ORIGINAL ARTICLE

The effects of running velocity-matched treadmill versus overground-simulated soccer match-play on heart rate and rate of perceived exertion in recreationally trained soccer players: A preliminary study

Raja Mohammed Firhad Raja Azidin[1,2,3]*

[1]Faculty of Sports Science and Recreation, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia, [2]National Football Academy, UiTM-MOHE-FAM, Shah Alam, Selangor Malaysia, [3]Selangor Football Club, Shah Alam, Selangor, Malaysia

ABSTRACT

Background: There are various attempts to replicate the demands of soccer match-play, simulating the irregular pattern of locomotion based on motion analysis of actual soccer match-play, using either treadmill or underground protocols.

Aims: The aim of this preliminary study was to investigate whether the modified treadmill versus overground soccer-specific simulation replicated the physiological effects of match-play.

Methods: Six healthy (n = 6) recreationally soccer-trained male players (age, 24 ± 2 years; height, 173 ± 7 cm and body mass, 76 ± 6 kg) participated in this repeated measure design study. During the testing session, each player completed a 45-min treadmill and overground-simulated match-play involving the same average running velocity. Heart rate and rating of perceived exertion (RPE) were recorded every 5 min throughout the simulation.

Results: The physiological responses in the overground simulation (heart rate 169 ± 9 beats.min^{-1}; RPE 14 ± 1) were significantly greater than the treadmill simulation (heart rate 145 ± 12 beats.min^{-1}; RPE 12 ± 1).

Conclusions: The heart rate and RPE response in the overground simulation was consistent with soccer players during actual match-play. The treadmill simulation, however, demonstrated a lesser physiological response compared to that as observed during match-play likely due to the exclusion of utility movements and high accelerations and deceleration.

Key Words: Heart rate, overground, rating of perceived exertion, soccer, treadmill

***Address for correspondence:**
E-mail: firhad@uitm.edu.my
Submitted: 30-Apr-2022 **Revised:** 22-Jun-2022 **Accepted:** 23-Jun-2022 **Published:** 11-Aug-2022

INTRODUCTION

Soccer is characterized by an intermittent and irregular pattern of play. There have been various attempts to replicate the demands of soccer match-play, simulating the irregular pattern of locomotion based on motion analysis of actual soccer match-play. Several soccer-specific treadmill (Drust et al., 2000; Greig et al., 2006) and overground (Lovell et al., 2013; Small et al., 2010)-based simulations were used to assess physiological and mechanical responses to such intermittent exercise. These simulations attempt to re-create the activity pattern observed in real matches but with the benefit of being able to control distance covered and velocity patterns closely and being able to undertake experimental assessments of the player's response in a laboratory-based environment.

Access this article online	
Quick Response Code:	Website: https://www.mohejournal.org
	DOI: 10.4103/mohe.mohe_20_22

How to cite this article: Azidin, R. M. (2022). The effects of running velocity -matched treadmill versus overground- simulated soccer match-play on heart rate and rate of perceived exertion in recreationally trained soccer players: A preliminary study. *Malaysian Journal of Movement, Health & Exercise, 11(1),*46-49.

The overground soccer-specific aerobic field test (SAFT^{90}), developed by Small et al. (2010) is arguably the most ecologically valid match-play simulation, including multidirectional and agility movements, and frequent acceleration and deceleration as is inherent to match play. This likely represents the musculoskeletal loads experienced during match-play better than the other types of simulation, making it suitable for assessing the effect of match-play on physiological, hormonal and neuromuscular responses.

Treadmill-based simulations have several limitations, including that they only involve straight-line running and do not incorporate utility movements. As a result, it could be considered that treadmill protocols developed to date do not adequately simulate the physical demands and activity profile found during actual soccer matches. Alternatively, overground protocols may offer greater ecological validity with the incorporation of utility movements. At present, whether any treadmill or overground simulations can adequately recreate multidirectional soccer match-play remains highly questionable. Furthermore, to the best of our knowledge, there are no studies that have investigated the effect of treadmill versus overground soccer-specific simulation with velocity, distance and activity profile matched.

Therefore, the main aim of this preliminary study was to investigate the differences between modified treadmill versus overground soccer-specific simulation protocol to replicate the physiological effects of match-play. This study compared a running velocity-matched treadmill-based simulation to evaluate the effect of added multi-directional movements in the overground simulation. Based on the multi-directional and higher acceleration and deceleration movements in the overground simulation, it is hypothesised that the overground simulation would result in a physiological response that is similar to that reported for actual match-play and that this would be a greater physiological response compared to the treadmill-based version of the simulation.

