Effects of Two Different Tapering Protocols on Fitness and Physical Match Performance in Elite Junior Soccer Players

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Abstract

Krespi, M, Sporiš, G, and Trajković, N. Effects of two different tapering protocols on fitness and physical match performance in elite junior soccer players. *J Strength Cond Res* XX(X): 000–000, 2018—The purpose of this study was to determine the effects of 2 different tapering protocols on fitness and physical match performance in elite junior soccer players. One-hundred fifty-eight elite junior soccer players (mean age: 17.1 $\pm$ 0.79 years; mean height: 177.9 $\pm$ 6.64 cm; mean body mass: 71.3 $\pm$ 7.96 kg; and mean body mass index: 22.5 $\pm$ 1.66 $kg \cdot m^{-2}$) were randomly assigned to 2 groups: an exponential ($n = 79$) and a linear tapering ($n = 79$) group. Training sessions were conducted 3 times per week for 8 weeks. After 4 weeks of training and 4 weeks of tapering, participants were assessed in terms of body composition, physical fitness, and distance covered within a match. Both groups showed similar changes for body composition. The exponential group showed better improvement than the linear group in the 5- and 30-m sprints, countermovement jump, and $\dot{V}O_2max$ ($p < 0.05$). The exponential tapering group had larger changes ($p < 0.05$) than the linear group in medium running (8–13 $km \cdot h^{-1}$) (6%; effect size = 0.26 compared with 5.5%; effect size = 0.22) and sprinting (>18 $km \cdot h^{-1}$) (26%; effect size = 0.72 compared to 21.7%; effect size = 0.60). The results show that exponential tapering produced better effects on speed, power, and endurance abilities than the linear protocol. Our results confirmed the reports of others that suggest that volume is the optimal variable to manipulate while maintaining both the intensity and the frequency of sessions.

Key Words linear, exponential, training, performance

Introduction

Tapering is a progressive reduction in physiological and psychological training load and has become a widely accepted method for maximizing performance after a preparation period (31). The main aim of tapering is to improve an organism's adaptation to competitive demands (31,47). According to the basic supercompensation model, the fatiguing stimulus has lower values during the tapering period, which allows the body to supercompensate by increasing physiological values above pretraining values (47). Currently, 3 tapering systems have been used in an attempt to establish the optimal strategy for performance in sports (47). The first is step tapering, where training load decreases immediately by 50%, and this level is maintained during the whole tapering period; the second is linear progressive tapering, where training load decreases by 5% in the initial stage and keeps decreasing by the same amount every workout; and the third is exponential tapering, where training load decreases in a nonlinear manner (47). Previous results show that athletes can improve performance by approximately 6%, strength by 20%, and $\dot{V}O_2max$ by almost 10% after a tapering period (25,31,49).

In soccer, players often rely on physiological (body composition as well as motor and functional abilities), psychological (mental preparedness), technical, tactical, and team-related factors (2,9). The game is characterized by running at different intensities, dribbling, sprints, jumps, and fast movement changes (42). A soccer player changes directions approximately every 3 seconds (45), and players make a total of 1,400 direction changes during the game (1) with approximately 200 intense actions (2). Previous studies have examined how the effects of tapering on the physiological abilities of soccer players allow them to achieve such competitive performance (12,16,18,34). Findings from these studies have shown that tapering may improve performance in repeated sprint ability (RSA) up to 4% (34), decrease symptoms of allergies (18), increase testosterone levels and the testosterone/cortisol ratio (12), and enhance the distance covered and number of sprints (16).

There has been a lack of studies investigating the effects of both linear and exponential tapering protocols on body

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composition, physical fitness, and distance covered in soccer. Moreover, previous studies have used a maximum of a 2-week tapering period to determine possible effects of tapering on analyzed variables (12,16,18,34). To the best of our knowledge and after an extensive literature review, there has only been one study investigating the effects of tapering protocol on physical match performance in soccer players (19). The aforementioned authors found large effect changes in intensity running, high-intensity running, high-speed running activities, and number of sprints between standard and taper week in favor of taper week. Therefore, it is necessary to investigate whether these 2 tapers produce the same or different effects over a longer period. Thus, the main purpose of our study was to explore and determine the effects of 4-week linear and exponential tapering protocols on body composition, physical fitness, and distance covered in male junior soccer players. It was hypothesized that exponential tapering would be more effective than linear tapering for improving fitness and physical match performance in elite junior soccer players.

