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Exponential versus linear tapering in junior elite soccer players: effects on physical match performance according to playing positions

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ABSTRACT The purpose of the present study was to investigate the effects of exponential and linear tapering protocols on the distance covered according to playing positions among junior elite soccer players. One-hundred and fifty-eight junior elite soccer players (mean age: 17.07±0.79 years; mean height: 177.85±6.64 cm; mean weight: 71.27±7.96 kg; mean body-mass index: 22.50±1.66 kg/m^2) were randomly selected into two groups: (1) exponential and (2) linear tapering group. Training sessions were conducted three times a week for eight weeks. After four and eight weeks of the tapering period, participants were measured in the distance covered according to four basic playing positions on the field: (1) goalkeepers, (2) defenders, (3) midfielders, and (4) forwards. The results showed that the largest effects between the pre- and post-measurement had defenders in the exponential and goalkeepers in the linear group, goalkeepers in the distance covered by slow and medium running in both groups, forwards in fast running and sprinting in the exponential group, and midfielders in the linear group. In conclusion, our results suggest that the exponential tapering protocol brought somewhat larger effects, especially in fast running and sprinting in forwards and slow and medium running in goalkeepers. Future studies need to implement both the exponential and the linear tapering protocols in order to enhance performance but favouring the exponential to produce larger effects.

KEY WORDS tapering, soccer, juniors, situational efficiency, effects

Introduction

The game of soccer is often described as a team and contact sport characterized by different running intensities, jumps, acceleration and deceleration, and tackling (Valter Di Salvo et al., 2007; Valter Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009). Previous studies have shown that senior elite players cover between 10,500 and 12,000 metres per soccer match, with around 10% of high-intensity activities (Dellal et al., 2011; Dellal et al., 2010). Junior soccer players, however, cover between 9,000 and 10,000 meters per soccer match, have lower heart rate responses (82% vs 93% in senior players) and blood lactate concentrations (Wong et al., 2008). Additionally, a few studies have found positional differences between players, especially in the anthropometric characteristics and different physiological demands of each player (Bloomfield, Polman, & O'Donoghue, 2007; Rampinini, Coutts, Castagna, Sassi, & Impellizzeri, 2007). In general, midfielders cover a greater distance than other players on different playing positions, whereas forwards perform more sprinting activities and defenders dribble a shorter distance (Rampinini et al., 2007).

Over the past two decades, numerous studies have recorded activities performed by the players in different playing positions, aimed to discover which physical match activities are most important for soccer requirements (Buchheit et al., 2014; Valter Di Salvo et al., 2009; Fessi et al., 2016; Sarmento et al., 2014). The physiological and psychological requirements for soccer can be achieved through training load reduction (Inigo Mujika & Padilla, 2003). Training load reduction, i.e. reduction of the physiological and psychological load

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before the competition period, is known as "tapering" (Inigo Mujika & Padilla, 2003). The tapering protocol may improve and enhance performance in both athletes from individual and team sports (Bosquet, Montpetit, Arvisais, & Mujika, 2007; Elloumi et al., 2012). Previous findings have shown that a high training load during the training period could impair performance (Slattery, Wallace, Bentley, & Coutts, 2012). In general, it has been proposed that training load should decrease in order to reduce the frequency and volume of training but not the intensity (Bosquet et al., 2007).

To the best of our knowledge and after an extensive literature review, there has only been one study investigating the effects of the tapering protocol on physical match performance in soccer players (Fessi et al., 2016). Their results showed large effect changes in intensity running, high-intensity running, high-speed running activities, and the number of sprints between the standard and the taper week in favour of the taper week. However, there has been no study investigating the effects of two different tapering protocols on physical match performance in soccer players. Neither has there been a study investigating those effects according to different playing positions. Thus, the main purpose of the present study was to investigate the effects of the exponential and linear tapering protocol on distance covered according to playing positions in junior elite soccer players.

