

The Effect of a Customized Supplement Drink on Blood Lactate of Han-Madang Taekwondoin and Their Ability to Execute Momdollyo and Poomsae Techniques

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Abstract

Purpose: The adequate use of sport-related modern knowledge such as new findings regarding nutritional and dietary supplements is an essential prerequisite of success in modern professional sport. **Methods:** In this semi-experimental study, 11 nationally prominent Taekwondoin with 8 to 12 years of experience and profile of (Age: 20 ± 6 years, height: 178 ± 12 cm, weight: 67 ± 11 kg, wrist circumference: 17 ± 1 cm) were selected as subjects. The level of blood lactate, the time and speed of execution of Poomsae forms, and the number of Momdollyos successfully performed in 20 seconds were measured separately in a pre-test phase, after the intake of a placebo, and after the consumption of supplement drink. **Results:** Statistical results showed that lactate levels significantly increased compare to pre-tests in both groups. Although this increasing was not significant between groups in Momdollyo ($p=0.599$) and Poomsae ($p=0.303$). Indeed, number of successfully executed and also time of performance were significantly different in both Momdollyo ($P=0.000$) and Poomsae ($P=0.033$). **Conclusion:** Intake of discussed customized decaffeinated supplement drink increased speed and number of execution of Poomsae forms and Momdollyo techniques but it seems that lactate levels depends on other factors in taekwondoin.

Keywords: Sports Drink, Blood Lactate, Speed, Taekwondo

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INTRODUCTION

The modern professional sports are not solely focused on talent and exercise, but are also involved with a range of support factors such as professional training, psychology, scientific diets, and correct use of supplements, so the majority of professional athletes often use most or all of these factors, including authorized supplements, to maximize their athletic performance. Taekwondo is an Olympic sport with a large number of practitioners, a decent fan-base, and a competitive environment, and most Taekwondoin must often use scientific diets and supplements to excel in national and international competitions, so provision of professional advice regarding sport-specific authorized supplements with minimal side effects is essential and may even prevent life threatening complications. Taekwondo is quite popular in Iran and Iranian Taekwondoin often excel in regional and international competitions. Han Madang is one of taekwondo's main disciplines with a set of diverse and attractive techniques and an annual international championship competition (in South-Korea), often attended by athletes of more than 50 countries. Han Madang is a Korean term meaning a family gathering, where family members demonstrate their achievements and innovations so that they could be judged by their peers. In accordance with this meaning, Han Madang championships include a variety of competitions that are arranged to enable all family members with any physical, mental, psychological and technical ability to participate in this gathering. Han Madang competitions act as a showcase for a wide range of taekwondo skills and therefore have a particular appeal for the world's master Taekwondoin, so these competitions could be considered as International Taekwondo festivals or exhibitions (Park & Ahn 2016). In these exhibitions, all sorts of Taekwondoin with any nationality, age, sex, color, and race can demonstrate the result of their yearlong efforts, so each competition often exhibits numerous innovations and breaking of several records (Park & Ahn 2016). The Momdollyo record contest and the authorized Poomsae contest (participated by teams of two or three athletes) are some of the more popular Han Madang competitions. Speed is the essential factor of these two competitions, so this study seeks to investigate the efficacy of a supplement drink in improving the performance of athletes participating in these contests.

Buffers are supplements with proven ergogenic effects, which are particularly popular for high-intensity interval trainings (Artioli et al 2007; Greenwood, Cooke, Ziegenfuss, Kalman, Antonio 2015). Research conducted on the ergogenic effects of these substances have reported that buffers can act as a strong barrier against the early release of lactic acid and hydrogen ions, restore the PH of blood on the verge of acidosis, and improve the athletic performance by delaying the fatigue and exhaustion (Artioli et al. 2007; Douroudos et al. 2006; Lee, Lim, & Ji 2006; Hirakoba, Maruyama, & Misaka 1993; Matson & Tran 1993; Schuback, Essen-Gustavsson & Persson 2002). Most studies that have investigated the bicarbonate consumption have only done so in a single instance, and most of them have reported no significant impact on athletic performance (Kozak-Collins, Burke, & Schoene 1994; McNaughton, Ford, & Newbold 1997; Garrett & Kirkendall 2000). However, in an interval-based sport such as taekwondo, an athlete who wants to earn a medal must be able to compete in several tough matches in a single day. Therefore, to simulate a taekwondo tournament, which is often held in several continuous rounds, this study performed two instances of test parted by a one-hour rest. These tests are more likely to demonstrate the physiological benefits of sodium bicarbonate supplement, because bicarbonate is a powerful absorber of hydrogen ions and prevents premature blood acidification and consequent exhaustion, and thereby can improve athletic performance, especially in the next instance of practice or competition (Artioli et al 2007; Lee, Lim, & Ji 2017).

