The Effects of Tapering on Repeated Sprint Ability (RSA) and Maximal Aerobic Power in Male Soccer Players

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Abstract

The purpose of this study was to examine the effects of 2-week tapering on anaerobic aerobic power and repeated sprint ability (RSA) in male soccer players. Eighteen collegiate male soccer players performed interval training 2 times a week for 8 weeks.

The interval training consisted of 4 x 4 min running at an intensity of 90–95% of maximal heart rate (MHR), separated by periods of 3-min jog at 55–65% of MHR. The players were then randomly and equally divided into two groups: the control (C: age=20.5±1.51 yr; height =178.5±3.7 cm; body mass=73.61±4.53 kg) and taper (T: age =21.75±1.48 yr; height =178.62±2.72 cm; body mass =72.37±4.04 kg) groups. During taper period, C group continued weekly training and T group reduced volume training by 50% for two weeks. Before and after tapering, 20-meter shuttle run test and Running-based Anaerobic Sprint Test (RAST), consists of six times 35m discontinuous sprints, and [Lac]peak at the end of the RAST were performed. Statistical significance was set at P < 0.05. In the T group total sprint time (TT) to complete the 6×35-m sprints (31.17 ± 1.66 s vs. 32.52 ± 1.57 s; P = 0.004) and sprint decrement as fatigue index (FI) improved significantly (5.7 ± 2.02 vs. 5.9 ± 2.13 s; P= 0.005) with the [Lac]peak at the end of the RAST significantly greater (11.85 ± 0.95 mmol.L-1 vs. 11.74 ± 0.96mmol.L-1; P = 0.005), but no changes were observed in the aerobic power (P=0.169). None of the investigated parameters showed a significant change in the C group (P>0.05). It can be concluded that tapering can improve RSA in soccer players.

Keywords: Tapering, soccer, aerobic power, RSA.
Introduction
Maximal aerobic power (VO$_{2\text{max}}$) and repeated sprint ability (RSA) are considered essential soccer-specific fitness components for high-level players (Reilly et al., 2000; Reilly and Bangbooo., 1998). Thus, coaches and players are constantly seeking new training methods to optimise these factors during preparation phase. To maximize the training effects, there needs to be a balance between training work-loads and sufficient periods of rest (Halson et al., 2002; Halson and Jeukendrup, 2004). Therefore, a proper manipulation of training variables (intensity, volume, and frequency) must be performed. If the volume and intensity of training are inappropriately high and the recovery periods are restricted, the athlete will be under the risk of overreaching and overtraining (Halson et al., 2002; Halson and Jeukendrup, 2004).

A practice which is commonly considered to create maximal performance and minimize overtraining probability is to decrease training work-loads some days before the major event (Houmard et al., 1994; Banister et al., 1999; Costil et al., 1985; Hooper et al., 1999; Mujika et al., 2003; Thomas et al., 2009). This reduction in the training load is commonly termed "taper" (Banister et al., 1999; Gibala et al., 1994; Houmard et al., 1994; Johns et al., 1992; Mujika et al., 2000).

The goal during taper periods is to reduce the negative physiological and psychological impact of daily training (i.e., accumulated fatigue), rather than achieve further improvements in the positive consequences of training (i.e., fitness gains) (Mujika and Padilla, 2003). During a taper, several variables including volume, frequency and intensity of training sessions can be manipulated to maximise performance. Meanwhile, the duration of the taper period can play an important role as well (Mujika and Padilla, 2003; Mujika et al., 2004; Bishop and Edge, 2005).

