The effect of instep kick in intermittent sprint on heart rate and external workload

by

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Contain

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Abstract

Purpose: The aim of this study was to investigate the relationship between heart rate and external workload in intermittent sprint with and without instep kick.

Participants: 20 male junior players participated in the field experiment consisting of different exercise with blocks of sprint.

Method: The exercise was conducted on two different days and the order of the sprint with and without instep kick was changed each day. One sprint is 32 meters in total and last 5 to 6 seconds, with a 180 degrees turning point halfway. A new sprint was performed every 30 seconds. Recovery time between the 2 blocks of sprints was about 3 minutes. The exercise was used as a part of normal training regime which means that it was not added to the team's weekly training dosage. Heart rate (HR) was recorded by the Polar Team 2 system and ZXY tracking device was used to record position and acceleration of the players from which work and power were calculated.

Result: No significant effect was found for instep kick or players playing position in intermittent sprint. Significant differences were observed for average heart rate (HR_{avg}) and peak heart rate (HR_{peak}), but not for duration of heart rate peak in seconds (T_{PHR}) between the two days. Considering interaction between day and different blocks of sprint, significant differences was found for HR_{avg}, HR_{peak} ($p < 0.01$), but not for duration of T_{PHR}. For absolute work (AW), peak power acceleration ($P_{peak\text{-}acc}$) and peak power deceleration ($P_{peak\text{-}dec}$) statistical significant differences were not observed between days and blocks of sprint. No significant effect was found for interaction between condition and day for these variables.

Conclusion: This study demonstrated that neither an instep kick nor playing position has an effect on sprint performance, meaning that adding instep kick into intermittent exercise does not affect performance regarding heart rate and external workload.

Introduction

In soccer frequent fluctuations between high and low exercise intensities, that incorporates unpredictable changes and unorthodox patterns of movements e.g., moving backwards, sideways, suddenly changing direction and heading occurs often (Drust et al., 2007, Rampinini et al., 2007a, Stølen et al., 2005, Bangsbo et al., 2006). Soccer matches impose a range of demands on the players. To cope with these demands the players have to possess the necessary fitness. This fitness aspect consists of different physiological characteristics that impose both aerobic and anaerobic power, muscle strength, flexibility and agility (Svensson & Drust, 2005, Reiley, 2005). The soccer played today seems to be more demanding than before. A study by Strudwik and Reilly (2001) in Reilly (2005) compared English Premier League players work rate profiles between season 1998-2000 and seasons before 1992. Their findings show that the players covered 1.5 km more in a game compared with the players playing before 1992. Together with changes in the rules, such as penalizing time-wasting and prohibiting goalkeeper from picking up a back pass, have raised the tempo and focus on training program that can meet the new demands.

The distance a player cover in sprinting seems more relevant for scientific investigating than the total distance a player run, since result of scientific research show that high-intensity exercise separate top class player from players of lower standard (Mohr et al., 2003). A recent study by Bradley et al., (2009) on English FA Premier League soccer matches show that the players performed low-intensity activity (e.g., walking and jogging) 85.4% of the total time. High intensity running were performed only 9.0% of the total time, which consisted 6.4% high-speed running (19.8-25.1 $km \cdot h^{-1}$) and 0.6% sprinting (>25.1 $km \cdot h^{-1}$). Bradley and his colleagues reported that the mean distance covered in high-intensity running and very high-intensity running were 2492 meter and 905 meter respectively. This is consistent with other studies that have reported a total sprint distance during a game ranging from 700-1000 meters (Spencer et al., 2005). The number of sprints reported in a soccer game varies greatly and number of sprints differs from the first to second half of a soccer game (Bradley et al., 2009, Bangsbo et al., 2006, Spencer et al., 2005). Other findings suggest that lengths, duration and recovery time between sprints varies. Mean sprint distance varies from 10-20 meter with a duration of 2-10 seconds and a sprinting recovery ratio ranging from 1:1 to 1:5 (Spencer et al., 2005, Glaister 2005, Stølen et al., 2005).

It is important for both players and coaches to obtain objective information about the player's physical capacities to spot possible weaknesses and design training programs that are effective. Several different tests are used to obtain such information, e.g., laboratory tests, lactate thresholds tests, muscle strength tests and different field tests (Svensson and Drust, 2005, Hoff, 2005, Impellizzeri et al., 2005b, Hoff and Helgerud, 2004, Nicholas et al., 2000). Among these tests, intermittent sprint and repeated sprint ability (RSA) have been popular among coaches and applied sport scientists (King & Duffield, 2009, Bishop et al., 2007, Rampinini et al., 2007a, Greig et al., 2006, Dupont & Millet, 2005, Edge et al., 2005, Little & Williams, 2005, Zafeiridis et al., 2005, Dupont et al., 2004, Lakomy & Haydon, 2004, Newmann et al., 2004, Balsom et al., 1992). These tests try to describe the outcome of the training and its process. The outcome reflects the internal load and the training process reflects the external load (Impellizzeri et al., 2005b). In the literature, terms like internal workload, internal training load and intensity, are used interchangeably. Although the terms are often not clearly defined, most authors actually refer to metabolic rate (energy expenditure).