In a research by Artioli et al. (2007) authors investigated the impact of sodium-bicarbonate ingestion on simulated judo performance; they used two different training programs to evaluate the performance of subjects: the first program consisted of three instances of judo-specific tests (on 10 subjects) and the other one consisted of four instances of Wingate test for upper limbs (on 14 subjects), and in each program, athletes consumed 0.3 g of sodium bicarbonate per kg of body weight or placebo two hours before the test. These researchers reported that the use of sodium bicarbonate improves the performance in 2nd and 3rd instances of first training program and 3rd and 4th instances of second training program, and improves the peak power in 4th instance of second training program. They then argued that in intense short term exercises, release of lactic acid alters the acid-base balance, and the amount of released lactic

acid depends on the number of involved motor units and intensity and duration of exercise; but the use of bicarbonate act as a buffer against acidosis and alkalosis of blood and restores it to normal condition, and thereby delays the fatigue and improves the anaerobic power, especially in the next instance of exercise (Artioli et al 2007).

In the present study, the increased PH of subjects after taking sodium bicarbonate, especially in the second test, can be attributed to buffer like property of this supplement, which delays the exhaustion by absorbing the hydrogen ions produced at inter-test rest period. While some studies have not reported any change in the blood lactate and PH after taking sodium bicarbonate (Nielsen et al, 2002; Webster, Webster, Crawford, & Gladden 1993) other researchers believe that intake of sodium bicarbonate increases the level of lactate and PH after an interval exercise (Artioli et al 2007; Lee, Lim, & Ji 2017). In a study conducted by Khaledan et al. (2008) on the effect of sodium bicarbonate on acid-base balance of the blood of wrestlers, authors reported that taking this supplement increases the lactate and PH of blood after intense interval exercise (Khaledan, Mirdar, Sedaghatzadeh, & Gorgi 2008). Matson and Tran have reported that the intake of sodium bicarbonate increases the alkalinity of extracellular environment, increases the PH and HCO_3 , and improves the anaerobic power and the time-to-exhaustion (Matson & Tran 1993). Most studies have attributed the increased level of blood lactate accumulation to increased speed and duration of exercise and base power of subjects, and have attributed the increased level of blood PH after the intake of bicarbonate supplement to the buffering effect of this supplement.

Method

This paper presents a cross-sectional and quasi-experimental applied research that investigates the effect of a decaffeinated customized drink on the blood lactate and speed of Momdollyo technique and Poomsae forms 4-7 performed by male professional Han Madang Taekwondoin.

Population and Sample

After reviewing the records of 20 Han Madang Taekwondo champions in one of Iran's provinces (Semnan), 11 black belts Taekwondoin with 8 to 12 years of experience and body profiles of Table (4) were selected to participate in the tests. In a pre-test meeting held by researchers, participants received a full report and explanation about the procedures of

experiments and then filled the legal, health and PARQ forms. At the end of this meeting, the schedule of tests was determined and announced to participants.

