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Iron Nutritional Status of Karate Players: A Review

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Abstract

It has been suggested that iron depletion before anemia may impair performance. Karate players have risk factors for iron depletion. This study reviewed the related literature with respect to the iron nutritional status of karate players and dietary treatments. Examining iron intake in related studies indicated that the iron intakes of female players were lower than those of male players. A high prevalence of iron deficiency was reported only in female karate players. A high prevalence of hemolysis was found not only in sparring players, but also in kata (forms performed alone) players. Dietary modification is the preferred strategy to ensure adequate iron intake, maintenance of iron levels, and as the first line of action to prevent iron deficiency. Because most reports on iron nutrition status of karate players are from Japan and all studies are cross sectional, future research investigating the iron nutritional status of karate players should include (i) Studies from Western countries and (ii) Longitudinal studies. These studies should focus on adolescents since there is a paucity of information in the literature in this area.

Keywords

Karate players; Anemia; Iron deficiency; Serum ferritin; Hemolysis; Haptoglobin

Introduction

Karate is derived from a martial art developed in Okinawa, Japan [1,2] and is one of the most popular martial arts practiced both within and outside Japan [3]. The Federation of All Japan Karate Organizations belongs to the World Karate Federation, which is recognized by the International Olympic Committee, and karate will make its first appearance as an Olympic sport at the 2020 Summer Games in Tokyo, Japan [4,5].

Karate competition held under the World Karate Federation rules has 2 modalities: sparring and kata. Sparring is the execution of defensive and offensive techniques while freely moving against an opponent. Kata are set forms in pre-established sequences of defensive and offensive techniques and movements, performed alone against imaginary opponents [6,7]. Because World Karate Federation sparring is considered noncontact, punches and kicks must be controlled or stopped before contact with the scoring area. A score is awarded when a technique is performed to a scoring area according to the following criteria: good form, sporting attitude, vigorous application awareness (zanshin), good timing, and correct distance. The correct distance, in senior competition, is a punch or kick somewhere between skin touch and 5 cm from the face, head, or neck. When contact is deemed by the referee to be too strong, it will be penalized [8]. Kata performance judgement gives equal weight to both the major criteria: technical performance and athletic performance. Concentration, power, and potential impact must be displayed in the techniques, and strength, power, and speed as well as grace, rhythm, and balance must be demonstrated [8].

There are distinct differences between kata and sparring competitions. There is no physical contact in kata as opposed to sparring, in which there is physical contact. Therefore, most injuries during karate tournaments occur during sparring [9]. Hematomas, contusions and strains, which may cause hemolysis, are the most frequent injuries during sparring competitions [10]. Also, most injuries during regular karate training occur during sparring exercise. Bruises are the most common injuries and blood loss due to nose bleeds sometimes occur during sparring exercise [11]. This implies the blood iron status of kata and sparring competitors may be different. In addition, because highly competitive karate practitioners cross-train by undertaking strenuous running and weight training programs to increase endurance, muscle development and power [9], they have risk factors for iron depletion. These include poor iron and protein intake, hemolysis caused by repeated foot strikes and muscular damage due to physical contact, blood and iron loss due nose bleeding in both sexes and by menstruation in women, gastrointestinal and urinary tract problems, and iron loss through sweating.

The American College of Sports Medicine, American Dietetic Association, and Dietitians of Canada [12] reported that the incidence of iron depletion is high in athletes, especially women. It has been suggested that iron depletion before anemia may impair performance [13]. Therefore, it is important to assess iron intake and blood iron status to prevent anemia. The purpose of this study was to review the related literature and examine the iron nutritional status of karate players who compete under the World Karate Federation rules.

Search Strategies

MEDLINE in the PUBMED and Google Scholar search were conducted for articles relating to anemia in karate players. The keywords “iron nutrition”, “anemia”, “sports anemia”, “iron deficiency anemia”, “hemolysis”, “karate” were used. After applying limits for articles addressing karate players and published in English, only 5 article were located. Bibliographies were cross-referenced to locate articles missing from the literature search. As results, 8 full articles (6 articles written in English and 2 in Japanese) were located. A summary of articles reviewed is presented in Tables 1 and 2.

Definitions

The commonly used definition for anemia is a low hemoglobin (Hb) concentration below the standard value [14] (i.e. below 13 g/dl for men and 12 g/dl for women) [15-19]. The decreased Hb reduces exercise performance despite a compensatory increase in cardiac output [20]. Iron deficiency anemia was more predominant in female athletes compared to males, and this was attributed to the additional

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Table 1: Studies reported dietary iron intake, without measuring blood iron status.

