The Effect of 45 Min of Soccer-Specific Exercise on the Performance of Soccer Skills

Original investigation

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Abstract

**Purpose:** The aim of the study was to examine the effect of fatigue, developed during prolonged high-intensity intermittent exercise, on the performance of soccer shooting and dribbling skill. **Methods:** Nine semi-professional soccer players with a mean age of 20.7 ± 1.4 years volunteered to participate in the study. Participants completed a slalom dribble test and the Loughborough Soccer Shooting Test (LSST), before and directly following performance of three 15-minute bouts of a modified version of the Loughborough Intermittent Shuttle Test (LIST). **Results:** Mean heart rates and mean 15-m sprint times remained unchanged across the three bouts of the LIST. Following the LIST slalom dribbling time increased significantly by 4.5 ± 4.0% \((P = 0.009)\), whilst the mean total points scored during the LSST was significantly reduced by 7.6 ± 7.0 points \((P = 0.012)\). When fatigued the frequency of shots in the LSST achieving the highest score of 5 points was reduced by 47% whilst the frequency of shots achieving the lowest 0 point score increased by 85%. **Conclusion:** Results show that whilst 45 min of exercise caused no decrements in sprint performance there were significant reductions in the ability to perform soccer-specific skills. Both the speed (dribbling time) and accuracy (shot performance) with which soccer-specific skills were executed was impaired following exercise replicating one-half of a soccer match.

**Keywords:** Fatigue, shooting, dribbling, sprinting

Introduction

Performance in soccer is dependent upon many factors, including, technical, tactical, mental and physiological.\(^1\) Throughout the course of a match players will experience fatigue, manifested through a reduced work rate, a reduced ability to perform high intensity exercise\(^2\) and a progressive reduction in muscle strength towards the end of match-play.\(^3\) Resistance to fatigue is a key factor which determines the effectiveness of a player’s ability to continually perform efficient and precise movements within soccer.\(^4\) Lyons *et al.*\(^5\) highlighted that the development of fatigue may be the determining factor of success and failure, the difference between winning and losing. Additionally, soccer is characterised not only by a player’s ability to perform repeated high intensity work but also the maintenance of efficient execution of skills when in possession of the ball, such as passing, dribbling and shooting, especially towards the end of play.\(^2,6\)

While soccer involves a multiplicity of skills, Reilly & Holmes\(^7\) described that the most frequently utilised actions of passing, dribbling and controlling are the fundamental skills that are essential for retaining possession and are precursors for the completion of a skilled performance, regardless of playing position or skill level. The action of shooting may be considered to be an even more crucial skill, with Ali *et al.*\(^8\) highlighting that the fundamental principle of soccer is to score more goals than the opposing team.
Ultimately, skill to execute a successful pass, dribble with pace and control, or shoot at goal with accuracy, will determine the outcome of a game.8

The influence of fatigue on physical performance has been well researched in soccer, with previous research showing impaired physical abilities during and after brief periods of high-intensity activity,2 following 45 min of soccer-specific exercise,9,10 and at the end of competitive and simulated games.2,3,11 Conversely, Lyons et al.12 highlighted that ecologically sound studies investigating fatigue and its effects on soccer-specific skills are surprisingly rare. Impaired skill has been reported during competitive match-play,13,14 however, the variability inherent to a game makes it difficult to translate findings from one match to the next. To overcome match variability standardised, soccer-specific, protocols have been developed to replicate match-play.9,15,16 Following a 90 min Loughborough Intermittent Shuttle Test (LIST) a 5 % reduction in dribbling skill has been observed,6 as has a significant reduction in shooting skill.17 This previous research highlights an impaired ability to perform soccer-skills at the end of a match. Similarly, it has also been shown that soccer-skill is impaired following a bout of brief high-intensity exercise.18 However, it is not clear whether skill deteriorates at any other stage during a game. Sprint and jumping ability are known to be impaired following only 45 min of soccer-specific exercise9,10 but the ability to perform soccer-specific skills after a similar time period is unknown. Therefore, the aims of the current study were to investigate whether completing a 45-min LIST impairs the ability to both dribble with the ball and shoot at goal. A further aim was to determine individual variability in the magnitude of any change in the execution of skills when fatigued, and relate this to estimated smallest worthwhile changes in performance.

