

MANAGEMENT & COACHING

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Impact of the color of equipment on competition outcomes in Premier League karate

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Key words: *karate*, color of equipment, *kumite*, referee, combat sports

Abstract

Background. Research is needed to better understand the color of uniform and its underlying effects in sports, in order to achieve fairness and equal opportunities for athletes.

Problem and aim. In studies where the impact of the color of athletes' equipment on the outcome of matches has been investigated, the results have varied. The aim of this study was to investigate if the color of the protective equipment worn by karate *kumite* athletes had an impact on the competition outcome after excluding seeded athletes.

Methods. A total of 351 matches in the 2020 Premier league competition were analyzed. Binomial analysis was used to determine differences in a match outcome by the color of equipment. T-test for independent groups was used to investigate the difference in points scored, recovery time and the number of warnings based on the color of the equipment.

Results. The blue equipment worn by karate *kumite* competitors was associated with a higher proportion of wins (58.5% vs. 41.5%, $p = 0.03$) and more points scored (383 vs. 290 points, $p = 0.01$) than the red equipment, only among male athletes. The mean (sd) recovery time was longer for both male (12.0 ± 1.3 vs. 7.1 ± 1.0 min, $p = 0.004$) and female (11.0 ± 0.9 vs. 6.5 ± 0.7 min, $p = 0.001$) athletes wearing red rather than blue. However, recovery time was not associated with more wins, for either male ($p = 0.63$) or for female ($p = 0.62$) athletes.

Conclusions. In conclusion, blue equipment in karate *kumite* may lead to more wins and more points scored than for male athletes wearing red.

Introduction

Equality is one main principle in sports competitions. This means that the conditions for the competition should be the same for all competitors [Guttman 2004]. Referees deal with many external factors, such as athletes, trainers, spectators, media, and internal factors such as their own qualities, physical, cognitive, and psychosocial capabilities [Fidalgo 2013]. A big challenge for judges is to process fast information under time pressure [MacMahon, Mildenhall, 2012]. There is a limitation in the human information processing system [White *et al.* 2018]. Techniques in combat sports can for example range from 0.101s to 0.293s [Chaabene *et al.* 2013] which could be difficult to perceive by the judges for making a correct decision in the match.

Therefore, technology such as video review has been effective in increasing fairness in competition for athletes in combat sports [Carlsson *et al.* 2020].

A color can be like a trigger point for human emotions and can provoke aggression [Gülle, Beyleroğlu, Hazar 2016]. Red color has long been associated with aggression and dominance [Hagemann, Strauss, Leifßing 2008; Krenn 2015] while blue color has not been seen as an intimidating color [Dijkstra, Preenen, 2008]. It has been further reported that research is needed to better understand the uniform color and its underlying effects in sports, to achieve fairness and equal opportunities for athletes [Krenn 2015].

In studies where the impact of the color of the athletes' equipment on the match outcome has been

investigated, the results have varied [Hill, Barton 2005; Hagemann, Strauss, Leißing 2008; Dijkstra, Preenen 2008; Falcó, Conchado, Estevan 2016; Pollet, Peperkoorn 2013; Julio *et al.* 2015]. In a study of combat sports in the Athen Olympic games 2004 it was found that the athletes wearing red outfits had more wins than those wearing blue outfits ($\chi^2 = 4.19$, $p = 0.041$) when analyzing the color of the males' gear and protection equipment in boxing, taekwondo, Greco-Roman wrestling and free-style wrestling [Hill, Barton 2005]. Further, Hagemann, Strauss, Leißing (2008) examined forty-two experienced taekwondo referees (males, $n = 29$ and female $n = 13$) by letting the referees judge competitors via videotapes. They found that the referees gave more points to competitors who had red protective gear compared to those wearing blue protective gear ($t = 2.85$, $p < 0.01$).