It has been assumed that training intensity is a key factor to maintain training-induced adaptations (Hickson et al., 1985; Mujika et al., 2000; Kubukeli et al., 2002; Houmard et al., 1994; Neufner, 1989; Mujika and Padilla, 2003) and a slight reduction of training frequency (20%) for the highly trained athletes and a more reduction (30-50%) for the moderately trained athletes is appropriate for improving performance (Mujika and Padilla, 2003). Standardized training volume reductions of 50-70% have been shown to bring about various significant performance-enhancing physiological changes (Mujika and Padilla, 2003) including improved maximal oxygen uptake (Jeukendrup et al., 1992; Zarkadas et al., 1995; Dressendorfer et al., 2002; Margaritis, 2003; Neary et al., 2003a, 2003b) and anaerobic performance (Costil et al., 1985; D’Acquisto et al., 1992; Jeukendrup et al., 1992; Mujika et al., 2002) in various well-trained athletes such as runners (Shepley et al., 1992; Houmard et al., 1994), cyclists (Martin et al., 1994; Jeukendrup et al., 1992; Dressendorfer et al., 2002), swimmers (Costil et al., 1985; Johns et al., 1992; Raglin et al., 1996; Hooper et al., 1998; Trappe et al., 2000), and triathletes (Zarkadas et al., 1995; Banister et al., 1999).

Investigations have reported VO$_{2\text{max}}$ enhancements of 6.0% in cyclists reducing their weekly training volume by 50% during 7 days (Neary et al., 2003a). VO$_{2\text{max}}$ of well trained triathletes also increased (3%- 9.1%) following two weeks of taper (Zarkadas et al., 1995; Banister et al., 1999; Margaritis et al., 2003). Enhancement in peak power output and peak blood lactate concentration after maximal exercise as a result of tapering have been reported (Bonifazi et al., 2000; D’Acquisto et al., 1992; Mujika et al., 2000; Jeukendrup et al., 1992; Shepley et al., 1992), indicating positive effect of tapering on maximal performance capabilities.

While taper is a well-established practice for numerous athlete groups including swimmers, runners, and cyclists, to our knowledge, there are presently limited experimental evidence to show that this practice is effective in soccer players. Therefore, this study was designed to examine the effect of a two-week tapering period on RSA and maximal aerobic power in male soccer players.
Research Method

Participants

Eighteen trained collegiate male soccer players volunteered to participate in this study. The study was approved by the institutional research ethics board. All subjects were informed of any risks and discomfort associated with the experiment before giving their written consent to participate. Table 1 presents selected characteristics of the subjects at the outset of the study. Although physically active, all subjects were considered untrained and had not been participating in a regular exercise program for at least 3 months prior to the start of the study. During the study, players were not allowed to participate in any other training program that would impact the results.

Study Design

The total duration of the present study was 10 weeks. After baseline testing, subjects completed eight weeks of interval training program. Then, they were randomly divided into two equal groups matched for the [Lac]peak records: the control group (C: age=20.5±1.51 yr; height=178.5±3.7 cm; body mass=73.6±4.53 kg; n=9) continued weekly training volume for more two weeks, the taper group (T: age =21.75±1.48 yr; height =178.62±2.72 cm; body mass =73.93±4.60 kg; n=9) proceeded with a 50% reduction in training volume relative to the weekly training volume performed by the control group for this two-week period. Training volume in this study was defined as the training time in each session.

Figure 1: Schematic overview of study design

Procedures

At the outset of the study (baseline testing), then before and after the 2-week tapering, the pre- and post-tapering tests were performed. In addition to anthropometric measurements, the tests included the Running-based Anaerobic Sprint Test (RAST) and 20-meter shuttle run test in order to assess RSA and maximal aerobic power, respectively. The tests were performed in the afternoon between 5 and 7 pm, on a natural grass training field, using regular soccer shoes. Players were instructed to avoid intense exercise for the 24-hour period before each testing session. All participants were instructed to maintain their current dietary habits throughout the duration of the study.

