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Section II- Exercise Physiology & Sports Medicine

The Incidence and Occurrence of Injuries to Junior Rugby League Players in a Tropical Environment

by
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This study investigated the effect of the environment, jersey color and ground conditions on injury rates in junior rugby-league players in a tropical environment. Injury, environment and ground condition data were collected during each game, over one season (n = 12 rounds). The study investigated three teams (n = 64): one under-16 team in striped jerseys and two under-14 teams in black and orange jerseys. The injury rates for the under-16 team (83.3/1000 hrs) were higher than for the under-14 teams in black (69.9/1000 hrs) and orange (59.9/1000 hrs) jerseys. In the under-16 team, a negative correlation (r = -0.66, p < 0.05) was found between players' injuries and heat index, while in the under-14 team in black jerseys, a positive correlation was observed (r = 0.90, p < 0.01), although in the under-14 team in orange, no significant correlation was found (r = 0.140, p > 0.05). In the under-14 team in black, a significant correlation (r = 0.80, p < 0.01) between players' injuries and the temperature was observed. However, no correlations were found with any other variables per group (p > 0.05) and injury rates were not different between the teams (p > 0.05). While ground conditions had no effect on injury rates, it appears that the heat acted as a protection against injury for teams with striped and orange jerseys. However, black jerseys may put players at an increased risk of injury during hot and humid day games.

Key words: *ground conditions, heat, humidity, garment color.*

Introduction

Rugby league is a collision sport that is played at both the junior and senior levels in contrasting environments around the world. Unfortunately, muscular skeletal injuries are common in this sport due to the physical nature of the game. While many studies have investigated the incidence of injury amongst senior rugby league players, only few have focused on the incidence of injury in junior players (King et al., 2014). Furthermore, all the studies that examined the incidence of injuries in junior rugby league players have been conducted in subtropical environments. To date, no studies have been performed to determine whether tropical environments and subsequent alterations in ground conditions influence the incidence of injury in junior rugby league players.

A study investigating the incidence of injury in senior professional rugby league players found that when the playing season was changed from the winter to the summer months the players' risk of injury had actually doubled (Gissane et al., 2003). The authors of that study suggested that the observed increase in the injury rate might be due to higher temperatures and harder ground surfaces experienced during the summer months, although they were not measured directly. Another study that investigated the incidence of injury in junior rugby league players noted a higher rate of injury during times of low rainfall and suggested that this might be due to harder ground conditions, however, again the ground conditions were not

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measured (Gabbett, 2008). Only one study has investigated the relationship between injury rates in the rugby league and ground conditions (Gabbett et al., 2007) and no significant relationship between match injury rates and ground surfaces was found. However, the ground surfaces were only measured subjectively with categories of 'heavy', 'slippery', 'firm' and 'hard'. To date, there have been no studies investigating the relationship between injury rates of rugby league players and ground conditions using objective measures. Also, it has been suggested that dark-colored clothing increases heat absorption and is an extrinsic risk factor for heat illness (Marshall, 2010). However, no studies have investigated the relationship between the environment, the color of the jersey and the incidence of injury in the rugby league, particularly for junior players. Therefore, the aim of this study was to document the incidence and occurrence of injuries in junior rugby league players in a tropical environment and objectively measure the ground and environmental conditions to identify what impact they might have on the incidence of injury.

Methods

Participants

The participants were sixty-four junior rugby league players registered with the same club competing in the Cairns District Junior Rugby League competition. Twenty four of the players were members of one under 16 team (U16) wearing striped jerseys, while the remaining forty players were members of two under 14 teams (U14), with one wearing black colored jerseys (U14B) and another wearing orange colored jerseys (U14O). The physical characteristics of the U14 and U16 players are reported in Table 1.