Methods

Experimental Approach to the Problem

One hundred fifty-eight elite junior soccer players were randomly assigned to the exponential tapering group (ETG; $n = 79$) or the linear tapering group (LTG; $n = 79$). Players followed the same exercise training program for 4 weeks before the tapering period, which also lasted 4 weeks. Measurements were performed 1 week before and the week after the tapering period. Participants were familiarized with all testing procedures at least 48 hours before any experimental testing. After fasting, participants reported to the laboratory in the morning for assessment of body composition. After these measurements, performance tests (including the 5-, 10-, and 30-m sprints, sprint "96369" with a 180° turn, RSA test, squat jump [SJ], and countermovement jump [CMJ]) were conducted. Maximal oxygen uptake ($\dot{V}O_2max$) was used as a test for functional capacity. Moreover, we included the distance covered by the player during the soccer match. The results of the measurements before and after the 2 different tapering protocols were statistically compared.

Subjects

One hundred fifty-eight ($N = 158$) elite Croatian junior soccer players (all measurements expressed as mean ± *SD*: mean age: 17.1 ± 0.79 (16-18 years old); mean height: 177.9 ± 6.64 cm; mean body mass: 71.3 ± 7.96 kg; and mean body mass index: 22.5 ± 1.66 $kg \cdot m^{-2}$) were randomly assigned to the ETG ($n = 79$) or the LTG ($n = 79$). Randomization was performed with replacement, and all participants had an equal chance of being selected. There were 14 forwards, 18 defenders, 40 midfielders, and 7 goalkeepers in the exponential group and 15 forwards, 13 defenders, 45 midfielders, and 6 goalkeepers in the linear taper group. Before the study began, each participant provided consent, and for participants younger than 18 years, their parents/guardians also provided written informed consent to participate in the study. All participants were told about potential risks during the study. The participants knew they could withdraw from the study at any time without any penalty. During the study, participants were not allowed to participate in another training program that could potentially bias the results. All procedures performed in this study were in accordance with the Declaration of Helsinki and were approved by the institutional review board of the Faculty of Kinesiology, University of Split, Croatia.

Procedures

For the purposes of this study, we included body composition assessment of the study participants along with fitness tests and distance covered within a match. The variables included in body composition were height (cm), body mass (kg), body mass index ($kg \cdot m^{-2}$), sitting height (cm), % body fat, muscle mass, and water in the body. Body fat percentage (%BF), muscle mass, and water in the body were measured by a foot-to-foot bioelectric impedance analyzer (BIA, Tanita TBF 410; Tanita, Tokyo, Japan). The analyzer incorporates both a weighing scale and a foot-to-foot bioelectric impedance analyzer. Bioelectric impedance analyzer measurements were taken at least 2 hours after a meal and on an empty bladder. Age, sex, and height were manually entered. The device displayed body mass and %BF predicted using embedded equations. Studies have shown high correlation between %BF estimated by dual-energy X-ray absorptiometry and that estimated by Tanita foot-to-foot BIA scales (22,43). Tanita foot-to-foot BIA scales are portable devices that perform well in measuring %BF in children (43).

Fitness tests included the 5-, 10-, and 30-m sprint, sprint "96369" with a 180° turn, RSA test, SJ, and CMJ. Maximal oxygen uptake ($\dot{V}O_2max$) was used as a test for functional capacity.

Physical Fitness. 5-, 10-, and 30-m sprints. All sprint tests were performed on a grass sports field, and the players wore soccer shoes to replicate playing conditions. The ability to rapidly accelerate from a standing position was measured over 5-, 10-, and 30-m with infrared photoelectric cells (RS Sport, Zagreb, Croatia) positioned at exactly 5-, 10-, and 30-m from the starting line at a height of 1 m. Players were instructed to start each sprint from a standing start with their front foot 0.5 m behind the first timing gate and were instructed to sprint as fast as possible. They then ran as quickly as possible along the 30-m distance and were told to initially adopt a forward lean. The time between trials was a minimum of 3 minutes to enable full recovery. Time was recorded in hundredths of a second, and the average value from 3 sprint attempts was used as the final result.

Sprint "96369" with 180° Turn. Players started after the signal and ran 9 m from starting line A to line B (the lines were white, 3-m long, and 5-cm wide). Having touched line B with one foot, they made either a 180° left or right turn. All following turns had to be made in the same direction. The players then ran 3 m to line C, made another 180° turn, and ran 6 m forward. Subsequently, they made another 180° turn (line D) and ran another 3 m forward (line E) before making the final turn and running the final 9 m to the finish line (line F). This test was reliable and valid for estimating the preplanned agility of soccer players (42).