	Age	Height	Weight	Wrist circumference
Unit of measurement	Year	centimeter	Kilogram	centimeter
Mean	20.0	178.6	66.7	17.0
Standard deviation	3.4	8.6	7.5	0.7

Inclusion and Exclusion Criteria

Participants needed to have at least three 45-minute exercises (as intense as the test) every week over the past 3 months; they also needed to have no history of cardiovascular diseases or recent history of treatment by medical or supplementary substances. Subjects were asked to refrain from eating and drinking caffeine and alcoholic substances before the test, avoid any exercise at least 48 hours before the test, refrain from the consumption of ergogenic substances such as vitamins, nutritional supplements, herbs, and also cigarettes for at least a week before the test, and avoid intense activities during that period (Bishop, Fitzgerald, Porter, Scanlon & Smith, 2005; Walker, Caudwell, Dixon, & Bishop 2006).

Protocol

Considering the diversity of Madang Han Taekwondo contests and techniques, two of the more popular contests, namely Momdollyo record and Poomsae form contests, were used to study the physical response of Taekwondoin. In these tests, participants were required to perform forms 4 to 7 of Poomsae technique (attacks and defends by hands and feet in the authorized manners, performed individually or as a team), and Momdollyo technique (turning kick) without exiting the designated area (a 2m² square) in 20 seconds. In Momdollyo test, participants were required to rotate around one foot and swing the opposite foot and use heels or soles of that foot to kick and break 1-cm thick wooden plates held by a member of support staff at the height of abdomen; the number of plates broken within the 20-second period were counted and recorded as the result pertaining to the participant (Park & Ahn 2016).

Research Variables

This study used a decaffeinated drink containing 3.5 g sodium chloride, 2.9 grams trisodium citrate dehydrate, 1.5 grams potassium chloride, 20 grams dextrose Anhydrous, and half a liter water plus 8% glucose (Pfeiffer et al. 2011; Rollo & Williams 2010; Currell & Jeukendrup 2008). The target variables of this study included the time, the speed, and the number of performed techniques, and the blood lactate of participants after the intake of abovementioned drink.

Research Method

In the pre-test meeting, the anthropometric characteristics of participants were measured and recorded (Table 1). To reduce the extent of interference on target variables, this study was performed via a double-blind arrangement in two sessions scheduled one week apart from each other. On the morning of the test, subjects were seated to rest for 10 minutes and then blood samples were taken from their fingers. Next, the placebo drink (mixture of a tablespoon of wheat flour, some lemon juice - as flavoring agent-, and 500cc of water) were administered to participants. After 40 minutes of rest, participants performed some supervised light exercise for 5 minutes to warm up and then performed the required techniques. After 6 minutes (the minimum time required for substance to affect the blood) blood lactate of participants was again measured by a lactometer.

All data including blood lactate, the time, speed, and count of performed techniques, and power and fatigue index calculated based on test guidelines were organized into subject-specific sheets. After completion of first phase and recording of placebo results, participants were asked to continue their weekly activities, avoid the use of nicotine, alcohol, stimulant drugs, and nutritional supplements, repeat the diet of past week as much as possible, and refrain from any exercise for at least 48 hours before the test. A week later, all procedures of the first test were repeated, but this time the supplement described in the previous sections was administered -instead of placebo- to subjects. The recorded and calculated results were again organized into subject-specific sheets, and were then analyzed in conjunction with previous observations.

RESULTS

The results showed that the intake of discussed supplement drink improved the athletic performance of Taekwondoin, since it increased the number of performed Momdollyo techniques and decreased the time required to perform Poomsae forms. The number of Momdollyo techniques performed after the intake of placebo was between 19 and 38 with an average of 25.64; and after the intake of supplement drink this variable reached to between 22 and 38 with an average of 27.27. The times required for execution of Poomsae forms 4-7 after the intake of placebo was between 02:00 and 02:02 with an average of 121.45s; but after the intake of supplement drink this variable reduced to between 01:42 and 2:01 with an average of 109.45s (Table 2).

Table 2: Time and numbers of Poomsae and Momdollyo

Variable	Unit	Technique	Group	Count	Mean	Standard deviation	T-statistic	Degrees of freedom	P
Number of successful execution	numbers	Momdollyo	Placebo	11	25.64	5.82	2.463	10	0.000*
			supplement drink	11	27.27	4.61			
Time of execution	seconds	Poomsae forms 4-7	Placebo	11	121.45	0.93	-6.186	10	0.033*
			supplement drink	11	109.45	6.65			

Table 2 examines the effect of intake of supplement drink on the time required to execute Poomsae forms and the number of successful execution of Momdollyos. The P values obtained in this table indicates that intake of supplement drink decreased the time of execution of Poomsae forms and increased the number of successful execution of Momdollyo technique.