Design and Procedures

A prospective cohort observational study was conducted over the course of the 2015 season, starting in April and finishing at the end of August comprising 12 rounds of fixtures with a total of 36 games under investigation. The U16 games were played in a Friday afternoon (i.e., after 6 pm), while the majority of the U14 games were played on Saturday around midday (11 am - 1 pm). Participants received a clear explanation of the study, including the risks and benefits of participation and written consent was obtained from both the participants (i.e., minors) and their parents/guardians before participation. All procedures were approved by the Institutional Human Research Ethics Committee, James Cook University, and were conducted in accordance with the Declaration of Helsinki.

Injury data were collected by direct observation at all games by the principal investigator and consultation with each team's designated sports trainer. Injury data were recorded using a standardized reporting form which identified the position of the injured player, when and how the injury occurred, location and type of the injury as well as the severity of the injury. To allow for comparison with other rugby league injury studies, an injury was defined as any pain or disability that occurred during participation in a rugby league match that was sustained by a player, irrespective of the need for match or training time loss or for first aid or medical attention (King et al., 2009). The injury incidence was reported using the standardized method of converting the number of injuries to a ratio of injuries per 1000 playing hours (/1000 hrs) and injuries were classified as either transient (no competition / training time lost), minor (1 week missed), moderate (2 to 4 weeks missed) or major (5 or more weeks missed) (King et al., 2009).

The players completed a battery of tests during the season to ascertain their physiological characteristics. It included anthropometric measures (body height, body mass and body fat percentage), flexibility, lower-body muscular power, agility, sprint speed, and maximal aerobic power assessment. Player's height was measured using a stadiometer (Hart Sport, Queensland, Australia), while body mass and body fat percentage were evaluated using TANITA bioelectrical impedance scales. All tests were conducted outdoors on a natural grass playing surface. Following a standardized warm up, players' trunk flexibility was measured using a standardized sit and reach test as described by Lemmink and colleagues (2003). Lower-body muscular power was assessed by the vertical jump test using a Yardstick vertical jump device (Swift Performance Equipment, New South Wales, Australia). The players' agility was measured with the 505 agility test (Draper and Lancaster, 1985) using dual beam electronic timing gates (Swift Performance Equipment, New South Wales, Australia). The speed of the players was evaluated with a 40 m sprint test, with 10 and 20 m splits, using dual beam electronic timing gates (Swift Performance Equipment, New South Wales, Australia). Maximal aerobic power was assessed using the multi-stage fitness test (MSFT) as described previously (Mota et al., 2009). Three trials of each test were completed, except the MSFT where one trial was completed, with the best trial being recorded for reporting purposes.

Daily weather variables (temperature, relative humidity [RH] and rainfall) were prospectively obtained from the Bureau of Meteorology's local monitoring station closest to the field where the games were played. Such data were also prospectively collected from Brisbane and Sydney at the same time as for the Cairns games for comparison. The heat index (HI) for each game was obtained by combining the air temperature and relative humidity and using an associated heat index table to determine the human-perceived equivalent temperature (Monteiro et al., 2013).

Ground conditions were collected using a penetrometer to measure ground hardness and a soil-moisture reader (HydroSense II, Logan, USA) to evaluate ground moisture content. Ground hardness and ground moisture measurements were taken at 18 locations around the field to evenly cover all areas of the playing field. Measurements were taken starting from the try line then progressing to the 20 m and 40 m line, then on to the 40 m, 20 m and try line at the other end of the field. Along these lines three measurements were taken, 10 m in from the left sideline, middle of the field and 10 m in from the right sideline.

The method for assessing ground hardness with the penetrometer was similar to a previous study (Orchard, 2001). For each location, the penetrometer was not moved between drops so that the third drop always gave the highest reading. An average of three shocks (drops) at the 18 locations around the field was taken as the official reading. The average measurements for the first, second and third drops for the whole field were added together and divided by three to give one reading which was recorded as the overall measurement (e.g. 3 drop average = [1^{st}+2^{nd}+3^{rd} drop averages] divided by 3).

