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# The Effects Sodium Bicarbonate Intake on Blood Variables During High Intensity Exercise of Sprinter

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# 단거리 달리기선수의 고강도 훈련 시 중탄산염 섭취가 혈액변인에 미치는 영향

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**Abstract** The purpose of this study was to investigate the effect of bicarbonate intake on blood variables during high-intensity training of sprinters. 30 male/female elites with more than 3 years of experience that are registered to S city as a sprinter was categorized into three groups: control group, training group, and $HCO_3^-$ and training group. Training group and $HCO_3^-$ and training group went through a high-intensity exercise program (80-90% HR max) which escalated every 2-3 weeks, for 90 minutes at a time, 5 days a week, 8 weeks in total. $HCO_3^-$ and Training group took in 300㎎ of bicarbonate per one kilogram of body weight, in 90 minutes before the start of the high-intensity exercise program, once a day for 8 weeks. As a result of the study, the effect of bicarbonate intake on blood variables during high-intensity training of sprinters showed a positive effect on the increase of pH and the decrease of lactic acid in $HCO_3^-$ and training group. Also, the increase of $Ca^{2+}$, $Na^+$, $K^+$ was shown in training group and $HCO_3^-$ and training group, whereas there were no indications of significant change in $Mg^{2+}$ in all three groups. It can be confirmed that the intake of bicarbonate during high-intensity training shows effective changes in the increase of pH and the decrease in lactic acid among changes in blood variables. Therefore, it can be seen that the intake of bicarbonate during high-intensity exercise is effective in improving exercise capacity.

**Key Words :** Bicarbonate, Sprinters, High-intensity exercise, Athletic career, Blood variables

**요 약** 본 연구는 단거리 달리기선수의 고강도 훈련 시 중탄산염 섭취가 혈액변인에 미치는 영향 규명하는데 연구의 목적이 있다. S시 남·여 단거리달리기 선수로 등록된 운동경력 3년 이상의 엘리트 선수 30명을 대상으로 통제집단, 훈련집단, 중탄산염 투여와 훈련집단의 세 집단으로 설정 후, 고강도 운동프로그램은 통제집단과 중탄산염 투여와 훈련집단을 대상으로 80-90%HRmax 운동강도를 2-3주마다 증가시키며, 총 8주간, 주 5일, 1회 90분 실시하였다. 중탄산염 섭취는 중탄산염 투여와 훈련집단을 대상으로 체중 1kg당 300㎎을 고강도 운동프로그램 시작 90분 전 1일 1회 8주간 섭취하였다. 연구결과, 단거리달리기 선수의 고강도 훈련 시 중탄산염의 섭취가 혈액변인에 미치는 효과는 중탄산염 투여와 훈련집단에서 수소이온농도의 상승과 젖산의 감소에 긍정적인 효과가 나타났으며, $Ca^{2+}$, $Na^+$, $K^+$은 훈련집단과 중탄산염 투여와 훈련집단에서 유의한 증가가 나타났다. $Mg^{2+}$은 세 집단 모두에서 유의한 변화를 나타내지 않았다. 고강도 훈련 시 중탄산염의 섭취가 혈액변인의 변화 중 수소이온농도의 증가와 젖산의 감소에 효과적인 변화가 나타나는 것을 확인 할 수 있다. 따라서 고강도 운동 시 중탄산염의 섭취가 운동능력의 개선에 효과적임을 알 수 있다.

**키워드 :** 중탄산염, 단거리달리기 선수, 고강도 훈련, 운동경력, 혈액변인

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## 1. Introduction

The champion of the 100m sprint champion was the characteristic of each Olympic Games, and the champion was "the fastest person in the world". After the first modern Olympic Games, the dramatic world record trend was promoted by the major improvements in running surface and shoes along with training methodology and careful practice. Since sprint running is a key competence that underpins performance in many sports, there is a vast body of scientific literature dedicated to sprint training. Most sprint-related training interventions have been reported to have a positive effect on sprint function, and it was hypothesized that various methods can easily improve sprint performances[1-3].