METHODS

Participants

Six healthy male recreational soccer players volunteered to participate in the study. Participants reported to train 1–2 days per week, for 1–2 h per training session. The mean (±standard deviation [SD]) age, height and body mass were 24 ± 2 years, 174 ± 6 cm and 74 ± 8 kg, respectively. Participants were questioned on their injury history and none had a recent (<6 months) knee or thigh injury. Written consent was obtained from all the participants and the study was performed in accordance with the university ethics committee guidelines.

Experimental design

A repeated measures study design was used to determine the physiological responses of the treadmill and overground-simulated soccer match-play. Participants were required to attend 3 (one familiarisation and two testing) sessions separated by 4–8 days. During the testing session, each participant first completed a 10-min warm-up (consisting of light jogging and dynamic movements). Then, participants were randomly assigned (counter-balanced order) to complete either a 45 min overground or treadmill simulation. During both simulations, participants' heart rate and rating of perceived exertion (RPE) were monitored. Each participant performed all testing periods at the same time of day to account for the effects of circadian variation. Participants attended the laboratory in a 3 h post-absorptive state, having performed no vigorous exercise or consumed any alcohol or caffeine in the 24 h before testing.

Soccer match simulations

The overground match simulation was based on SAFT^{90} as devised by Small et al. (2010) to replicate soccer match-play, include multidirectional utility movements, and frequent accelerations and decelerations. The course distance was modified from 20 m to 15 m. Compared to the original SAFT^{90} simulation, participants were required to perform additional course lengths to ensure, they completed a similar total distance of approximately 5.39 km in 45 min (Small et al., 2010). The overground simulation had four vertical poles incorporated for the participants to navigate through or around using various utility movements [Figure 1].

The movement intensity and activities (standing, walking, jogging, striding and sprinting) performed by the participants while completing the overground course was maintained using verbal cues on an audio recording. A 15-min intermittent activity profile [Figure 2] was developed and repeated three times during the 45-min simulated soccer match-play. No contact actions such as kicking or tackling were performed.

A treadmill simulation was then designed to elicit a similar average running velocity and activity profile as the overground simulation, yet it was conducted on a motorised treadmill (LOKO S55, Woodway GmbH, Steinackerstraße, Germany). The treadmill simulation imposed relatively slow changes in velocity, accelerating and decelerating the treadmill at 0.50 m.s^{-2}, which is lower than what would typically be observed during the overground protocol. The 15-min activity profile for the treadmill simulation resulted in a distance covered of 1.98 km, giving a 45-min total distance covered of 5.96 km. While having the same velocity profile, lower accelerations and decelerations during the treadmill simulation resulted in a slightly higher total distance than the 5.39 km in the overground simulation. Table 1 shows the average duration spent on one single bout per activity during match simulation.

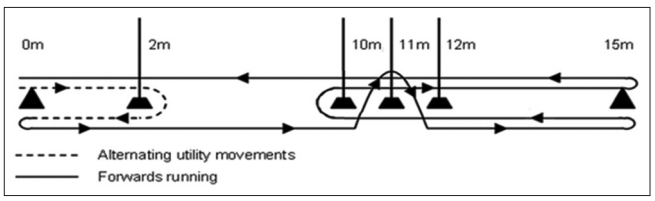

Figure 1: A schematic diagram of the overground match simulation. The simulation was performed with the participants performing either backwards running or side stepping around the first field pole (dashed line), followed by forwards running through the course, navigating the middle three field poles

Heart rate and rating of perceived exertion assessment

Heart rate (Polar heart rate system, Electro, Finland) and RPE (20-point Borg scale) were monitored every 5 min throughout the simulation.

Statistical analyses

Statistical analysis was carried out using a statistical software package (IBM SPSS Statistics for Windows. Version 20.0. Armonk, NY: IBM Corp). Mean and SD were calculated for each dependent variable. A two-way analysis of variance was performed to compare differences in heart rate and RPE over time (0, 45, 60 min) and between conditions (overground vs. treadmill). The alpha level was set at 0.05.

RESULTS

Heart rate

The mean heart rates during exercise (time 5–45 min) for the treadmill and overground simulations were 145 ± 13 and 168 ± 8 beats.min^{-1} respectively, with a significant interaction observed between simulation and time ($F_{1.7,8.9}$ = 5.96, p = 0.025). While heart rates increased over time relative to baseline within each simulation ($F_{2.8,13.9}$ = 229.5, p < 0.001), the heart rates increased significantly more for the overground simulation compared to the treadmill simulation [$F_{1,5}$ = 68.9, p < 0.001; Figure 3a].