Statistical Analysis

All injury data were expressed as a ratio of the number of injuries per 1000 playing hours and percentage. Using previously described analytical methods (King, 2006; King et al., 2009), the injury characteristics between the U16, U14B and U14O teams were descriptively compared. Based on the Shapiro-Wilk test, all data were normally distributed. Accordingly, an independent T-test was used to determine differences in physiological characteristics between the U16 and U14 players and for differences in the HI between different locations. A Pearson's product moment correlation coefficient was calculated to identify any relationships between the dependent variables. The level of significance was set at 0.05. All data were analyzed using IBM SPSS Statistics 22 (IBM Corporation, Armonk, USA).

Results

With respect to environmental temperature and the injury incidence, there was a significant negative correlation between the HI and the rate of injury for the U16 team (r = -0.660, $p < 0.05$; Figure 1). However, there was a significant positive correlation (r = 0.904, $p < 0.01$) between the HI and the rate of injury for the U14B team. No correlation was found between the HI and the rate of injury (r = 0.140; $p > 0.05$) for the U14O team (Figure 1). With all teams combined, no correlation was found with the injury rate and temperature (r = -0.01, $p = 0.96$) and RH (r = -0.01, $p = 0.98$). However, when examining the teams individually, in the U14B team, a significant positive correlation between the injury rate and temperature (r = 0.80, $p < 0.01$), but not RH (r = 0.51, $p = 0.11$) was found.

With all teams combined, no correlation was found between the rate of injury and ground hardness (r = -0.131, $p > 0.05$; Figure 2) or ground moisture (r = -0.182, $p > 0.05$; Figure 2), although there was a significant correlation between ground moisture and ground hardness (r = 0.930, $p < 0.01$; Figure 2). No correlation was found between temperature and ground hardness (r = -0.090, $p > 0.05$; Figure 3) or ground moisture (r = -0.099, $p > 0.05$; Figure 3). However, there was a significant positive correlation with RH and ground hardness (r = 0.508, $p < 0.01$; Figure 3) and ground moisture (r = 0.485, $p < 0.01$; Figure 3).

For comparisons of the incidence of injuries between age groups, the incidence in the U16 team was 83.3/1000 hrs, while the U14B and U14O teams recorded incidences of 69.9/1000 hrs and 55.9/1000 hrs, respectively. For comparisons of the incidence of injuries between the first and the second half of the season, the U16 team had a lower injury rate during the first half (84.5/1000 hrs) compared to the second half (115.9/1000 hrs) of the season. In the U14B team, a higher incidence of injuries was observed in the first (92.3/1000 hrs) compared to the second half (54.8/1000 hrs) of the season, while in the U14O team the injury rate was relatively consistent between the first (61.5/1000 hrs) and the second half (51.3/1000 hrs) of the season.

All games by the U16 team were played in the late afternoon, while only 36.3% and 9.1% of the games by the U14B and U14O teams were played at this time of day, respectively. The average HI for the day games in Cairns (32.8° ± 3.7°C) was significantly higher ($p < 0.05$) than the HI for the late afternoon games in Cairns (26.3°C ± 4.2°C). Also, the HI for the day games in Cairns was significantly greater ($p < 0.05$) compared to the HI recorded on the day games for Brisbane (25.6°C ± 4.2°C) and Sydney (21.7°C ± 2.4°C) during the same time over the playing season.

Discussion

The present study is the first to objectively report the relationship between the incidence of rugby league injuries and ground conditions with all other investigations either using subjective measures to assess ground conditions (Gabbett et al., 2007; Orchard, 2004) or not measuring them at all (Gissane et al., 1998; Hodgson Phillips et al., 1998). While a number of ground condition characteristics were correlated, no correlations were identified between the incidence of injury and the ground condition characteristics for any of the teams. Interestingly, the current study showed that the teams reported different seasonal variations of injury rates with the U16 team recording a late season bias of injuries, the U14B team having an early season bias and the U14O team not having any seasonal bias of injury.