Method

Subjects
Nine male semi-professional soccer players (age 20.7 ± 1.4 years, stature 177.7 ± 6.1cm, body mass 73.5 ± 7.6kg), playing in the Welsh Division 2 League, participated in the study. The participants were from a range of outfield playing positions and were involved in regular training and match-play. The institutional ethical committee approved the project and written informed consent was obtained from all participants.

Experimental Design

Participants completed a slalom dribble test7 and the Loughborough Soccer Shooting Test (LSST)8 on two occasions; once in isolation and then repeated on another day following a 45 min modified version of the Loughborough Intermittent Shuttle Test (LIST).16 In the first session participants were given the opportunity to practice the skills tests, each test was first demonstrated by the researcher with participants then given two full practice attempts of each test. Participants then completed a standardised warm-up before completing test trials of the dribble and shooting tests, which were used as the pre-LIST condition. In the warm-up participants completed 10 min of dynamic movement drills increasing in movement intensity and including brief sprints (~15 m). After completing the skills tests participants were familiarised to the LIST by completing a 15 min block of
the test. In the second session participants completed the 45 min LIST immediately followed by the slalom dribbling test and LSST. Participants completed both test sessions within 2 days and at the same time of day to avoid any circadian influences. Heart rates were monitored throughout the LIST using Polar heart rate monitors (Polar Electro, Finland). Both the LIST and slalom dribble test were performed in an indoor sports hall with the LSST completed on an adjacent sand based Astroturf.

**Slalom dribble**

Soccer dribbling skill was assessed using the slalom dribble test. The test was chosen due its good ecological and construct validity as well as high intraclass correlation coefficient indicating a high test-retest reliability ($r = 0.95$). The test assesses total body movement, requiring participants to dribble around a set obstacle course as quickly as possible. The dimensions for the slalom course are shown in Figure 1. On the starter’s command the participant dribbled the ball from behind the start line to the right of the first cone and then alternately around the outside of the remaining 5 cones in a zig-zag path. The participant stopped and left the ball at the sixth cone before travelling in a straight line across the finish line (Figure 1). The time taken to negotiate the obstacle course was measured and recorded using Smart Speed timing gates (Fusion Sport, Brisbane, Australia). The participants were required to perform the slalom dribble twice, with a rest of 1 minute between trials with the mean of both times used as the test score.

**Loughborough Soccer Shooting Test**

Shooting accuracy was assessed using the Loughborough Soccer Shooting Test, which has been suggested to be a valid and reliable method of assessing soccer skill in research. All boundary lines of the test were marked on the floor using 5 cm grey tape. Shots were taken from within a square “shooting zone” measuring 8.5 x 8.5 m, which was marked with the nearest line being 16.5 m from the goal line. Four cones were used to mark each corner of the shooting zone with a standard gymnasium bench being placed on the middle of the far side of the zone to act as a rebound board (Figure 2). A full size soccer goal measuring 2.44 x 7.32 m was split into scoring zones and was marked using 5 cm grey tape and luminous orange rope measuring 1 cm in diameter (Figure 2). The study did not utilise the life-size goalkeeper or sports radar to measure shot speed as detailed by Ali et al. Ali et al. argue that the use of the static goalkeeper enhances ecological validity. However, the authors acknowledge that introducing high ecological validity could have reduced the reliability of the test. Furthermore, the authors reported a low correlation ($r = 0.36$) between shot speed and points scored suggesting that there is no relationship between shot speed and shooting accuracy during the test.