The Running-Based Anaerobic Sprint Test (RAST)

The test consists of six times 35m discontinuous sprints. Each sprint represents a maximal effort with 10 seconds allowed between each sprint for the turnaround. The time for each sprint was used as the criterion score during the RAST. A photoelectric cell timing system (Alge-Timing Electronic, Vienna, Austria) linked to a digital chronoscope was used to record each sprint and rest interval time with an accuracy of 0.001 seconds. The fastest time (FT), total sprint time to complete the 6×35-m sprints (TT) and sprint decrement (SD) as fatigue index were calculated by dividing the sum of the sprinting times for 6 sprints by the best possible total score and then multiplying by 100 (Fitzsimons). According to Fitzsimons et al. (1993) total sprint time (TT) to complete the 6×35-m sprints and sprint decrement as fatigue index (FI) were considered as RSA variables.
Peak Blood Lactate Concentration ([Lac]Peak)
Blood samples from a finger prick were obtained during 2 min after completion of the RAST for the measurement of [Lac]_{peak} (Accusport blood lactate analyser, Boehringer, Mannheim, Germany).

Aerobic Power Test
At least 90 min after completion of RAST, 20-meter shuttle run test was performed as described by Paliczka et al. (1987). Briefly, the test consisted of shuttle running at progressively increased speed between 2 markers placed 20 m apart. The pace of the test controlled by audio bleeps from a CD-player at appropriate intervals. Each subject was required to be at one end of the 20-m course at the signal. A start speed of 8.5 km.h$^{-1}$ was maintained for 1 minute, and thereafter the speed was increased 0.5 km.h$^{-1}$ every minute. The test score achieved was the number of 20-m laps completed before the subject either withdrew voluntarily from the test or failed to arrive within 3 m of the end line on 2 consecutive tones. Each subject’s VO$_2$ was derived by the formula, VO$_2$max = 6.0 (maximum speed achieved) - 2 24.4 (St Clair Gibson et al., 1998).

Training and Taper
The interval training which consisted of 4x4 min at 90-95% of HR$_{max}$, with a 3-min jog at 55-65% HR$_{max}$ in between, was conducted twice per week (Sunday and Tuesday) for 8 weeks. This training model can increase both VO$_2$max (Helgerud et al., 2001) and anaerobic endurance of soccer players (Sporis et al., 2008). The players HR$_{max}$ was estimated (220-age) and heart rate (HR) was monitored during the interval training (Finland or Polar Team System). During the 2-wk taper period, the volume of interval training was reduced to 50% for the T group (2 x 4min at 90-95% of HR$_{max}$), while the C group continued their interval training without change. The investigator supervised all sessions.

Statistical Analyses
Before using a statistical parametric technique, the assumption of normality was verified by the Kolmogorov-Smirnov test. Student’s unpaired $t$-tests were used to compare subjects’characteristics between the two training groups before the taper period. Differences between groups and within groups over time were analysed using a 2×2 (group×time) repeated-measures ANOVA with main effects for group and time, and a group×time interaction. Assumptions were checked using Levene tests (equality of within-group variances), Box M tests (equality of within group covariance matrices). Within group changes from pre- to post-tapering were also examined using $t$-tests for dependent measures. Statistical significance was set at $p<.05$. Data are presented as means ± SE.

Results
All subjects completed the 10 week training period and data from all subjects were included in the analyses.

Table 1: Values for maximal aerobic power (VO$_2$max ), total sprint time (TT), fatigue index (FI), and peak blood lactate concentration ([Lac]$_{peak}$) achieved during RAST in the taper (T) and control (C) groups at the start of the study

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<tr>
<td>Age (yr)</td>
<td>22.55 ± 2.01</td>
<td>21.22 ± 1.39</td>
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<tr>
<td>Height (cm)</td>
<td>178.22 ±3.06</td>
<td>178.34 ± 3.70</td>
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Table 1: Values for maximal aerobic power ($VO_{2max}$), total sprint time (TT), fatigue index (FI), and peak blood lactate concentration ([Lac]_{peak}) achieved during RAST in the taper (T) and control (C) groups at the start of the study - continued

| Weight (kg) | 73.37 ± 4.17 | 73.58 ± 4.26 |
| VO_{2max} (ml.kg^{-1}.min^{-1}) | 49.88 ± 2.31 | 50.22 ± 2.33 |
| TT (s) | 33.26 ± 1.83 | 33.00 ± 1.71 |
| FI (%) | 6.2 ± 2.1 | 6.04 ± 2.3 |
| [Lac]_{peak} (mmole.L^{-1}) | 11.30 ± 0.95 | 11.32 ± 0.98 |

Values are means ± SD; n=9 subjects per group.