Another study that investigated the color of taekwondo's electronic protective gear in a competition setting showed no significant difference ($\chi^2 = 1.33$, $p = 14$), when analysing wins and losses between taekwondo athletes wearing red protection and blue protection gear according to weight and gender in a total of 462 matches [Falco, Conchado, Estevan 2016]. In Mixed Martial Arts (MMA), Pollet & Peperkoorn [2013] investigated wins and losses by coding the color of athletes' uniforms (shorts and gloves) in 210 matches at the Ultimate Fighting Championships (UFC). They found that the color of an athlete's uniform was not associated with more wins (Win/loss; $\chi^2 = 4.153$, $p = 0.386$). Studies that examined blue and white color in judo found no significant effect of a specific color on winning after they had excluded the seeded athletes [Dijkstra, Preenen 2008; Julio *et al.* 2015]. They excluded the seeded athletes for the reason that seeded athletes had a 67% chance of wearing blue in the second and third rounds, with a winning probability of 86% and 56%, respectively [Dijkstra, Preenen 2008]. Also, a study [Dijkstra, Preenen, van Essen 2018] that was analyzing weight categories for both men and women in 45,874 judo matches found no winning bias to a specific color, between blue uniform compared to white ($\chi^2 = 0.098$, $p = 0.8$).

There are several limitations of the existing studies. Hagemann, Strauss, Leißing [2008] for example did not examine the referees in a competition setting which could have an impact on the reliability of the result. Referees are dealing with many different factors such as high psychological stress [Anshel, Weinberg 1999; Kaissidis-Rodafinos, Anshel 1993; Kaissidis-Rodafinos, Anshel, Porter 1997; Stewart, Ellery 1998] and crowd noise which can lead to higher anxiety and therefore making wrong decisions [Balmer *et al.* 2007]. External factors are therefore important to include when examining referee bias. Pollet, Peperkoorn [2013] have also several limitations in their study. For example, the shorts have sponsor labels in MMA which are often in bright neon fonts, which could do the color of the shorts less salient [Pollet, Peperkoorn

2013]. It's important therefore to examine standardized protection equipment where no sponsors' labels can affect the brightness of the color. Further, those studies that had examined red and blue protection equipment in a competition setting [Hill, Barton 2005; Falco, Conchado, Estevan 2016] have not investigated if seeded athletes can impact the outcome of wins. We know for example from Dijkstra, Preenen [2008] and Julio *et al.* [2015] that there was no difference in winning between the colors white and blue after seeded athletes had been excluded from the analysis. Therefore, seeded athletes also need to be excluded when investigating the impact of wins between red and blue equipment in combat sports.

The impact of the color of the gear and equipment has been investigated in many different combat sports, such as boxing, wrestling, judo, and taekwondo. Still, there is no study investigating whether a specific color of athlete's protective equipment in karate has an impact on match outcome. In karate it is possible to compete in two different forms, *Kata* and *Kumite*. *Kata* is a form where you will do a prearranged set of techniques [Chaabene *et al.* 2013]. In *kumite* you will exchange defensive and offensive techniques against an opponent [Kanazawa 2013]. To compete in *kumite*, most athletes have a large part of their body covered with standardized protection equipment that is either red or blue. Karate athletes must wear a red or a blue belt, but also foot protectors, shin protectors and combat sport gloves in the same color as the belt [World Karate Federation 2020].

In *kumite*, a score is awarded when the technique involves good form, sporting attitude, vigorous application, awareness (*zanshin*), good timing and correct distance [World Karate Federation 2020]. *Kumite* athletes deliver techniques such as kicks, sweeps and punches to different point areas on the opponent [World Karate Federation 2020]. Each match is 3 minutes long for both male and female athletes [World Karate Federation 2020]. The *kumite* matches are judged by one referee and four judges. The judges signal judgment on stepping outside the mat, warnings, and penalties, and have the right to vote on any decision to be taken. A minimum of two judges must agree for the points to be awarded to the athlete [World Karate Federation 2020].

The metabolic rate of karate *kumite* athletes is high [Beneke *et al.* 2004], so the potential for exhausted athletes to obtain more time to recover can increase their chance of winning the matches. No previous study has investigated if there is a difference in recovery time between athletes with red equipment compared to blue equipment, after seeded athletes (top 8 ranked athletes) have been excluded, and consequently whether recovery time explains the winning rate ascribed to equipment color.

The aim of this study was therefore to investigate whether the color of World Karate Federation (WKF) standardized protection equipment in karate *kumite* had

an impact on the competition outcome after excluding seeded athletes. In addition, recovery time and its influence on competition outcome were also investigated.

Methods

Study design

An observational analysis of the Paris Premier League 2020 (held in Paris, 24–26 January 2020) was made. The data were collected over a period of six months (February 2020 – July 2020). The video recordings of all analysed matches were available on a public domain (Youtube). The recordings were observed with a 720 progressive scan standard. As no personal data were collected, no ethical approval was required.

