Karacan, S.; Colakoglu, F. The Effects of Rope or Weighted Rope Jump Training on Strength, Coordination and Proprioception in Adolescent Female Volleyball Players. *J. Sports Med. Phys. Fitness* **2011**, *51*, 211–219.
77. Ammar, A.; Brach, M.; Trabelsi, K.; Chtourou, H.; Boukhris, O.; Masmoudi, L.; Bouaziz, B.; Bentlage, E.; How, D.; Ahmed, M.; et al. Effects of COVID-19 Home Confinement on Eating Behaviour and Physical Activity: Results of the ECLB-COVID19 International Online Survey. *Nutrients* **2020**, *12*, 1583, doi:10.3390/nu12061583.
78. Ruiz-Roso, M.B.; de Carvalho Padilha, P.; Matilla-Escalante, D.C.; Brun, P.; Ulloa, N.; Acevedo-Correa, D.; Ferreira Peres, W.A.; Martorell, M.; Bousquet Carrilho, T.R.; de Oliveira Cardoso, L. Changes of Physical Activity and Ultra-Processed Food Consumption in Adolescents from Different Countries during Covid-19 Pandemic: An Observational Study. *Nutrients* **2020**, *12*, 2289, doi:10.3390/nu12082289.