Impellizzeri et al., (2005b) state that to quantify internal training load it is important to evaluate both its outcome and the actual internal training load. This is because challenges with assessment of internal training load have raised questions about heart rate (HR) and oxygen consumption (VO_{2maks}) as measurements for estimating energy expenditure. Recent studies have shown that HR can be a valid measurement for training intensity during steady state training conditions, but not for other training condition like weight training exercises and intermittent exercise (Drust et al., 2007, Impellizzeri et al., 2005b). During both weight training and intermittent exercise HR responds relatively slowly to abrupt changes in work rate (Drust et al., 2007, Impellizzeri et al., 2005b). Recent studies have shown that using accelerometer and heart rate monitoring together improves the measurement of physical activity compared to using the devices separated (Plasqui & Westerterp, 2005, Strath et al., 2005). Like assessment of internal training load, the assessments of external training load have some main challenges. Carlign et al., (2008) state that due to the lack of a "golden standard" for testing validity, reliability and objectivity of motion analyses, there are few validation studies. Another challenge is that accelerometer data is complex and requires sophisticated analysing (Matthews, 2005, Stratch et al., 2005).

Intermittent sprinting is starting and stopping at intervals. Intermittent sprinting is one of the test used in training to simulate the high-intensity exercise periods in a game, because these tests consist of several sprints interspersed with brief recovery periods that ensure physical responses similar to those occurring during actual match play, e.g., decrease in muscle pH, phosphocreatine and ATP store, and activation of anaerobic glycolysis (Spencer et al., 2005, Glaister, 2005, Mohr et al., 2005). The physiology behind intermittent exercise shows that short duration sprinting is provided by anaerobic ATP usage with contributions from both PCr degradation and anaerobic glycolysis (Spencer et al., 2005). Both number of sprints, recovery time between sprints and type of recovery have been suggested to affect sprint performance (King & Duffield, 2009, Bishop et al., 2007, Edge et al., 2005, Spencer et al., 2005). Glaister (2005) state that multitude of factors may attribute to maintain multiple sprint performance. Many issues regarding physiological response to multiple sprints are still remained unsolved. Especially information about sprint work and inherent variation in work-rate profile of players is limited (Drust et al., 2007, Glaister, 2005, Spencer et al., 2005).

Soccer performance depends on myriads of skills, not only physiological capacities and RSA. Kicking, passing, dribbling and soccer throw-in are some of the skills that have received attention (Mallo and Navarro 2007, Rampinini et al., 2007b, Markovic et al., 2006, Impellizzeri et al., 2005a, Shan and Westerhoff, 2005, Nunome et al., 2006, Nunome et al., 2002, Lees and Nolan 1998). Many methodological challenges, e.g., test design, synchronizing of different equipment and analyzing techniques, have made it difficult to draw prevailing conclusions on overall workload and technical components in soccer both in matches and in training settings (Drust et al., 2007, Reiley 2005, Shan and Westerhoff, 2005). Small-sided training games are one way to investigate soccer skills influence on physiological parameters. Studies have shown that these training regimes obtain intensity that is similar or even higher than experienced during match-play (Hill-Haas et al., 2009a, Hill-Haas et al., 2009b Mallo & Navvaro, 2007, Rampinini et al., 2007b). At the same time this training requires the players to perform both technical and tactical components (Mallo and Navarro, 2007). The exercise intensity during these games can easily be manipulated (Rampinini et al., 2007b) and these small-sided games can be as effective as aerobic interval training in junior soccer players (Impellizzeri et al., 2005a). Studies on short-passing ability in junior soccer players have shown that match-related fatigue induced a decline in short-passing ability, and that aerobic training in form of intermittent activities can attenuate this decline (Impellizzeri et al., 2008, Rampinini et al., 2008). Therefore training regimes that incorporate ball activity have evoked attention both among coaches and scientists.

Studies on the basic biomechanics of instep kick show that upper body movement, alteration in trunk position, hip- and knee flexion-extension and ankle push off contribute to an instep kick (Nunome et al., 2006, Shan & Westerhoff, 2005, Nunome et al., 2002). Such a kick may therefore affect the intensity of intermittent sprinting. An instep kick is a kick were the supporting foot is placed at the side of the ball. The kicking leg is first moved backwards and flexed at the knee. The forward motion of the leg is initiated by rotating of the pelvis around the supporting leg and by bringing the thigh of the kicking leg forward while the knee still is flexed. Then the thigh begins to decelerate and during this deceleration the shank is extended about the knee to its almost full extension at ball contact. The leg remains straight through the ball contact and begins first to flex during the long follow through. An instep kick is most widely used for maximal kicking effort (Kellis & Katis, 2007, Lees & Nolan, 1998). However there has been little scientific research on physical expenditure that compares high intense intermittent exercise with and without instep kick.

The aim of this study is to investigate the relationship between heart rate (as a raw indicator of internal workload) and power (as measure for external workload) in intermittent sprint with and without instep kick. The main question in this study is: Does the execution of an instep kick in intermittent sprint influence heart rate and power compared to non execution of instep kick in intermittent sprint? Additional purpose was to check for differences in performance taking into account players' playing position. A field experiment was elected for future investigation.

