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PROSPECTIVE COHORT STUDY

Electrolyte Replacement Strips and their Perceived Effect on Performance and Cramping: A Survey Study

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ABSTRACT

Introduction: Exercising athletes lose electrolytes during exercise. Hydration and electrolyte supplementation have been extensively researched regarding cramping and performance, often with conflicting results. The purpose was to study the perceived impact electrolyte replacement strips have on cramping and recovery. These strips are absorbed buccally, bypassing the gastrointestinal route.

Materials and methods: Our hypothesis was: During exercise, subjects using electrolyte replacement strips will feel that performance, cramping, and recovery are improved. The electrolyte strips used, Enlyten SportStrips™ a product of Healthsport Inc., are a bioabsorbable strip containing sodium, chloride, and potassium. A total of 100 subjects participated in this survey study. The institutional review board approved the study and waived consent. Subjects completed a survey addressing their perceptions of the effects of using electrolyte strips during exercise. Questions were related to cramping, performance, and overall perception of how hydration and electrolytes affect these parameters, specifically addressing the effectiveness of these electrolyte strips.

Results: Average age of subjects was 29.5 years, with 81 males and 18 females (one subject did not indicate gender); 69% of the subjects used the product correctly. On the survey, "Agree" represented a score of 4 or 5 on a 5-point Likert scale; 94% of subjects believe that hydration helps performance, 71% believe that electrolytes help performance, and 49% believe that sports drinks help performance; 81% believe that electrolytes prevent cramping, and 56% believe that sports drinks prevent cramping. There were differences in responses between correct and incorrect users of the strips: 74% of those who used the product correctly felt that strips help performance, compared with 51% of incorrect ($p > 0.05$); 69% of those using the strips correctly indicated that they cramped less when using the strips, compared with 61% of those using them incorrectly ($p > 0.05$); 63% of those using the strips correctly indicated that they recovered quicker with the strips, compared with 32% of those using them incorrectly ($p = 0.005$).

Conclusion: Athletes identify hydration and electrolytes as important components to preventing cramping and enhancing performance. During exercise, a majority of respondents felt that electrolyte strips helped performance, reduced cramping, and enhanced recovery. Those who used the product correctly tended to find the product more beneficial. Electrolyte supplementation may play a role in enhanced performance and recovery in exercising athletes. Buccal absorption is emerging in a variety of markets, and its use for athletic performance is a logical next step.

Keywords: Electrolytes, Enlyten, Exercise, Recovery.

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Conflict of interest: An author, Claude T Moorman III, is on the medical advisory board for Enlyten SportStrips™.

INTRODUCTION

Electrolytes are essential to the proper function of multiple different cellular processes. Electrolytes are consumed and excreted in our bodies on a daily basis. For athletes, maintaining this homeostasis is imperative both for proper cellular function and for maximizing performance. Drinks, foods, medicines, and supplements are all sources for daily electrolyte intake that are eventually excreted in sweat, urine, and feces. Sedentary humans lose approximately 2–3 L of fluid a day, while studies have shown that this can increase to 12–20 L in intensively training athletes.[1] These losses require electrolytes to be constantly supplied before, during, and after exercise to ensure optimal performance and recovery.

The supplementation of electrolytes has been researched extensively regarding prevention of cramping, hydration, recovery, and performance.[2-6] Studies have also examined sweat rate, sweat composition, and fluid loss in relation to exercise and performance.[7-11] A number of these studies address the beverages athletes consume and the substances contained within these products.

The intestinal absorption of electrolytes during exercise has been researched with varying results.[2,12] Electrolyte strips were created in an attempt to bypass

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Fig. 1: Enlyten SportStrips™, enlyten.com

intestinal absorption, providing electrolytes via the buccal mucosa. Absorption through the buccal mucosa has been studied as an alternative to intestinal absorption and has been shown to be an effective medium for the delivery of drugs, such as captopril, peptides, proteins, polysaccharides, nucleic acids, amphetamine, estradiol, and ouabain, as well as for electrolytes.[12-15] Delivery of drugs through the buccal mucosa is expanding quickly to include a variety of prescription and over-the-counter medications. Studies using antihypertensive medications have shown that it takes less time to reach peak plasma drug concentration when administered through the oral mucosa compared with peroral administration.[14] To date, Enlyten SportStrips™ (Fig. 1) are the first electrolyte product to use a bioabsorbable strip to provide electrolytes for absorption via the buccal mucosa. This study is the first time this product has been studied. In contrast, intestinal absorption and intravenous methods for electrolyte replacement have been well studied.

