Online Weekly Educational Newsletters Improve High-School Athlete's General and Sports-Related Nutrition Knowledge to Prevent a Risk of Relative Energy Deficiency in Sport

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ABSTRACT

Objectives: To assess the effectiveness of educational nutrition newsletters on nutrition knowledge in high school athletes, designed to reduce the risk of relative energy deficiency in sport (RED-S) through improved dietary habits.

Design: Quasi-experimental

Methods: General nutrition knowledge, sports nutrition knowledge and eating habits and patterns in high school athletes were compared using pre- and post- surveys. Athletes' nutrition related knowledge was evaluated by comparing final grades of the surveys. Athletes' eating habits and patterns were evaluated by comparing specific survey questions. The intervention was developed utilizing the social cognitive theory.

Setting: New York (online/remote)

Participants: 6 high-school athletes scored on the pre- and post-surveys and received the weekly newsletters. 4 athletes were female, and 2 athletes were males.

Intervention: A series of 4 weekly newsletters were emailed to participants at the start of each week. Topics of the newsletters pertained to RED-S and included an overview of RED-S, carbohydrates, protein, and vitamin D/calcium.

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Results: Weekly newsletters significantly increased high school athletes' knowledge pertaining to RED-S, general nutrition, and sports related nutrition ($p < 0.05$). 33% of participants showed an improvement in dietary habits and behaviors. The weekly newsletters had no significant effect on improving eating habits or eating patterns ($p > 0.05$).

Conclusions and Implications: Online weekly educational newsletters utilizing the social cognitive theory is an effective mass media teaching technique to significantly improve high school athletes' general and sports nutrition knowledge. Further research is needed on interventions to improve dietary habits.

INTRODUCTION

When it comes to sports, nutrition and dietary habits are some of the most important factors that can impact the level of performance in athletes, as well as long-term health. To obtain peak performance and uphold that level of performance, athletes must nourish their bodies correctly to sustain overall health. One way to ensure optimal performance and health is by maintaining

energy balance between food consumption and energy exertion.

If an unbalanced energy state occurs overtime, athletes are at risk of developing a serious condition known as relative energy deficiency in sport, or RED-S. RED-S is a state of health that results from an insufficient intake of calories and/or excessive energy expenditure. When a state of chronic energy deficiency ensues, the functioning of multiple body systems can become impaired.[1] The body does not have enough energy to support exercise and certain body functions. Overtime, this condition can affect bone health, menstrual function, hormone function, metabolic rate, immune function, organ function, cardiovascular health, and psychological health.[1,2] These systems and functions often become disrupted or altered in an attempt of the body to conserve energy.[1] The disruption and alteration of these systems leads to impaired immune response to illness, decreased bone density, amenorrhea and endocrine disfunction such as increased cortisol levels, reduced triiodothyronine, reduced luteinizing hormone pulsatility and hypoestrogenism.[1] RED-S also leads to impaired judgment, decreased coordination, decreased concentration, irritability, depression, decreased glycogen stores, decreased muscle strength, decreased endurance performance, increased injury risk and decreased training response overall.[1] All of these disruptions and dysfunction indicate the seriousness of this condition, especially in young, growing athletes.

RED-S is often observed in high performing male and female athletes, with a prevalence ranging from 22-58% across various sports.[1] RED-S is caused mainly by inadequate energy intake which leads to low energy availability (EA) in the body. In other words, the balance between energy intake and energy output is no longer balanced and the body is exerting more energy than what is being taken in through food. Couple inadequate energy intake with frequent episodes of intense physical activity, and the risk of RED-S is greatly increased.[4] Low EA presents a major risk to athletes in general but is specifically a risk for young athletes.[1]

Obtaining adequate energy and nutrients and adhering to proper dietary habits is a major concern for high school aged athletes. This population frequently under consumes energy, both intentionally and unintentionally and often, are not aware of the risks this can present to their health and performance.[1] Low EA is a concern specifically when it comes to adolescent and young athletes with a prevalence of 14-63%. Since low EA often leads to RED-S, this population is at the highest risk of developing RED-S and experiencing any negative impacts of low EA on performance and health.[1]

A study was conducted through a nutrition company called Nutrition for Optimal Performance in November 2021. This company focuses on sports related nutrition for improving performance and health for teams and individual athletes. High school cross-country athletes were asked to complete a questionnaire to assess the risk of RED-S and current nutrition knowledge. The questionnaire included questions from validated tools such as the RED-S CAT, LEAF-Q, and SCOFF as well as questions assessing nutrition knowledge, anthropometrics, a diet recall and low EA, and physical activity levels. This study was able to reveal that the majority of participants were at a risk of RED-S due to inadequate oral intakes in the setting of increased energy expenditure and had food and nutrition related knowledge deficits regarding what RED-S is and general nutrition.