The maximum speed during the 100m race is closely related to the total running time[4]. Therefore, maximum speed sprinting was highly important in 100m races. The possibility of running at higher maximum speeds will also improve performance in 200m and 400m races and long-distance and triple jumps[5]. Therefore, examining the determinants of maximum speed sprint performance is helpful not only to improve 100m performance, but also to improve performance in other events.

In sprinting, quick response and speed is a decisive factor that determines the outcome of the race. Sprinting which requires much strong power during a short period of time represents an anaerobic exercise that synthesizes ATP without using oxygen. Therefore, it is important to improve the activity of the ATP-PC system and the lactic acid system in the 100, 200 and 400 meter events, which are short-distance runners[6]. The increase in lactic acid concentration in the blood due to the performance of high-intensity anaerobic exercise function as a direct factor to decrease the concentration rate of pH, and the $HCO_3^-$. This reduced pH causes muscle fatigue and downgrades muscle contractility, leading to unavailability in performing high-intensity exercise for a long time, which ultimately affects the ability to perform. The alkaline components of bicarbonate, one of the pH buffers, holds the acid-base balance of blood by increasing the pH of blood as it neutralizes the lactic acid accumulated during the anaerobic energy metabolism of high-intensity exercise.

Choi et al[7] reported that administration of bicarbonate could delay muscle fatigue by acting as a buffer to increase the pH concentration. As a result of measuring sprinting abilities after exhaustive running, Shearman et al[8] studied 15 endurance athletes discovered that the group administered with bicarbonate showed a significant increase in performance.

In addition, Price et al[9] reported that as a result of repeating cycling and resting at various intensities, it showed an effect on performance improvement in the bicarbonate-administered group. Jeon et al[10] also reported that the administration of bicarbonate to the general public or trained athletes showed positive changes.

On the other hand, Han[11] reported that the results of bicarbonate administration to the judo athletes did not show any effect on oxygen intake, maximum oxygen intake, and anaerobic threshold increase. Kang et al[12] stated that positive effect on exercise duration improvement, but did not show significant difference in maximum oxygen intake and ventilation threshold.

According to the previous studies, the exercise type of aerobic energy metabolism did not show any change in general, whereas the exercise type of anaerobic energy metabolism reported positive results. Therefore, the effect of bicarbonate administration was expected to have a greater effect on neutralizing the accumulation of blood lactic acid due to short-term high-intensity anaerobic energy metabolism. The experiment would carry more validity when it was aimed at athletes who are typical sprinters of short-time, high-intensity exercise, and no research has yet been conducted on this. In addition, most of the preceding studies described earlier were limited to one-time only and were not conducted for a long period of time.

In order to prove the effect on the buffering action of bicarbonate during short-time maximal exercise in the anaerobic energy metabolism process, it should be examined that how the intake of bicarbonate of sprint runners affects the blood variables related to muscle contraction such as pH, lactic acid, $Ca^{2+}$, $Mg^{2+}$, $Na^{+}$, $K^{+}$. Therefore, this study aims to contribute to improving the performance of sprinting by examining the effect of bicarbonate intake on blood variables.

## 2. Research Method

### 2.1 Subject of Study

The subject of the study was an elite athlete with over three years of experience that are registered to S city as a sprinter, between 17 to 19 years old. The physical characteristics of the subjects are equal to Table 1.

### 2.2 Experimental Method and Treatment

This study was conducted to analyze the effect of bicarbonate intake on blood variables during high-intensity training in sprinters.

#### 2.2.1 Body Composition Examination and Information of Subjects

The subjects of this study used in-Body 520 to examine the weight, height and body fat percentage before and after the program, and they arrived at the laboratory 60 minutes before the measurement and took sufficient stability prior to the measurement.

