Abstract

**Purpose:** While electrolytes and immunity are highlighted as important in terms of the relationship between health and physical activity, immunoglobulin plays such a decisive role in the immune function that defends the human body, and it occurs in multiple tissues, such as the skin, lungs, blood, muscle, etc., affecting an increased risk of infection, including sleep deprivation, mental stress, malnutrition, and weight loss. Hence, this study was conducted to examine the effect of short-term weight loss on body composition and blood electrolyte and immunoglobulin concentrations among non-excellent and excellent Judo athletes.

**Method:** The subjects of this study were 14 male athletes who were currently active as Judo athletes at university and had over 5 years of athlete experience and weight loss experience. For the statistical processing of this study, the mean and standard deviation for each item were calculated using the SPSS 12.0 statistical program, and the Two-way repeated ANOVA was performed according to group (non-excellent athlete and excellent athlete) and time (before the weight loss, 6 days after the weight loss, immediately after the competition, 30 minutes recovery period), and in the case of an interaction effect, the post-test was conducted by contrast test for each period and paired t-test for each period.

**Results:** The changes in body weight(A), total weight without fat(B), and body fat percentage(C) are demonstrated before and after the weight loss(6 days), immediately after the competition, and 30 minutes in the recovery period(A). In terms of the change of body weight over time by group(A), both groups significantly decreased(p<.001) at the weight loss(6 days after) compared to before the weight loss. The changes in Ca(A), Na(B), K(C) and Mg(D) before and after the weight loss(6 days after), immediately after the competition, and 30 minutes of recovery are demonstrated. Comparing the change(A) of Ca between groups by group, both groups significantly decreased during the reduction period compared to before the weight loss(p<.001). The changes in IgA (A), changes in IgG(B), changes in IgM(C) and changes in IgD(D) are demonstrated before and after the weight loss(6 days), immediately after the competition, and after 30 minutes of recovery. Comparing the change in IgA between the periods by group, there was a significant increase in the excessive weight loss(after 6 days) in the excellent athlete group compared to before the weight loss(p<.001).

**Conclusion:** Weight loss is considered to have a negative impact on performance improvement and affect the pre-match condition and performance. Based on the results of this study, the scientific weight loss methods and appropriate short- and long-term weight loss will serve as the important basic data for further research to improve the athletic performance among the athletes of weight class.

**Keywords:** Judo Athlete, Weight Loss, Body Composition, Blood Electrolyte, Immunoglobulin

1. Introduction

Victory conditions in Judo must be supported by physical factors for prompt and smooth movement and judgement[1]. In Judo, the athletes with good physique and physical strength
have advantageous match performance, yet it is a natural result that victory or defeat is determined by technical factors between the athletes[2]. However, in the competitions that are divided by weight class, such as Judo, the participation after losing weight before the competition may have a decisive effect on victory or defeat. As such, Judo, a weight class competition, includes nutritional management according to time, method, and period in the training process to provide a systematic and reasonable method to maintain the athlete's condition, prevent fatigue, and replenish energy, thereby making efforts toward improving athletic performance and game operation ability[3][4]. However, the currently and widely used weight loss method not only harms the athlete's health, yet also leads to a decrease in physical strength and a decrease in skills[5]. However, it is difficult to limit weight loss because athletes participating in Judo have a strong belief that they can achieve more favorable performance through the weight loss[6][7].

Since the difference in terms of physique and weight between the players rather than physical factors appears to be an important factor in terms of having relevance to performance, and with a view to minimize the impact on competition results due to many differences in physique and weight, many researchers and leaders have developed a systematic training method. Various methods of weight loss are implemented to ensure the safety and better performance of the athletes[8]. In Judo, which is a speculative event that is divided by weight class, most of them compete after losing weight. In such a situation where strength and muscular endurance are important, short-term weight loss has a negative impact on the health and life of athletes due to a decrease in muscle mass and lack of nutrients and body water in the body[9]. Steep changes in the body composition that occur mainly in short-term weight loss cause malnutrition and dehydration symptoms, reduce the health and athletic performance of athletes, and negatively affect the immune function that forms the body's defense system[10].

It has been demonstrated that dehydration and the lack of nutritional intake due to weight loss increase the concentration of calcium, a part of electrolytes related to muscle contraction, that can affect the electrolyte concentration[11]. In a study of 10 high school male wrestlers, electrolytes increased immediately after the weight loss compared to before the weight loss[12]. In another previous study, in a study conducted on 24 male university Taekwondo athletes, sodium(Na) increased and potassium(K) decreased during short-term weight loss[8]. In the human body, electrolytes act as a buffer system to adapt to changes in acidity, change body fluids and maintain cell membrane permeability. The role of these electrolytes in generating alkaline digestive juices, such as bile and bile, is closely related to exercise that consumes a large amount of water and energy, so the interest in them has increased[13]. The weight loss of athletes of weight class is mostly executed by controlling water and restricting diet, so the secretion of sweat due to dehydration causes water loss and electrolyte imbalance in the body, which negatively affects the performance[14].