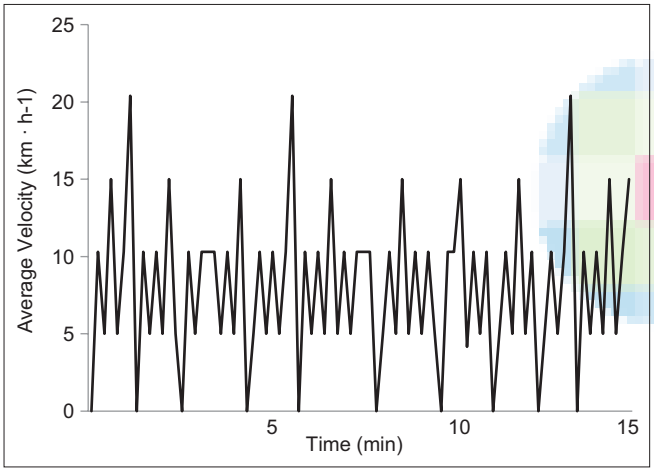

Figure 2: Illustration of the 15- min velocity profile of the modified overground simulation which was repeated three times to recreate locomotion of 45- min soccer match-play

Rate of perceived exertion

The mean RPE during exercise (time 5–45 min) was 12 ± 1 and 14 ± 2 for the treadmill and overground simulations, respectively, showing a trend towards significant interaction between simulation and time ($F_{2,10}$ = 3.52, p = 0.069). While RPE increased over time relative to baseline within each simulation ($F_{1.6,8.2}$ = 47.8, p < 0.001), the RPE increased significantly more for the overground simulation relative to the treadmill simulation [$F_{1,5}$ = 13.0, p = 0.015; Figure 3b].

DISCUSSION

The primary findings of this preliminary study were that the modified overground match simulation induced a similar physiological response as in SAFT^{90} (Lovell et al., 2013) and during actual match-play (Mohr et al., 2003; Thatcher and Batterham, 2004). We also found that, despite average running velocity being matched, we observed a significantly greater increment of heart rate and RPE in the overground simulation compared to the treadmill simulation.

Effects of soccer match simulations on heart rate

The magnitude of the heart rate response tended to increase as a function of exercise duration, suggesting a cumulative effect of the physiological strain. The mean heart rate response in the overground simulation was 169 ± 8.8 beats.min^{-1}. A soccer player's average heart rate during match play has been shown to range from 156 to 167 beats.min^{-1} depending on the level of the players (Mohr et al., 2003; Thatcher and Batterham, 2004). These heart rate responses are slightly higher to the SAFT^{90} simulation (Lovell et al., 2013), which was reported as range of 157–161 beats.min^{-1}. As the present overground simulation course was 5 m shorter compared to the SAFT^{90}, it incorporated more acceleration and deceleration movement activity, likely leading to slightly greater physiological stress.

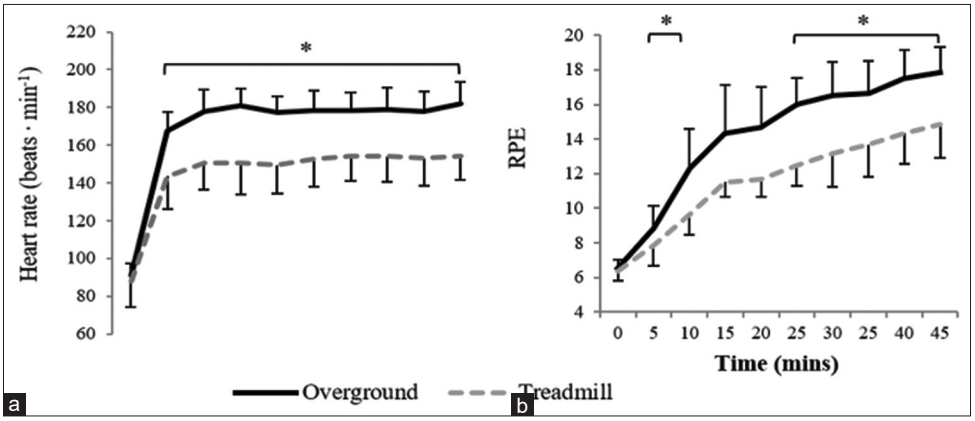

Figure 3: Heart rate (a) and RPE (b) changes over time during treadmill and overground simulations. *Indicates a significant difference between simulations. RPE: Rating of perceived exertion

The mean heart rates during the treadmill simulation were considerably lower at 145.4 ± 13.5 beats.min^{-1}. Furthermore, a previously published treadmill simulation study reported a mean heart rate value of 125 beats min^{-1} (Greig et al., 2006). Those results are below the values recorded during actual soccer match play (Mohr et al., 2003; Thatcher and Batterham, 2004).and those in the present study's overground simulation. In contrast, one study had reported higher heart rate values of 161.0 ± 8.0 beats.min^{-1} in an intermittent treadmill simulation (Drust et al., 2000). While their activity profile incorporated only 46 changes in movement intensity over the 45 min, compared to 84 during the present study, this resulted in substantially longer time spent performing individual movement bouts (walking 35.3 s, jogging 50.3 s, cruising 51.4 s and sprinting 10.5 s). Therefore, a substantially greater amount of time was spent performing the high-intensity activities, totalling more than 50% of the total distance covered compared with 16% observed during 45 min of actual matches (Thatcher and Batterham, 2004) and just over 15% during the SAFT90 simulation. In addition, their players completed a total distance in excess of ~9 km during the 45-min treadmill protocol which is substantially further than what is covered (5–6 km) during typical 45-min match-play (Stolen et al., 2005).