#### 2.2.2 Intake of Bicarbonate

Sodium bicarbonate ($NaHCO^3$)was put into a gelatin capsule and taken orally along with 200 ㎖ of water in order for $HCO_3^-$ and training group to intake it easily. 0.3g (300㎎) per 1 kg of the subject's body weight was administered once a day. The dosage was based on the results of Linderman et al[13] and Price et al[9] that the administration of bicarbonate showed effective results in a dose of 300mg per 1㎏ bodyweight but showed ineffective results if the dose of less. In addition, the bicarbonate intake was undergone 90 minutes prior to the start of training[14,15], for eight weeks per day, as a result of consideration of the average time bicarbonate can reach its highest level in the blood.

#### 2.2.3 High Intensity Training Program

This study's high intensity training program targeted training group and $HCO_3^-$ and training group and designed to exercise five times a week (Mon to Fri), for eight weeks in total as seen in Table 2, 3, 4. Exercise intensity was increased gradually every week as in Table 2, 3, 4, and it was subdivided by day of the week as in Table 2, 3, 4 to diversify exercise items.

**Table 1. The Physical Characteristic of Subjects**

| Group | N | Height(Cm) | Weight(Kg) | Fat(%) | Age(yrs) | Career(yrs) |
|---|---|---|---|---|---|---|
| Control Group | 10 | 167.01±2.17 | 60.17±4.34 | 12.02±2.85 | 17.25±0.46 | 5.00±2.50 |
| Training Group | 10 | 172.03±1.52 | 62.35±3.08 | 11.40±3.45 | 17.00±0.96 | 4.91±1.47 |
| $HCO_3^-$ + Training Group | 10 | 170.61±2.19 | 62.28±2.59 | 11.31±1.38 | 17.50±0.51 | 5.00±2.30 |

Table 2. Interval Exercise Program

| Item | | Exercise | Time (90 min) | Period (Week) | Intensity |
|---|---|---|---|---|---|
| Warm Up | Mon Wed Friday | Jogging, Stretching | 20 min | 1~3Week | 80%HRmax |
| 1st Exercise | | Interval Training/100m × 5 set | 10 min | | |
| 1st Rest | | Break Time | 10 min | | |
| 2nd Exercise | | Interval Training/100m × 5 set | 10 min | 4~6Week | 85%HRmax |
| 2nd Rest | | Break Time | 10 min | | |
| 3rd Exercise | | Interval Training/100m × 5 set | 10 min | | |
| Cool Down | | Jogging, Stretching | 20 min | 7~8Week | 90%HRmax |

Table 3. Aquatic Exercise Program

| Item | | Exercise | Time (90 min) | Period (Week) | Intensity |
|---|---|---|---|---|---|
| Warm Up | Tuesday | Jogging, Stretching | 20 min | 1~3Week | 80%HRmax |
| 1st Exercise | | Underwater pitch 60sec×2set | 10 min | | |
| 1st Rest | | Break Time | 10 min | | |
| 2nd Exercise | | Underwater pitch 40sec×2set | 10 min | 4~6Week | 85%HRmax |
| 2nd Rest | | Break Time | 10 min | | |
| 3rd Exercise | | Underwater pitch 20sec×2set | 10 min | | |
| Cool Down | | Jogging, Stretching | 20 min | 7~8Week | 90%HRmax |

Table 4. Hill Exercise Program

| Item | | Exercise | Gradient | Time (90 min) | Period (Week) | Intensity |
|---|---|---|---|---|---|---|
| Warm Up | Thursday | Jogging, Stretching | | 20 min | 1~3Week | 80%HRmax |
| 1st Exercise | | Rising hill 60×3 | 20° | 10 min | | |
| 1st Rest | | Break Time | | 10 min | | |
| 2nd Exercise | | Rising hill 120×2 | 15° | 10 min | 4~6Week | 85%HRmax |
| 2nd Rest | | Break Time | | 10 min | | |
| 3rd Exercise | | Down hill 60× 3 | 20° | 10 min | | |
| Cool Down | | Jogging, Stretching | | 20 min | 7~8Week | 90%HRmax |

#### 2.2.4 Blood Collection and Analysis Method

Prior to the blood sampling, the sampling process, purpose, and expected side effects were fully explained to the subjects and 15㎖ of blood was collected from the left forearm main vein. The blood was collected four times in total before and after training, and the blood was collected 1) before the bicarbonate intake, 2) 90 minutes after bicarbonate intake (bicarbonate intake was limited to $HCO_3^-$ and training group blood was collected from all groups), 3) After high intensity training (control group was excluded from the training blood was collected from all groups), and 4) After 8 weeks and blood collection analysis was conducted on every groups.

