The Effect of an Intercollegiate Soccer Game on Maximal Power Performance

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Catalogue Data

Key words: athletes, sport, exercise, female
Mots-clés: athlètes, sport, exercice, femme

Abstract/Résumé
The effect of a competitive soccer match on maximal power performance was assessed on 19 members of an NCAA Division III female soccer team. Performance testing occurred within 24 hours prior to the game (Pre), immediately postgame (IP), and 24 hours post-game (24P). Each subject performed a squat jump (SJ) and countermovement jump (CMJ). Comparisons between starters (n = 10) and nonstarters (n = 9) revealed no between-group differences in power performance at IP, but starters were found to have significantly lower power and force measures at 24P than nonstarters. There were significant correlations between playing time and peak force during the SJ at 24P (r = –0.47), and between playing time and peak power during the SJ at IP (r = –0.57) and 24P (r = –0.51), and during the CMJ at IP (r = –0.49). Comparisons between different positions revealed no differential fatigue patterns. Results of this study show that power performance appears to be maintained for the duration of a soccer match but declines significantly within 24 hours after the match. Position played does not appear to affect performance decrements seen at 24 hours postmatch.

L’effet d’un match de soccer sur la puissance aérobie maximale est étudié chez 19 joueuses de la division III de la NCAA. On a évalué la puissance aérobie maximale 24 h avant (Pre), immédiatement après (IP), et 24 h après le match (24P). En outre, chaque sujet effectua un saut à partir d’une position accroupie (SJ) et un saut précédé d’un contre-mouvement

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préparatoire (CMJ). Les comparaisons entre les joueurs partants (n = 10) et les autres (n = 9) n’indiquent pas de différence de puissance à IP; les valeurs de force et de puissance des joueurs partants sont significativement plus faibles à 24P que chez les autres joueurs. On observe des corrélations significatives entre le temps de jeu et la force de crête au cours de SJ à 24P (r = –0,47) et entre le temps de jeu et la puissance de crête au cours de SJ à IP (r = –0,57) et à 24P (r = –0,51) et au cours de CMJ à IP (r = –0,49). On n’observe aucune différence dans la modalité de fatigue selon les postes occupés. Les résultats de cette étude indiquent que la puissance aérobie maximale est conservée durant le match, mais qu’elle est moindre 24 h plus tard. Le post occupé ne semble pas être un facteur associé à la baisse de performance observée 24 h après le match.

Introduction

The number of individuals playing soccer throughout the world has clearly made this sport the most popular athletic event today. More than 60 million soccer players are registered worldwide, and an equal number are thought to be unregistered (Kirkendall, 2000). Despite the sport’s high popularity, there is limited research concerning the physiological and performance responses to a soccer game. In these few studies, the primary focus has been on the elite male athlete. It has been shown that during a soccer game players will cover approximately 10 km, and that 8 to 18% of their movements will be performed at maximal intensity (Bangsbo et al., 1991; Reilly and Thomas, 1976; Withers et al., 1982). These studies also suggest that the intensity of performance is related to the athlete’s level of ability. Athletes playing at the elite level tend to play the game at a higher intensity than players at lower levels (Ekblom, 1986).

The soccer player does not have any distinguishable physiological characteristics that separate him or her from athletes of other sports. However, when comparing soccer players at various levels of competition, the elite players tend to be stronger and show greater cardiovascular endurance than less elite players (Cometti et al., 2001; Wisloff et al., 1998). Although the strength level of a soccer player does not match that of a strength trained athlete in a power sport such as American football, strength does appear to have a positive relationship to performance for the soccer player (Wisloff et al., 1998). Similarly, the aerobic capacity of a soccer player does not match that seen in an endurance athlete, but a high aerobic capacity (VO₂max exceeding 62 ml·kg·min⁻¹) appears to be common among elite soccer players (Kirkendall, 2000).

