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The impact of divergent karate disciplines on blood iron markers

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ABSTRACT

A substantial body of previous research on karate has focused on tactical aspects or physical characteristics, with limited investigation into its effects on blood parameters. The present study examined the impact of two distinct resistance exercise modalities on blood indicators related to anemia.

The subjects comprised 42 male athletes (15 kata, 27 kumite) and 22 female athletes (6 kata, 16 kumite) belonging to a university karate club. Given that the subjects had approximately 10 or more years of karate experience, this study is a follow-up utilizing data from health examinations conducted during their first year. The parameters that were the focus of the investigation included red cell count, hematocrit, hemoglobin concentration, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, serum iron, and ferritin concentration. Anemia was defined according to the World Health Organization criteria. In the male population, the hematocrit level is less than 13 grams per deciliter of blood. In the female population that is not pregnant, the hematocrit level is less than 12 grams per deciliter of blood. The assessment of hypoferritinemia was conducted by employing a range of serum ferritin thresholds, namely <15, <30, and <50 μg/L. Among the subjects, one male kumite athlete exhibited a hemoglobin concentration below 13.0 g/dL, indicative of anemia. No female athletes were found to have anemia. However, a significant disparity in ferritin levels was observed between female and male athletes, with the former exhibiting lower levels in both kata and kumite disciplines. Red cell count, hemoglobin, mean corpuscular hemoglobin concentration, serum iron, and ferritin levels were found to be significantly higher in males compared to females. No substantial gender disparities were observed for mean corpuscular volume and mean corpuscular hemoglobin. A significant disparity was observed between the mean values of MCHC in kata and in kumite. No significant differences were identified in the following parameters: red blood cell count, hematocrit, hemoglobin, mean corpuscular volume, mean cell hemoglobin, serum iron, and ferritin concentrations.

Ferritin concentrations were found to be low in 40 out of 64 subjects (62.5%). When grouped by cut-off values: The following data were obtained from the analysis of water samples: 15 μg/L: 6 individuals (1 male kumite, 5 female kumite), 30 μg/L: 7 individuals (3 female kata, 1 male kumite, 3 female kumite), <50 μg/L: 11 individuals (2 male kata, 5 male kumite, 4 female kumite). Therefore, the existence of potential disparities in iron nutrition is a plausible hypothesis.

I. Introduction

Iron deficiency, which is caused by a lack of this essential trace element, is one of the most common nutritional problems worldwide. It is defined as a state in which the body's iron stores and supply to various tissues are insufficient. The etiology of this condition is believed to be multifactorial, including insufficient iron intake, specific diseases, and, in women, blood loss due to menstruation. The depletion of iron stores can occur rapidly or very slowly, depending on the balance between iron intake/storage and requirements. Moreover, the rate at which true iron deficiency develops in individual tissues and intracellular organelles is contingent on intracellular mechanisms for iron recycling and the metabolic turnover rate of iron-containing proteins. A substantial body of research has been dedicated to investigating the impact of exercise and nutrition on iron status. It has been established that exercise itself induces alterations in iron status. A substantial body of research involving athletes has demonstrated a propensity for low serum ferritin levels[1,2]. This finding is particularly well-supported by results from endurance runners. Iron deficiency anemia (IDA) has been identified as the most prevalent nutritional disorder among female athletes, with many cases believed to arise from inadequate dietary iron intake[3,4]. However, individuals undergoing rigorous exercise training are believed to have elevated iron requirements in comparison to non-athletes. This phenomenon can be attributed to various factors, including the loss of existing intracellular iron due to profuse sweating and the shedding of epithelial cells from the skin and gastrointestinal tract[5,6]. Additionally, reduced iron absorption from the gastrointestinal tract can contribute to the observed anemia. Furthermore, intense physical impact on areas such as the feet, depending on the sport, can lead to hemolysis[6]. Recent reports indicate that mild resistance exercise improved latent iron deficiency in young women without requiring iron supplementation[7], suggesting that different types of exercise may have varying effects on iron nutritional status[8]. However, the majority of research on the effects of resistance exercise on iron status has been conducted in animal experiments. Moreover, extant research has predominantly centered on sports where the distinction between aerobic and resistance exercise is readily apparent. To elucidate the question of whether iron intake varies by sport, studies involving human subjects are necessary.