### 2.3 Data Processing

In this study, the statistical program SPSS 18.0(Chicago, IL, USA) was used for data processing. All results were described in mean± standard development, and two-way repeated measure ANOVA was performed to verify the differences of the effects of bicarbonate intake on blood variables during high intensity exercise of sprinter in between the groups. As a post verification, tukey's test was performed. The significance level of all tests was set to $p<0.05$.

## 3. Results

### 3.1 Change in pH

Table 5 shows the results of changes in pH among the effects of bicarbonate intake on blood variables during high-intensity training for sprinters. There was a statistically significant difference between the pH group and the time-dependent interaction effect ($p<0.001$). Followed post-hoc verification, in case of $HCO_3^-$+TG, showed a statistically significant difference immediately after exercise compared to CG ($p<0.05$).

### 3.2 change in Lactic Acid

Table 6 shows the results of changes in lactic acid among the effects of bicarbonate intake on blood variables during high-intensity training in sprinters. There was a statistically significant difference between the lactic acid group and the time-dependent interaction effect ($p<0.001$). Followed post-hoc verification showed a statistically significant difference immediately after exercise ($p<0.001$) and 8 weeks after exercise ($p<0.01$) in the case of $HCO^{3-}$+TG compared to CG.

### 3.3 Changes in $Ca^{2+}$

Table 7 shows the results of changes in $Ca^{2+}$ among the effects of bicarbonate intake on blood variables during high-intensity training in sprinters. There was a statistically significant difference between the $Ca^{2+}$ group and the time-dependent interaction effect ($p<0.001$).

**Table 5. The change of pH (mean±SD)**

| | | Pre | Taking HCO3- After 90Min | Right After the Training | 8Weeks | Interaction (Group*Time) | |
|---|---|---|---|---|---|---|---|
| | | | | | | F | p |
| pH (mmol/ℓ) | CG | 7.30±0.04 | 7.30±0.37 | 7.30±0.03 | 7.27±0.02 | 11.364 | $<0.001^{***}$ |
| | TG | 7.28±0.04 | 7.28±0.38 | 7.26±0.03 | 7.27±0.04 | | |
| | $HCO^{3-}$ +TG | 7.29±0.03 | 7.26±0.03 | $7.28±0.03^{\#}$ | 7.32±0.03 | | |

*p<0.05, **p<0.01, ***p<0.001; tested by two-way ANOVA with repeated measure
#p<0.05, ##p<0.01, ###p<0.001; tested by Tukey post-hot compared to control group
CG: Control Group ; TG: Training Group ; $HCO_3^-$+TG: Intake $HCO_3^-$ and Training Group

**Table 6. The change of LA (mean±SD)**

| | | Pre | Taking HCO3- After 90Min | Right After the Training | 8Weeks | Interaction (Group*Time) | |
|---|---|---|---|---|---|---|---|
| | | | | | | F | p |
| Lactic Acid (mg/dℓ) | CG | 13.36±2.77 | 13.31±2.76 | 130.31±20.67 | 13.46±2.56 | 11.199 | $<0.001^{***}$ |
| | TG | 13.61±2.97 | 13.62±3.01 | 130.40±10.45 | 9.20±0.86 | | |
| | $HCO^{3-}$ +TG | 12.12±2.28 | 10.83±2.58 | $100.21±10.30^{\#\#\#}$ | $9.66±1.51^{\#\#}$ | | |

*p<0.05, **p<0.01, ***p<0.001; tested by two-way ANOVA with repeated measure
#p<0.05, ##p<0.01, ###p<0.001; tested by Tukey post-hot compared to control group
CG: Control Group ; TG: Training Group ; $HCO_3^-$+TG: Intake $HCO_3^-$ and Training Group