**Procedure for the LSST**

The test began with the ball being placed on the marked circle located in the centre of the shooting zone. The participant’s initial position was to stand facing away from goal towards the bench, within playing distance of the ball. After the call of the investigator,
the player was required to sprint to the cone he had been directed to move to, touch the top of it, and then return to the ball in the centre of the square. After playing a rebound pass off the bench, the player then controlled the ball if necessary, turned, and shot at the goal within the shooting area. The player was required to follow the shot by sprinting between two cones positioned 5.5 m away from and directly in front of the goal. Each participant performed a single trial consisting of 10 shots, with a rest period of 30 seconds between each shot sequence. There were 10 trial orders that were randomly selected for each player (five to the left and five to the right). The scoring areas marked out within the goal reflect the optimal placement of a shot to beat an opposing keeper. Any shots that were taken from outside the designated shooting zone or took more than 8.5 seconds to complete were discounted. The time taken to complete each shot sequence was measured using a Casio Digital stopwatch (HS-30W-1V, Casio Electronics Co, Ltd, London, UK). Performance in the LSST was measured as the total score achieved within the stated criteria.

**Modified Loughborough Intermittent Shuttle Test**

The test used in the study was a modification of the original LIST protocol. In the original protocol submaximal workloads were completed at speeds relative to maximum velocity during a multistage fitness test, consequently, there is variability in the amount of external work completed across participants. In the current study fixed work intensities were used, standardising the external workload completed and allowing the possibility of testing multiple participants simultaneously. The exercise intensities/shuttle durations used in the study were based on results previously published using a LIST and replicated the speeds observed during soccer match-play. The test required participants to run between two lines, 20 m apart, at various speeds. The running and walking speeds during each 20 m of the test were dictated by audible beeps and verbal instructions pre-recorded onto a compact disc. To assist with pacing different pitch audible beeps signalled when a participant should be turning and when they should be in the middle of the 20 m shuttle. The exercise protocol utilised consisted of 15 minute activity blocks. The activity blocks followed the same activity pattern as in the original LIST protocol and included:

- 3 x 20 m at a walking pace of 5 km·h⁻¹
- 1 x 15 m at maximal running speed (plus 5 m deceleration)
- 4s recovery
- 3 x 20 m at a running speed of 9 km·h⁻¹
- 3 x 20 m at a running speed of 14 km·h⁻¹

This pattern of exercise, lasting for 90 seconds, was repeated ten times forming a 15 minute block which was then followed by a rest period of 3 minutes. Participants were allowed to consume water ad libitum during the 3 min rest period. Fifteen metre sprint times performed during the LIST were measured and recorded using Smart Speed timing gates (Fusion Sport, Brisbane, Australia). Participants completed test trials in pairs and each participant had their own LIST and slalom dribble course. Each pair of participants...
shared a single LSST area but worked simultaneously, with one participant resting whilst the other participant completed a shot.

**Statistical Analysis**
A one-way repeated measures ANOVA was used to determine whether there were any differences in mean sprint times and heart rates recorded during each 15 min block of the LIST. A Bonferroni post-hoc test was employed to determine the level of significance where appropriate. Homogeneity of variance was evaluated using Mauchly’s test of sphericity and when violated the Greenhouse-Geisser adjustment was used. Paired sample t–tests were used to analyse the data obtained from the soccer-specific skills tests performed pre and post LIST. A comparison was also made between LSST trials with any points excluded as a consequence of not achieving the performance time criteria (8.5 s limit) included. For descriptive purposes a frequency distribution of the different points scored during the pre and post-LIST LSST trials was compiled. Data from pre-LIST skills trials were used to estimate the smallest worthwhile change in performance based on 0.2 of the between-subject standard deviation (SD). All data are presented as the mean ± SD. The significance level was set at $P < 0.05$ for all analyses. All statistical analyses were calculated using SPSS for Windows, version 12 (SPSS Inc., Chicago, IL, USA).