Procedures

The book of results and livestream of Paris Premier League 2020 were used for analysing the kumite matches. There were 671 matches accessible. To be included there needed to be information about sex, competitor (red/blue), total point scored, total warnings, color of the winner, world ranking and recovery time. Total points scored, warnings and color of the winner were coded at the end of each match. A total of 135 matches did not fulfill the inclusion criteria. In addition, the matches of the seeded athletes ($n = 185$) were excluded due to the reason that the seeded athletes who were wearing blue protection equipment in their first match had a winning outcome of 73%. Seeded athletes also had 71% and 55% chance of wearing blue protection equipment in their second, respectively third match. We expected under the null hypothesis that if seeded athletes are excluded, the color of athletes' equipment should not have any impact on the match outcome.

A final sample of 351 matches (female; $n = 180$ and male; $n = 171$) was analysed.

Statistical analysis

Binomial analysis was used to determine differences in match outcome (wins/lost) by the color of equipment. Further, a t-test for independent groups was used to investigate difference in points scored, recovery time and number of warnings due to the color of equipment. In addition, logistic regression was used to determine if winning was associated with recovery-time. The IBM SPSS Statistics software (version 26.0) was used for the statistical analyses. The level of statistical significance was set to $p < 0.05$.

Reliability testing

Two observers, who are advanced karatekas and licensed coaches on a national level, performed the analyses. Thirty of the matches were analysed by both observers in order to determine inter-observer reliability. To assess the

intra-observer reliability, one observer analysed all 351 matches twice. Cohen's kappa (κ) was used to calculate the both the intra-observer and inter-observer reliability for each variable. All κ values were larger than 0.85, which indicates high reliability [Landis, Koch 1977].

Results

Overall, the color of the equipment was not significantly associated with the proportion of wins (Red equipment; 46.2% vs. blue equipment; 53.3%, $p = 0.24$). However, when analysing data separated by sex, a significant association was found in males (red equipment; 41.5% vs. blue equipment; 58.5%, $p = 0.032$), but not in females (red equipment; 51.7% vs. blue equipment; 48.3%, $p = 0.71$).

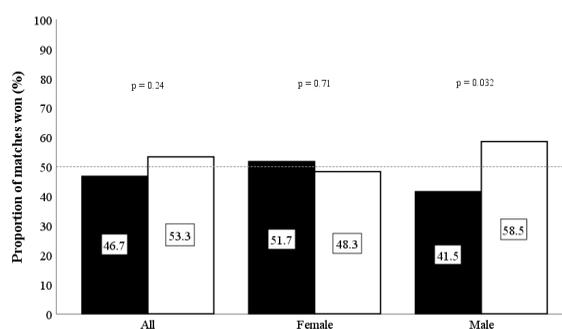


Figure 1. Comparison of proportion matches won by the color of the equipment, overall and separately by sex. Black bars represent wins for red, white bars represent wins for blue. The horizontal dotted line indicates equal distribution (50%) of wins.

Overall, the mean (sd) recovery time between matches was 11.5 ± 0.9 min for competitors with red equipment and 6.8 ± 0.7 min for those with blue equipment. The difference was statistically significant ($t = 4.190$, $p < 0.001$). When distributed according to sex, female athletes with red equipment had a mean recovery time between the matches of 11.0 ± 0.9 min, while those athletes that had blue equipment had a 6.5 ± 0.7 min. In males, athletes with red equipment had a mean recovery time between the matches of 12.0 ± 1.3 min, while those athletes that were wearing blue equipment had 7.1 ± 1.0 min between the matches. The difference was statistically significant for both sexes (females; $t = 3.001$, $p = 0.003$, males; $t = 2.925$, $p = 0.004$). However, the logistic regression showed that winning was not associated with recovery time (Wald= 0.038, d.f = 1, $p = 0.84$). The same result was found when distributed according to sex (females; $p = 0.62$, males; $p = 0.63$).

Overall, there was no significant difference in points scored due to color of the equipment (red equipment; 47%, 686 points vs. blue equipment; 53%, 774 points, $t =$

1.453, $p = 0.18$). However, when separated by sex, there was a significant difference in points scored in males (red equipment; 43%, 290 points vs. blue equipment; 57%, 383 points, $t = -2.607$, $p = 0.01$) but not in females (red equipment; 50.3%, 396 points vs. blue equipment; 49.7%, 391 points, $t = 0.132$, $p = 0.89$).