Table 3 examines the effect of tests conducted on blood lactate of participants. The P values show that the exercise procedure increased the blood lactate of participants in both placebo and experimental instances.

Table 3: Lactate levels in different groups according paired t-student test

Variable	Unit	Technique	Group	Time of measurement	Count	Mean	Standard deviation	T-statistic	Degrees of freedom	P
Lactate	Mmol/L	Mondollyo	Placebo	During the rest	11	5.16	2.17	6.051	10	0.000*
				After the execution	11	12.15	3.54			
			supplement drink	During the rest	11	4.17	0.83	6.503	10	0.000*
				After the execution	11	11.43	3.64			
		poomsae forms 4-7	Placebo	During the rest	11	5.39	3.08	2.358	10	0.040*
				After the execution	11	9.23	4.79			
			supplement drink	During the rest	11	3.89	0.90	4.347	10	0.001*
				After the execution	11	11.21	5.48			

Table 4: Lactate levels in different groups according Independent t-student test

Variable	Unit	Technique	Group	Time of measurement	Count	Mean	Standard deviation	T-statistic	Degrees of freedom	P
Lactate	Mmol/L	Mondollyo	During the rest	Placebo	11	5.16	2.17	-1.28	10	0.231
				supplement drink	11	4.17	0.83			
			After the execution	Placebo	11	12.15	3.54	-0.53	10	0.599
				supplement drink	11	11.43	3.63			
		Poomsae forms 4-7	During the rest	Placebo	11	5.39	3.08	-1.48	10	0.171
				supplement drink	11	3.89	0.90			
			After the execution	Placebo	11	9.23	4.79	1.09	10	0.303
				supplement drink	11	11.21	5.48			