Consequently, the primary focus was placed on karate, a form of resistance exercise and a sport that demands significant explosive power. Karate is a martial art that has evolved from indigenous fighting styles and Chinese boxing. It is a sport that engages the majority of the body's muscles. Additionally, karate is traditionally classified into two distinct forms: kumite and kata. These forms differ in terms of their style and muscle usage. Kata is defined as a predetermined sequence of movements executed at high velocity in relation to an imaginary opponent, while kumite is characterized as non-contact combat[9].

In kata, athletes execute movements in various directions within a defined space. This is not a symbolic fight performed alone; rather, it is considered a fight against one or more invisible opponents. The number of kata techniques incorporated varies by style, and each is referred to by a distinct name. The fundamental elements of proper kata technique include kime (a brief isometric muscle contraction performed at the end of a technique), expressiveness, and rhythm. During the competitive event, athletes execute predetermined kata styles (designations), each with a specified required duration. Athletes who have advanced to the finals are required to perform one fixed kata style (designation), with a duration of at least 60 seconds and no more than 80 seconds. In addition to this, they are required to perform one freestyle kata (special kata) in accordance with the World Karate Federation (WKF) system style. Athletes are subject to a penalty for each second that exceeds or falls short of this limit[10].

Kumite, in contrast, involves the execution of ceremonial techniques as opposed to actual combat. These matches consist of non-contact combat and symbolic techniques, yet competitors demonstrate the potential power of their movements, executing techniques as if they were real. In the Senior Men's division, kumite matches are scheduled to last three minutes, while in the Senior Women's, Cadet, and Junior divisions, the duration is set to two minutes. In the event of a tie, the match is extended by one minute, and the athlete who executes a valid technique first is declared the

winner. In the event that the tie persists, the winner is determined by a panel of judges[10].

A substantial body of previous research on karate has centered on tactical studies[11] or physical characteristics[12]. However, there has been limited examination of the effects of karate on blood. The present study investigated the impact of two distinct resistance exercise disciplines on blood indicators related to anemia.

II. Methods

1. ETHICAL CONSIDERATIONS

This study was conducted in accordance with the ethical standards set forth by the Kokushikan University Ethics Committee, which approved the study's protocol (approval number: 25021). All research protocols were in accordance with the ethical standards for human subjects research as outlined in the Declaration of Helsinki. Prior to obtaining written consent, participants were provided with detailed explanations regarding the study's purpose, procedures, potential risks, and benefits. Participants were granted the autonomy to discontinue their involvement in the study at any time.

2. SUBJECTS

The subjects comprised 42 male athletes (15 kata, 27 kumite) and 22 female athletes (6 kata, 16 kumite). These athletes belonged to the university karate club. Participants provided written and verbal informed consent. The data for this study was derived from health checkups conducted in April of the first year of university. On the day of the examination, the subjects were instructed to refrain from physical activity and samples were collected while they were at rest. The survey items included red blood cell count (RBC), hematocrit (Ht), hemoglobin concentration (Hb), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), serum iron, and ferritin concentration.

Anemia was defined based on World Health Organization (WHO) criteria[13] as hemoglobin levels below 13 g/dL in males and below 12 g/dL in non-pregnant females. WHO has not established a clear cutoff value for ferritin alone. However, many medical institutions utilize a value of 12 ng/mL or below as a diagnostic criterion for iron deficiency or iron deficiency anemia. The assessment of hypoferritinemia was conducted by employing various thresholds, including serum ferritin levels below 12, 30, and 50 μg/L[13,14].