The importance of power in the soccer player, reflected by both speed and vertical jump ability, has been demonstrated in several studies (Cometti et al., 2001; Mangine et al., 1990; Rösch et al., 2000). These studies have shown that both elite and high level players have significantly faster sprint times and jump heights than less skilled players. It has also been suggested that sprint and jump performance may even be a determinant of success in soccer (Cometti et al., 2001).

The research on physical performance and the soccer player suggests that high levels of physical fitness—strength, speed, power, and endurance—may be important factors contributing to the success of the soccer player. This information is important to the coach in helping to create performance standards and criteria for team selection. Yet only a limited number of studies have examined the ability
of the athlete to maintain physical performance and recover after participating in a competitive contest. Such information can be invaluable to a coach to prepare a team for contests that follow in rapid succession as occurs during tournament play. Thus the primary purpose of this study was to examine the effects of a competitive soccer match on maximal power performance in an NCAA Division III female college soccer team. A secondary purpose was to compare the effects of a competitive soccer game on maximal power performance between athletes playing different positions: midfielders, forwards, and defenders.

Methods

SUBJECTS

Nineteen members of an NCAA Division III female soccer team volunteered as subjects for this study. Following an explanation of all procedures, risks, and benefits, each player gave her informed consent to participate in the study. The institutional review board of the college approved the research protocol. The subjects were divided into two groups. The first group (ST) consisted of 9 starters (mean ± SD): age 20.0 ± 1.0 yrs; height 162.4 ± 3.8 cm; body mass 57.7 ± 4.7 kg. The second group consisted of 10 nonstarters (NS): age 18.2 ± 0.4 yrs; height 164.2 ± 7.8 cm; body mass 62.1 ± 8.3 kg. We did not include the goalies, and one starter was unable to perform several of the testing sessions, so she was removed from the study. The subjects of this study were members of the defending NCAA Division III national championship team and finished the season with only one loss, which occurred during the semifinal round of the national championship.

EXPERIMENTAL PROTOCOL

The game chosen for the study was the last home game of the regular season. It was expected to be competitive between two conference rivals. All subjects reported to the human performance laboratory on four occasions for anaerobic power measurements. The first visit was 24 hours prior to the game. An additional pre-game performance test occurred approximately 30 minutes before the game. All subjects reported back to the laboratory within 15 minutes after the game for post-game testing (IP). The final testing session occurred approximately 24 hours following the game (24P).

Prior to each performance test except IP, the athletes warmed up by participating in their usual program of exercises completed before a practice or a game. After the warm-up they reported to the lab for testing. During each testing session they all performed a squat jump (SJ) and a countermovement jump (CMJ). Order of testing was randomly assigned. A period of 20 to 40 seconds separated the jumps to allow testing to proceed as quickly as possible. To minimize the time of testing, one maximal attempt was performed for each test. This protocol for measuring maximal power in a relatively large group of athletes during a competitive contest has been used when there is little time allotted for testing (Hoffman et al., 2002).

The SJ began with the athlete standing on the floor, her hands on her hips. She then lowered herself to a self-selected depth and maintained that position for 3 sec to eliminate any stretch-shortening cycle contribution to the subsequent jump.
On the command of “Go,” she performed a maximal vertical jump. For the CMJ the athlete again stood on the floor with her hands on her hips. She then lowered herself to a self-selected depth and immediately performed a maximal vertical jump, landing back on the floor. For all jumps, subject displacement was recorded for subsequent calculation of jump height, velocity, force, and power data.

For both the SJ and CMJ tests, samples were collected at 500 Hz for 4 sec. A position transducer (Celesco model PT 9510, Canoga Park, CA) was attached to the waist to measure displacement of the center of mass. A software package (Ballistic measurement system, Innervations, Muncie, IN) was used to calculate jump height, force, power, and velocity data. The system was calibrated before each testing session. Displacement/time data were filtered using a Butterworth 4th order digital filter and a cutoff frequency of 20 Hz prior to differentiation by the finite difference technique to calculate velocity/time data. High test-retest reliabilities ($r > 0.97$) have been reported with this testing apparatus (Newton et al., 1999).