Table 1

Physiological Characteristics of the U16 and U14 players

Test	U16		U14	
	Mean	S.D.	Mean	S.D.
Body Height (m)	1.78*	0.04	1.68	0.07
Body Mass (kg)	76.63*	8.95	62.23	12.84
Vertical Jump (cm)	53.8*	5.42	42.72	9.23
10 m sprint (s)	1.78	0.10	1.85	0.17
20 m sprint (s)	3.07	0.16	3.33	0.37
40 m sprint (s)	5.61	0.33	6.00	0.54
505 agility (s)	2.47	0.14	2.56	0.22
VO_{2max} (ml/kg/min)	46.08*	6.67	37.79	6.07

** Significantly greater than in the U14 team (p < 0.01)*

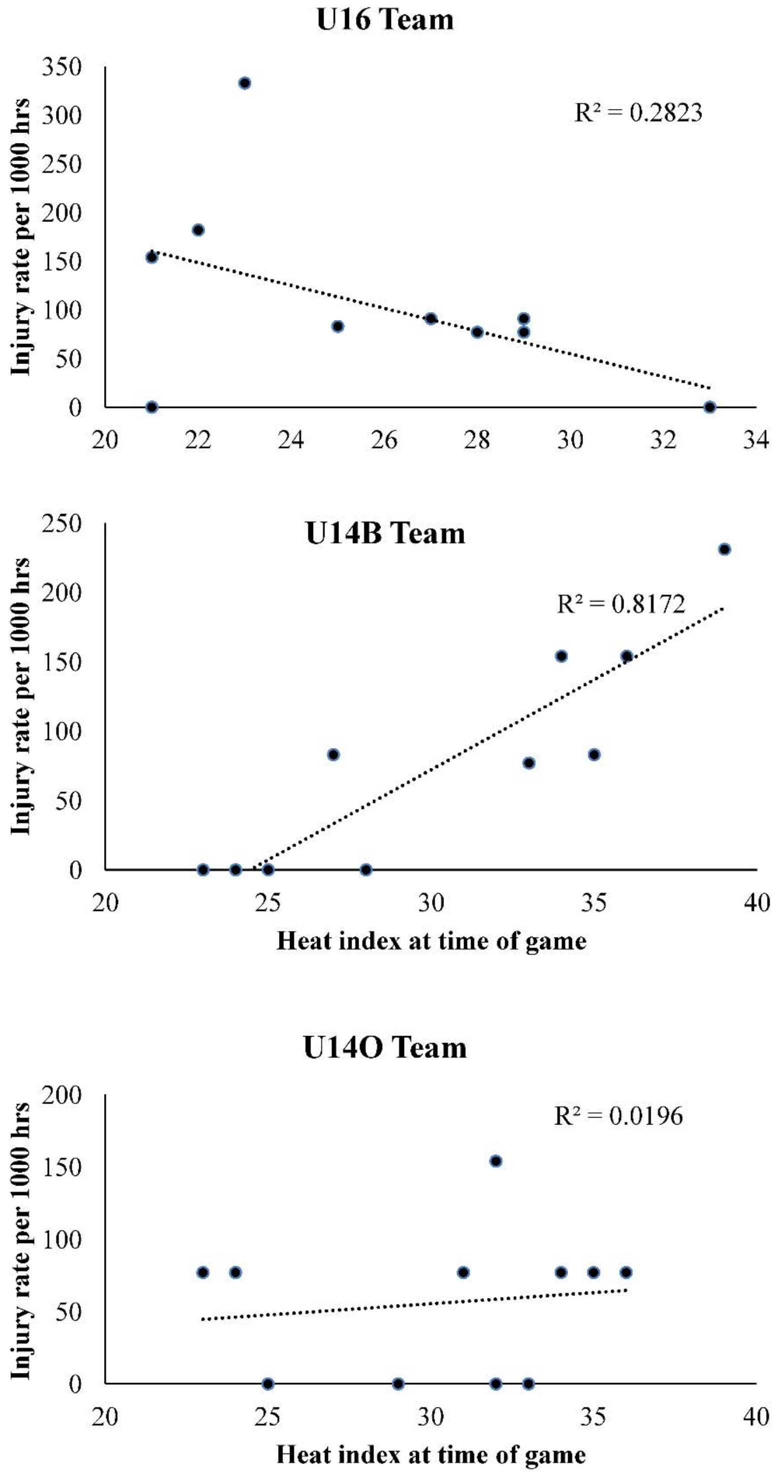

Figure 1

Correlations between the injury rate and the heat index during games played by the U16, U14B and U14O teams