Method

Participants

The subjects in this study were juniors in an elite soccer club in Norwegian Premier League. 20 male elite junior players (mean age 17,6 ± 1,1 years, mean height 181 ± 5,8 cm, mean weight 73 ± 6,7 kg) participated in the study. The players who participated in these tests were all outfield players. Goal keepers did not participate. Consent was obtained from the physical coach of the team on behalf of the players. The coach has chosen the training regime for scientific investigating and he leaded the training season. Our role was to observe the training and standardized the training regime in a way that made it usable for scientific investigation, without changing the "essence" of the training. RBK and ZXY collected the data and have approved to use the data in this study.

Exercise protocol

The protocol consists of an AB-BA design performed on two separated days. Each day 2 blocks of 6 sprints were performed, 6 sprints with instep kick and 6 sprints without instep kick. The order of the sprint with and without instep kick was changed each day. A new sprint was performed every 30 seconds. One sprint was 32 meters in total and lasted 5 to 6 seconds, with a 180 degrees turning point halfway (at 16 meters). Recovery time between the 2 blocks of sprints was about 3 minutes. The exercise was used as a part of normal training regime, which means that it was not added to the team's weekly training dosage. The team was in the initial stages of the preparatory phase of their season when the tests were performed. Before the test the players met to prepare. Attachment of the sport chip and the polar transmitter is led and controlled by the physical coach to ensure correct use of the sport chip on both systems. Prior to the sprints subjects performed a warm-up program of approximately 20 minutes duration. Warm-up program consisted of exercises with ball and sprint exercises. This program was constructed and led by the physical coach of the junior team. The sprint distance was measured using tape measure and the track was outlined using 16 meters end marking line as starting line, and cones marking the turning point (see figure 1). The players were instructed to run forward in a straight line, and turn 180 degrees when feet were in line with turning point marked with a cone. They were also instructed to stand erect after finishing each sprint to make a clear offset, such that sprint starts were easier to indentify. The players were instructed to use maximum effort when performing the instep kick and to aim straight forward. The ball was placed on the finishing line. The weather conditions on test day 1 were -6 degrees Celsius and on test day 2 – 9 degrees Celsius. The tests were performed pm16.30, under stable conditions (no wind or snow) both days. The test was performed on artificial turf with under heating.

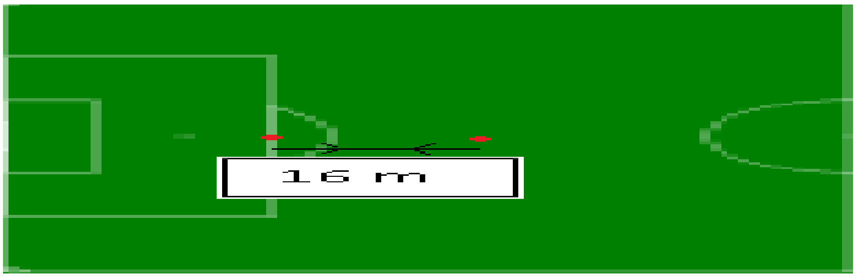

Figure 1. Situation under which the test were performed.

Measurement

The weight of the players was measured by using a digital weight. Weight was measured prior to training and the players wear normal outdoor training clothing and shoes. Clothing and shoes was not deducted from total weight in the analysis because this reflects the player's actual mass during sprinting. Prior to the sprint exercise the physical coach had measured maximal heart rate (HR_{max}) values using standardized YO YO Intermittent Recovery 2 test (YO YO IR2). The HR_{max} value is estimated from the HR values at the end of the test and divided by 0.96, because at 1720 meters, or towards end of YYIR2-test, soccer players reach an average 96% of peak heart rate (HR_{peak}). (Krustrup et al., 2003). This test was performed in March and April 2009. HR was recorded by the Polar Team 2 system and was retrieved at a sample rate of 0.33Hz (by resampling in the Polar software).

ZXY tracking device (ZXY Sport Tracking AS, Trondheim) was used to record position and acceleration of the players at a sample rate of 40Hz. The ZXY tracking system is a wireless position registration system using Cordis RadioEye™ (RadioNor Communications AS, Trondheim). The ZXY system records player position in 2 dimensions, and acceleration in 3 dimensions. The accuracy of position tracking depends on the setting of the radio eyes. The calibration of the system was performed using a radio-controlled vehicle with a ZXY sports chip (10 gr, 42 x 32 x 12 mm) attached. The resolution of the system for the current data collection was about 0.5 m. Acceleration data planned used for calculation of force and thereby power had to be ignored in further analysis and all values were based on ZXY position data. To calculate force and power from acceleration with a decent accuracy, the orientation of the accelerometer must be known or assumed to be constant. But the orientation at this stage could not be measured properly, and therefore the protocol was designed to compensate this. Therefore sprint runs in a straight line with 180 degrees turns were chosen. Still, the data for the horizontal accelerations resulted often in unrealistic values. This was most likely because of the forward bending movements of the upper body and interindividual differences in chip orientation in erect position.

Processing of the HR data

HR_{peak} is founded from the highest peak HR value, and registered both for the first 6 sprints and the last 6 sprint both days (see figure 2). The time the players have a HR value within 95% of HR_{max} is calculated in seconds (T_{PHR}). This was calculated using a formula for calculation of percent to find the HR values that are within the 95% window and then using this value and the peak to calculate the time spent within the 95% of HR_{max}.