The primary purpose of this survey study was to evaluate athletes' perceptions about the effectiveness of electrolyte strips. Additionally, we sought to evaluate athletes' beliefs about hydration and electrolyte supplementation in relation to performance and cramping during exercise.

MATERIALS AND METHODS

This was an anonymous survey study. The project was reviewed and approved by our Institutional Review Board. The inclusion criteria were: Subjects of any age who had used electrolyte strips three or more times during exercise in the past 3 to 6 months. Subjects were recruited by word of mouth, the internet, and local athletic teams and organizations. No participants were paid to participate in the study; however, some athletic teams received free product. Subjects completed either a paper copy of the survey that was returned by fax or mail, or they completed an online form that was sent via secure e-mail. Conventional descriptive statistics were used to evaluate subject responses and Student's t-tests were used to compare the difference between those who used the product correctly and those who used the product incorrectly. Significant p-value was assigned at 0.05.

RESULTS

One hundred subjects participated in the survey, with 81 males and 18 females (Table 1). One respondent did not indicate gender. The average age of the participants was 29.52 years. Subjects indicated participation in the following sports: Running (n = 29), football (n = 26), basketball (n = 14), cycling (n = 14), soccer (n = 12), tennis (n = 9), lacrosse (n = 9), golf (n = 6), weight training (n = 6), baseball (n = 4), volleyball (n = 4), swimming (n = 3), hiking (n = 3), triathlons (n = 3), skiing (n = 3), roller blading (n = 3), racquetball (n = 2), skating (n = 2), snowboarding (n = 1), judo (n = 1), yoga (n = 1), aerobics (n = 1), surfing (n = 1), squash (n = 1), softball (n = 1), and wrestling (n = 1). Some subjects indicated participation in more than one sport. These participants were mostly in university athletics with some being in intramural activities. Correct use indicated placement of the strips in the cheek or along the gums in the mouth, and incorrect use indicated that the strips were placed on the tongue or the roof of the mouth. Although in this study no focus group was used, a test population of professional football players was used. The survey was designed to assess the hypothesis regarding the perceived effect on cramping and recovery. For the analysis, "Agree" indicated a response of 4 or 5 on the 5-point Likert scale, "Neutral" indicated a response of 3, and "Disagree" indicated a response of 1 or 2.

Regarding the respondents' general beliefs about how electrolytes and hydration affect performance and cramping (Table 2), 94% believe that proper hydration helps performance; 71% believe that electrolytes help performance, and 81% believe that electrolytes prevent cramping. Of those that responded, 49% believe that sports drinks help performance and 56% believe that sports drinks prevent cramping.

Table 3 summarizes the results of questions pertaining to the use of the electrolyte strips. A large number of respondents (31%) did not use the product as it was intended, and thus the results were divided into those who used the strips correctly (69 respondents) and those

Table 1: Demographics

	Average	*Range*
Age (years)	29.52	9–64
Height (inches)	70.93	54–82
Weight (lb)	192.30	46–650

Table 2: Subjects' beliefs about performance and cramping

Question	*% Agreed*	*% Neutral*	*% Disagreed*	*Mean*	*Median*
Believe hydration helps performance	94	3	3	4.5	5
Believe sports drinks prevent cramping	56	36	8	3.64	4
Believe sports drinks help performance	49	43	8	3.57	3
Believe electrolytes help performance*	72	26	2	3.99	4
Believe electrolytes prevent cramping*	82	17	1	4.19	4

*One person did not answer this question

Table 3: Effects of Enlyten SportStrips™

Question	*Used product*	*Agreed (4/5)*	*% Agreed*	*Neutral (3)*	*% Neutral*	*Disagreed (1/2)*	*% Disagreed*	*Mean*	*Median*	*p-value*
Feel that strips helped performance	Correctly	51	74	16	23	2	3	4	4	
	Incorrectly	16	52	15	48	0	0	3.7	4	
	Total	67	67	31	31	2	2	3.9	4	0.098
Feel that strips hindered performance	Correctly	2	3	8	12	59	86	1.8	2	
	Incorrectly	1	3	5	16	25	81	1.8	2	
	Total	3	3	12	12	84	84	1.8	2	0.98
Cramped less when using strips	Correctly	48	70	19	28	2	3	4	4	
	Incorrectly	19	61	11	36	1	3	3.8	4	
	Total	67	67	30	30	3	3	3.9	4	0.49
Recovered quicker when using strips	Correctly*	45	66	22	32	1	1	3.9	4	
	Incorrectly	10	32	20	65	1	3	3.4	3	
	Total	55	56	42	42	2	2	3.8	4	0.0046

*One person did not answer this question

who used them incorrectly (31 respondents); 74% of subjects who used the strips correctly felt that the strips helped performance, compared with only 51% of subjects who used the strips incorrectly ($p > 0.05$). Similarly, 69% of correct users felt that the strips decreased cramping, compared with 61% of incorrect users ($p > 0.05$); 63% of subjects who used the strips correctly felt that the strips helped them to recover more quickly, while 32% of those who used the strips incorrectly agreed that the strips helped them to recover more quickly ($p = 0.005$).