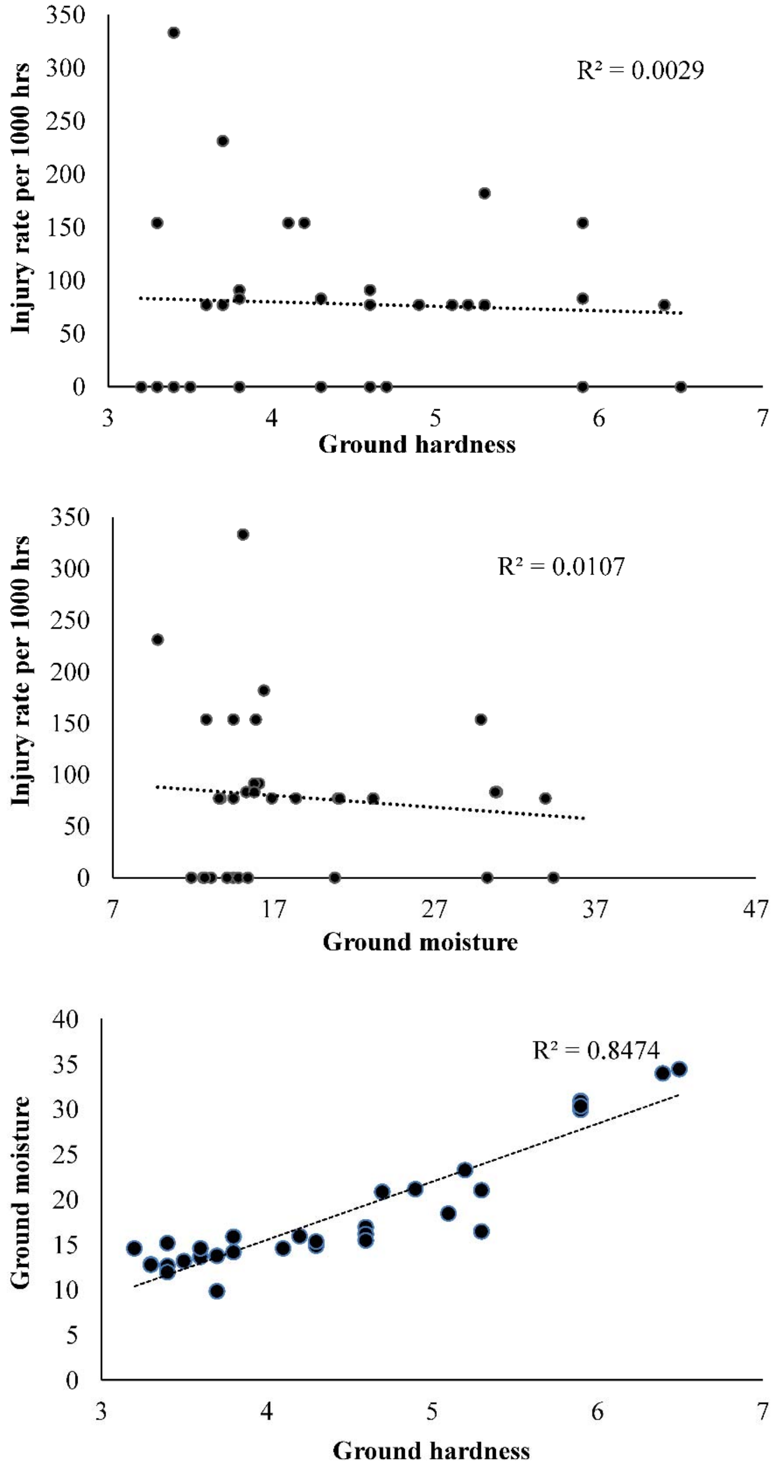

Figure 2
Correlations between the injury rate and ground conditions for the pooled data