Repeated Sprint Ability Test. The RSA test involved 6 repetitions of maximal 2 × 15-m shuttle sprints (6 seconds) departing every 20 seconds (adapted from a previous running test that has been shown to be reliable and valid in estimating RSA) (7). During the approximately 14-second recovery between sprints, subjects were required to stand passively. Two seconds before starting each sprint, the subjects were asked to assume the start position as detailed for the 10-m sprints and await the start signal from an experienced researcher. Strong verbal encouragement was provided to each subject during all sprints.

Squat and Countermovement Jumps. Squat jump and CMJ performances were determined using a force platform (Quattro Jump, version 1.04; Kistler Instrument AG, Winterthur, Switzerland) at a sampling rate of 500 Hz. Jump height was determined as the center of mass displacement, calculated from the force-time record. Center of mass displacement was determined by double integration of the vertical force data (28) and the vertical force-time data were exported as text files and analyzed using a customized Microsoft Excel spreadsheet. The onset of movement for each CMJ trial was determined according to Owen et al. (36). According to aforementioned authors, the onset of movement occurs when vertical force decreases by 5 *SD*s from the body mass, during a period of quiet standing. In the SJ, subjects were instructed to squat to a self-selected depth of approximately 90° of knee flexion, pause 3 seconds in this position, and then jump as high as possible. During these jump movements, the subjects kept their hands on hips. Subjects were instructed to avoid any downward movement, and they performed a vertical jump by pushing upward, keeping their legs straight throughout. Downward movement during SJ was identified based on the force-time record. The position of the feet was standardized during all tests at shoulder width. The CMJ was begun from an upright position, then squatted to a self-selected depth of approximately 90° of knee flexion, and jumped immediately as high as possible without pausing. Also, the use of arm swing is allowed here. One minute of rest was allowed between 3 trials of each test, and the best jump was used in subsequent analyses.

Maximal Oxygen Uptake ($\dot{V}O_2max$). We used the standard ramp treadmill test protocol (46). The starting speed was 3 $km \cdot h^{-1}$, with speed increments of 1 $km \cdot h^{-1}$ every 60 seconds. Subjects walked the first 5 steps (up to 7 $km \cdot h^{-1}$) and continued running from 8 $km \cdot h^{-1}$ until volitional exhaustion. Expired gas was sampled continuously, and O_2 and CO_2 concentrations in expired gas were determined using the Quark b2 breath-by-breath gas exchange system (COSMED, Rome, Italy) with analyzers calibrated before each test using precision reference gases. Heart rate was collected continuously during the tests using a telemetric heart rate monitor (Polar Electro, Kempele, Finland) and stored in PC memory. Minute ventilation, oxygen uptake ($\dot{V}O_2$), expired carbon dioxide ($\dot{V}CO_2$), and respiratory exchange ratio were averaged over 10 seconds in the mixing chamber mode, with the highest 30-second value (i.e., the highest value measured over 3 consecutive 10-second periods) used in the analysis. Players were deemed to have attained $\dot{V}O_2max$ if the following criteria were attained, as advocated by Vucetić et al. (46): (a) volitional exhaustion; (b) achieving a plateau in $\dot{V}O_2$ (highest values were calculated as the arithmetic means of the 2 consecutive highest 30-second values); and (c) HR ≥90% of age-predicted maximum. If players did not meet all criteria, the trial was repeated for that player on another day. Three subjects were made to repeat 1 of their 3 exercise trials. For all trials, all players satisfied the defined criteria for the attainment of $\dot{V}O_2max$.

Distance Covered. Each player was filmed with close-up video during the entire match. VHS-format cameras (NV-M50; Panasonic, Ottobrunn, Germany) were positioned at the side of the pitch at the level of the midfield line with a height of

TABLE 1. Conditioning program for both groups in the first 4 weeks.*

>	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week 1	Continuous running	Strength; TE/TA training	Continuous running	TE/TA training	Strength/prevention training	Continuous running	Day of rest
Week 2–4	Strength; TE/TA training	Interval training	Strength; TE/TA training	Interval training	TE/TA training/ prevention training	Interval training	Day of rest

*TE/TA = technical-tactical training.