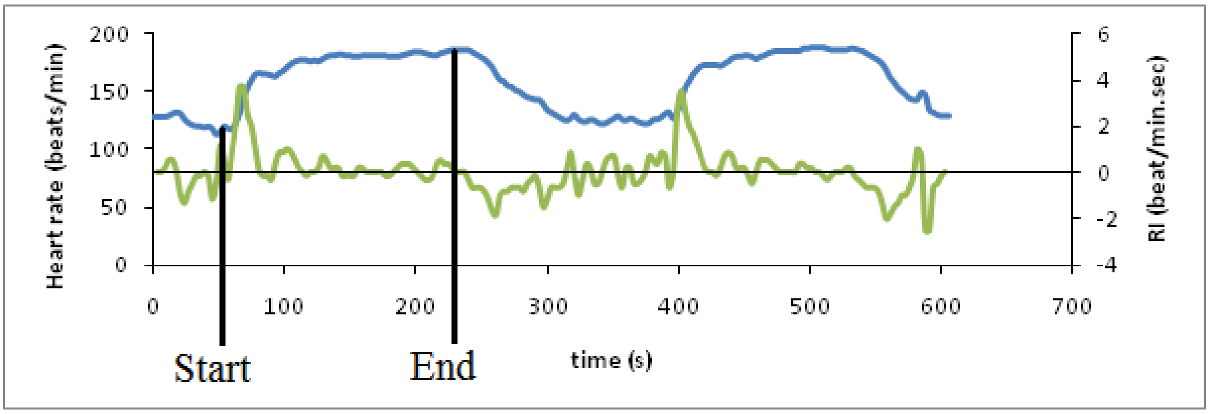

Figure 2: Time trace of the HR (blue line) and its rate of change (green line) for one player. The graph shows that HR gradually increases to a point where HR becomes constant high and decline slowly during the recovery period. The highest HR was observed in the recovery period between the sprints and immediately after the last sprint in each block.

Processing of the ZXY signal

The processing of the signal was done in the following way: The start and end of each sprint was determined by visual inspection of the signal (see figure 3). The start of the sprint was defined as the point where power exceeded the zero level and remained above zero until reaching a first obvious peak value. The end of the sprint was often more difficult to identify as the players did not tend to make a sudden stop at the finish line. The end was therefore defined as the occurrence of the last (of two) negative power peaks. This peak always occurred very close to the point where the players reached the position they had at the above defined start point. Note that this point was not always the true start line.

The ZXY position data were recorded for both running direction (x) perpendicular to this direction (y) in the horizontal plane. Because the players run in straight lines in one direction, it was expected that no or minimal deflection in the time series of the performance variables in the y-direction would occur. We checked a small number of signals for this, and the expectation was confirmed. Thus, the y-direction was not considered further in the analysis. A low pass filter was used on the position data leading to a frequency band from 0-1 Hz. The position data were used to calculate performance parameters. Velocity (v) and acceleration (a) were derived by applying a 5-point differentiating filter on the position-time trace once and twice. Peak velocity for the turn ($v_{peak\text{-}turn}$) and return ($v_{peak\text{-}return}$) runs were easily distinguished as return velocity was recorded as negative. Power was calculated as the product of v, a, and body mass. Both positive and negative power peaks were obtained. Peak positive power is produced during acceleration ($P_{peak\text{-}acc}$) and negative power during deceleration ($P_{peak\text{-}dec}$). The average values for the 6 sprints were used for further analysis. In the present analysis, the location of occurrence (during turn or return run) of these peak powers was not identified. Finally, total absolute work that was done (acceleration) and absorbed (deceleration) was found by integrating the absolute values of power over time during the entire sprint (turn and return in one). All calculations were done in Matlab (R2009b) (The MathWorks, Natick, MA).

Figure 3. User interface for identifying start and end of the sprints. (For details please see text).

Statistical analysis

Data are reported using mean values and standard error of the mean (SEM). Statistical analyses were performed using two-way ANOVA for repeated measurement in SPSS version 17. Statistical significance was set at $p < 0.05$.

This field experiment consisted of an AB-BA design, but due to challenges with the devices measuring external workload, the data from the last six sprints without instep kick on day one is missing. Lacking the data from this sprint session has made it difficult to control for sequence effects between the two days and between different conditions. Despite this, the data consist of two full sessions with instep kick and one session without instep kick. Therefore it was decided to perform a one way ANOVA on the two block with instep kick, to check for order in which the blocks were executed (test – re-test analysis) (n = 14) and a one-way ANOVA on the data from day 2 on the effect of instep kick (n = 17). Eight participants have full data on HR, therefore it was decided to perform two-way ANOVA (full) for HR data (see table 1).

Table 1. Number of participants used in the different analysis in this study.