**Table 7. The change of $Ca^{2+}$ (mean±SD)**

| | | Pre | Taking HCO3- After 90Min | Right After the Training | 8Weeks | Interaction (Group*Time) | |
|---|---|---|---|---|---|---|---|
| | | | | | | F | p |
| $Ca^{2+}$ (mg/dℓ) | CG | 9.90±0.29 | 9.79±0.42 | 9.90±0.36 | 9.90±0.30 | 15.498 | $<0.001^{***}$ |
| | TG | 10.33±0.27 | $10.30±0.21^{\#\#}$ | 10.13±0.24 | $10.48±0.44^{\#}$ | | |
| | $HCO^{3-}$ +TG | 9.44±0.35 | 9.68±0.25 | 10.16±0.44 | $10.43±0.38^{\#}$ | | |

*p<0.05, **p<0.01, ***p<0.001; tested by two-way ANOVA with repeated measure
#p<0.05, ##p<0.01, ###p<0.001; tested by Tukey post-hot compared to control group
CG: Control Group ; TG: Training Group ; $HCO_3^-$+TG: Intake $HCO_3^-$ and Training Group

As a result, post-hoc verification showed statistically significant differences of TG compared to CG at 90 minutes ($p<0.01$) and 8 weeks ($p<0.05$) after ingestion of bicarbonate of TG. In the case of $HCO^{3-}$+TG, there was a statistically significant difference after 8 weeks ($p<0.05$).

### 3.4 Changes in $Mg^{2+}$

Table 8 shows the results of changes in $Mg^{2+}$ among the effects of bicarbonate intake on blood variables during high-intensity training in sprinters. There was no statistically significant difference between the $Mg^{2+}$ group and the time-dependent interaction effect ($p<0.5$). The post-hoc verification also showed no significance in both TG and $HCO^{3-}$+TG compared to CG.

### 3.5 Changes in $Na^{+}$

Table 9 shows the results of changes in $Na^{+}$ among the effects of bicarbonate intake on blood variables during high-intensity training in sprinters. There was a statistically significant difference between the $Na^{+}$ group and the time-dependent interaction effect ($p<0.001$).

**Table 8. The change of $Mg^{2+}$ (mean±SD)**

| | | Pre | Taking HCO3- After 90Min | Right After the Training | 8Weeks | Interaction (Group*Time) | |
|---|---|---|---|---|---|---|---|
| | | | | | | F | p |
| $Mg^{2+}$ (mg/dℓ) | CG | 1.88±0.12 | 1.85±0.15 | 1.89±0.11 | 1.90±0.10 | 0.736 | <0.5 |
| | TG | 1.90±0.12 | 1.90±0.11 | 1.80±0.09 | 1.88±0.70 | | |
| | $HCO^{3-}$ +TG | 1.81±0.10 | 1.86±0.15 | 1.81±0.15 | 1.81±0.06 | | |

*p<0.05, **p<0.01, ***p<0.001; tested by two-way ANOVA with repeated measure
#p<0.05, ##p<0.01, ###p<0.001; tested by Tukey post-hot compared to control group
CG: Control Group ; TG: Training Group ; $HCO_3^-$+TG: Intake $HCO_3^-$ and Training Group

**Table 9. The change of $Na^{+}$ (mean±SD)**

| | | Pre | Taking HCO3- After 90Min | Right After the Training | 8Weeks | Interaction (Group*Time) | |
|---|---|---|---|---|---|---|---|
| | | | | | | F | p |
| $Na^{+}$ (mEq/ℓ) | CG | 139.13±1.89 | 139.00±1.86 | 140.50±1.41 | 139.13±1.89 | 14.540 | <0.001*** |
| | TG | 140.75±0.71 | 140.13±2.30 | 141.63±1.85 | 142.50±1.07## | | |
| | $HCO^{3-}$ +TG | 137.75±2.32 | 140.00±1.60 | 142.00±1.70 | 143.25±1.67### | | |