First author	Dietary information Subjects	Iron intake (mg/day)	%RDA
Miyahara 2006 [26]	3-weekday dietary record National level 30 male and 20 female senior high school players	male: 10.7±3.1 female: 8.3±3.2	male: 92.1±30.0 female: 69.2±27.0
Teshima 2002 [27]	3-weekday dietary record National level 29 male and 16 female collegiate players	male: 10.8±2.9 female: 8.2±2.0	male: 97.6±31.0 female: 68.1±17.0
Oda 2018 [28]	Food frequency questionnare 20 female national team members 15 female collegiate players	elite: 10.6±3.5 collegiate: 5.1±1.2	elite: 124.1±40.7 collegiate: 59.9±13.7
Oda 2013 [29]	Estimated at the training camp National team members: 20 male sparring group (M-Spar-G) 7 male kata group (M-Kata-G) 11 female sparring group (F-Spar-G) 7 female kata group (F-Kata-G)	not shown	M-Spar-G: 164.8±29.3 M-Kata-G: 156.7±27.5 F-Spar-G: 88.4±16.0 F-Kata-G: 95.7±11.7
Imamura 2018 [30]	Food frequency questionnare 4 world champions: Male sparring player (M-Spar) Male kata player (M-Kata), Female sparring player (F-Spar) Female kata player (F-Kata)	M-Spar: 9.5 M-Kata: 16.3 F-Spar: 10.9 F-Kata: 8.8	M-Spar: 232 M-Kata: 136 F-Spar: 84 F-Kata: 104
%RDA: Percentage of Recommended Dietary Allowance			

Table 2: Studies reported both dietary iron intake and blood iron status.

First author	Dietary information Subjects	Iron intake (mg/day)	Blood iron status
Miyahara 2013 [9]	Food frequency questionnare National team members: 19 male sparring group (M-Spar-G) 8 male kata group (M-Kata-G) 11 female sparring group (F-Spar-G) 7 female kata group (F-Kata-G)	M-Spar-G: 10.5±6.8 M-Kata-G: 12.4±4.5 F-Spar-G: 8.9±3.3 F-Kata-G: 8.9±1.3	・Iron deficiency: 30% players in F-Spar-G 57% in F-Kata-G ・Intravasucular hemolysis: 74% in M-Spar-G 75% in M-Kata-G 80% in F-Spar-G 43% in F-Kata-G
Imamura 1997 [31]	3-weekday dietary record 26 male collegiate karate players: 16 black belt group (BBG) and 10 white belt group (WBG).	BBG: 10.3±3.3 WBG: 9.1±2.1	・red blood cell count, iron, Hb, hematocrit within the normal ranges
Nuviala 1996 [32]	7-day dietary survey19 Spanish national and international female karate players.	12.7±3.7 (12 players (63.1%) did not reach the iron intake of 15 mg/day)	・Iron deficiency: 9 players (47.3%) ・Anemia: 2 players (10.5%) ・Hemolysis was not observed
Hb: hemoglobin			

loss of iron due to menstruation. Among the studies reviewed, the overall incidence of iron deficiency anemia in athletes ranged from 15-40% [20].

Iron deficiency reduces oxygen transport capacity and oxidative capacity at the cellular level, and develops rapidly or very slowly depending on the balance between iron intake and iron requirements [14]. Iron deficiency can occur with or without the development of anemia [20] and can be defined as occurring when the body's iron stores become depleted and a restricted supply of iron to various tissues becomes apparent [14,15,20]. Transferrin is a protein that transports iron in plasma, whereas ferritin levels are an indicator of iron stores. In iron deficiency, transferrin saturation decreases, while total iron binding capacity increases [15,20].

Hemolysis is defined as the breakdown of erythrocytes in blood that frees the hemoglobin and intracellular contents from cells [21]. Serum haptoglobin binds the released Hb in order to prevent its urinary excretion; therefore, when hemolysis occurs, serum haptoglobin decreases. Hemolysis is assessed by plasma free Hb and/or serum haptoglobin concentrations [17,18,22,23].

Recommended Dietary Allowance for Iron Intake

The Japanese recommended dietary allowance (RDA) for iron intake for people aged 18-29 years is 7 mg/day for males and 10.5 mg/day for females [24]. These levels are lower than the RDA in the USA, especially in women (8 mg/day for males and 18 mg/day for females) [25].

Iron Nutritional Status in Karate Practitioners

Most reports on iron nutrition status of karate players are from Japan [9,26-31]. Table 1 gives the summary of the studies [26-30], which reported dietary iron intake, without measuring blood iron status. Among these, 2 studies [26,27] reported iron intake of daily living environment of highly competitive male and female senior high school players [26] and collegiate karate players [27]. The results of these studies showed that iron intakes, in mg/day as well as %RDA, of female players were lower than those of male players. Another study [28] compared nutrient intake between female elite players who were members of the national team (national members) and female collegiate karate players. The results showed that the iron intake of the elite players was well above RDA and of the collegiate players was

below RDA. One study [29] examined the nutrient intake of male and female national members during a training camp. Even though food was provided at the training camp as buffet style in this study, the iron intake of the male players was well above of RDA and female players was below RDA. Another study [30] examined the nutrient intakes daily living environment of 4 world champions. In this study, none of the athletes were on a diet or took supplements. They wanted to satisfy nutrient needs by eating a balanced diet, were eager to obtain information on proper diet, and were aware of the importance of a well-balanced diet. Examining iron intakes in these studies [26-30], it appears that iron intakes of female players were lower than those of male players Tables 1 and 2.