3. STATISTICS

Results are presented as mean ± standard deviation. Normality was assessed using the Shapiro–Wilk test, and homogeneity of variances was evaluated using Levene's test. One-way analysis of variance was applied when the data met the assumptions of normality and homogeneity of variance, whereas the Kruskal–Wallis test was used for group comparisons of non-normally distributed data. When appropriate, post hoc multiple comparisons were performed using the Steel–Dwass test. A p-value < 0.05 was considered statistically significant. All statistical analyses were conducted using JMP Pro 18 (SAS Institute Inc., Cary, NC, USA).

III. Results

1. PHYSICAL CHARACTERISTICS

Physical characteristics are shown in Table 1. Analysis of physical characteristics showed that height, body weight, and body mass index (BMI) were significantly greater in male participants than in female participants. Height was significantly associated with kumite participation, with taller individuals more likely to engage in kumite training, whereas no such association was observed for kata. No significant differences were observed in weight, BMI, or career among the different sports disciplines.

Table 1. Physical characteristics.

		Kata		Kumite		ANOVA	
		male	woman	male	woman	Sex	Type
Hight	cm	166.0 ± 3.3	154.2 ± 2.7	171.7 ± 7.4	160.7 ± 5.9	<0.001	0.030
Weight	kg	67.9 ± 7.3	50.4 ± 3.7	70.6 ± 8.7	57.0 ± 7.7	<0.001	0.305
BMI	kg/m^2	24.6 ± 2.5	21.2 ± 1.5	23.9 ± 2.1	22.0 ± 2.6	<0.001	0.572
Career	years	13.0 ± 1.4	13.8 ± 0.8	12.6 ± 2.3	12.5 ± 2.0	0.388	0.615

BMI : Body mass index

2. THE EFFECT OF GENDER ON BLOOD PARAMETERS ASSOCIATED WITH ANEMIA

Blood indicators are shown in Table 2. RBC, Ht, Hb, MCHC, serum iron, and ferritin concentrations were found to be significantly higher in males compared to females. No substantial gender disparities were identified for MCV, MCH,

Table 2. Blood indicators

		Kata				Kumite				ANOVA	
		male		woman		male		woman		Sex	Type
RBC	$\times 10^4/\mu L$	495.4 ± 26.7		479.6 ± 36.2		517.6 ± 39.5		456.3 ± 31.4		0.212	< 0.001
Ht.	%	45.9 ± 1.7		43.0 ± 1.7		46.9 ± 1.0		42.4 ± 2.5		0.253	<0.001
Hb	g/dL	14.9 ± 0.7		13.9 ± 0.7		15.0 ± 2.5		13.3 ± 0.8		1.000	<0.001
MCV	fL	92.8 ± 3.4		89.8 ± 3.9		90.9 ± 4.4		93.1 ± 4.8		0.609	0.39
MCH	pg	30.1 ± 1.1		28.9 ± 1.1		29.0 ± 2.0		29.3 ± 1.7		0.157	0.85
MCHC	%	32.5 ± 0.9		32.3 ± 0.7		32.0 ± 1.0		31.5 ± 0.6		0.041	0.07
Plasma iron	µg/dL	88.4 ± 22.9		78.6 ± 17.2		100.7 ± 39.6		66.8 ± 21.2		0.496	0.00
Ferritin	ng/mL	82.0 ± 35.7		38.0 ± 41.1		73.1 ± 30.1		37.0 ± 29.1		0.205	0.00

RBC: Red Cell concentrate, Hb: Hemoglobin, Ht.: Hematocrit HCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration

3. THE IMPACT OF DISCIPLINE ON BLOOD PARAMETERS ASSOCIATED WITH ANEMIA

A significant increase in MCHC was observed between kata and kumite. No significant differences were observed in the following parameters: RBC, Ht, Hb, MCV, MCH, serum iron, and ferritin concentration.

One male kumite athlete exhibited an Hb level that fell below the anemia cutoff value of 13.0 g/dL. An analysis of the data set revealed that none of the female athletes participating in either kata or kumite had an Hb level below 12.0 g/dL.