**STATISTICAL ANALYSIS**

Data were analyzed using a two-way repeated-measures analysis of variance. In the event of a significant main effect, post hoc comparisons using the Bonferroni method were applied to determine pairwise differences. Due to an unequal and small sample size, we made comparisons between different playing positions using a Kruskal-Wallis analysis of variance. In the event of a significant $F$-ratio, post hoc analyses were accomplished by Mann-Whitney U tests corrected by the Bonferroni method. Pearson product moment correlations between playing time (taken from the official scorer’s game statistics sheet) and performance measures were computed. A criterion alpha level of $p \leq 0.05$ was used to determine statistical significance. All data are reported as mean ± SD.

**Results**

Initial analysis determined that there were no significant group or time differences between the two pregame test measurements. Therefore all subsequent analyses employed the mean score of both pregame measurements as the pregame (Pre) measurement result. All 19 athletes participated in the contest (minutes played ranged from 13 to 90). The effects on anaerobic power performance between starters and nonstarters can be seen in the figures. No significant differences were seen in peak power during the SJ (Figure 1) within or between starters and nonstarters. During the CMJ there was a significant decline in peak power between Pre and 24P in ST only (Figure 2). In addition, a significant difference in peak power during the CMJ was also seen between the groups at 24P. Significant declines in peak force from IP to 24P were seen in both the SJ and CMJ (Figures 3 and 4) in ST only. In addition, peak force outputs for ST were significantly lower at 24P than those seen for NS. No significant differences within or between groups were seen in the time to peak force (Figure 5) or in the maximal rate of force development (Figure 6).

The correlations between playing time and anaerobic power performance variables can be seen in Table 1. Significant correlations were observed between playing time and both CMJ and SJ peak power measures at IP ($r = -0.49$ and
Figure 1. Peak power during the squat jump (mean ± SD).

Figure 2. Peak power during the countermovement jump (mean ± SD). * Significant group difference; a = Significantly different from Pre for ST.

Figure 3. Peak force during the squat jump (mean ± SD). * Significant group difference; b = Significantly different from IP for ST.
Figure 4. Peak force during the countermovement jump (mean ± SD). * Significant group difference; b = Significantly different from IP for ST.

Figure 5. Time to peak force (mean ± SD).

Figure 6. Maximum rate of force development (mean ± SD).
There were no other significant correlations between playing time and any of the other anaerobic power performance variables. Interestingly, when examining the correlation between playing time and the Δ scores (IP–Pre) of the anaerobic power performance variables, we found no significant correlations.

Comparisons of the effect of a competitive game on anaerobic power changes and recovery between different positions on a soccer team are shown in Table 2. No significant differences in any of the performance variables were seen between defenders, forwards, and midfielders.

**Discussion**

This study provided a unique opportunity to examine the effect of a competitive soccer game on both CMJ and SJ performance and recovery in college athletes. The game selected for the study was the final home game of the season. It became one-sided, a 5–0 victory, and allowed the coaches to play the entire squad. Never-
theless, the difference in time played between starters (56.5 ± 14.0 min) and non-starters (29.0 ± 13.9 min) was still statistically significant. The game was played in the evening with ambient temperature at game time of 7 °C and 30% relative humidity. The results of this study provide one of the first scientific examinations of the performance response to participation in a competitive soccer game.

Pregame performance comparisons between starters and nonstarters were interesting in that the nonstarters did slightly better than starters in all performance measures, although significant differences were only seen for peak force during the CMJ. This is in contrast with some studies which have demonstrated that speed, anaerobic power, and endurance may be an important determinant of success in