Effects of soccer match simulations on rating of perceived exertion

The rate of perceived exertion profiles was in line with heart rate response profiles during both simulations. Similar as with heart rate responses, subjective RPE during the overground simulation (14.1 ± 1.2) was significantly greater than during the treadmill simulation (11.5 ± 0.8). This result is consistent with observations from previous studies using overground (Nicholas et al., 2000) and treadmill (Greig et al., 2006) soccer match simulations.

The lower heart rate and RPE response shown during the treadmill compared to the overground simulation may have been due to a number of factors. First, using a motorised treadmill, this may have reduced the fatiguing effect by automatically administering acceleration and deceleration demands. Research has observed approximately 500 deceleration movements during a soccer match (Bloomfield et al., 2009), which has been postulated to increase the eccentric stress. The lower physiological responses to running on a motorised treadmill may be attributed to the absence of such a high number of self-performed accelerations and decelerations. Second, the treadmill simulation generates only forwards locomotion, ignoring the presence of a broad range of utility movements as part of soccer match-play. Up to 36.9% of total distance covered during soccer matches are performed using utility movement (Thatcher and Batterham, 2004). These movements have been reported to significantly enhance the physiological load, metabolic cost and muscular fatigue in soccer (Bangsbo, 1994).

CONCLUSIONS

The modified overground simulation resulted in heart rate and RPE responses that were consistent with those found during actual match-play. The overground simulation imposed significantly higher heart rate and RPE response than treadmill simulation at the same average running velocity and activity profile. Therefore, this preliminary study has demonstrated that the exertion during the overground simulation is a better approximation to that of actual match-play than during the treadmill simulation, supporting the added value of incorporating accelerations and decelerations as well as utility movements that are inherent to actual match-play. The close similarities between physiological responses observed during the present study and values reported from actual match-play justify the use of overground simulations for replicating the demands of soccer, more so than treadmill simulations, supporting the use of the modified overground protocol as an ecologically valid soccer match-play simulation.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

Bangsbo, J. (1994). Energy demands in competitive soccer. *Journal of Sports Sciences, 12,* S5-12.

Bloomfield, J., Polman, R., & O'Donoghue, P. (2009). Deceleration and turning movement movements performed during FA Premier League soccer matches. In Reilly., T., & Korkusuz, F., editors. *Science and Soccer VI* (pp. 174-81). Abingdon: Routledge.

Drust, B., Reilly, T., & Cable, N. T. (2000). Physiological responses to laboratory-based soccer-specific intermittent and continuous exercise. *Journal of Sports Sciences, 18(11)*, 885-892. doi: 10.1080/026404100750017814.

Greig, M., McNaughton, L. R., & Lovell, R. J. (2006). Physiological and mechanical response to soccer-specific intermittent activity and steady-state activity. *Research in Sports Medicine, 14(1)*, 29-52. doi: 10.1080/15438620500528257.

Lovell, R., Midgley, A., Barrett, S., Carter, D., & Small, K. (2013). Effects of different half-time strategies on second half soccer-specific speed, power and dynamic strength. *The Scandinavian Journal of Medicine & Science in Sports, 23(1)*, 105-113. doi: 10.1111/j.1600-0838.2011.01353.x.

Mohr, M., Krustrup, P., & Bangsbo, J. (2003). Match performance of high-standard soccer players with special reference to development of fatigue. *Journal of Sports Sciences, 21(7)*, 519-528. doi: 10.1080/0264041031000071182.

Nicholas, C. W., Nuttall, F. E., & Williams, C. (2000). The Loughborough Intermittent Shuttle Test: A field test that simulates the activity pattern of soccer. *Journal of Sports Sciences, 18(2)*, 97-104. doi: 10.1080/026404100365162.

Small, K., McNaughton, L., Greig, M., & Lovell, R. (2010). The effects of multidirectional soccer-specific fatigue on markers of hamstring injury risk. *The Journal of Science and Medicine in Sport, 13(1)*, 120-125. doi: 10.1016/j.jsams.2008.08.005.

Stolen, T., Chamari, K., Castagna, C., & Wisloff, U. (2005). Physiology of soccer: an update. *Sports Med*, *35(6)*, 501-536. doi: 10.2165/00007256-200535060-00004.

Thatcher, R., & Batterham, A. M. (2004). Development and validation of a sport-specific exercise protocol for elite youth soccer players. *The Journal of Sports Medicine and Physical Fitness, 44(1)*, 15-22.