Chart 1: The number of successful execution of Mom dolleyo

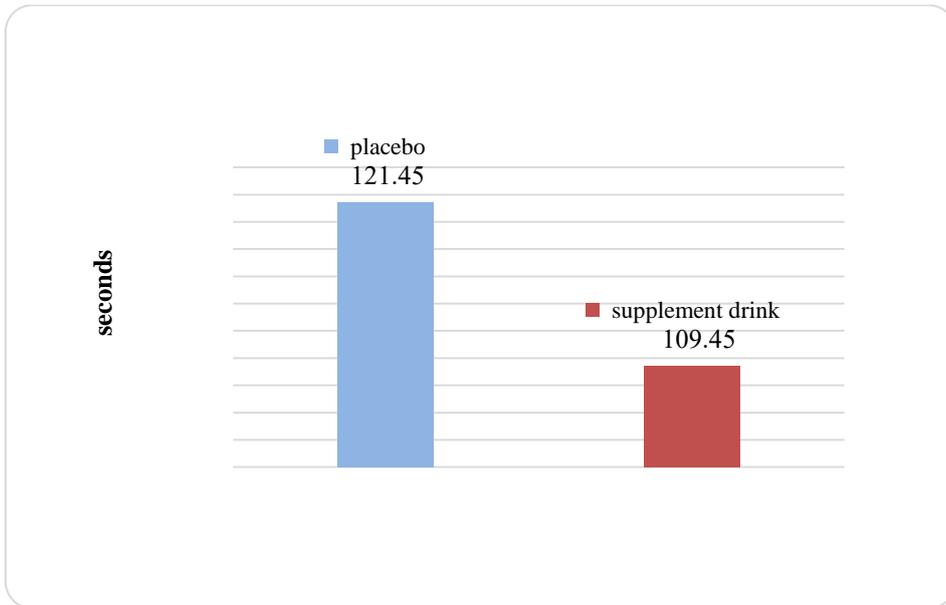


Chart 2: The time required to execute Poomsae forms 4-7

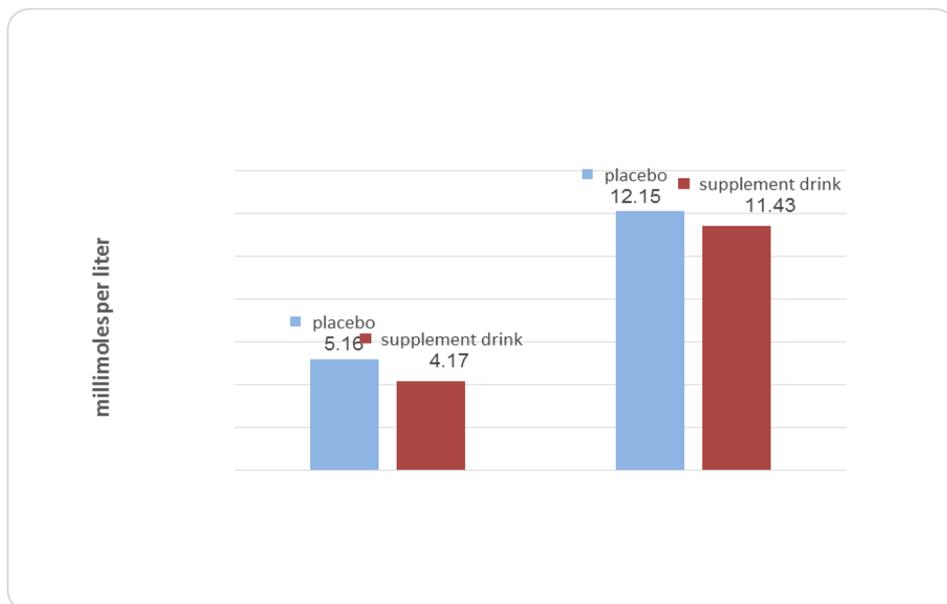
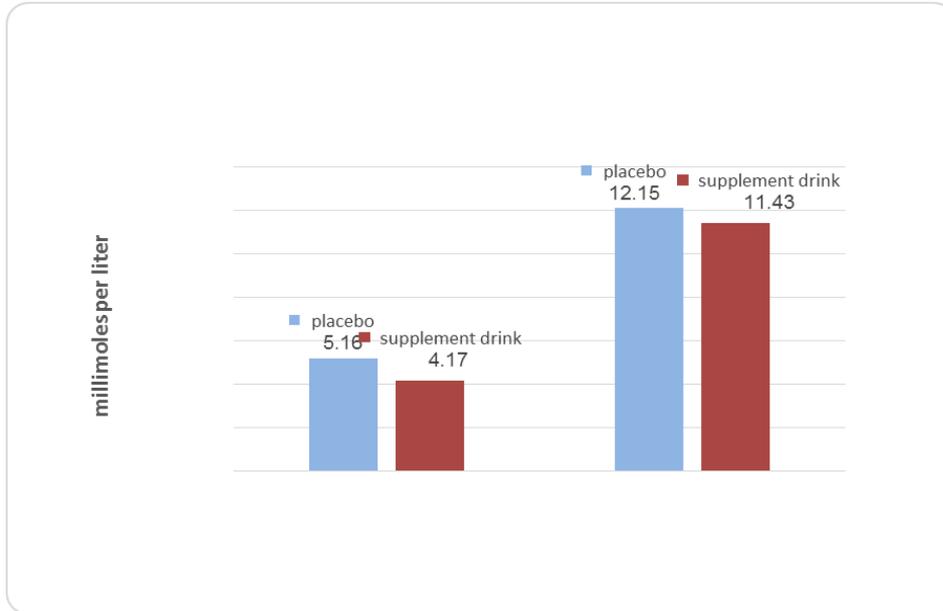
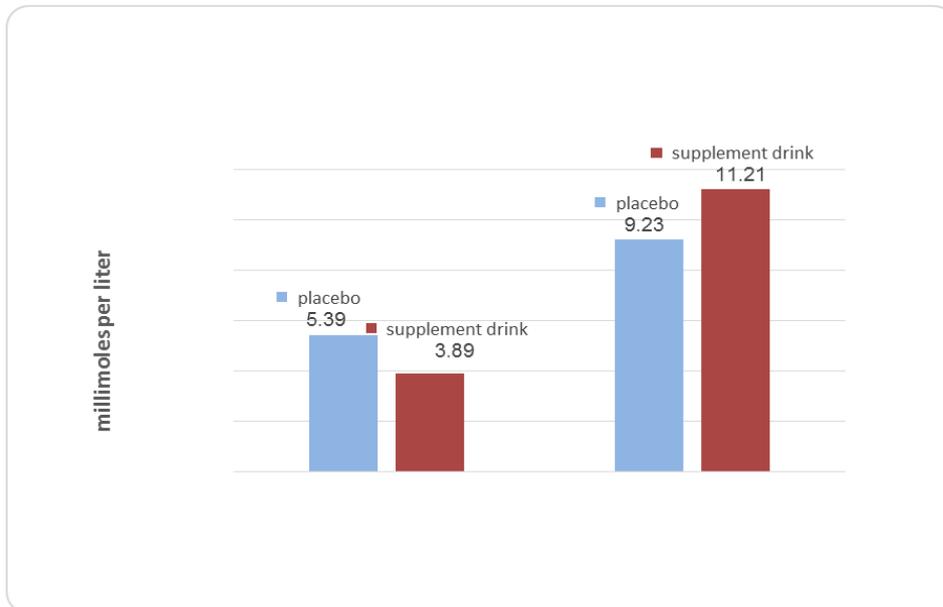