Two studies from Japan [9,31] and one study from Spain [32] investigated both iron intake and blood iron status of karate players. Table 2 gives the summary of these studies [9,31,32]. Imamura et al. [31] examined 26 male collegiate karate players and reported that blood hematocrit, iron, red blood cell count, and Hb were within the normal ranges, although their iron intakes were below the RDA. Nuviala et al. [32] investigated 19 Spanish female karate players. The results showed that 12 players (63.1%) did not reach the minimum iron intake of 15 mg/day; 9 players (47.3%) had iron deficiency (ferritin levels under 20 ng/ml); and 2 players (10.5%) had anemia (Hb levels under 12 g/dl). Miyahara et al. [9] examined iron nutritional status of male and female national members and found a high prevalence of iron deficiency only in female athletes, while only one of the male players had iron deficiency. Because the mean intakes of iron were higher in male groups and lower in female groups than the respective RDAs, the principal cause of iron deficiency found in the female players may be due, at least in part, to low iron intake. A high prevalence of iron deficiency has been reported in elite female soccer players [19], female runners [33], female professional handball, volleyball, soccer, and judo players [34], and in male and female top-level basketball players [35].

Regarding intravascular hemolysis, the above mentioned study by Nuviala et al. [32] did not observe hemolysis as shown by a high haptoglobin value, similar to the control group. They stated that this may be because they practice kata in which there is no physical contact, as opposed to sparring, in which there is physical contact. However, in contrast to this study [32], Miyahara et al. [9] reported a high prevalence of intravasucular hemolysis, which was judged as a haptoglobin level below the standard value. Because a high prevalence of hemolysis was found not only in male and female sparring players, but also in male and female kata players, mechanisms other than physical contact that cause hemolysis must also be considered. Robinson et al. [36] suggested intravascular hemolysis could be caused by intramuscular destruction, osmotic stress, and membrane lipid peroxidation caused by free radicals released by active leukocytes. They also stated that intravascular hemolysis can even be regarded as a physiological means to provide heme and proteins for muscle growth. However, if hemolysis persists throughout the training season, haptoglobin may be saturated with Hb, and Hb that could not bind to haptoglobin may be excreted from urine. Along with low dietary iron intake, this may lead to iron deficiency. Escanero et al. [37] examined iron stores in male professional soccer players. They obtained blood samples at the beginning, in the middle, and at the end of the season and reported that serum ferritin decreased significantly at the end of the season. Thus, it appears that seasonal changes in blood iron status in karate players need to be examined in the future research.

Foot striking in runners has been the most often reported reason for intravascular hemolysis [22,23,38]. This also occurred in rugby players [17], soccer players [18], and swimmers [39].

Recommendations

Iron deficiency treatments include oral supplements, intramuscular or intravenous injections [40,41], and dietary iron treatments, in which modification of diet through dietary advice and counselling, as well as inclusion of iron-fortified foods or naturally iron-rich foods in the daily diet [41]. Burden et al. [40] performed a systematic review and meta-analysis and concluded that iron treatments improve the iron status and aerobic capacity of iron-deficient non-anaemic endurance athletes. However, conventional treatments with oral iron supplements and injections often cause side effects including abdominal discomfort, constipation, and nausea [41,42] and may present a risk of iron overload associated with unnecessary or unmonitored usage [43]. Marx [44] stated that increased iron stores are more dangerous than iron depletion and iron deficiency anemia, especially in adults. Therefore, as suggested by Alaunyte et al. [41] and Hinton [45], dietary modification is the preferred strategy to ensure adequate iron intake, maintenance of iron status, and as the first line of treatment in the prevention of iron deficiency.

Iron-fortified products have been successfully used to increase Hb, serum ferritin levels and to reduce the risk of iron deficiency in general adult populations [41]. Consuming a diet naturally rich in iron is a sensible way for athletes to avoid anemia. This may be achieved by eating red meat, beans, lentils, dark green leafy vegetables and eggs [46]. Burke et al. [47] reported that increasing bioavailable iron by eating red meat may have effects on the maintenance of blood iron markers.

Directions for Future Research

Because most reports on iron nutrition status of karate players are from Japan [9,26-31], more research from Western countries, where karate is also very popular sport, is needed to better elucidate the iron nutritional status of karate players. The diet of the Japanese population is quite different from that of the population living in the Western countries in general. Japanese dietary habits are characterized by a high carbohydrates intake, along with low protein and fat [48].

Thus, future research investigating the iron nutritional status of karate players should include (i) studies on iron nutritional status of karate players from Western countries, (ii) longitudinal studies (pre-, during, and post-season), and (iii) directing research towards the underlying mechanisms for intravascular hemolysis because a high prevalence of hemolysis was found not only in sparring players, but also in kata players. These studies should, in particular, focus on adolescents since there is a paucity of information in the literature in this area.

Conclusion

The most reasonable interpretation of the currently available data is that 1) Iron intakes of female karate players were lower than those of male players; 2) A high prevalence of iron deficiency was reported

only in female karate players; and 3) A high prevalence of hemolysis was found not only in sparring players, but also in kata players. Dietary modification is the preferred strategy to ensure adequate iron intake, maintenance of iron status, and as the first line of treatment in the prevention of iron deficiency.

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