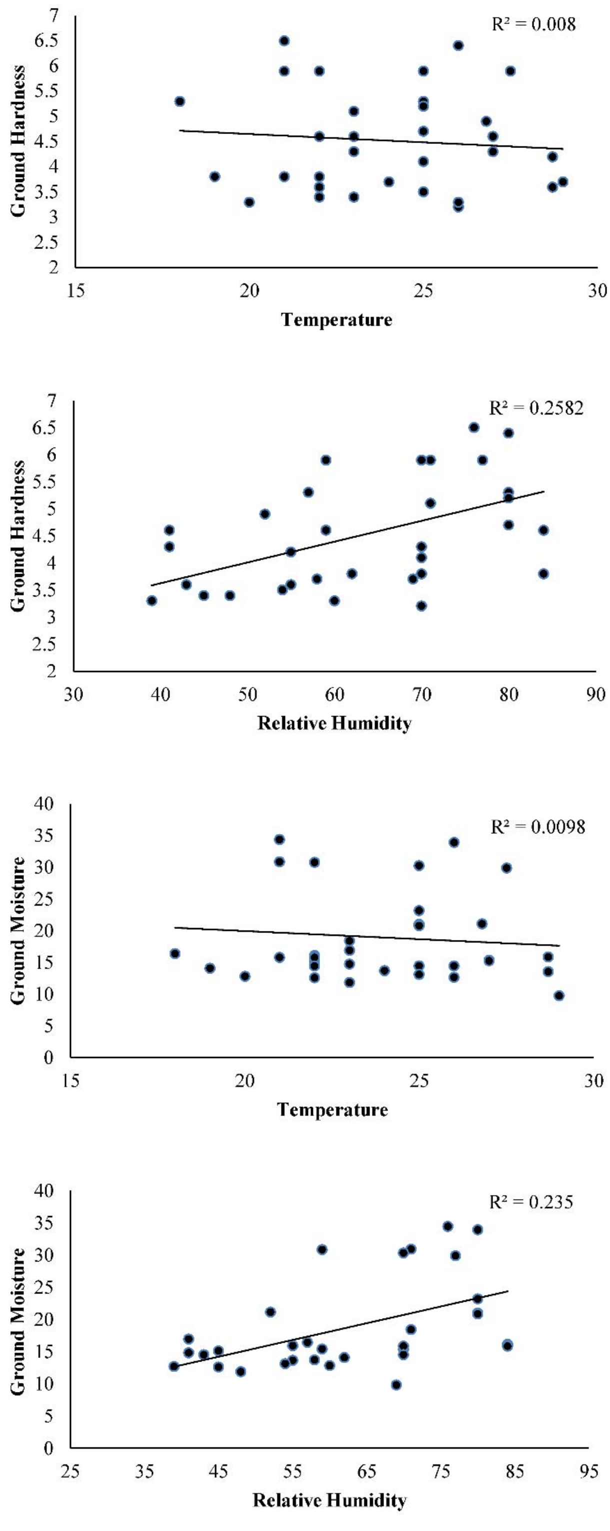

Figure 3

Correlations between ground conditions, temperature and humidity for the pooled data

According to rugby league studies conducted in warmer climates, there appears to be a late season bias of injury rates with the majority of injuries occurring during the second half of the season (Gabbett, 2000, 2003). However, all of these studies were conducted in subtropical environments where the environmental conditions were significantly cooler than the tropical conditions recorded in this study. In the present study, while a late season bias of injuries was seen with the U16 team, this was not observed with either of the U14 teams. Based on the results of the present study, given that correlations were not observed between ground conditions and injury rates, it appears that seasonal variations observed in the incidence of injuries may not be influenced by ground conditions, but by the heat experienced during the game and the color of the jerseys worn by players. However, it is also important to note that the findings may have been influenced by the time of day, given that there were discrepancies in playing times between the U14 and U16 games. Further research is warranted to determine whether seasonal variations affect injury rates while standardizing for playing times with a greater sample size.