Day	Condition 1	Condition 2
1	Sprint 1-6 with instep kick n HR = 8 n ZXY = 16	Sprint 1-6 without instep kick n HR = 8 n ZXY= 0
2	Sprint 1-6 without instep kick n HR = 8 n ZXY = 18	Sprint 1-6 with instep kick n HR = 8 n ZXY = 17

Result

Heart rate

The results are presented in figure 4, 5 and 6. Statistical significant effects were observed for HR_{avg} and HR_{peak} between the two days with p values ranging from 0.014 and 0.009 respectively, but not for T_{PHR}. Different sprint conditions had no observed statistical significant effect on HR_{avg}, HR_{peak} and T_{PHR}($p > 0.05$). Interaction between days and conditions gave statistical significant effects with p values ranging from 0.003 for HR_{avg} and 0.007 for HR_{peak}, but not for T_{PHR} ($p > 0.05$). For HR_{avg} and HR_{peak} the 2nd sprint block gave higher HR each day.

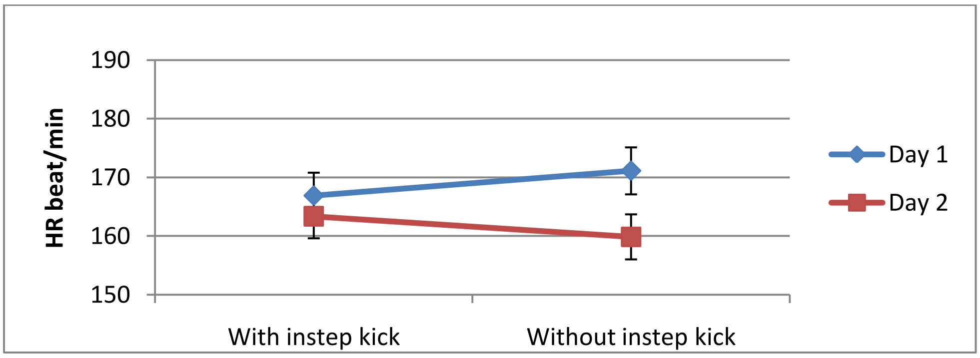

Figure 4. Analysis of HR_{avg} between the 2 days and between different conditions. HR_{avg} day 1 was 167 and 171. SEM was 3.94 and 4.01 respectively. HR_{avg} day 2 was 160 and 163. SEM was 3.84 and 3.74 respectively.

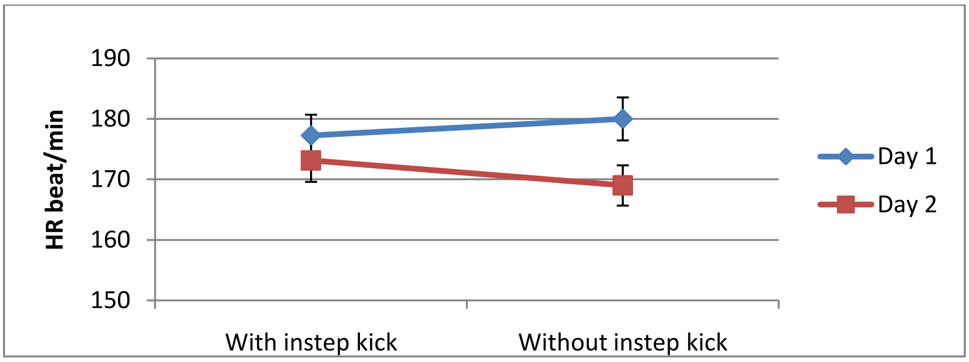

Figure 5. HR_{peak} between the 2 days and the different conditions. HR_{peak} day 1 was 177 and 180. SEM was 3.45 and 3.56 respectively. HR_{peak} day 2 was 169 and 173. SEM was 3.33 and 3.53 respectively.

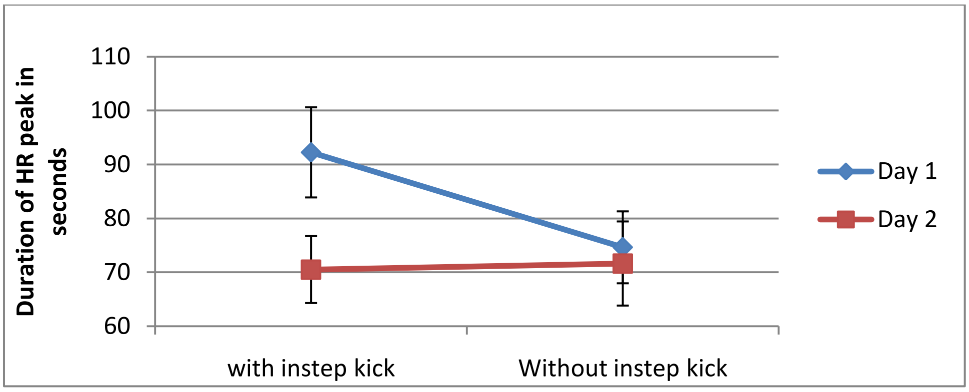

Figure 6. Analysis of T_{PHR} between the 2 days and different conditions. T_{PHR} day 1 was 95 and 75 seconds. SEM was 8.37 and 6.67. T_{PHR} day 2 was 72 and 71 seconds. SEM was 7.80 and 6.21.