Chart 3: Blood lactate during the rest and after the execution of Momdollyo technique**Chart 4:** Blood lactate during the rest and after the execution of Poomsae forms 4-7

DISCUSSION

This study examined the effect of a decaffeinated supplement drink containing carbohydrates and sodium bicarbonate and found that the intake of this drink improves the athletic performance of Taekwondo in by decreasing the time required to execute Poomsae forms and increasing the number of Momdollyo s successfully executed within a limited duration. There were also some changes in blood lactate of participants before and after the designated exercises, but these changes were not predominant and, as other researchers have argued, could be attributed to the dose of supplement (Artioli et al 2007; Lee, Lim, & Ji 2017; Currell & Jeukendrup 2008). The increased level of PH measured at first and second test (as compared to pre-test), or in other words, the limited extent of changes in this parameter as compared to changes in base values at similar stages could be attributed to enhanced buffering effect caused by intake of bicarbonate, which could be considered as an advantage for Taekwondo in.

A study by Dorados et al. (2006) has reported that consumption of bicarbonate prevents the exercise induced acid-base imbalance and can improve the athletic performance by maintaining the PH level (Douroudos et al. 2006). In summary, their results show that, based on measurements conducted after two instances of ergo-jump test, consumption of sodium bicarbonate leads to insignificant increase in blood lactate response and anaerobic power, and significant increase in blood PH of athletes (Douroudos et al. 2006). A study by Gwacham et al. has reported that the intake of a caffeine-taurine energy drink does not affect the sprint performance and anaerobic power of athletes; however, only a small number of studies have investigated the effect of these drinks on anaerobic performance of girls and women (Gwacham & Wagner 2012). Alford has studied the effects of Red Bull energy drink and has reported that this drink can improve aerobic and anaerobic performance of athletes by 9 to 24 percent (Alford, Cox, & Wescott 2001). A research by Alsunni (2001) has also shown that carbohydrate protein drinks can improve the speed and reflex of athletes by 8 to 12 percent. He has also studied two types of popular energy drinks (Shark and Jeans), whose ads claim that they can improve speed and endurance, and anaerobic power, delay accumulation of lactic acid, and increase hematocrit and iron reserves; he has reported that consumption of these carbohydrate drinks

can replace the lost water (prevent dehydration) and maintain blood glucose and stored glycogen (Alsunni 2011). In highly competitive sports where differences between contestants are small, minor factors can determine the winners or losers of contest. One of the limitations of this study is the lack of a standard test designed specifically for taekwondo; so declaring a definite statement about the effects of sodium bicarbonate dietary supplement and its interaction with blood indices and athletic performance cannot be done without further research. This paper studied the effect of a customized supplement drink on blood lactate, and athletic performance of Han Madang Taekwondoin (the time required to execute Poomsae forms 4-7, and the number of successfully executed Momdollyos); the targeted parameters were obtained by gathering the required data from 11 nationally prominent Taekwondoin before and after they executed the designated techniques.