TABLE 2. Training protocol for both tapers ($3\times \cdot wk^{-1}$, 4×4 minutes of running from 90 to 95% heart ratemax).

Linear tapering		Exponential tapering	
Weeks	Series × min	Weeks	Series × min
5	4 × 4	5	4 × 4
6	3 × 4	6	2 × 4
7	2 × 4	7	1 × 4
8	1 × 4	8	1 × 4
Pause 4 min–40% of heart ratemax		Pause 4 min–40% of heart ratemax	

approximately 10 m and a distance of 30 m from the touchline. Videotapes were later replayed on a monitor for computerized coding of activity patterns, and videos were analyzed with the Focus 3 analyzer system. Video-based time-motion analysis requires individual players to be filmed and has commonly been used in soccer (3,14). The intra-observer reliability of video-based time-motion analysis has been previously reported (24,48). Soccer match performance was categorized in 5 classes: walking/jogging (0.4–3.0 $km \cdot h^{-1}$), slow running (3.0–8.0 $km \cdot h^{-1}$), medium running (8.0–13.0 $km \cdot h^{-1}$), fast running (13–18 $km \cdot h^{-1}$), and sprinting (>18 $km \cdot h^{-1}$). In addition, we calculated total distance covered as the sum of all categories combined. Data from 5 matches for each team were analyzed. All results are expressed in meters.

Tapering Protocol. In the first phase of the study, in agreement with soccer clubs, all the measurements were performed in the morning period between 9:00 and 12:00. For 2 days before testing, participants did not have any type of training with a significant load because such training could potentially have affected the results. All variables within the study were measured at 3 time points: initial test, mid-test, and final test. The mid-test was performed 4 weeks after the initial measurement. During this 4-week period, both

TABLE 3. Basic descriptive statistics of the study participants in body composition ($N = 158$).

Study variables	Pre-test, mean ± *SD*	Mid-test (after 4 wk), mean ± *SD*	Post-test (after 8 wk), mean ± *SD*	Time	Time × group
Height (cm)					
Exponential	179.04 ± 7.48	179.07 ± 7.49	179.01 ± 7.38	0.065	0.472
Linear	178.10 ± 7.15	178.17 ± 7.20	178.11 ± 7.18		
Sitting height (cm)					
Exponential	101.13 ± 5.16	101.15 ± 5.10	100.99 ± 5.20	0.251	0.247
Linear	100.52 ± 5.38	101.47 ± 5.43	100.99 ± 5.71		
Body mass (kg)					
Exponential	71.85 ± 7.66	71.94 ± 7.74	72.00 ± 7.80	<**0.001***†	0.890
Linear	71.38 ± 7.47	71.27 ± 7.44	71.30 ± 7.48		
Body mass index ($kg \cdot m^{-2}$)					
Exponential	22.41 ± 1.97	22.43 ± 2.04	22.45 ± 2.06	**0.048**†	0.631
Linear	22.40 ± 1.46	22.42 ± 1.47	22.43 ± 1.47		
Fat mass (%)					
Exponential	6.40 ± 2.61	6.39 ± 2.58	6.35 ± 2.53	<**0.001***†‡	0.620
Linear	6.05 ± 1.57	6.03 ± 1.60	6.01 ± 1.55		
Water (%)					
Exponential	43.74 ± 3.44	43.75 ± 3.47	43.74 ± 3.41	0.194	0.670
Linear	43.94 ± 3.96	43.96 ± 4.00	43.94 ± 3.98		
Muscle mass (%)					
Exponential	60.85 ± 14.32	60.95 ± 14.34	61.12 ± 14.38	<**0.001***†‡	0.312
Linear	60.90 ± 15.70	60.96 ± 15.56	61.10 ± 15.85		

*Difference between pre- and mid-test.
†Difference between the pre- and post-test.
‡Difference between the mid- and post-test $p < 0.05$.
Bold values = statistical significance.

experimental groups followed the same 4-week training program (Table 1). After the mid-test, both groups underwent different tapering protocols: linear or exponential. Training for both groups was maintained at 3 sessions per week and consisted of four 4-minute running exercises with an intensity of 90–95% heart ratemax separated by 4-minute jogging periods at 40% heart ratemax. Tapering protocols lasted for 4 weeks and were followed by the final measurement. In total, the protocols lasted for 8 weeks and used the same training methods. Furthermore, all participants had similar levels of physical activity outside the testing period and had similar dietary protocols. Details of both tapering protocols are presented in Table 2.