Ferritin concentration was found to be low in 40 of the 64 athletes (62.5%) examined. When grouped by cut-off values: The following data are reported for athletes in the competition: For concentrations less than 12.0 µg/L, there are five athletes, including one male kumite athlete and four female kumite athletes. For concentrations less than 30 µg/L, there are seven athletes, including three female kata athletes, one male kumite athlete, and four female kumite athletes. For concentrations less than 50 µg/L, there are 11 athletes, including two male kata athletes, five male kumite athletes, and four female kumite athletes.

IV. Discussion:

This study examined the differences in blood iron indicators between karate kata and kumite athletes. Among the subjects, one male kumite athlete exhibited an Hb concentration below 13.0 g/dL, indicative of anemia. Anemia was not observed in any of the female athletes. However, a significant disparity in ferritin concentrations was observed between female and male athletes, with lower concentrations being observed in the female group. Koehler et al.[15] reported that the incidence of anemia among young elite athletes is low in both men and women (approximately 7%)[15]. In this study, only one university athlete (1.6%) was anemic, which corroborates the findings of previous research. However, a notable disparity in iron status was observed between the sexes, particularly with regard to low ferritin concentration, which was more prevalent among female athletes than among male athletes. This finding is consistent with the findings of previous studies that reported a significantly higher prevalence of iron deficiency in female athletes[15-18].

Hemoglobin concentration, which is used to determine anemia, and ferritin concentration, which reflects iron stores, showed significant gender differences; however, no significant differences were observed between disciplines. In contrast, MCHC was significantly higher in kata than in kumite. MCHC, a hematological parameter indicating hemoglobin concentration per red blood cell[19], is commonly used to classify anemia and is typically reduced in conditions such as iron deficiency

anemia[20]. Because this was a follow-up study, dietary surveys were not conducted, and dietary iron intake could not be assessed. Nevertheless, we previously reported a strong correlation between MCHC and ferritin concentration[21]. In addition, ferritin levels may be elevated in the presence of inflammation[22]. Furthermore, ferritin levels may appear elevated due to inflammation. Consequently, while hemoglobin and ferritin levels, which are conventionally used to diagnose anemia, showed no difference, a discrepancy arose in MCHC. This finding indicates that MCHC may serve as a useful parameter for excluding the influence of inflammation when utilizing ferritin concentration for the assessment of anemia. Moreover, these results suggest that practitioners of kumite may be more susceptible to iron deficiency than practitioners of kata.

The recommended daily intake of iron for athletes is set at 15-18g for both men and women[23]. However, it is important to note that iron is a mineral for which meeting intake requirements is extremely difficult. Even the National Health and Nutrition Examination Survey shows that meeting the recommended intake (7–10.5g) is rarely achieved[24]. Consequently, the 15 g recommendation imposes a substantial burden on athletes.

This study is pioneering in its effort to compare iron nutritional status across karate disciplines. Karate is classified as a form of resistance exercise. Nevertheless, the study suggested the possibility of differences in iron nutritional status between kumite (sparring) and kata (forms). These findings lend support to the hypothesis that iron intake varies by discipline[25].

However, the study's limitations must be acknowledged. The statistical power constraints of a small cohort and the lack of dietary surveys or follow-up studies due to its cross-sectional nature are notable limitations. To overcome these limitations, future research should collaborate with other universities to increase the sample size. Although tracking evaluations is important, it is considered useful to first conduct cross-sectional studies to examine whether iron intake differs across disciplines, regardless of karate.

V. Conclusion

In summary, among the university karate athletes who participated in this study, only one individual satisfied the WHO definition for anemia. However, a significant proportion of the female participants (3 kumite athletes and 8 kata athletes) exhibited low ferritin levels below 30 ng/mL. This study is pioneering in its analysis of the prevalence of iron deficiency by karate discipline. In the future, we intend to conduct larger cohort studies at multiple sites to evaluate the prevalence of iron deficiency, confirm and examine its validity, and contribute to improving iron deficiency among athletes. It is also anticipated that this will serve as an opportunity to alleviate pressure regarding iron intake.

Conflict of Interest Statement:

None.

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