Electrolyte and immunity have emerged as important in the relationship between health and physical activity, and immunoglobulin plays a decisive role in the immune function to defend the human body, and they also affect the increased risk of infection, such as stress, malnutrition, and weight loss[15]. Yaegaki et al.(2007) reported that there was no significant difference in immunoglobulin levels depending on the degree of weight loss in a study conducted on athletes participating in weight class, while Umeda et al.(2004) reported that the steep weight loss among the Judo athletes decreased immunoglobulin[16][17][18][19]. Notwithstanding the fact that weight loss has a negative impact on immunoglobulins in the body, the athletes are repeatedly losing weight for competitive performance. Hence, this study was conducted to examine the effect of short-term weight loss on body composition and blood electrolyte and immunoglobulin concentrations among the ordinary players(OP) and excellent players(EP) Judo athletes.
2. Research Method

2.1. Research subjects

The subjects of this study were 14 male athletes who were currently active as Judo athletes at university and had over 5 years of athlete experience and weight loss experience. Seven out of 14 college students were selected from among the OP who had experience only in the municipal and provincial competitions. Considering the fact that they are professional athletes, the weight loss method that is usually used for physical and psychological condition was adjusted according to their weight class. The characteristics of the study subjects are demonstrated in Table 1.

Table 1. Subject’s physical characteristics.

<table>
<thead>
<tr>
<th>Group</th>
<th>Item</th>
<th>Age (years old)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>Lean mass (kg)</th>
<th>Body fat (kg)</th>
</tr>
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<tbody>
<tr>
<td>OP</td>
<td></td>
<td>22.00 ±2.64</td>
<td>176.57 ±5.99</td>
<td>83.90 ±14.37</td>
<td>62.92 ±8.40</td>
<td>16.78 ±5.84</td>
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<tr>
<td>EP</td>
<td></td>
<td>22.42 ±1.27</td>
<td>175.42 ±5.85</td>
<td>83.38 ±16.57</td>
<td>64.38 ±8.97</td>
<td>13.88 ±8.90</td>
</tr>
</tbody>
</table>

Note: Mean ± standard deviation.

2.2. Experimental method

2.2.1. Weight loss and training method

The athletes participating in the experiment were fully informed about the purposes and were restricted on the intake of certain drugs, alcohol and beverages containing caffeine during the weight loss period. As for the weight loss method, excluding the cool-down exercise and warm-up exercise, 120 minutes of induction technique training was the basic basis, and weight loss was achieved through the main exercise and diet control. Furthermore, the 6-day weight loss of the two groups resulted in a weight loss of 6-7% during the weight loss period according to a set plan. The weight loss method was reduced by using a combination of diet restriction and exercise through a reduction of 500 kcal per day based on previous studies on weight control by Katsilambros(2000)[20]. The simulated game after the weight loss(6th day) was held at K University’s Judo arena for 5 minutes according to the international competition format under the same conditions as the actual game.

2.2.2. Body composition measurement

The body composition was measured using the InBody 720(Biospace, Korea), which applies the Bioelectrical Impedance Analysis, to measure the subject’s body weight, lean mass, and total weight without fat percentage(% fat).

2.2.3. Electrolyte, immunoglobulin analysis method

A professional with a license to practice medicine directly collected blood from the brachial fluid 4 times before the weight loss, 6 days after the weight loss, right after 5 minutes of competition, and 30 minutes after recovery. After the blood collection, the blood was placed in an anticoagulant-treated tube and was centrifuged for 15 minutes at 3000 rpm in a centrifuge for...
measurement and analysis, and the test method for IgA, IgG, and IgM among the immune substances was based on the principle of immunoturbidity using immunoturbidimetric assay, and IgA(IgG, IgM) formed a precipitate with specific antibodies in the reagent and was measured at 340 nm wavelength. The reagent used was Cobas Integra IgA(Roche, Switzerland), and the measuring device was Cobas Integra(Roche, Switzerland).

2.3. Data processing method

For the statistical processing of this study, the mean and standard deviation for each item were calculated using the SPSS 12.0 statistical program, and the two-way repeated ANOVA was performed according to group(non-excellent athlete and excellent athlete) and time(before the weight loss, 6 days after the weight loss, immediately after the competition, recovery period 30 minutes), and in the case of an interaction effect, the post-test was conducted by contrast test for each period and paired t-test for each period. The statistical significance level was set to 0.05.