Statistical Analyses

Basic descriptive statistics are presented as the mean ± *SD*. To assess whether data were normally distributed, the Kolmogorov-Smirnov test was used. Statistical power was calculated using the G-power software. The intraclass correlation coefficient (ICC) and coefficient of variation (CV) were used to determine the reliability of the fitness tests. To test whether the main effect of group (exponential vs. linear), the main effect of time (pre-test, mid-test, and post-test), and the group × time interaction were significant, a 2 × 3 between-within analysis of variance (ANOVA) was used. Homogeneity of variance was tested using Levene's test, and differences between groups and trials were assessed using Bonferroni correction. Our approach was to remove outliers by eliminating any points that were above the mean +2 *SD* or below the mean −2 *SD*. For each ANOVA, partial eta-squared (η^2) was calculated as a measure of effect size (ES). Values of greater than 0.02, 0.13, and 0.26 were considered small, medium, and large effects, respectively. Statistical analyses were performed using the Statistical Package for Social Sciences program (SPSS version 23). An a priori alpha level of $p \leq 0.05$ was used.

Results

The Kolmogorov-Smirnov test showed that data were normally distributed. The statistical power was 0.94. The ICC and CV for the 5-m sprint, 10-m sprint, and 30-m sprint were $r = 0.958$ and 0.93%, $r = 0.958$ and 0.82%, and

Table 4. Basic descriptive statistics of the study participants in physical fitness (*N* = 149).

Study variables	Pre-test, mean ± *SD*	Mid-test (after 4 wk), mean ± *SD*	Post-test (after 8 wk), mean ± *SD*	Time	Time × group
Sprint 5 m					
Exponential	1.14 ± 0.14	1.13 ± 0.15	1.02 ± 0.17	<**0.001***†‡	**0.021**§
Linear	1.16 ± 0.14	1.15 ± 0.17	1.06 ± 0.17		
Sprint 10 m					
Exponential	2.09 ± 0.15	2.04 ± 0.13	1.94 ± 0.16	**0.001***†‡	0.060
Linear	2.06 ± 0.21	1.98 ± 0.17	1.97 ± 0.18		
Sprint 30 m					
Exponential	4.36 ± 0.22	4.34 ± 0.22	4.25 ± 0.24	<**0.001***†	**0.003**§
Linear	4.30 ± 0.18	4.25 ± 0.20	4.22 ± 0.18		
96369 agility test with 180°					
Exponential	7.52 ± 0.37	7.46 ± 0.36	7.41 ± 0.29	<**0.001**†‡	0.927
Linear	7.51 ± 0.42	7.48 ± 0.44	7.41 ± 0.40		
Repeated sprint ability					
Exponential	6.99 ± 0.37	6.90 ± 0.38	6.74 ± 0.37	<**0.001***†‡	0.383
Linear	6.98 ± 0.43	6.88 ± 0.44	6.73 ± 0.45		
Squat jump (cm)					
Exponential	41.66 ± 4.67	42.06 ± 4.41	42.77 ± 4.65	<**0.001**†‡	0.263
Linear	41.63 ± 4.61	41.68 ± 4.24	42.07 ± 4.45		
CMJ (cm)					
Exponential	53.16 ± 5.42	53.69 ± 5.36	54.73 ± 5.09	<**0.001**†‡	**0.024**§
Linear	51.52 ± 5.15	51.77 ± 5.12	52.05 ± 5.19		
$\dot{V}O_2max$ ($mlO_2 \cdot kg^{-1} \cdot min^{-1}$)					
Exponential	56.73 ± 3.91	56.98 ± 3.89	57.88 ± 4.10	<**0.001**†‡	**0.030**§
Linear	55.76 ± 5.50	56.03 ± 5.56	56.48 ± 5.66		

*Difference between pre- and mid-test.
†Difference between the pre- and post-test.
‡Difference between the mid- and post-test.
§$p < 0.05$–significant interaction (time × group).
Bold values = statistical significance.

$r = 0.979$ and 0.65%, respectively. The ICC and CV for the measurement of sprint "96369" with 180° turn were $r = 0.924$ and 1.62%. The ICC and CV for the measurement of SJ and CMJ were $r = 0.911$ and 2.89% for the SJ, $r = 0.927$ and 3.30% for the CMJ, respectively. The ICC and CV for the measurement of RSA were $r = 0.932$ and 1.82%, respectively.