The U16 team played all of their games in the late afternoon, while the U14 teams played the majority of their games around midday. Considering that the HI was significantly higher during the games played by the U14 teams, the players would have experienced greater thermal stress than the U16 players when the temperature was significantly cooler. This greater thermal exposure by the U14 players might in part have reduced the match intensity and playing speed and therefore decreased the risk of injury. In fact, in the U16 team a significant negative correlation between the injury rate and HI was found, suggesting that their rate of injury was higher in cooler conditions. It has been found that athletes' performances are reduced in hot and humid conditions even if they are native to that environment (Voltaire et al., 2003). Moreover, it has been shown that there is a strong correlation between the incidence of injury and match intensity and match speed with the incidence of injury increasing as the match intensity and speed increases (King et al., 2010). The U14O team, who played the majority of their games around midday, were found to have no correlations between their injury rates and the environmental conditions, but had a consistently low incidence of injury throughout the season. It is possible that the added thermal stress experienced by the U14O team throughout the season may have acted as a protection against injury by reducing the match intensity and match speed. Indeed, the incidence of injury recorded in this study is relatively low in comparison to other studies using a similar methodology in cooler subtropical locations (Estell et al., 1995; King, 2006).

In contrast, the U14B team was found to have a significant positive correlation between their rate of injury and the HI during their games, suggesting that the rate of injury may have increased with a greater HI. The discrepancies between these findings and those obtained by the U16 and U14O teams may be due to the time of day in which games were played and the differences in the color of the jersey. As mentioned earlier, the games played by the U16 team were in the late afternoon, which time is typically cooler due to little sunlight (Marshall, 2010; Nielsen, 1990). Conversely, the games played by the U14B team were during the day when the conditions are substantially hotter and humid. Whilst both the U14B and U14O teams played the majority of their games around the same time of day, the U14B team wore a black colored jersey, while the U14O team wore a lighter colored orange jersey. It has been found that heat absorption due to sunlight is greater in black garments than it is in lighter colored garments (Nielsen, 1990) and is an extrinsic risk factor for heat illness (Marshall, 2010). Therefore, by wearing a black colored jersey, the U14B players may have experienced greater thermal stress than their opponents who wore lighter colored jerseys. It has also been found that when athletes' core temperature is high, they will modify their pacing strategies and reduce playing intensity (Aughey et al., 2014). Consequently, the U14B team may have been at a higher risk of being injured due to having their playing intensity reduced while their opponents, in lighter colored jerseys, did not. However, we acknowledge that the jersey color was not crossed-over, and that the time of game play was not standardized between age groups (i.e., U14 and U16). Subsequently, future research should examine whether jersey color affects injury rates for the U16 players as it is the case in U14 players, and whether injury rates are affected between day-time and night-time games for players within the same age bracket (i.e., compare injury rates between day- and night-time games for the U14 as well as the U16 teams).

While the U16 and U14O teams recorded more injuries in the second half of the match compared to the first half, the U14B team recorded just as many injuries in the first half as they did in the second half although these injuries occurred towards the end of both halves. Therefore, it may be that the mismatch in playing intensity brought on by thermal stress from the black jerseys may have occurred about half way through the halves. However, caution should be taken when interpreting these results as core temperature during the game, match intensity and speed were not measured. Further research examining the objective measures of heat stress and its association with match intensity and speed and injury rates in field-based sports is warranted.

Conclusions

According to the findings from the current study, a number of practical implications can be drawn upon. Firstly, greater emphasis should be placed on environmental temperature and humidity than ground conditions when monitoring sport-related injuries. Secondly, players with a darker colored jersey may be at a higher risk of injury than those wearing a lighter colored jersey. Finally, sporting organizations should be mindful of uniform design and color in a tropical location in an effort to minimize thermal stress and reduce players' risk of injury.

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