Methods

Participants

One-hundred and fifty-eight (N=158) elite Croatian junior soccer players (mean age: 17.07±0.79 yrs.; mean height: 177.85±6.64 cm; mean weight: 71.27±7.96 kg; mean body-mass index: 22.50±1.66 kg/m^2, mean training experience: 9.42±1.54 years) were randomly selected into the exponential tapering group and linear tapering group. Randomization was done with replacement, in which each participant 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. Basic descriptive statistics of the study participants in the distance-covered variables are presented in Table 2. Before the study began, each participant gave assent, and their parents/guardians had given informed consent to participate in the study. All participants were told about potential risks during the study. During the study, participants were not allowed to be in another training program that could potentially bias the results. All the procedures performed in this study were in accordance to the Declaration of Helsinki and were approved by the Institutional Review Board of the Faculty of Kinesiology, University of Split, Croatia.

Match activities

With the Focus 3 analyser system, we also included the distance covered by players during the soccer match and categorized this into five classes: (1) walking/jogging (0.4-3.0 km/h), slow running (3.0-8.0 km/h), medium running (8.0-13.0 km/h), fast running (13-18 km/h) and sprint (>18 km/h). We also included total distance covered, as a sum of all categories combined. All the results were expressed in metres.

Testing protocol

In the first phase of the study, in agreement with soccer clubs, all the measurements were done in the morning period between 9.00-12.00 h. Two days before the testing, the participants did not have any type of training with significant load, which could potentially affect the results. All variables within the study were measured three times: the initial, transitive and final periods. The transitive measurement was done four weeks after the initial measurement. After the transitive measurement, both experimental groups underwent different tapering protocols: linear or exponential. Training for both groups was held three sessions per week and consisted of 4×4 min running exercises with the intensity of 90-95% heart rate$_{max}$ separated with a four-minute jogging period of 40% heart rate$_{max}$. The tapering protocol lasted for four weeks, followed by final measurement. In total, the whole protocol lasted for eight weeks. It is noteworthy that coaches used the same training methods of teaching. Furthermore, all participants had similar levels of physical activity outside the testing period and had similar diet protocols. Detailed protocols of both tapers are presented in Table 1.

TABLE 1 Training protocol for both tapers (3×/week, 4×4 min of running to from 90-95% heart ratemax)

Linear tapering		Exponential tapering	
Weeks	**Series × minutes**	**Weeks**	**Series × minutes**
1	4×4	1	4×4
1	3×4	1	2×4
1	2×4	1	1 ×4
1	1×4	1	1×4
Pause 4 minutes – 40% of heart rate$_{max}$		Pause 4 minutes – 40% of heart rate$_{max}$	

Statistical analysis

Basic descriptive parameters are presented as means ± standard deviations. To assess whether the data were normally distributed, a Kolmogorov-Smirnov test was used. To test if the main effect of the factor *Group* (exponential vs linear), the factor *Position* (goalkeepers vs defenders vs midfielders vs forwards), the factor *Time* (pre-test, mid-test, and post-test) and the factorial interactions *Group×Position, Group×Time, Position×Time*

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and Group×Position×Time were significant, a 3-factorial between-between-within 2×4×3 ANOVA was used. Homogeneity of variance was tested by using Leven's test, and differences between groups and trials were determined by using the Bonferroni correction. Data have been identified as outliers if was out of M ± 2σ interval. Partial-eta squared (partial η^2) was used for effect size assessment. Statistical analyses were performed by using the Statistical Package for Social Sciences software (SPSS ver. 23). Type one error was set at α=5%.

Results

First, we calculated the coefficient of variation (CV) for every variable measured three times. Results showed small variation between three measurements in height (CV=0.001), sitting height (CV=0.002), weight (CV=0.002), body-mass index (CV=0.004), % of fat-mass (CV=0.006), % water (CV=0.001) and % of muscle mass (CV=0.002). In motor abilities, the results in CV showed somewhat larger variations in 5 m sprint (CV=0.083), 10 m sprint (CV=0.059), 30 m sprint (CV=0.025), 96369 agility test (CV=0.023), repeated sprint ability (CV=0.018), squat jump (CV=0.033) and squat jump with arm swing (CV=0.029). Last, in functional abilities, results in VO2max showed small CV (0.012). Basic descriptive statistics of the study participants are presented in Table 2. As shown, defenders and midfielders had the biggest distance covered, opposed to forwards and goalkeepers (p<0.05). Midfielders covered around 2000 metres in medium running, yet midfielders and forwards covered approximately 400 m by sprinting. In the distance covered by walking/jogging,