Changes in, TT, FI, [Lac]_{peak}, and maximal aerobic power of the two groups in pre- and post-tapering period are summarized in Table 2. TT decreased significantly over time in T ($P=0.004$) but not in C ($P = 0.082$); the decrease in TT was significantly greater in T compared to C ($P = 0.010$). FI decreased significantly over time in T ($P = 0.005$) but not in C ($P = 0.104$); the decrease in FI was not significantly greater in C compared with that of C ($P = 0.054$). [Lac]_{peak} increased significantly over time in T ($P=0.005$) but not in C ($P = 0.082$); the increase in [Lac]_{peak} was significantly greater in T compared to C ($P=0.010$).

Maximal aerobic power was the same before and after the taper period in both T (54.80 ±1.93 vs. 54.50 ±1.26 ml.kg^{-1}.min^{-1}; $P=0.169$) and C (54.22±1.48 vs. 53.88±1.76 ml.kg^{-1}.min^{-1}; $P=0.08$).

Table 2: Pre-tapering vs. post-tapering values for maximal aerobic power ($VO_{2max}$), total sprint time (TT), fatigue index (FI), and peak blood lactate concentration ([Lac]_{peak}) achieved during RAST in the taper (T) and control (C) groups

| Weight (kg) | T group (N=9) Pre-tapering | 72.37 ± 4.04 | C group (N=9) Pre-tapering | 72.52 ± 3.91 |
| VO_{2max} (ml.kg^{-1}.min^{-1}) | 54.80 ± 1.93 | 54.50 ±1.26 | 54.22±1.48 | 53.88±1.76 |
| TT (s) | 32.52 ± 1.57 | 31.17 ± 1.66*† | 32.42 ± 1.56 | 32.41 ± 1.58 |
| FI (%) | 5.9 ± 2.13 | 5.7 ± 2.02* | 5.8± 2.12 | 5.8± 2.14 |
| [Lac]_{peak} (mmole.L^{-1}) | 11.74 ± 0.96 | 11.85 ± 0.95*† | 11.70±0.90 | 11.70±0.86 |

Values are means ± SE.* Significant difference from pretaper period value, $P < 0.05$. † Significant difference from C group, $P < 0.05$.

Discussion

The major findings of the present study were that 2 wk of reduced volume training in male collegiate soccer players led to improved TT, FI, and [Lac]_{peak}. In addition, despite a 50% reduction in the total amount of training volume, levels of VO_{2max} were maintained. These findings demonstrate that tapering can improve RSA while maintaining adaptations gained from previous training.

The present findings showed that following the taper, improvements of T in TT compared with pre-tapering and C group were significant. This improvement in TT appeared to be attributable to an improved ability to maintain sprint performance during the RAST. Significant decrease in FI across the six sprints following the taper in T support this. This is in line with studies of Bishop and Edge (2005) suggesting that the 10-day taper in female soccer players was associated with a significant decrease in work decrement during the RAST.

The better TT and FI, together with greater [Lac]_{peak} in T, may related to the increase of the buffering capacity (Laursen and Jenkins, 2002) or/and muscle glycogen concentration (Balsom et al., 1999) along with increasing the activity of anaerobic enzymes that have been shown increase during taper periods by several studies (Coutts et al., 2007). However, it has been reported that glycogen breakdown during brief, high intensity exercise is independent of starting levels (Vandenberghe et al., 1995). Therefore, an increase in muscle glycogen is unlikely to benefit the brief repeated-sprint performance assessed in the present study. Therefore, post taper increase in [Lac] may due to an increase in the buffering capacity and/or activity of glycolytic enzymes that result in delayed fatigue.
and better performance during RAST. It should be noted that during RAST, any fatigue may not manifest itself during one bout of 35-m sprinting but may become apparent during the subsequent bouts. So, improvement of TT and SD without FS alternation is not surprising.