*p<0.05, **p<0.01, ***p<0.001; tested by two-way ANOVA with repeated measure
#p<0.05, ##p<0.01, ###p<0.001; tested by Tukey post-hot compared to control group
CG: Control Group ; TG: Training Group ; $HCO_3^-$+TG: Intake $HCO_3^-$ and Training Group

**Table 10. The change of $K^{+}$ (mean±SD)**

| | | Pre | Taking HCO3- After 90Min | Right After the Training | 8Weeks | Interaction (Group*Time) | |
|---|---|---|---|---|---|---|---|
| | | | | | | F | p |
| $K^{+}$ (mmol/ℓ) | CG | 4.02±0.23 | 3.99±0.22 | 3.96±0.16 | 4.03±0.19 | 7.690 | <0.01** |
| | TG | 4.33±0.22 | 4.24±0.26 | 4.50±0.19## | 4.12±0.14 | | |
| | $HCO^{3-}$ +TG | 3.88±0.31 | 3.85±0.22 | 4.01±0.34 | 4.30±0.20# | | |

*p<0.05, **p<0.01, ***p<0.001; tested by two-way ANOVA with repeated measure
#p<0.05, ##p<0.01, ###p<0.001; tested by Tukey post-hot compared to control group
CG: Control Group ; TG: Training Group ; $HCO_3^-$+TG: Intake $HCO_3^-$ and Training Group

As a result, post-hoc verification showed a statistically significant difference after 8 weeks for TG compared to CG ($p<0.01$). In the case of $HCO^{3-}$+TG, a statistically significant difference after 8 weeks ($p<0.001$).

### 3.6 Change in $K^+$

Table 10 shows the results of changes in $K^+$ among the effects of bicarbonate intake on blood variables during high-intensity training in sprinters. There was a statistically significant difference between the $K^+$ group and the time-dependent interaction effect ($p<0.01$). As a result, post-hoc verification showed a statistically significant difference immediately after exercise ($p<0.01$) in the case of TG compared to CG. In the case of $HCO^{3-}$+TG, a statistically significant difference appeared after 8 weeks ($p<0.05$).

## 4. Disscussion

This study was conducted to investigate how the intake of bicarbonate of sprinters while their high-intensity training influences blood factors such as pH, lactic acid, $Ca^{2+}$, $Mg^{2+}$, $Na^+$, and $K^+$. The changes in blood variables after bicarbonate intake showed that the buffer reaction of bicarbonate to lactic acid and pH, that positive changes ($p<0.001$) were observed within the normal range, which is identical to the previous researches' results by Linderman et al[16], Kim, Yoon & Sung[17], McNaughton, Dalton & Palmer[18], and Han[19]. In particular, the result of changes in pH and lactic acid indicated a significant difference in $HCO^{3-}$+TG after exercise.

The intake of bicarbonate after anaerobic exercise of 80-90% HRmax showed positive effects on the decrease of lactic acid and the increase of pH, and it was confirmed that the intake of bicarbonate during high-intensity exercise played an important role as a buffer for maintaining the acid-base balance of body fluid.

$Na^+$, $K^+$, $Ca^{2+}$, $Mg^{2+}$, and minerals are dissociated into ions in body fluids and serve as regulators or adjuvants in all areas of the human body. As these ions exchange in the thin cortex of the nerve cell membrane, nerves are transmitted. Therefore, maintaining an appropriate amount of ions in the body is important for the promotion of metabolic functions and neurotransmission for muscle contraction.

$Ca^{2+}$ serves a very important role in nerve impulse transmission and muscle contraction during exercise. It is not only an important ion for neurotransmission at the terminal synapse of a nerve but also a factor that causes muscle contraction by decomposing ATP in the muscle fiber after acetylcholine was delivered to the muscle fiber membrane. Its normal range is 8.6 to 10.5㎎/㎗, and in this study, the increase in $Ca^{2+}$ within the normal range after ingestion of bicarbonate was considered to have a positive effect on muscle nerve transmission and muscle contraction.