TABLE 2 Basic descriptive statistics of the study participants (N=158)

Study variables	Exponential tapering group			Linear tapering group		
	Pre	Mid	Post	Pre	Mid	Post
	mean±SD	mean±SD	mean±SD	mean±SD	mean±SD	mean±SD
Walking/jogging (0.4-3.0 km/h)						
Forwards	5418.08±259.50	5465.38±279.00	5535.77±290.45*	5449.33±248.44	5514.00±247.75	5603.33±229.86*†
Midfielders	5461.27±219.14	5508.67±186.20	5577.33±186.29*	5404.61±207.67	5471.54±208.96	5528.46±201.56*†
Defenders	5576.15±201.04	5639.49±211.26	5724.87±213.95*	5577.11±209.54	5628.67±201.22	5707.33±186.05*
Goalkeepers	2392.86±235.28	2465.71±243.37	2554.28±245.21*	2456.67±189.44	2510.66±180.66	2633.33±136.63*†
Slow running (3.0-8.0 km/h)						
Forwards	1369.23±225.03	1415.38±229.73	1480.38±209.77*	1293.33±228.24	1358.00±224.70	1433.73±212.03*
Midfielders	1514.86±256.81	1597.24±256.32	1679.22±233.59*	1582.56±253.05	1620.12±240.33	1736.07±247.48*†
Defenders	1466.67±284.52	1549.87±269.02	1648.33±233.27*	1419.23±186.57	1478.46±205.18	1563.54±202.32*†
Goalkeepers	964.28±85.21	1035.71±109.22	1078.57±116.11*	948.33±105.91	991.67±114.79	1058.33±113.03*
Medium running (8.0-13.0 km/h)						
Forwards	1715.38±343.62	1764.61±259.28	1856.92±235.70*	1680.00±265.11	1694.67±257.93	1781.33±233.75*†
Midfielders	1878.38±360.66	1935.00±361.20	2011.35±358.47	1797.62±447.17	1817.14±445.31	1862.38±441.97
Defenders	1802.50±456.18	1858.12±463.35	1930.00±446.39	1765.38±377.15	1812.31±376.30	1886.92±367.39
Goalkeepers	977.14±109.14	1064.28±143.51	1152.86±142.79*	1002.00±177.46	1086.83±190.51	1124.67±190.48
Fast running (13.0-18.0 km/h)						
Forwards	628.57±113.87	684.28±121.15	745.35±132.61*	700.00±146.38	724.33±139.60	760.67±143.45*
Midfielders	667.57±154.66	704.49±149.43	765.57±155.70*	670.29±157.22	706.01±151.10	768.44±154.30*
Defenders	714.70±132.01	758.82±134.48	822.94±134.76*	719.23±152.12	764.61±154.68	831.54±144.48*
Goalkeepers	528.57±108.52	561.43±114.23	612.86±102.91*	566.67±101.65	590.00±105.99	636.67±109.53*
Sprinting (>18 km/h)						
Forwards	402.86±159.15	448.57±158.54	517.50±167.82*	410.00±113.39	426.67±118.06	464.70±121.00*†
Midfielders	407.50±150.87	451.40±149.13	516.25±153.27*	404.44±144.53	442.00±147.14	501.78±148.19*
Defenders	382.35±138.00	424.41±139.68	472.06±138.46*	401.55±166.02	446.92±155.59	493.85±160.86*
Goalkeepers	242.86±97.50	279.28±99.93	295.71±95.01	226.67±106.90	247.50±103.85	286.87±107.07*
Total distance covered						
Forwards	9561.12±2096.54	9678.22±2347.94	10035.92±2216.51	9532.66±2071.39	9717.67±2159.84	10043.73±2232.64
Midfielders	9655.50±1613.38	9868.87±1799.03	10219.92±1862.33	9857.36±1810.85	10092.75±2020.95	10401.73±2469.01
Defenders	9940.37±1745.84	10228.57±1847.30	10596.14±2178.27	9881.66±1698.26	10128.30±1985.90	10480.39±2150.18
Goalkeepers	5103.13±334.70	5404.24±477.48	5721.37±420.90*	5198.56±358.07	5424.65±415.12	5737.28±426.17*