**Results**

**Loughborough Intermittent Shuttle Test**
The mean heart rates achieved during the first, second and third bouts of the LIST were $155 \pm 11 \text{ b-min}^{-1}$, $155 \pm 13 \text{ b-min}^{-1}$ and $156 \pm 12 \text{ b-min}^{-1}$, respectively, with no significant differences between bouts ($P > 0.05$). The overall mean HR throughout the LIST was $155 \pm 12 \text{ b-min}^{-1}$, corresponding to $78 \pm 5.7\%$ of predicted HR maximum. Sprint performance remained unchanged over the three bouts of the LIST with mean sprint times of $2.54 \pm 0.15 \text{ s}$ during bout 1, $2.56 \pm 0.14 \text{ s}$ during bout 2 and $2.58 \pm 0.14 \text{ s}$ during bout 3 ($F = 2.44, P = 0.12$).

**Skill Performance**
A statistically significant difference was observed between the dribbling skill trials performed before and after the prolonged exercise, with the post-LIST trial showing a $4.5 \pm 4.0\%$ increase in mean slalom dribbling time when compared to the pre-LIST trial ($P = 0.009$, Figure 3A). The smallest worthwhile change in dribbling time was estimated to be $1.1\%$. All nine participants displayed an increase in mean dribbling time following the LIST, with two participants recording an increase of $< 1.1\%$ and the remaining seven participants showing an increase ranging between $1.5 - 11.4\%$.

Figure 3B shows the mean total points scored for the pre and post-LIST LSST trials. There was a significant reduction in the points scored ($–7.6 \pm 7.0, P = 0.012$) when the shooting test was performed after the LIST. The smallest worthwhile change in performance was estimated to be $6.5\%$. From eight participants who recorded a reduced LSST score after the LIST, six participants showed a change in score $> 25\%$. The frequency with which all participants scored points from each scoring zone during the
LSST is shown in Figure 4. In the pre-LIST LSST there were a similar amount of shots achieving the maximum and minimum points score of 5 and zero, respectively. Following the LIST results showed a 47% decrease in the number of shots that scored 5 points and an 85% increase in the number of shots that scored zero points. Removing the time requirement to make each shot within 8.5 s and including shots taken outside of this limit made no significant difference to the pre-LIST LSST score ($P = 0.19$), however, it did significantly improve ($P < 0.007$) the points score recorded for the post-LIST LSST trial (Figure 2). With the 8.5 s time limit removed from both pre and post-LIST LSST trials the overall reduction in points scored was $-5.6 \pm 7.5$ points, which bordered on significance ($P = 0.057$). With the time limit removed only four participants recorded a reduction in the post-LIST LSST score $>25%$.

**Discussion**

There were no significant decrements in sprint performance during exercise simulating one-half of a soccer match. Over the same time period soccer-specific skills were found to be significantly impaired. This included a reduced ability to both dribble and shoot at goal following 45 min of intermittent exercise. The magnitude of the change in the skills tests suggest there was a “real” negative change in performance for the majority of participants for both dribbling and shooting. However, for some individuals it was the inability to shoot within the prescribed time requirements that resulted in poorer post-LIST shooting scores, rather than the ability to shoot on target.

The total distance covered during the 45-min LIST (6,000m) is comparable with distances covered during the first half of a soccer match. The overall HR response was slightly below that reported during match-play and during a 90 min LIST, however, the HR values were still within the expected range. Sprint performance was not impaired throughout the 45-min LIST protocol, which is in agreement with previous research. The absence of any decrements in sprint performance will in part be due to the relatively short distance (15 m) over which sprints were completed. Force generating capacity and acceleration have been shown to be restored relatively quickly during a set of repeated sprints, whereas the ability to maintain speed over longer distances can be reduced.