The amount of lactic acid released during an exercise depends on the number of involved motor units and its intensity and duration, and the use of sodium bicarbonate during intense short-term exercises can maintain the acid-base balance, since the consumed bicarbonate acts as a buffer against acidosis and alkalosis of blood and helps it maintain its normal condition, and thereby delays the fatigue and improves the anaerobic power, especially in multiple repetitions (Geraldini, Cruz, Romero, Fonseca, & Campos 2017). The use of sodium bicarbonate also increases the alkalinity of extracellular environment, increases the PH and HCO_3 , and improves the anaerobic power and the time-to-exhaustion. Sodium bicarbonate supplements act as a strong buffer against the release of lactic acid and hydrogen ions, prevent the blood PH to go into acidosis conditions, and improve the athletic performance by delaying the early fatigue and exhaustion, and this can also be seen in the results pertaining to athletic performance of Han Madang Taekwondoin executing Momdollyo technique and Poomsae forms. Momdollyo technique is a short-term intense exercise and anaerobic glycolysis and Phosphagen system is the most important source of ATP energy required for the execution of such techniques, since it facilitates the breakdown of Phosphocreatine (Pcr) into Creatine phosphate and reconversion of adenosine diphosphate (ADP) to (ATP); as anaerobic glycolysis becomes activated, glucose-6-phosphate released from muscle glycogen or glucose in the body turn into lactate and produce ATP through phosphorylation

reactions. Muscle glycogen stores tapped by anaerobic process and later by Phosphagen system are another source of energy for the short-term intense exercises, especially in the execution of Poomsae forms, so they can be utilized to prevent early exhaustion (Orrù et al. 2018). The discussed drink contains significant amounts of carbohydrates, which can increase the muscle glycogen stores, improve the neuromuscular transmission, and contractability and performance of muscles, and more importantly, prevent blood lactate accumulation and increased acidity of cellular environment, and thereby delay the fatigue and exhaustion.

CONCLUSION

Intake of discussed customized decaffeinated supplement drink increased speed and number of execution of Poomsae forms and Momdollyo techniques but it seems that lactate levels depends on other factors in taekwondo.

REFERENCES

- Alford, C., Cox, H., & Wescott, R. (2001). The effects of red bull energy drink on human performance and mood. *Amino acids*, 21(2), 139-150.
- Alsunni, A. A. (2011). Are Energy Drinks Physiological?. *Pakistan Journal of Physiology*, 7(1), 44-49.
- Artioli, G. G., Gualano, B., Coelho, D. F., Benatti, F. B., Gailey, A. W., & Lancha, A. H. (2007). Does sodium-bicarbonate ingestion improve simulated judo performance?. *International journal of sport nutrition and exercise metabolism*, 17(2), 206-217.
- Bishop, N. C., Fitzgerald, C., Porter, P. J., Scanlon, G. A., & Smith, A. C. (2005). Effect of caffeine ingestion on lymphocyte counts and subset activation in vivo following strenuous cycling. *European journal of applied physiology*, 93(5), 606-613.
- Currell, K., & Jeukendrup, A. (2008). Superior endurance performance with ingestion of multiple transportable carbohydrates. *Medicine+ Science in Sports+ Exercise*, 40(2), 275.
- Douroudos, I. I., Fatouros, I. G., Gourgoulis, V., Jamurtas, A. Z., Tsitsios, T., Hatzinikolaou, A., ... & Taxildaris, K. (2006). Dose-related effects of prolonged NaHCO₃ ingestion during high-intensity exercise. *Medicine and science in sports and exercise*, 38(10), 1746-1753.