Basic descriptive statistics for morphological characteristics are presented in Table 3. Neither the linear nor exponential groups had significant changes in height or sitting height variables. In the exponential group, body mass increased by 0.2% (ES = 0.02), body mass index increased by 0.2% (ES = 0.02), and % muscle mass increased by 0.4% (ES = 0.02); by contrast, % fat mass decreased up to 0.8% (ES = 0.02). In the linear group, body mass decreased by 0.1% (ES = 0.01), body mass index increased by 0.1% (ES = 0.01), and % muscle mass increased by 0.3% (ES = 0.01); by contrast, % fat mass decreased by 0.7% (ES = 0.01). The largest changes between trials occurred in the exponential group between the second and third trial in % fat mass (−0.6%; ES = 0.01) and % muscle mass (0.3%; ES = 0.01).

The results in Table 4 indicate differences in physical fitness between trials and groups. Time changes occurred in all tested variables. In the exponential group, the biggest positive changes between the first and third trials occurred in the 5-m sprint, with a difference between trials of 8.0% (ES = 0.77); the difference was 1.4% in the 10-m sprint (ES = 0.97), 2.4% in the 30-m sprint (ES = 0.48), 3.0% in the CMJ (ES = 0.30), and 2% in $\dot{V}O_2max$ (ES = 0.29). In the linear group, the effect of linear tapering produced the largest changes in the 5-m sprint (7.0%; ES = 0.64), 10-m sprint (7.0%; ES = 0.41), and RSA (3.6%; ES = 0.57). However, greater changes occurred in the exponential group than in the linear group in the 5- and 30-m sprints, CMJ, and $\dot{V}O_2max$ ($p < 0.05$).

Table 5 shows differences in distance covered during the game between trials and groups. In the exponential group, the distance covered increased by 2.5% for walking/jogging (ES = 0.03), 11% for low-intensity running (ES = 0.52), 6% for medium-intensity running (ES = 0.26), 15% for fast running (ES = 0.69), and 26% for sprinting (ES = 0.72). The total distance covered increased up to 6% (ES = 0.38). In the linear group, the

Table 5. Basic descriptive statistics of the study participants in distance covered parameters ($N = 158$).

Study variables	Pre-test, mean ± *SD*	Mid-test (after 4 wk), mean ± *SD*	Post-test (after 8 wk), mean ± *SD*	Time	Time × group
Walking/jogging (0.4–3.0 km·h^{-1})					
Exponential	5,374.30 ± 556.89	5,431.26 ± 554.35	5,508.23 ± 550.87	<**0.001***†‡	0.922
Linear	5,318.56 ± 665.48	5,376.76 ± 663.02	5,456.42 ± 662.47		
Low running (3.0–8.0 km·h^{-1})					
Exponential	1,445.83 ± 296.78	1,520.78 ± 298.84	1,599.32 ± 290.37	<**0.001***†‡	0.615
Linear	1,505.06 ± 321.90	1,579.97 ± 324.37	1,651.08 ± 324.45		
Medium running (8.0–13.0 km·h^{-1})					
Exponential	1754.66 ± 429.86	1778.15 ± 462.48	1865.89 ± 424.36	<**0.001***†‡	**0.048§**
Linear	1,698.81 ± 428.47	1734.49 ± 427.36	1792.34 ± 423.22		
Fast running (13.0–18.0 km·h^{-1})					
Exponential	658.00 ± 146.13	699.68 ± 145.18	760.55 ± 150.61	<**0.001***†‡	0.099
Linear	675.33 ± 151.87	710.55 ± 148.61	767.28 ± 152.62		
Sprinting (>18.0 km·h^{-1})					
Exponential	402.56 ± 144.13	447.51 ± 143.38	507.69 ± 147.33	**0.001***†‡	<**0.001§**
Linear	406.33 ± 142.63	442.59 ± 145.72	494.44 ± 147.67		
Total					
Exponential	8,988.78 ± 1,281.13	9,171.68 ± 1,439.69	9,516.16 ± 1,496.11	<**0.001***†‡	0.149
Linear	9,607.85 ± 1,187.42	9,757.02 ± 1,201.11	10,064.65 ± 1,224.97		

*Difference between pre- and mid-test.
†Difference between the pre- and post-test.
‡Difference between the mid- and post-test.
§$p < 0.05$–significant interaction (time × group).
Bold values = statistical significance.

distance increased by 2.6% for walking/jogging (ES = 0.21), 9.7% for low running (ES = 0.45), 5.5% for medium running (ES = 0.22), 13.6% for fast running (ES = 0.60), and 21.7% for sprinting (ES = 0.60). The total distance covered increased by 4.7% (ES = 0.38). The ETG had larger changes in medium running and sprinting than the linear group ($p < 0.05$).