Previous research has identified a reduced ability to complete soccer skills during the second half of a soccer match and following a 90 min LIST; however, reduced skill was also accompanied by reduced physical performance in these instances. The implications of the present study are that skill can deteriorate by the end of the first half of a soccer match, and decrements in skill may precede any decrements in sprint performance. The effect of exercise on the performance of sports skills has been suggested to follow an inverted-U trend. The inverted-U response is thought to be linked to both physiological (warming-up and fatigue) and psychological (arousal) factors. Whether this relationship actually exists in a complex sport such as soccer is not clear. Whilst soccer-skill was previously known to be impaired following 90 min of exercise, results of the present study show that skill is already reduced following only 45 min of exercise.
The skills tests utilised in the current study required participants to complete whole-body movements whilst performing skills with the ball, reflecting the demands of competitive match-play. Both the slalom dribble and shooting tests focused on the physical execution of skill and minimised any requirements for perceptual abilities (such as decision making, visual scanning, spatial awareness and anticipation), which would also be important during competitive play. Nonetheless, a test involving an accuracy requirement will always partially rely on some perceptual abilities, which could be susceptible to fatigue. However, it has been argued that when using a sport-specific skills task participants are able to utilise self-control strategies to optimise performance when fatigued and any decline in cognitive performance is minimal. The absence of any decline in sprint performance during the LIST suggests that the subsequent reduction in skills post-LIST was not caused by a reduced ability to sprint/move during those tests. Instead it is likely that decreased performance was due to impaired motor control when working with the ball, which included dribbling in the slalom test and passing, possibly controlling and shooting with the ball in the LSST.

A number of authors have shown that skill over a 90 min simulated soccer match is better maintained with carbohydrate feeding. Total muscle glycogen depletion is unlikely to have occurred following only 45 min of exercise in the present study, although depletion in specific repeatedly recruited fibres may have occurred and may have contributed to the decline in soccer skills. Muscle damage has also been shown to occur following a 90-min LIST and suggested to occur following 45 min of soccer-specific exercise. Muscle damage is associated with changes in the sense of joint position and force production, which could interfere with motor control in skilled movements. Reducing susceptibility to muscle damage, for instance by utilising the repeated bout effect, may be one method to attenuate any decline in soccer skills during the first half of a soccer match. Impaired soccer-skill has also been suggested to be related to lactate accumulation following a brief bout of high-intensity activity. Reduced skill in a 35-min intermittent tennis test was suggested to be linked to lactate accumulation, with lactate levels similar to those expected during a LIST. Davey et al. suggested that players should avoid physiologically stressful conditions in training as this would impair their ability to practice and stabilise their skills. An alternative approach may be to focus on technical training under conditions of fatigue to ensure players can maintain skill execution when fatigued. It has also been suggested that increasing the exercise capacity of players will help to delay the onset of fatigue and impairment of skills during a soccer match. However, players with improved fitness may simply work at a greater intensity and still suffer fatigue during a match, a suggestion that is supported by the observation that players of lower and higher standards perform less physical work and fewer skilled actions in the second half of a match compared to the first.

Whilst all participants showed some increase in dribbling time when fatigued it is important to interpret the magnitude of the individual changes. Hopkins has suggested that when testing team players the smallest worthwhile change in performance can be estimated as 0.2 of the between-participant standard deviation, a procedure that has previously been employed with soccer-skills testing. Seven of the nine participants
experienced a reduction in excess of the estimated smallest worthwhile effect of 1.1%, suggesting the likelihood that the majority of participants experienced a “real” negative change in dribbling skill following the 45-min LIST.

Performance in the LSST was significantly impaired following the 45-min LIST, supporting previous observations following a 90-min LIST \(^\text{17}\). From data obtained in a reliability study, Ali et al. \(^\text{8}\) reported a critical value equating to a minimum worthwhile change in LSST score of 6.9% in first team university soccer players. Based on the same criteria results of the present study indicate a smallest worthwhile effect of 6.5%, which is in good agreement with the previous research. However, detecting such small changes in LSST performance is unrealistic given the amount of random variation inherent to this measure. Ali et al. \(^\text{8}\) found the coefficient of variation for points scored during the LSST to be 49.4%, with the authors concluding that this level of variability reflects the game of soccer itself. Given the level of random variation present in the LSST a smallest worthwhile change in performance of 25% was chosen, reflecting 0.5 of the within-participant variation, a criteria previously used with performance testing of athletes involved in individual sports. \(^\text{28}\) Based on the more stringent criteria, 6 participants showed a decrease in shooting performance greater than the critical value of 25%.