External workload

Figure 7 and 8 show the results. To study sequence effect between the two days the first block of 6 sprints day 1 was compared with the last block of 6 sprints day 2. Both blocks incorporate sprinting with instep kick. The results indicate that there is not any statistical significant difference between sprint blocks with instep kick between the two days, for AW, $P_{peak\text{-}acc}$ and $P_{peak\text{-}dec}$ ($p > 0.05$). Players' playing position in between subject factor had no statistical significant effect on this outcome ($p > 0.05$). Considering interaction between day and different sprint blocks, no significant effect for $P_{peak\text{-}acc}$ and $P_{peak\text{-}dec}$ ($p > 0.05$) were observed. AW was not significant but had a p value of 0.053. Taking into account players' playing position in the team the p value for AW was not affected much by positional differences since the p value changed from 0.053 to 0.077. When bodyweight were used as a covariate this had a clear effect on the p value for AW. The effect was then reduced to 0.167 from 0.053.

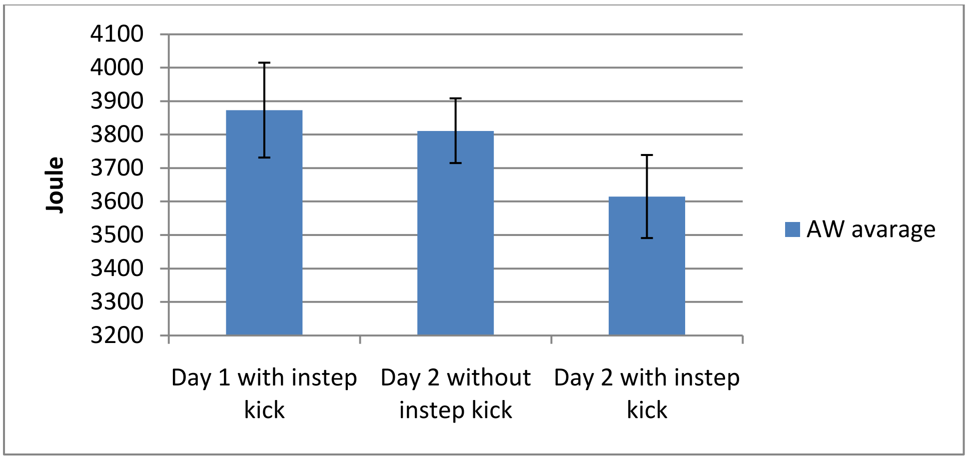

Figure 7. AW for all players with obtained data. AW for the three conditions was 3872, 3811 and 3614. SEM was 141.69, 96.65 and 124.06 respectively.

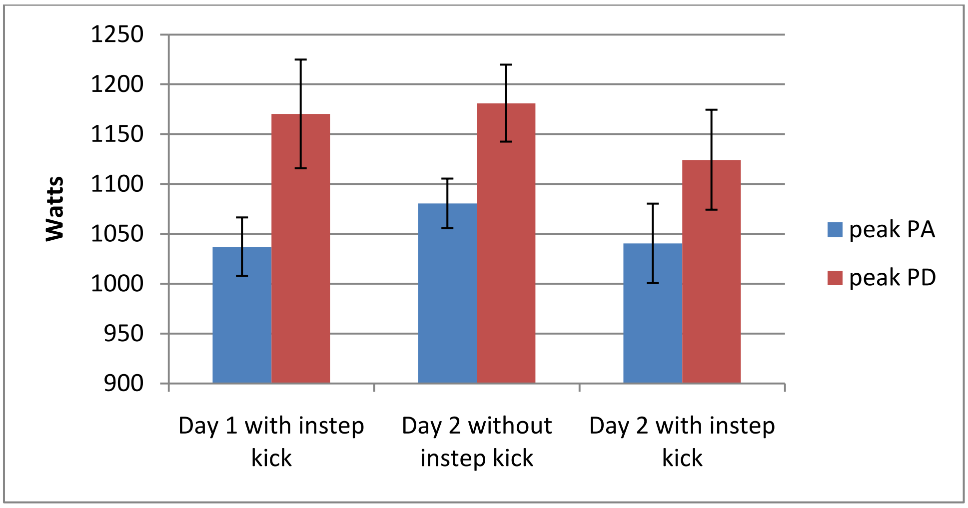

Figure 8: $P_{peak\text{-}acc}$ and $P_{peak\text{-}dec}$ for all players with obtained data. $P_{peak\text{-}acc}$ for the three conditions was 1037, 1080 and 1040. SEM was 29.31, 24.91 and 39.86. $P_{peak\text{-}dec}$ for the three days was 1170, 1181 and 1124. SEM was 54.51, 38.61 and 50.13.

Discussion

The purpose of this study was to investigate whether an instep kick affects HR and external workload during intermittent sprinting. The results in this study show that instep kick or players playing position does not affect performance in intermittent sprinting. Differences were observed for HR. HR was higher during day 1 and during the 2nd sprint blocks each day, showing an interaction between day and condition. External workload was not affected.