3. Result

3.1. Change in the body composition

Figure 1. Change in body weight(A), lean mass(B), and body fat(C) during the short-term weight loss period.

<Figure 1> demonstrates the change in body weight(A), lean mass(B), and change in the body fat percentage(C) before and after the weight loss(6 days after), immediately after the competition, and during the 30-minute recovery period. In the change of body weight over time by group(A), both groups significantly decreased(p<0.001) in the weight loss group(6 days after)
compared to before the weight loss \((p<.001)\). Yet, it increased significantly at 30 minutes of recovery \((p<.05)\). In the change of total weight without fat \((B)\), both groups significantly decreased in the weight loss \((after 6 days)\), yet increased significantly in the excellent players group than in the OP group \((p<.001)\), and was superior to the non-excellent athlete immediately after the competition. It increased significantly in the athlete group \((p<.01)\), and also significantly increased in the excellent athlete group than in the non-excellent athlete group at 30 minutes of recovery \((p<.05)\). In terms of the change of total weight without fat, both groups significantly decreased \((p<.001)\) compared to before the weight loss \((after 6 days)\), yet immediately after the competition, both groups increased, yet there was no significant difference. In the 30-minute recovery period, there was a significant increase in the excellent athlete group \((p<.01)\).

### 3.2. Changes in the blood electrolytes

*Figure 2.* Change in Ca(A), Na(B), K(C), and Mg(D) during the changes in blood electrolytes period.

<Figure 2> demonstrates the changes in calcium \((\text{Ca})\) \((A)\), Na \((\text{Na})\) \((B)\), K \((\text{K})\) \((C)\), and magnesium \((\text{Mg})\) \((D)\) before and after the weight loss \((6 days)\), immediately after the competition, and 30 minutes of recovery. Comparing the change \((A)\) of Ca between the groups for each period, both groups significantly decreased during the reduction period compared to before the weight loss \((p<.001)\). Regarding the weight loss \((after 6 days)\), the Judo athlete group significantly increased immediately after the competition \((p<.05)\) and decreased significantly at 30 minutes of recovery \((p<.05)\). Comparing the change in Na for each group \((B)\), both groups significantly increased immediately after the competition \((p<.01)\) for the weight loss \((6 days after)\) compared to before the weight loss in both groups \((p<.01)\). decreased significantly. The OP group significantly increased imme-
diately after the competition, and decreased significantly \( p < .05 \) after excessive weight loss \( \text{(after 6 days)} \) and 30 minutes of recovery. There was no significant difference between the groups by period. Comparing the change \( C \) of \( K \) by group between the periods, as for the weight loss \( \text{(after 6 days)} \), the EP group significantly decreased immediately after the competition, and the non-excellent athlete group significantly decreased immediately after the competition and at 30 minutes of recovery. Similarly, when comparing the change in \( \text{Mg} \) between the periods for each group, both groups significantly increased in the excessive weight loss \( \text{(after 6 days)} \) compared to that before the weight loss. Regarding the weight loss \( \text{(after 6 days)} \), there was no significant change in the Judo athlete group, and the non-excellent athlete group significantly decreased at 30 minutes of recovery. Across the entire period, the weight loss group of the EP significantly increased \( \text{(after 6 days)} \), yet decreased significantly \( p < .05 \) at 30 minutes of the recovery period.

### 3.3. Changes in the blood immunoglobulin

Figure 3. Change in IgA(A), IgG(B), IgM(C), and IgD(D) during the changes in blood electrolytes period.

<Figure 3> demonstrates the change in IgA(A), change in IgG(B), change in IgM(C), and the change in IgD(D) before and after the weight loss \( \text{(6 days)} \), immediately after the competition, and 30 minutes of recovery. Comparing the change in IgA between the periods by group, there was a significant increase in the excessive weight loss \( \text{(6 days after)} \) in the EP group compared to before the weight loss \( p < .001 \), and there was no significant change in the OP group. The OP group increased immediately after the game, yet decreased by 30 minutes during the recovery period, yet there was no significant difference. Comparing the change \( B \) of IgG between the
periods by group, the weight loss (6 days after) was significantly increased in the excellent athlete group compared to before the weight loss (p<.001), and there was no significant change in the OP group. For excessive weight loss (after 6 days), both groups significantly increased immediately after the competition (p<.01), and significantly decreased at 30 minutes of recovery (p<.05). In comparison of the change in IgM(C), there was a significant increase in the excessive weight loss (6 days after) in the EP group compared to before the weight loss (p<.01), and there was no significant change in the non-excellent athlete group. In the comparison of the change in IgD(D), there was a significant increase in the excessive weight loss (after 6 days) in the EP group compared to before the weight loss (p<.001). Between the groups by period, the EP group demonstrated significantly higher weight loss than the OP group (after 6 days), immediately after the competition, and 30 minutes of recovery (p<.05).