DISCUSSION

Our hypothesis was: During exercise, subjects using the electrolyte strips will feel that performance, cramping, and recovery are improved. The survey responses supported this hypothesis. This survey study was designed to ascertain people's perceptions about the effectiveness of the electrolyte strips. Furthermore, we evaluated athletes' beliefs about hydration and electrolyte supplementation as it relates to athletic performance and cramping prevention. We were interested to see how the subjects' perceptions of general hydration and electrolytes related to use of the electrolyte strips.

The survey began by addressing the beliefs of subjects concerning the effects of hydration, electrolytes, and sports drinks on performance and cramping. The first question revealed that 94% of respondents believe that proper hydration improves performance and that 72% of respondents also indicated belief that electrolytes enhance performance. However, when the athletes were asked if sports drinks enhanced performance, only 49% agreed. A similar gap was observed when subjects were asked about cramping: 82% believe that electrolytes reduce cramping, while only 56% believe that sport drinks prevent cramping. One would expect that the agreement would be similar for these two questions. The beliefs about hydration are not surprising, since prior research has consistently shown a strong relationship between hydration and performance.[5,6,16] However, this does not explain why only half of those surveyed felt that sports drinks helped performance, as sports drinks are simply the combination of fluids and electrolytes. Clearly, there is a disconnect between subjects' beliefs about hydration and electrolytes, and their beliefs about the corresponding effectiveness of sport drinks.

Prior research concerning intestinal absorption has varied greatly.[2,12,13,17] Gisolfi et al[2] reported three findings involving intestinal absorption: First, that there was no difference in water or electrolyte absorption rate between resting, exercising, or recovery periods; second, that there was no difference in absorption rate between 30, 50, and 70% of maximal exercise; and third, that there was significantly greater fluid absorption with a carbohydrate-electrolyte (CE) beverage than with water alone. Maughan et al[11] showed that time to peak concentration was longer in exercising subjects than in resting subjects,

concluding that intestinal absorption is less efficient during exercise. Barclay et al[18] found that water absorption in the jejunum was significantly reduced during moderate cycling exercise. Hill et al[19] showed that exercise even as low as 55% of maximum performance could decrease absorption of water compared with resting conditions. On the contrary, Fordtran and Saltin[20] showed that exercise had no influence on the absorption rate of glucose, water, sodium, chloride, potassium, or bicarbonate. The buccal mucosa is a novel method of drug delivery, and it is being utilized and examined in new ways for prescription drugs, as well as electrolyte supplementation.[13] While electrolyte supplementation via the buccal mucosa has yet to be studied *in vivo* in humans, it has been studied and determined to be an efficient method of electrolyte supplementation *in vitro* and in other mammals.[12] Orlando et al[12] studied sodium transport across the buccal mucosa in humans as well as in rabbits, dogs, and hamsters, finding that electrolyte transport across the buccal mucosa is active, rather than passive, which translates into quicker absorption of sodium than would occur with passive or intestinal absorption.

When analyzing the data, it was noted that a significant number of subjects were using the strips incorrectly. When the strips are placed incorrectly, they do not come into direct contact with the buccal mucosa, so it is less likely that any significant absorption takes place via this route. Strips placed on the tongue or roof of the mouth would come into contact with saliva more easily and be swallowed, thereby entering the gastrointestinal tract, and effectively negating the potential benefits of the buccal absorption method. We observed that those who used the strips incorrectly seemed to have less satisfaction with the effectiveness of the electrolyte strips. When used properly, the strips offer a method of electrolyte supplementation via the buccal mucosa. In order to accurately depict any differences between the delivery systems, it must be known for certain which system is being used. For this reason, the respondents were divided into two groups: Those who used the electrolyte strips correctly, and those who used them incorrectly. Correct use was defined as placement of the strips between the cheek and the outside of the teeth, either directly on the cheek or along the gumline. Incorrect use was defined as placement of the strips on the tongue or roof of the mouth. For this survey, 69% of people indicated correct use of the strips.