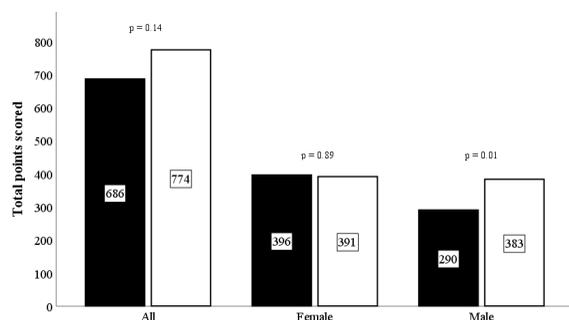


Figure 2. Comparison of total points scored by the color of the equipment, overall and separately by sex. Black bars represent points scored for red, white bars represent points scored for blue.

Overall, there was no significant difference in total warnings given by the referee when comparing color of the equipment (red equipment; 51.9%, 579 warnings vs. blue equipment; 48.1%, 537 warnings, $t = -1.184$, $p = 0.24$). The same result was found when analysing males (red equipment; 53.50%, 313 warnings vs. blue equipment; 46.50%, 272 warnings, $t = 1.430$, $p = 0.15$) and females (red equipment; 50.1%, 266 warning vs. blue equipment; 49.9%, 265 warning, $t = 0.047$, $p = 0.96$) separately.

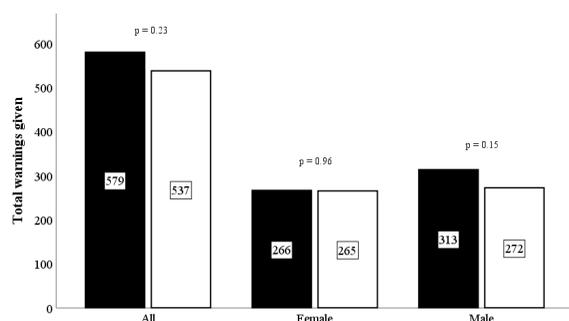


Figure 3. Comparison of warnings by the color of the equipment, overall and distributed according to sex. Black bars represent warnings given to red, white bars represent warnings given to blue.

Discussion

The aim of this study was to investigate if the color of the equipment in WKF karate had an impact on the outcome of the match when seeded athletes were excluded. We expected under the null hypothesis that if seeded athletes (top 8 athletes) are excluded, the color of athletes' equipment should not have any impact. The

main finding was that blue color of the equipment was associated with more wins and points scored by male but not by female athletes. Therefore, the null hypothesis was rejected for male athletes. The opposite result was found by Hill, Barton [2005] and Hagemann, Strauss, Leißing [2008]. They observed more wins and points by athletes that were wearing red equipment than those wearing blue equipment [Hagemann, Strauss, Leißing 2008; Hill, Barton 2005]. Red color has long been associated with aggression and dominance [Hagemann, Strauss, Leißing 2008; Krenn 2015]. Red color seems to have more advantage in full contact combat sports as boxing, taekwondo, wrestling and Greco-Roman wrestling [Hagemann, Strauss, Leißing 2008; Hill, Barton 2005] compared with semi-contact sports like karate. Our results show that blue color of the equipment was associated with more wins and points in the male category. This may indicate that blue color can have more advantages in semi-contact sports than full contact sports. However, further research is needed to clarify why blue color is more advantageous in semi-contact sports before making a conclusion.

Research has shown that colors can act as a trigger point for human emotions [Gulle, Beyleroglu, Hazar 2016]. Similarly as in our study, previous research has found that the color of the equipment had a significant effect on males but not on females, in the sports of boxing, taekwondo, wrestling and Greco Roman wrestling [Hill, Barton 2005]. Hill and Barton [2005] argued for that the color could have psychological and hormonal influences depending on sex. Therefore, color may not be of equal importance in karate for females and for males. However, as the sport develops with more female members, it may be possible that we would see the same effect of color in females.

If our study had included also seeded athletes, an even stronger association between color of equipment and winning outcome would have been found in the male athletes. One explanation to why our study found an association when seeded athletes were excluded could be that other top-ranked athletes (that are not seeded) also have a higher winning outcome than the other ranked athletes if they start wearing blue equipment in their first match. The percentage of successful attacks and blocking actions is higher in winners compared to defeated athletes [Tabben *et al.* 2013]. The skill difference among the top 10 ranked male athletes may differ compared to other ranked athletes as well, which will result in more wins for blue. Therefore, the results of this study could have been different if the top 10 ranked male athletes were also excluded in addition to the seeded athletes (top 8 ranked athletes).