<table>
<thead>
<tr>
<th>Variable</th>
<th>Defenders (n = 6)</th>
<th>Forwards (n = 5)</th>
<th>Midfielders (n = 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass (kg)</td>
<td>60.9 ± 4.2</td>
<td>60.5 ± 7.3</td>
<td>59.0 ± 9.1</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>164.1 ± 4.5</td>
<td>166.0 ± 6.4</td>
<td>161.1 ± 6.9</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>29.2 ± 1.6</td>
<td>28.4 ± 1.0</td>
<td>29.5 ± 2.6</td>
</tr>
<tr>
<td>Playing time (min)</td>
<td>46.7 ± 28.2</td>
<td>39.3 ± 19.2</td>
<td>40.7 ± 5.5</td>
</tr>
<tr>
<td>MRFD Pre (kg·sec⁻¹)</td>
<td>15764 ± 4234</td>
<td>17261 ± 3731</td>
<td>18334 ± 2403</td>
</tr>
<tr>
<td>MRFD IP (kg·sec⁻¹)</td>
<td>15807 ± 3445</td>
<td>17648 ± 2171</td>
<td>18895 ± 3981</td>
</tr>
<tr>
<td>MRFD 24P (kg·sec⁻¹)</td>
<td>16803 ± 2829</td>
<td>16398 ± 4297</td>
<td>19614 ± 3432</td>
</tr>
<tr>
<td>TPF Pre (sec)</td>
<td>0.33 ± 0.30</td>
<td>0.58 ± 0.33</td>
<td>0.42 ± 0.29</td>
</tr>
<tr>
<td>TPF IP (sec)</td>
<td>0.58 ± 0.43</td>
<td>0.40 ± 0.39</td>
<td>0.51 ± 0.31</td>
</tr>
<tr>
<td>TPF 24P (sec)</td>
<td>0.56 ± 0.3</td>
<td>0.39 ± 0.38</td>
<td>0.66 ± 0.35</td>
</tr>
<tr>
<td>PP CMJ Pre (w)</td>
<td>3303 ± 655</td>
<td>3445 ± 441</td>
<td>3033 ± 468</td>
</tr>
<tr>
<td>PP CMJ IP (w)</td>
<td>3238 ± 757</td>
<td>3201 ± 525</td>
<td>3160 ± 574</td>
</tr>
<tr>
<td>PP CMJ 24P (w)</td>
<td>2832 ± 617</td>
<td>3074 ± 919</td>
<td>2926 ± 480</td>
</tr>
<tr>
<td>PP SJ Pre (w)</td>
<td>3130 ± 751</td>
<td>3499 ± 648</td>
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<td>PP SJ IP (w)</td>
<td>3149 ± 492</td>
<td>3483 ± 391</td>
<td>3472 ± 546</td>
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<tr>
<td>PP SJ 24P (w)</td>
<td>2826 ± 945</td>
<td>3557 ± 708</td>
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<tr>
<td>PF CMJ Pre (N)</td>
<td>10830 ± 1305</td>
<td>9722 ± 1207</td>
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<tr>
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<tr>
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<td>9329 ± 1344</td>
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<tr>
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<td>11733 ± 3600</td>
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</tr>
<tr>
<td>PF SJ IP (N)</td>
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<td>10369 ± 1530</td>
<td>10879 ± 1658</td>
</tr>
<tr>
<td>PF SJ 24P (N)</td>
<td>9781 ± 2090</td>
<td>10134 ± 1717</td>
<td>10477 ± 2188</td>
</tr>
</tbody>
</table>

Note: MRFD = Maximal rate of force development; TPF = Time to peak force; PP = Peak power; PF = Peak force; CMJ = Countermovement jump; SJ = Squat jump; Pre = pretesting; IP = Immediate postgame testing; 24P = 24 hrs postgame testing.
soccer (Cometti et al., 2001; Wisloff et al., 1998). However, those studies made comparisons between athletes of different levels of play. In this study, which examined athletes of similar playing abilities—all in NCAA Division III—it is possible that factors other than physical fitness (e.g., experience, technical ability) were more important in determining starter and nonstarter status. These results might also be attributable to a good recruiting class that resulted in freshman players (7 of 10 subjects in NS) with greater athleticism then the returning veterans. Thus, in this instance playing experience may have contributed more than the player’s innate athletic ability toward playing time.