The primary question of this study was: Did athletes find the strips beneficial? 67% of respondents felt that the strips helped their performance during exercise. As shown in Table 3, 74% of people who used the product correctly indicated that they felt that the strips helped their performance, compared with 52% of people who used the product incorrectly. While the difference between the groups is not statistically significant ($p = 0.098$), it demonstrates an interesting trend that justifies the need for further research. Prior research by Sanders et al[9] found that orally replacing lost water and sodium during exercise maintained plasma volume. This leads to the question: Does maintained plasma volume translate to better performance? Von Duvillard et al[6] looked at 74 studies concerning fluid and electrolyte replacement during exercise and concluded that lack of fluid and electrolyte replacement leads to a decrease in exercise performance. However, Sharwood et al[21] found that there was no relationship between serum sodium levels and performance during the South African Ironman Triathlon. Twerenbold et al[22] found that there were no significant differences in performance when comparing high sodium concentration fluids, low sodium concentration fluids, and water. In this survey, the majority of respondents indicated that electrolyte strips helped their performance during exercise.

Of all respondents, 67% indicated less cramping during exercise when using electrolyte strips. When broken down, 70% of those who used the product correctly indicated less cramping, compared with 61% who used the strips incorrectly ($p = 0.49$). These findings are interesting because the literature concerning the relationship between electrolytes and cramping is highly controversial. Jung et al[23] found that while athletes exercising in a hot environment still got exercise-associated muscle cramps, the time to cramping was more than doubled in the trial when a CE beverage was consumed compared with when the subjects were hypohydrated. While this study did find significant results in time to cramping, the researchers were comparing subjects in a hypohydrated state with those being supplemented with a CE beverage, so any results observed could be due to electrolyte loss, dehydration, or a combination of both. In contrast, studies by Schwellnus et al[24] and Sulzer et al[25] found no clinically significant differences in athletes' serum sodium levels between crampers and noncrampers at the end of a 42 km or Ironman race, suggesting that serum electrolyte concentrations are not associated with development of exercise-associated muscle cramps. Our results are contrary to these findings. A majority of subjects in our study indicated that electrolyte supplementation with electrolyte strips decreased their cramping. However, this survey study only studied the perceived decrease in cramping and not actual cramping reduction.

The only question that yielded statistically significant differences between those who used the strips correctly and those who used them incorrectly involved recovery from exercise. Of the complete pool of subjects, 56% of subjects felt that the strips helped them to recover more quickly from exercise. However, when this was split

into correct and incorrect use, 66% compared with 32% of people experienced quicker recovery from exercise when using the strips (p = 0.005). We did not define "recovery" in the survey. Khanna and Manna[26] studied the effects of a CE drink on performance, blood glucose, lactate removal, and cardiovascular responses during exercise and recovery, finding significant improvement in total endurance time, heart rate responses, and blood lactate with the CE solution *vs* no supplement during both the exercise and recovery periods. While these results support the idea that electrolytes may have an effect on recovery from exercise, there are some flaws with the experimental design that call into question the significance of these results. In particular, subjects either did or did not receive a CE solution. This potentially led to dehydration and thus is not an accurate reflection of the utility of electrolyte supplementation. Merson et al[27] found that differing the sodium concentration of fluids ingested after 2% body mass loss due to exercise in the heat had no effect on exercise performance during subsequent exercise; however, they did find that urine output was significantly less, indicating that increased sodium chloride concentration provided more effective fluid retention than sodium-free beverages.

There are several limitations to this study. First and foremost, it is a survey study. Performance and cramping were not actually measured as part of the study. There was inherent selection bias for the participants in the study. Simply it was the first 100 people to respond that were included in the study. Also, the electrolyte strips were made available to many of the athletic teams; this could be a perceived endorsement by those athletic teams. Athletes might be under the conclusion that because the teams were using the strips, the strips must have been previously proven to enhance performance. Another thing to note is that there are several confounding variables that impact cramping and performance including: Oral rehydration, equipment, and environmental conditions, such as air temperature and humidity.

CONCLUSION

This survey showed that participants are open to the idea that electrolyte supplementation can have a positive perceived effect on performance and cramping. The results also show that participants who used electrolyte strips felt that the strips were effective at increasing performance, decreasing cramping, and quickening recovery. Further research is needed to quantitatively show how electrolyte strips affect these parameters. Studies examining the strips' effects on performance and cramping, as well as possibly analyzing absorption rate of the electrolytes are needed to obtain a better picture of the effectiveness and benefits of electrolyte strips.

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