One of the findings in this study is that, when comparing HR and external workload between different sprint conditions, the instep kick does not affect the performance. Hardly any scientific research has been done on intermittent sprint with and without instep kick. Research taking into account the balls effect on physical load and performance has traditionally been looking at small-sided games and tests evaluating soccer pass and/or shooting (Impellizzeri et al., 2008, Rampinini et al., 2008, Ali et al., 2007, Mallo & Navarro, 2007, Rampinini et al., 2007a, Rampinini et al., 2007b, Impellizzeri et al., 2005a, Impellizzeri et al., 2005b, Lyons et al., 2006). The result of studies on small-side games have shown that incorporating ball activity gives intensity that is similar or even higher than experienced during match-play both for elite and junior soccer players (Hill-Haas et al., 2009a, Mallo & Navvaro, 2007, Rampinini et al., 2007b). Studies showing higher intensity with ball activity have got this result because they have manipulated the exercise type, field dimension and whether there has been any coach encouragement. (Hill-Haas et al, 2009b, Rampinini et al., 2007b). Studies focus on passing ability found that short bouts of intense exercise frequently are accompanied by decline in skill and performance of short passing ability (Impellizzeri et al., 2008, Rampinini et al., 2008, Lyons et al., 2006). The protocol in this study was not designed to measure the ability to perform instep kick. Therefore the instep kicks quality cannot be linked to performance in this study.

Three-dimensional kinetic analysis of instep kicking performance has found that effective soccer kicking uses full-body and multi-joint coordination involving trunk, arm, leg, ankle and toe. (Nunome et al., 2006, Shan & Westerhoff, 2005, Nunome et al., 2002). These characteristics seem not to affect AW, $P_{peak\text{-}acc}$ and $P_{peak\text{-}dec}$ in this study. A close significant p value ($p = 0.053$) was observed for AW. Taking bodyweight into consideration as covariate this trend disappeared, suggesting that body weight interacts with the kicking action. In this study the ball activity only occurred once at each 5-6 seconds sprint. It seems unlikely to expect large differences in the variables reflecting internal- and external workload. However we expected some effects on $P_{peak-dec}$. The difference in $P_{peak-dec}$ between sprints with and without instep kick was expected to be strongest between the latest parts of the sprints. But it was not possible to separate values of $P_{peak-dec}$ at the 180 degrees turning point and at the finishing line.

Significant effects were found between the two days and for interaction between day and different sprint conditions for HR_{avg} and HR_{peak}. This means that the order of the sprint and not the different conditions is important for internal workload. The HR data show that the last sprint block always get the highest value. Studies on fatigue and RSA have found difference in players performance between the two half's and after a period of intense exercise, resulting in impairment in sprint ability (Mohr et al., 2005). Studies on fatigue in soccer has evidence for resynthesising of adenosine triphosphate (ATP) from anaerobic metabolism with a small contribution of aerobic metabolism and elevated oxygen uptake (VO_2) during recovery time for single sprint with duration of 5- to 6- seconds (Glaister et al., 2005). This is also evident for HR in this study (see figure 2). An elevated HR was observed for the players in the recovery period and the HR increased on to a point where it stayed constantly high before dropping. The highest HR was observed in the recovery time between the sprints and immediately after the last sprint in each block. During rest between the sprints and the blocks of sprints, HR declined slowly. This is in agreement with the findings of Seiler and Hetlelid (2005) who found the same pattern regarding HR. Impellizzeri et al., (2005b) have looked at several studies that have used HR to quantify training load. Their findings indicate that HR responds relatively slowly abrupt changes in work rate and not accurately reflect changes in VO_2 during intermittent exercise. This is because the nature of soccer is non-steady state, while the use of HR to describe and determine exercise intensity is based on the well-known linear relationship between HR and VO_2 obtained in laboratory using steady-state sub maximal workloads. (Åstrand & Rodahl, 1986 in Impellizzeri et al., 2005b). Another aspect with HR as measure is that its relevance does not apply to all training circumstances. Other factor that can influence HR is environmental factors like temperature and emotional stress (Esposito et al., 2004). Despite this factors influence on HR, Esposito et al., (2004) has shown that HR can provide useful information about the internal aerobic training load and its effectiveness, because the relationship between HR and VO_2 determined during soccer-specific exercise is not different from that found in a controlled setting.

Both recovery duration and type of recovery have effect on changes in sprint performance (Spencer et al., 2005). In this study passive recovery was used, and the recovery time between the two sprint blocks were 2.54 day 1 and 2.40 day 2. Recovery between the two exercises was 24 hours. Seiler and Hetlelid (2005) found limited impact of varying rest duration from 1 to 4 minutes on performance during repeated high intensity exercise. However 2 % increase in average running velocity was found when doubling the rest time from 1 to 2 minutes. Studies comparing different type of recovery have found that there is a little difference between active and passive recovery when looking at performance in intermittent-sprint exercise. (King & Duffield, 2009, Bishop et al., 2007). 24 hours of recovery between successive exercise bouts of intermittent sprint is thought to be enough to recover to the pre-exercised state (King & Duffield, 2009). For boys and teens this recovery time can be much smaller while for adult it can be longer (Zafeiridis et al., 2005). Therefore considering the relative small difference in recovery time between the different sprint blocks, the difference in recovery time or recovery type is unlikely to be the explanation for the difference between the conditions.