An interesting finding of this study was the lack of any significant decrement in anaerobic power performance from Pre to IP in either ST or NS. For starters this was quite surprising. We had hypothesized that there would be some decrease in anaerobic power performance, considering that a significant part of a soccer match is played at an intensity that can fatigue the anaerobic energy system (Kirkendall, 2000). However, due to the score of the game, many starters were substituted for early in the second half. This may have allowed them sufficient recovery time for the IP testing. In addition, the athletes appeared to be highly motivated during testing, and given the euphoria of winning the game, they may have had elevated catecholamine concentrations during testing.

Such an effect has been shown to augment anaerobic power performance (Kraemer et al., 1991). Unfortunately, catecholamine concentrations were not measured in the present study. Similar results have been seen in American football players immediately following a game (Hoffman et al., 2002), but that study also failed to measure plasma catecholamine levels. In addition, Ekblom (1986) and Kirkendall (2000) have also reported no change in isokinetic strength measures before and after a soccer match.

At 24P, significant reductions in peak power during the CMJ (15.5% compared to Pre), and peak force during both the CMJ and SJ (9.4% each compared to IP) were seen in ST. In addition, there was a 12.4% reduction in peak power during the SJ ($p > 0.05$) in ST between Pre and 24P. It is difficult to make comparisons to other studies examining anaerobic power performance changes following an actual competitive contest. Very few studies have investigated changes in these performance variables in athletes during and after a game, and we know of none that have examined soccer players. The results seen here appear to be similar to laboratory work involving eccentric exercise and muscle damage. Generally, in those studies the performance decrements associated with muscle damage are not seen until 24 to 48 hours following the exercise stimulus (Brown et al., 1997; Nosaka and Clarkson, 1995; Shellock et al., 1991). Soccer play includes both concentric and eccentric movements (Ekblom, 1986). Although speculative, the significant decline in power performance at 24P suggests there may have been some muscle damage resulting from the game. Unfortunately, we were unable to continue monitoring the recovery of the subjects.

Correlational analysis did show weak to moderate negative correlations ($p < 0.05$) between playing time and several power performance variables at IP and 24P. However, it is difficult to interpret these results. If playing time would have had a significant effect on performance test measurements, we would have expected to see a relationship between playing time and the $\Delta$ scores. It is unclear
why this relationship was not seen. But considering that playing time may be re-
related to the athlete’s position, it is likely, given the 5–0 score, that the athletes who
played the most (i.e., defenders) may have had a lower physical demand during
this game than athletes playing other positions.

When comparing defenders, forwards, and midfielders, we found no signifi-
cant differences in anaerobic power performance between these soccer positions,
despite differences seen in the activity profile of these positions. Midfielders can
play in both the offensive and defensive ends of the field, and as a result are gen-
erally seen to cover approximately a 5% greater distance during a game than the
other positions (Reilly, 1997). Forwards are primarily seen in the offensive end
of the field and primarily perform short, high-intensity sprints. Defenders play in
the defensive end of the field and generally at a much lower intensity (Reilly, 1997).
As a result, defenders can often play the full 90-min game without a substitution,
whereas forwards and midfielders require several periods of rest over the course of
the game.

The only subject in this study to play the entire game was in fact a defender.
It is likely that players with the greatest tendency to fatigue, forwards and
midfielders, would be substituted more often then players who do not have as
great an energy demand during play, i.e., defenders. Perhaps if the game score
were close, the coaches would have been forced to play their better players (ST)
for a longer period, thus resulting in a greater power decline.

In summary, during a contest in which the outcome was decided relatively
early and allowed for a liberal substitution pattern, anaerobic power performance
in both starters and nonstarters was maintained during posttesting. Decrements in
performance seen at 24 hours postgame in starters only suggests a delayed fatigue.
In addition, negative correlations were demonstrated between playing time and
performance responses. However, position does not appear to have a significant
effect on power performance during or after the competitive contest.

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*Received October 28, 2002; accepted in final form May 12, 2003.*