- Garrett, W. E., & Kirkendall, D. T. (Eds.). (2000). *Exercise and sport science*. Lippincott Williams & Wilkins.
- Geraldini, S., Cruz, I. D. F., Romero, A., Fonseca, F. L. A., & Campos, M. P. D. (2017). Isotonic sports drink promotes rehydration and decreases proteinuria following karate training. *Brazilian Journal of Nephrology*, *39*, 362-369.
- Greenwood, M., Cooke, M. B., Ziegenfuss, T., Kalman, D. S., & Antonio, J. (Eds.). (2015). *Nutritional supplements in sports and exercise*. Humana Press.
- Gwacham, N., & Wagner, D. R. (2012). Acute effects of a caffeine-aurine energy drink on repeated sprint performance of American college football players. *International journal of sport nutrition and exercise metabolism*, *22*(2), 109-116.
- Hirakoba, K., Maruyama, A., & Misaka, K. (1993). Effect of acute sodium bicarbonate ingestion on excess CO₂ output during incremental exercise. *European journal of applied physiology and occupational physiology*, *66*(6), 536-541.
- Khaledan A, Mirdar S, Sedaghatzadeh, Sh.; Gorgi. (2008). The effect of sodium bicarbonate on blood pH of wrestlers after high-intensity interval trainings. *Journal of Sports Sciences*. 29:39-59.
- Kozak-Collins, K., Burke, E. R., & Schoene, R. B. (1994). Sodium bicarbonate ingestion does not improve performance in women cyclists. *Medicine & Science in Sports & Exercise*.
- Lee CW, Lim JM, & Ji YS. (2006). The effect of sodium bicarbonate and creatine loading on kicking ability of taekwondo players. *J Strength Cond Res*. 21(5):217-26.
- Matson, L. G., & Tran, Z. V. (1993). Effects of sodium bicarbonate ingestion on anaerobic performance: a meta-analytic review. *International Journal of Sport Nutrition and Exercise Metabolism*, *3*(1), 2-28.
- McNaughton, L. R., Ford, S., & Newbold, C. (1997). Effect of sodium bicarbonate ingestion on high intensity exercise in moderately trained women. *The Journal of Strength & Conditioning Research*, *11*(2), 98-102.
- Nielsen, H. B., Bredmose, P. P., Strømstad, M., Volianitis, S., Quistorff, B., & Secher, N. H. (2002). Bicarbonate attenuates arterial desaturation during maximal exercise in humans. *Journal of Applied Physiology*, *93*(2), 724-731.

- Orrù, S., Imperlini, E., Nigro, E., Alfieri, A., Cevenini, A., Polito, R., ... & Mancini, A. (2018). Role of functional beverages on sport performance and recovery. *Nutrients*, *10*(10), 1470.
- Park, J., & Ahn, Y. (2016). Discussion on Aesthetic Value of Freestyle Taekwondo Poomsae Competitions. 88 *서울올림픽기념 국제스포츠과학학술대회*, 41-41.
- Pfeiffer, B., Stellingwerff, T., Zaltas, E., Hodgson, A. B., & Jeukendrup, A. E. (2011). Carbohydrate oxidation from a drink during running compared with cycling exercise. *Medicine and science in sports and exercise*, *43*(2), 327-334.
- Rollo, I., & Williams, C. (2010). Influence of ingesting a carbohydrate-electrolyte solution before and during a 1-hour run in fed endurance-trained runners. *Journal of sports sciences*, *28*(6), 593-601.
- Schuback, K., Essen-Gustavsson, B., & Persson, S. G. B. (2002). Effect of sodium bicarbonate administration on metabolic responses to maximal exercise. *Equine Veterinary Journal*, *34*(S34), 539-544.
- Walker, G. J., Caudwell, P., Dixon, N., & Bishop, N. C. (2006). The effect of caffeine ingestion on neutrophil oxidative burst responses following prolonged cycling. *International journal of sport nutrition and exercise metabolism*, *16*(1), 24-35.
- Webster, M. J., Webster, M. N., Crawford, R. E., & Gladden, L. B. (1993). Effect of sodium bicarbonate ingestion on exhaustive resistance exercise performance. *Medicine and Science in Sports and Exercise*, *25*(8), 960-965.