Discussion

The purpose of this study was to determine the effects of 2 different tapering protocols on fitness status and physical match performance in elite junior soccer players. We found significant changes in body composition parameters between the initial and final measurements. Specifically, we found a significant decrease in % fat mass and higher levels of % muscle mass in both the ETG and LTG. These changes may occur due to physiological changes and reduced training stress (31). Previous findings have shown that decreased training load may increase red cell volume and both hemoglobin and hematocrit levels as a result of the tapering period (40). In addition, greater muscle mass may be explained by the fact that both tapers produced neuromuscular benefits, such as muscle power development, muscle contraction properties, and the stretch-shortening (plyometric) cycle of the muscles used for specific sports (35,37). In general, it has been reported that tapering may increase erythrocyte volume up to 15% and testosterone levels up to 5% while decreasing muscle damage up to 70% (25,31,49). Moreover, it has been reported that 13–34% tapering induces increases in muscle glycogen and its distribution in both men and women (32,33), which can potentially lead to better sparing of carbohydrates by using fatty acids as an energy substrate, thus lowering fat mass (21,38).

Next, we observed significant time changes in sprinting and jumping abilities, as in the sprint "96369" test with 180° turn and aerobic endurance. As mentioned previously, a progressive reduction in the training load may improve power and strength up to 5–6% (25,31,49). Previous studies have shown significant decreases in sprint times over 10, 20, and 30 m and improvements in vertical jumping performance (9,15). Specifically, Coutts et al. (10) found a significant decrease of 2.1% in the 10-m sprint and a nonsignificant decrease of 0.37% in the 40-m sprint in team sports players. Similarly, Elloumi et al. (15) observed significant reductions of 3.2, 2.2, and 2.5% in sprint times over 10, 20, and 40 m, respectively. Vertical jumping performance increased by approximately 5% (10).

Several mechanisms may be related to such results. First, the tapering period may significantly increase the proportion of fast myosin heavy chains and a shift toward faster twitch type IIX, which physiologically produces twice as much contraction than IIA fibers (11). This shift may explain sprinting and jumping performance improvements because sprinting and jumping activities are fast and very high-velocity movement activities (27). Similar findings have been presented from individual-type sports, where tapering improves sprinting abilities in running, swimming, and cycling (19). Times on the RSA test significantly decreased after a tapering period, which is consistent with some previous studies (34). Significant improvements were reported in RSA, measured using the running-based anaerobic sprint test: these improvements consisted of 4% in the experimental group vs. 0.03% in the control group after 2 weeks of tapering. Tapering has also been shown to have beneficial effects on $\dot{V}O_2max$. Most recently, a study by Fortes et al. (17) showed that after a 3-week tapering period, $\dot{V}O_2max$ displayed significant enhancement in the experimental soccer group. Previous studies have concluded that $\dot{V}O_2max$ improvements occur due to activation of the PGC-1α complex, which is directly associated with control of carbohydrates and fats, enhancing fat and glucose oxidation, which can potentially improve aerobic endurance (41). Similar findings have been reported in other sports, such as kayaking (20), cycling (13,23,33), swimming (29,44), and running (30). We also found that exponential tapering produced increases in the 5- (8.0%) and 30-m sprints (2.4%), CMJ (3.0%), and $\dot{V}O_2max$ (2%). A previous study has shown that slow exponential tapering (volume reduction up to 65%) after a 2-week period improved 5-km running times by 2.4% and enhanced maximal power by 3.6%, whereas fast exponential tapering (volume reduction up to 50%) improved 5-km running times by 6.3% and enhanced maximal power by 7.0% (4). The authors concluded that exponential tapering may have better effects on aerobic and maximal power than step tapering. Given the inverse correlation between sprints and jumps, it is also possible that improvement in one test led to improvement in the other (8) due to the abovementioned physiological changes.