The LSST requires participants to make each shot within a set time limit, recreating the demands of the game where skills must be performed with limited available time. Removing the time limit requirement meant that post-LIST LSST performance was significantly improved when shots made outside of the time limit were included. With the time limit removed the overall group reduction in LSST performance bordered on significance (\(P = 0.06\)) and the number of individual players recording a drop-off in performance of >25% was reduced from 6 to 4 players. In terms of shooting ability players may be split into three categories; i) those showing no signs of fatigue, ii) those who can maintain shot accuracy but only by sacrificing speed of movement and iii) those who cannot maintain shot performance irrespective of time limits. The varied individual responses may reflect physiological differences in the ability to tolerate fatigue (peripheral or central), technical differences in the ability to execute skills when fatigued, \(^\text{24}\) or cognitive differences such as regulatory focus influencing the individuals strategic response to a skilled task \(^\text{29}\) or differing self-regulation strategies. \(^\text{24}\)

In a fatigued state players may be sacrificing speed of movement in order to maintain accuracy, a phenomenon that has been termed the speed-accuracy trade-off. \(^\text{17}\) However, speed and accuracy may change independently of one another, \(^\text{30}\) whilst different individuals may place different importance levels on each these of variables dependent on the task presented \(^\text{29}\) and possibly the level of fatigue experienced. Reduced speed of skill execution when fatigued is supported by the increase in slalom dribble times, which is attributed to reduced motor control when in control of the ball. During the LSST participants were unable to sacrifice speed due to the time limits imposed and as a consequence accuracy suffered. During the post-LIST trial the number of total shots with a zero score almost doubled, whereas the number of shots scoring five points almost halved. The changes in the distribution of points scored clearly reflect reduced shooting accuracy when fatigued, which would have obvious consequences during a game.
Practical applications

Decrements in the execution of soccer skills during a (simulated) match may precede any similar reductions in physical performance, such as sprint ability. Measurement tools should be used to assess the ability of players to complete important soccer skills when fatigued and appropriate training regimes employed to reduce any fatigue related impairment of soccer skills. However, more research is needed on the effectiveness of different types of interventions and training/coaching to improve the ability of players to maintain performance of soccer-specific skills throughout a game. Protocols allowing analysis of the speed-accuracy trade-off may be particularly useful in determining how different players cope with fatigue, which could include no impairment in speed or accuracy, impairment to one of these components (speed or accuracy) and impairment to both of these components (speed and accuracy). Such information may be useful for both team selection and producing individualised training programmes.

Conclusion

Participation in 45 min of simulated soccer match-play did not cause any decrements in sprint performance. Conversely, performance of prolonged intermittent exercise did significantly impair the ability to both dribble with the ball and shoot at goal. Therefore, a reduced ability to perform soccer-skills may precede any observed decline in sprint performance. On an individual basis the majority of players demonstrated a negative change in skill execution greater than the critical smallest worthwhile effect. It is clear that completing exercise equivalent to one-half of a soccer match may be sufficient to impair the ability to perform soccer-specific skills.

References


Figure 1 — Diagram of the slalom dribble test course
Figure 2 — Schematic of the Loughborough Soccer Shooting Test (I = investigator).
Figure 3 — A) Mean slalom dribble time before and after the LIST and B) Mean total points scored during the Loughborough Soccer Shooting Test before and after the LIST, with (filled squares) and without (open squares) an 8.5 s shot time limit. *Significant difference between pre and post-LIST trials, $P < 0.05$. **Significant difference between post-LIST LSST trials with and without an 8.5 s time limit, $P < 0.01$. 
Figure 4 — Frequency of points scored from all shots taken during pre and post-LIST trials of the Loughborough Soccer Shooting Test.