$Mg^{2+}$ was the only blood variable that showed no statistical significance as a result of the experiment. $Mg^{2+}$ had an antagonistic action with $Ca^{2+}$, which is involved in muscle contraction, while $Mg^{2+}$ works as a substance related to muscle relaxation. Blood tests for $Mg^{2+}$ that were conducted in this study didn't confirm the changes in the results. However, the study of Kim et al[20] stated that the short-term high-intensity exercise showed an increase in ionized $Mg^{2+}$ in the muscles whereas Jung et al[22] reported that there was no increase in $Mg^{2+}$ after exercise. Studies to date related to $Mg^{2+}$ and exercise are still controversial.

$Na^+$ acts on osmotic pressure, pH regulation, neurotransmission, and muscle contraction mechanisms. The result of this study showed the change in $Na^+$ was within the normal range. In the case of TG ($p<0.01$) and $HCO^{3-}$+TG ($p<0.001$), statistically significant differences appeared after 8 weeks. The normal range of Na+ is 135-145meq/L, and it's especially related to the water state in the body. An absence of significant changes in $Na^+$ in the control group might lead to speculation that it's because there was no loss of water caused by exercise. However, more significant statistical differences in $HCO^{3-}$+TG compared to TG, it can be indicated that the uptake of medium carbonate had an impact on the increase of $Na^+$. As to the increase of pH, it is figured that the nerve transmission was kept regular and even, by the activation of the voltage in the sodium channel within the normal range of $Na^+$.

After the bicarbonate intake, $K^+$ within the normal range functioned as a mutual adjustment with $Na^+$, thus maintained the muscle contraction mechanism by sustaining the ion pump to work smoothly. The normal range of $K^+$ is 3.5 to 5.5 mEq/L in the blood and in the case of low·hyperkalemia, nerve-muscle abnormalities appear.

In particular, according to Kang[23], in the case of metabolic alkalosis, $K^+$ depletes through the kidneys and exhibits hypokalemia. However, this study showed that $K^+$ level appeared as 3.88±0.31mEq/L before the experiment, and 8 weeks after 4.30±0.20mEq/L, which indicates that the dose of bicarbonate intake was not to show the metabolic alkalosis. The increase of $K^+$ after the exercise could be considered that it also increased as a result of lactic acid rise after exercise at 80-90% HRmax. In this regard, $HCO^{3-}$+TG increased after 8 weeks compared to it was before, but when compared with the values immediately measured after exercise in the target group, it appears that the intake of bicarbonate contributed to lowering the acidity of the blood.

As such, the intake of bicarbonate was considered to be directly involved or assisted in place of ions in the body that were mobilized to remove or neutralize the accumulation of waste products such as lactic acid, pH, and H+ caused by the anaerobic exercise of 80-90% HRmax.

## 5. Conclusion & Suggestion

This study was set in three groups of comparison groups, training groups, bicarbonate intake and training groups in order to determine the effect of bicarbonate intake on blood variables during high-intensity training of sprinters, and after performing the exercise program for 8 weeks to the following conclusions were given.

The effect of bicarbonate intake on blood variables during high-intensity training of sprinters was positive in the $HCO^{3-}$ and Training Group on the rise of pH and the reduction of lactic acid. $Ca^{2+}$, $Na^+$, $K^+$ showed significant increases in both target group and $HCO^{3-}$ and training group. $Mg^{2+}$ showed no significant change in all three groups.

As stated above, it is possible to confirm that the ingestion of bicarbonate during high-intensity training shows an effective change in the pH of the blood shift and the decrease in lactic acid. Therefore, intake of an appropriate amount of bicarbonate to improve the performance of exercise made by anaerobic metabolic processes, such as short-distance running, is expected to enable continuous high-intensity exercise for a long time by maintaining lactic acid and body pH balance and rapidly improving fatigue. Also, maintaining

$Ca^{2+}$, $Mg^{2+}$, $Na^{+}$, $K^{+}$, and the body ions in the normal range would have a positive impact on the muscle contraction mechanism, as it regularly sustains the nerve transfer. In this regard, further researches on related matters such as exercise type and the appropriate timing of the bicarbonate intake, and duration are required.

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