4. Discussion

Weight loss is a strategy of weight class athletes, which also impacts the victory and defeat. Many studies have been conducted on the physiological changes, biological and biochemical reactions of the human body during weight loss. Choma, Sporzo, & Keller (1998) reported a negative study result that inhibited function, and Freischlag, Koskinen, Laak, Rankinen, & Roukonen (1993) demonstrated conflicting views as a result of the study that there was no impact [21][22]. However, the goal of weight loss of athletes participating in physical sports is to compete in a lightweight class that is lower than their current body weight to obtain favorable performance. To achieve such a successful result, it is a situation in which weight loss is attempted repeatedly during the season with abnormal methods such as diet, high-intensity training, and dehydration to reduce the body fat to the extent possible and maintain the total weight without fat [23].

The effective weight loss of the weight class athletes is inextricably related to performance, which was presented as an important topic of interest in a study by kijin Kim, Seonjang Lee, and Inhyeon Jang (2000). The athletes participating in weight class competitions mainly apply a method of restricting diet for 3 to 5 days and a method of dehydration by controlling water in order to qualify [24]. In a study conducted on Judo athletes by Umeda, & Sugawara (2002) applying this method, weight loss through exercise and diet demonstrated a significant weight loss 1 day before the competition (2.8kg), and the reduction in the total weight without fat was 1.9 It has been reported that 68% in kg is due to total weight without fat [18][25]. This is considered to be due to the decrease in body water and the increase in the use of total weight without fat and protein as an energy source by restricting calories and voluntary dehydration through dietary restriction and high-intensity exercise. Furthermore, due to the steep weight loss before competition, the athletes in competitions by body weight may lose their balance before competition, which may adversely affect performance. Furthermore, during short-term weight loss due to dehydration, there is a high possibility of negative impact on the water metabolism through the imbalance in terms of the electrolyte concentration and decrease in the body fluid [26].

In particular, the loss of electrolytes in the body occurs concurrently with the loss of water centered on sweating during exercise. In this study, Ca was significantly decreased in both the Judo group and the group of friends in the excessive weight loss (after 6 days) compared to before the weight loss (p<.001), was significantly increased (p<.05), and decreased significantly in the recovery period (p<.05), and there was no significant difference in the group of friends, yet demonstrated a tendency to decrease over time. These results were consistent with the results of DaehueKoh and Seongchan Kim (2004) in the weight control of Taekwondo athletes where Ca decreased after the weight control and increased during the recovery period [27]. Such results demonstrate the fact that as a result of a decrease in Ca as Mg increases due to its
antagonistic action with Mg, it plays an important role in glucose metabolism by facilitating the reaction of synthesizing glucose into glycogen in the liver or muscle, glucose, which supplies energy to cells, and it is considered to be involved in the breakdown of fatty acids and amino acids.

Lactic acid, NH3, and LDH, which are fatigue-inducing substances that have an important impact on the exercise fatigue, are used as the indicators of the physiological exercise ability and the fatigue pattern analysis based on the energy metabolism\[28][29][30]. Supportive of such results, in this study, immunoglobulins(IgA, IgG, IgM, IgD) significantly increased during the excessive weight loss period and immediately after 5 minutes of competition. However, in the recovery phase, IgA, IgG, and IgM levels were significantly lower. Hence, in this study, the increase in immunoglobulin during short-term excessive weight loss is a change within the normal range, yet it is considered that it may cause an effect on immune function. Hence, in the case of domestic Judo athletes, most of them regularly lose weight, and if accumulated over a long period of time, it may cause an abnormal condition. Hence, it is considered that if the period weight loss is repeated continuously, it may affect the immune function.

5. Conclusion

Gathering the results of this study, the Judo athletes in Korea would be able to lose excess weight within 6-7% of their body weight over a short period of time, yet the long-term accumulation may cause abnormal conditions. Hence, it is considered that it may have a negative impact on the enzyme activity and immune function.

While the short-term excessive weight loss of the Judo athletes varies depending on the physical strength or physical characteristics of each individual, the excessive weight loss is considered to have a negative impact on the performance improvement and the pre-competition condition and performance. Based on the results of this study, the scientific weight loss methods and appropriate short- and long-term weight loss will serve as the important basic data for further studies to help improve the athletic performance of the athletes of weight class.

6. References

6.1. Journal articles


7. Appendix

7.1. Author’s contributions

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<td>- Significant contributions to concepts, designs, practices, analysis and interpretation of data ☑️</td>
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