Note. *-significant difference between mid and post-test; †- Significant difference between groups

the effect size between pre- and post- measurement ranged within 0.43 in forwards to 0.72 in defenders in the exponential group, and between 0.60 in midfielders and 1.07 in goalkeepers. In the slow and medium running variable, the biggest changes occurred in goalkeepers in both the exponential and linear groups between pre- and post-measurement. However, forwards in the exponential group enhanced their results between pre- and post-measurement (ES=0.95) in the distance covered by fast running than forwards in the linear group did (ES=0.41). The largest effect size occurred in forwards and midfielders in the exponential group between the pre- and post-measurement and in midfielders in the linear tapering group. Defenders and midfielders in both the exponential and linear tapering groups had the largest distance covered during the game: between 10,000 and 10,500 meters.

The interaction between groups (exponential vs. linear), playing positions (forwards, midfielders, defenders, and goalkeepers) and time (pre-, mid-, and post-) showed no statistically significant result ($F=0.486$; $p=0.819$; $\eta^2=0.010$) for distance covered by walking/jogging, also by distance covered by low running ($F=1.274$; $p=0.269$; $\eta^2=0.027$) and total distance covered ($F=1.090$; $p=0.368$; $\eta^2=0.021$). However, significant results occurred in the distance covered by medium running ($F=2.299$; $p=0.022$; $\eta^2=0.051$), where there were significant differences between forwards, midfielder and defenders opposed to goalkeepers. The interaction between groups (exponential vs. linear), playing positions (forwards, midfielders, defenders and goalkeepers) and time (pre-, mid- and post-) showed a statistically significant effect ($F=3.739$; <0.001; $\eta^2=0.074$) in the distance covered by fast running. Specifically, goalkeepers had the lowest time changes in contrast to forwards, midfielders, and defenders, while no significant differences occurred between those three playing positions ($p>0.05$). In the distance covered by sprinting, results showed significant effects in the interaction between time and playing positions ($F=4.350$; $p<0.001$; $\eta^2=0.093$), time and tapering group ($F=11.240$; $p<0.001$; $\eta^2=0.196$) and time, playing positions, and tapering groups ($F=5.944$; $p<0.001$; $\eta^2=0.153$).

Discussion

The purpose of the present study was to investigate the effects of exponential and linear tapering protocols on the distance covered according to playing positions in junior elite soccer players. Our results showed significant improvements following both linear and exponential tapering periods in soccer players in all playing positions. As mentioned by some previous studies, it is difficult to analyse match performance only through distance covered, since soccer represents a highly complex game (Coutts, Chamari, Rampinini, & Impellizzeri, 2008). However, our results are in accordance with some previous studies, which have reported certain aerobic enhancements in both individual sport athletes (Costill, King, Thomas, & Hargreaves, 1985; Inigo Mujika & Padilla, 2003; Sanchez et al., 2013) and team sport athletes (Coutts et al., 2008; Elloumi et al., 2012). In one of the most recent studies, the results showed that maximal oxygen uptake increased after a two-week tapering program in the experimental group of soccer players (Fortes, Vianna, Silva, Gouvêa, & Cyrino, 2016). It has been previously established that maximal oxygen uptake enhancements occur due to activation of the PGC-1α complex related to carbohydrates and fats control and enhancing fat and glucose oxidation, which can potentially improve aerobic endurance (Silva & Araújo, 2015). Similar physiological changes by following a tapering period have been reported in other sports, like kayaking (García-Pallarés, Sanchez-Medina, Pérez, Izquierdo-Gabarren, & Izquierdo, 2010), cycling (Neary, Martin, & Quinney, 2003), swimming (Trappe, Costill, & Thomas, 2001), and running (I Mujika et al., 2002). Moreover, tapering has been shown to increase oxygen extraction important for aerobic activities (Neary et al., 2003), to reduce muscle damage and catabolism, and to enhance anabolism and muscle glycogen stores (Coutts et al., 2008).