Another candidate to explain the greater in $[\text{Lac}]_{\text{peak}}$ following taper during the RAST might be the greater force productions capabilities of legs (Hirvonen et al., 1987; Gaitanos et al., 1993; Bishop and Edge, 2006). In fact, tapering has the potential to improve muscular power, specifically when maintaining training intensity along with sufficient reduction in training volume (Costill et al., 1991; Johns et al., 1992). Some studies have shown that improvements in tapered athletes are linked more closely to neuromuscular (Mujika, 1998; Raglin et al., 1996) and specific muscular changes than to change in metabolic process (Houmard and Johns, 1994; Johns et al., 1992; Pelayo et al., 1996; Shepely et al., 1992).

As known muscular strength (Kin-Islera et al., 2008) and neuromuscular activation of the contracting musculature (Mendez-Villanueva et al., 2008; Kinugasa et al., 2004; Racinais et al. 2007) are important factors that have a major role in anaerobic performance because with increased muscular strength the ability of muscles to generate muscular contraction in short-term high intensity activity also increases (Kin-Islera et al., 2008). Enhancement of TT and SD after tapering in the T group may therefore be, at least partly, related to improved strength.

It has also been suggested that aerobic fitness can influence anaerobic performance during sustained intermittent activities (Paliczka et al., 1987; Slaughter et al., 1988; Tomlin and Wenger, 2001) and some authors have reported significant correlations between the two (Dawson et al., 1993), but others have failed to do so (Wadley and Rossignol, 1998). Gaitanos et al. (1993) have suggested that the aerobic energy system was more important (compared with glycolysis) in power output maintenance during a long series of repeated sprints. They speculate that contribution of the aerobic system to ATP resynthesis was more significant when more repetitions were performed. Therefore, one possible reason for improved RSA test results without changing VO$_{2\text{max}}$ is that the protocol used in the present study contributed low number of runs (6 x 35) and short rest intervals (10 s).

Our results contrast with studies that have reported VO$_{2\text{max}}$ enhancements in cyclists (Jeukendrup et al., 1992; Neary et al. 2003a, 2003b) and well trained triathletes (Banister et al., 1999; Margaritis et al., 2003; Zarkadas et al., 1995). However, unchanged VO$_{2\text{max}}$ values as a result of a taper did not preclude runners (Houmard et al., 1994; Shepely et al., 1992) and swimmers ((D'Acquisto et al., 1992) from improving their performance.

A plausible explanation for unchanged VO$_{2\text{max}}$ in the present study might be due to subjects’ characteristics. Subjects of the present study are played at the university level and at least 3 mo before the start of the study had not regular intense training. However, most of studies reported VO$_{2\text{max}}$ enhancements had well-trained subjects (Jeukendrup et al., 1992; Neary et al. 2003a; Banister et al., 1999; Margaritis et al., 2003; Zarkadas et al., 1995). So, having low training experience might be one of the reasons for not changing in VO$_{2\text{max}}$ after tapering.

Although, the results of this study should be viewed in the context of the analyzed sample (colligate soccer players), it can be concluded that as a result of reduction of training volume, players performed better and were able to sustain higher blood lactate concentrations in intermittent short running test. Given the complexity of competition, and the number of psychological and physiological variables that must come together for peak performance, the results from this investigation give insight to the changes that occur in the anaerobic performance and VO$_{2\text{max}}$ that could improve performance of soccer players following a period of taper.

**Conclusion**

In conclusion, the present study showed that tapering was effective in producing significant changes in RSA by improvement of TT, FI, and $[\text{Lac}]_{\text{peak}}$. 
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References