In both males and females, the athlete wearing red equipment had longer recovery time than those athletes with blue equipment. The difference in recovery time was relatively large (4.7 min). However, winning was

not associated with recovery time. As the fact that the recovery time was not associated with wins, the World Karate Federation (WKF) could therefore remain their drawing system for karate premier league competitions.

In *karate kumite* too many warnings can result in losing the match [World Karate Federation 2020]. No difference was found in the warning between red and blue equipment, overall and separate by sex. Warning categories could be considered in future research as well when investigating referee bias in other combat sports.

In summary, our results show that the blue color of the equipment was associated with more wins and points in karate kumite. Those results can be of great importance for the WKF sports policy, having implications on the regulations in order to improve fairness and equality of the competition. There is a clear knowledge gap about how the blue color impacts male combat sports. Therefore, the psychology of blue color needs to be further investigated. In kumite, a large part of the body is covered by the protection equipment. Further research could therefore investigate whether the amount of color coverage influences the outcome of winning. Finally, future research would attempt to distinguish the influence of color on the performance of the athlete versus the referee/judges.

Our study investigated the recovery time and its influence on match outcome, which has not been done in any previous research. Even if our study considered recovery time and ranking, there are several limitations. We did not investigate differences in psychological parameters. Previous research has found that specific colors on the equipment can increase heart rate and strength during and before the fight [Dreiskaemper *et al.* 2013]. An experimental design would be plausible to study the effect of different colors. Also, an interview design could be highly necessary to provide a deeper understanding of how colors on equipment can impact human feelings. The second limitation is that only one single elite karate competition was included for the data collection, which may affect the generalisability of our result. Future studies could therefore include several competitions.

Conclusions

In conclusion, blue color of equipment in karate kumite was associated with more wins and more points scored than red color in male athletes. Those results can be of great importance for the WKF sports policy, improving fairness and equality of competition. Our results could also be of interest to policy makers in other sports. In addition, further research could determine the influence of the amount of color coverage, as well as to distinguish the influence of color on the performance of the athlete versus the referee/judges.

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Wpływ koloru sprzętu na wynik zawodów w karate Premier League

Słowa kluczowe: karate, kolor sprzętu, kumite, sędzia, sporty walki

Tłó. Istnieje potrzeba badań nad lepszym zrozumieniem znaczenia koloru i jego podstawowego wpływu na sport, w celu osiągnięcia sprawiedliwych i równych szans dla sportowców. Problem i cel. W badaniach, w których badano wpływ koloru sprzętu sportowców na wynik walki, wyniki były różne. Celem niniejszej pracy było zbadanie, czy kolor sprzętu ochronnego w *karate kumite* miał wpływ na wynik zawodów po wyłączeniu zawodników z listy rezerwowej. Metody. Przeanalizowano łącznie 351 meczów zawodów Premier League 2020. Zastosowano analizę dwumianową w celu określenia różnic w wynikach walk ze względu na kolor sprzętu. T-test dla grup niezależnych został użyty do zbadania różnicy w zdobytych punktach, czasie regeneracji i liczbie ostrzeżeń ze względu na kolor sprzętu.

Wyniki. Niebieski kolor sprzętu w *karate kumite* był związany z większym odsetkiem zwycięstw (58,5% vs. 41,5%, $p = 0,03$) i większą liczbą zdobytych punktów (383 vs. 290 punktów, $p = 0,01$) niż kolor czerwony tylko u mężczyzn. Średni (sd) czas regeneracji był dłuższy zarówno u mężczyzn ($12,0 \pm 1,3$ vs. $7,1 \pm 1,0$ min, $p = 0,004$), jak i u kobiet ($11,0 \pm 0,9$ vs. $6,5 \pm 0,7$ min, $p = 0,001$) w przypadku koloru czerwonego niż niebieskiego. Czas regeneracji nie był jednak związany z większą liczbą zwycięstw, ani u mężczyzn ($p = 0,63$), ani u kobiet ($p = 0,62$). Wnioski. Podsumowując, niebieski kolor sprzętu w *karate kumite* może prowadzić do większej liczby zwycięstw i większej liczby zdobytych punktów niż kolor czerwony u mężczyzn.