Next, our results showed that forwards had the largest changes between pre- and post-measurement in the exponential group, followed by defenders, yet the largest differences were observed in defenders in the linear group in the fast running variable. Similar findings were obtained in sprinting activities. Since this is the first study examining the effects of two different types of tapering on the distance covered during the soccer match, we concentrated on physiological and playing position demands required by each player. For example, findings have proved that forwards perform the most maximal sprints and for longer durations, along with higher levels of stopping and faster deceleration activities (Bloomfield et al., 2007). Furthermore, forwards are more engaged in actions that require specific activities, like jumping and heading the ball (Reilly, 2003). It is possible that forwards improved their performance, since studies have shown that velocity, agility, and speed are the most important characteristics during a soccer match (Gil, Gil, Ruiz, Irazusta, & Irazusta, 2007). Moreover, morphologically, they are much leaner and stronger players with somewhat better physiological characteristics than the other players on different playing positions, indicating that the result of the game primarily depends on the forwards group (Gil et al., 2007).

Along with forwards, midfielders showed the largest changes in sprinting activities. This could be explained by the fact that midfielders are engaged in significantly less walking and low running intensities, but spend the most time in running and sprinting activities (Bloomfield et al., 2007). Studies have also shown that midfielders have higher levels of maximal oxygen uptake (VO2max) and cover greater distances in contrast to the players in other playing positions (Reilly, Bangsbo, & Franks, 2000).

Goalkeepers were shown to produce the largest changes in walking/jogging and slow running activities in our study, which could be related to the fact that they perform the poorest in the endurance tests (Tumilty, 1993). Defenders in our study had the largest changes in slow running in contrast to other playing positions. In gen-

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eral, time changes in our study according to playing position could be explained by different playing roles on the field during the soccer match. Since different requirements are needed from each player, we speculate that both tapering protocols produce different effect changes. For example, goalkeepers mostly cover distance with walking/jogging and low intensity running. Since they use such activities the most, it is possible that tapering influenced the most specifically on those parameters. Moreover, similar values were obtained among forwards and midfielders, who had the largest changes in fast running and sprinting activities, especially in the exponential group. One meta-analysis has shown that training load reduction between 40-60% from maximal load in a period of two weeks causes the largest improvements in performance (Bosquet et al., 2007). This kind of training load reduction seems to have beneficial effects against muscle fatigue and training stress during the tapering period. Furthermore, we only looked at physical soccer match parameters, but not on psychological parameters. Future studies should take both physiological and psychological parameters into account, since previous findings have shown that certain monotony is related to the onset of overtraining combined with high training loads (Foster, 1998).

Our study has several limitations. First, we did not control for diet and other physical activities of the participants during the tapering period, which may potentially lead to bias. However, all the participants were instructed prior to the study to have somewhat similar diet and not to participate in other sport activities. Second, we did not analyse technical and tactical elements during the soccer match, along with the psychological abilities. It is necessary to establish the relation between technical-tactical elements and distance covered in different running intensities (Fessi et al., 2016).

In conclusion, our results show that both the exponential and linear tapering protocols improved distance covered by different running intensities in soccer players according to their playing positions. However, the exponential tapering protocol brought somewhat larger change effects, especially in forwards and midfielders in fast running and sprinting activities during the soccer match. Furthermore, results suggest that goalkeepers had the biggest improvements in distance covered by walking/jogging and low running, since their playing role requires this kind of activity. As mentioned before, future studies should focus on investigating how different tapering protocols may affect physical and psychological abilities and sport-specific (technical and tactical) elements during the soccer match.

Avoiding overtraining and optimizing performance could be achieved through the logical variation of training methods and volume loads. As mentioned earlier, a taper involves a reduction in the physiological and psychological stress, which could potentially enhance performance. Our results showed that decreasing the 5% of initial values or 5% of the previous session values in every forthcoming workout had similar effects on distance covered by different running intensities in soccer players according to their playing positions. However, forwards and midfielders in fast running and sprinting activities during the soccer match showed better improvements following the exponential tapering. The novel finding in the current study is that sprinting during matches was increased after exponential tapering in junior soccer players. However, caution is advised when interpreting the results of this study, bearing in mind the complexity and the various factors that could influence physical match activities. Our results confirmed the reports of others, which suggest that volume is the optimal variable to manipulate exponentially, i.e., reducing the volume of training while maintaining both the intensity and the frequency of sessions.

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