In addition, our study revealed significant time changes between the pre-training and 8-week post-training measurements of distance covered. To the best of the authors' knowledge, only one study has aimed to explore the effects of tapering on physical match performance in soccer players (16). Fessi et al. (16) showed that total distance (ES = 0.90), intense running (ES = 1.1), high-intensity running (ES = 1.3), high-speed running (ES = 1.1), and sprinting (ES = 1.2) significantly improved after a 7-week tapering period throughout the season. However, as highlighted by previous studies, soccer performance represents a complex construct, and several factors may contribute to changes during physical activity performance (6,26). More specifically, the playing position on the field, game location, level of competition, and technical-tactical requirements contribute to players' physical involvement (26). Our results could be explained by the fact that our tapering protocol consisted of interval training with active recovery running between series, which possibly led to aerobic performance improvements, as in some previous studies from individual (5) and team sports activities (10,15). As mentioned before, findings from our study can be explained by several physiological changes that may occur during the tapering period (16). For instance, tapering has been shown to increase the oxygen extraction important for aerobic activities (33), reduce muscle damage and catabolism, and enhance anabolism and muscle glycogen stores (10). One study has shown that soccer players may improve repeated sprint performance during soccer matches due to greater glycogen stores and aerobic enzyme activity (39). We also found that the ETG achieved somewhat better results in medium running (8.0–13.0 $km \cdot h^{-1}$) and sprinting ($>$18.0 $km \cdot h^{-1}$) than the LTG. As highlighted above, 2 previous studies reported that slow and fast exponential tapering protocols decreased 5-km running times by 2.4 and 6.3% and increased power by 3.6 and 7.0% relative to step tapering in triathlon runners, respectively (4). In their meta-analysis, Bosquet et al. (5) reported that in general, progressive tapering protocols provide a significant overall effect size for tapering-induced changes in performance. The authors concluded that a 2-week tapering period with exponential reduction of 41–60% without any modification in training intensity or frequency maximizes the probability of significant improvements in performance (5). However, the type of sport activity, level of competition, sex, and required tasks important for the particular sport modify the optimal tapering protocol.

Our study has several limitations. First, we did not strictly control for participants' diets or other physical activities during the tapering period, which may potentially lead to bias. However, all participants were instructed before the study to have somewhat similar diets and not to participate in other sports activities. Second, we did not analyze the 2 tapering groups according to playing positions; players in different playing positions may have experienced different adaptations and changes in response to the 2 tapering protocols. To the best of our knowledge, this is the first study examining the effects of 2 different tapering protocols on the physical fitness profiles of elite junior soccer players over a 4-week period. The results suggest that both linear and exponential tapering significantly contributed to performance improvements after 4 weeks. However, the exponential tapering protocol produced somewhat better improvements, especially in sprinting and jumping activities and $\dot{V}O_2$max. Both linear and exponential tapering protocols generate positive effects on motor and functional abilities; however, as proposed by previous studies, maximal gains are achieved by applying a progressive exponential tapering protocol with an exponential reduction of 41–60% over a 2-week period (5). In the current testing protocol, we used a change-of-direction speed test, which involved pre-planned action and no reactions to stimuli. Moreover, this is a prolonged test that requires a certain level of anaerobic endurance. Body composition was tested with a Tanita TBF 410, which is a portable professional-grade BIA scale that can be practically used in field situations; however, to our knowledge, studies with comparable accuracy are limited.

Compared with other studies, some of the current results were poor. The only possible explanation is that players' fitness levels and the training programs used before the start of the regular season differed across studies. However, data from the pre-season period were not reported by coaches.

Practical Applications

Peak performance can be achieved through the logical variation of training methods and volume loads. As mentioned above, a taper involves a reduction in the volume load, which potentially enhances performance. Our results showed that decreasing by 5% of initial values or 5% of the previous session values in every subsequent workout produced similar effects on body composition in junior soccer players. However, exponential tapering produced better effects in the 5- and 30-m sprints, CMJ, and $\dot{V}O_2$max than linear tapering. The novel finding in the current study is that sprinting during matches was increased after exponential tapering in junior soccer players; thus, this tapering protocol could be a powerful method for improving training results. Both tapers should be used in the preparation period; however, exponential tapering produced better effects on speed, power, and endurance than linear tapering. The current results indicate that strength and conditioning practitioners should consider exponential tapering due to associated improvements in soccer abilities such as sprinting, jumping, and players' pulmonary capacity. These improvements will increase their skills and are relevant for training sessions as well as competition and matches. However, caution is advised when interpreting the results from this study due to the complexity and number of factors that could influence physical match activity. Our results confirmed the reports of others that volume is the optimal variable to manipulate, specifically by exponentially reducing the volume of training while maintaining both the intensity and the frequency of sessions.

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