Another finding is that there is difference in the obtained HR values from day 1 to day 2 with highest values for day 1 compared to day 2. The different temperature between the two days of exercise can not explain the difference, because studies on cold exposure have found that performance is only affected when temperatures drop below -10/11 degrees (Mäkinen 2007, Nimmo, 2004). One explanation for the differences between the two days of exercise can be that the warm up program were different between the two days. Although the HR was not measured during the warm up program it seems that the program was harder day 1 then day 2. The warm up program day 1 consisted of more sprints and sprints were performed closer to the exercise compared with day 2. Another explanation can be that workload between the two days and nutrient preparation has affected the performance. Studies on nutrition and physical performance have shown that diet rich on carbohydrates and protein prior to exercise and fluid replacement during exercise extends performance in training (Dennis et al., 1997, Maughan et al., 1997). Welsh et al., (2002) ingestion of carbohydrates during intermittent high intensity exercise appears to improve performance of 20 m sprints and enhance self reported perception of fatigue.

In this study, we also investigated whether any differences are evident for the variables reflecting heart rate and external workload between different playing positions. No such significant effect was found, neither for heart rate nor external workload. Studies investigating difference in playing position have normally used motion analysis in games or standardized test of RSA (Bangsbo et al., 2006, Krustrup et al., 2006, Stølen et al., 2005, Strøyer et al., 2004, Castagna et al., 2003, Krustrup et al., 2003, Bunc & Psotta, 2001). Time motion analysis on game demands have discovered differences in number of sprints, distance covered, number of tackles and headers performed in a game between different players with different playing position (Bangsbo et al., 2006, Stølen et al., 2005). Studies using YO YO IR1 and YO YO IR2 test have found differences in distance covered between different playing positions (Krustrup et al., 2006, Krustrup et al., 2003). For YO YO IR2 tests it was observed that central defenders, fullbacks and midfielders performed higher in this test than attackers and goalkeepers (Krustrup et al., 2006). 8 participants had complete data on HR, therefore playing position was not taken into account in the HR analysis. The number of participants who had data on performance were 17, where 8 were defenders, 4 were midfielders and 5 were attackers. Difference in performance could not be connected to playing position for external workload.

Results of a recent study show that running speed, dribbling speed and agility performance is independent of playing position, indicating that soccer players have the same running speed and agility no matter what position their playing (Kaplan et al., 2009, Taskin, 2008). This is in agreement with this study's result. Another aspect to consider is that playing position for junior players is a relative concept. To exemplify this: Seven players who participated in this study were "labelled" with two playing position in the junior team. This is in agreement with Strøyer et al., (2004), although overall similarity in aerobic demands and motion patterns between young and elite soccer exists, specialization in playing position is much more pronounced in the older elite then in the younger. Strøyer et al., (2004) claim this indicate a more mature tactical understanding and a greater differentiation between tasks of different playing position for the older elite.

A field experiment approach was used in this study. Such an approach has both its strength and challenges. The strengths are related to the fact that field tests enhance the specificity of soccer training and this greater specificity increase the ecological validity. Furthermore, this study uses both measures on its outcome (performance) and one aspect of physiological load using heart rate as a raw indicator (Svensson & Drust, 2005). In this study the exercise was controlled and led by the coach. The exercise used is familiar for the players and frequently used in the normal training regime throughout the season. No additional load was added to the exercise. Minimal interference was done in execution of the exercise. Together with the coach the exercise was standardized. This standardizing incorporate information to the players prior to the test about not starting before the whistle signal, standing erect during the pauses and run forward in a straight line.

A field tests main weakness is less objective measure due to uncontrolled variables like temperature, wind, physiological factors like self-chosen strenuous effort etc (Drust et al., 2007, Reiley, 2005, Svensson & Drust, 2005). Although the protocol in this study is in line with previous studies protocol regarding the sprint distance, sprint duration, number of sprints and recovery between sprints used, caution to the protocols simulation of actual soccer match play have to be considered (Spencer et al., 2005). The sprint duration most used in previous studies is 5 or 6 seconds while number of sprint repetitions varies from 2 to 40. Spencer et al., (2005) state, that 6-7 sprints may best represent an intense bout of repeated sprint activity in soccer. Active recovery should be used in scientific investigation because this best reflect the way the soccer players recover during matches, although passive recovery is most used.

Another methodological issue regarding ZXY was that processing of the signal was not easy, because it was difficult to establish the finish of the sprint (see figure 3). The processing of the signal revealed that the position line that should start at the same point for all players, did in fact not always start at the same line, most probably due to “cheating”. The reason for this may be that all the players were very eager to finish first. Another issue to consider is that ZXY only measure whole body movements and not work (referred to as mechanical internal work) done by moving body segment relative to each other. Neither does it take into account the vertical direction e.g., work against gravidity or work against friction.

Practical applications

This study demonstrated that neither an instep kick nor playing position has an effect on intermittent sprint performance. Therefore for youth players there is no reason why an instep kick should not be incorporated in bouts of intermittent sprint independent of playing position. For example if the coaches incorporate both goals and goalkeeper in the sprint exercise this can force the player to both use maximal effort and precision. In this way the training both incorporates skill learning by practice in a sprint situation and give physiological effects. This is confirmed by a recent study by Impellizzeri et al., (2008). They found attenuate effects of aerobic training on the exercise-induced decline in short-passing ability in junior soccer players.

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