Existing research suggests that education strategies and programs aimed at athletes may be one of the most beneficial preventative measures to reduce and prevent the risk of RED-S. Currently, there is a gap between diet and nutrition knowledge surrounding low energy availability in sports. This area continues to show less-than-optimal results and indicates improvement is needed.[1] Few education initiatives exist to improve athlete understanding of low EA and its health and performance consequences. It has been suggested that implementation of a nutrition program could increase awareness and promote behavior change for improved energy balance in athletes.[1,3,4] More specifically, education programs centering around how athletes can consume proper diets to improve energy, protein, and nutrient intake as well as learn about the consequences of RED-S can help to prevent this condition.[1,3,4]

Although it has been addressed that there is a lack of knowledge in high school athletes when it comes to nutrition education surrounding diet and sports, as well as the risks of an inadequate diet, few studies have implemented a nutrition education program to determine if providing educational resources, will in turn, improve dietary habits and prevent RED-S. To address this concern, we created 4 weekly educational newsletters on important sports related nutrition topics. These topics included an overview of RED-S, carbohydrates, protein, and vitamin D/Calcium. The purpose of this study was to assess the effectiveness of educational nutrition newsletters on nutrition knowledge in high school athletes, ultimately preventing the risk of RED-S through improved dietary habits.

METHODS

Study Design

A quasi-experimental design with one intervention group was used. Pre- to post-intervention changes were measured among high school athletes who signed up to receive weekly newsletters. Online pre and post intervention surveys, developed through Qualtrics and delivered 6 weeks apart, were completed by the intervention group. The study was approved by The State University of New York at Oneonta's Institutional Review Board (IRB).

Intervention

A total of 4 weekly newsletters were created by researchers. The topics of the newsletters included an overview of RED-S, carbohydrates, protein/iron, and calcium/vitamin D. Content and information included in the newsletters consisted of detailed information on the importance of each topic and how it related to sports performance and health. Suggested actions to take and recipes to incorporate into the diet to improve habits, both generally and around sporting events, were included. One newsletter was emailed to participants and their parents at the start of each week for 4 weeks total. The intervention began on February 28th, 2022 and concluded on March 21st, 2022. The intervention occurred entirely online via email.

The intervention was based on the social learning theory which utilizes reciprocal determinism, expectations, and self-efficacy.[5] Social support from families and skill development from recipes, provided through the newsletters, were components of the intervention strategies. The type of intervention selected was based on proven research that demonstrated how mass media in the teenage population effectively increased involvement and nutrition knowledge.[6] Provided nutrition

education through participants reached via email newsletters was identified as an effective form of outreach.[7]

Participants

Newsletter participants were recruited through a listserv and social media groups and platforms. Emails were sent out to an existing Nutrition for Optimal Performance listserv that serves the target audience of high-school athletes. An explanation of the study, what to expect and links to the informed consent, assent, and parental consent were provided through the email. Social media groups and social media platforms were utilized for further recruitment. Posts were made by the owner of Nutrition for Optimal Performance that explained a survey-based study would be conducted on high school athletes. Interested high school athletes were asked to message the researcher to obtain the consent forms. Seven participants responded to the recruitment methods and signed the appropriate online informed consent, assent, and parental consent forms. Six participants successfully received all 4 newsletters at the start of each week and made up the intervention group (n = 6). One participant did not receive the emailed newsletters and was therefore excluded from the intervention group. De-identifying numbers were assigned to each intervention participant.

Tools

Survey items used in the evaluation were developed by the researchers and incorporated some components of a previously validated tool such as the nutrition for sport knowledge questionnaire (NSKQ).[8] The pre- and post-intervention surveys included demographics (age, sex, sport involved in), 19 multiple choice questions, and a food frequency and food health habits questionnaire. The 19 questions and food frequency and habits questionnaire related to the 4 specific subject topics of the newsletter: RED-S, carbohydrates, protein/iron, and vitamin D/calcium.

Knowledge of RED-S, general, and sports related nutrition concepts were evaluated using the 19 multiple choice questions. Multiple choice questions were created by researchers and incorporated questions from The Nutrition for Sport Knowledge Questionnaire (NSKQ).[9]

Diet habits and composition in general and before intense activity were evaluated using an adapted food frequency and habits questionnaire template.[10] Diet composition was evaluated by participants indicating how often they ate items (5 food groups) or meals (breakfast, lunch, and dinner) using a 5-point scale (“daily”, “4-5 times a week”, “2-3 times a week”, “once a week”, or “rarely”). Habits were assessed by asking if participants changed intakes before sporting events and if participants ate a snack before practice or a sporting event.

Procedures

The newsletters were sent out weekly on Mondays for 4 weeks between February 28th and March 21st. Participants were allowed to read and review the newsletters by themselves or with a parent. Even if a participant chose to review the newsletters with their parent(s) or a family member, intervention outcomes were assessed on the level of the individual participant who completed the pre- and post-newsletter survey. The pre-intervention survey was completed by 7 participants, and the post-intervention survey was completed by 6. Data analysis matched pre- and post-intervention survey responses for the six participants.

Data Analysis

Demographic data retrieved from the questionnaires were stored in Qualtrics. Results from participants lacked any evidence to suggest that there were any significant demographic differences between the newsletters. The focus of the data analysis was to determine if there was a significant improvement in RED-S, general and sports nutrition-related knowledge, and dietary habits to prevent a risk of RED-S.

Survey data was determined to not be normally distributed for multiple choice questions measuring knowledge and for meal consumption frequency. Researchers used non-parametric tests to determine significance of changes from pre- to post-intervention scores for nutrition knowledge changes and meal consumption frequency changes. Wilcoxon rank tests were used to analyze non normally distributed data in SPSS with $p < .05$ indicating significance for all comparisons. Survey data was determined to be normally distributed for food group consumption frequency and a paired t-test was used to analysis the data in SPSS with $p < .05$ indicating significance.

The researchers categorized each participant as either making a positive change to their diet or not making a positive change to their diet. A change was indicated by categorizing the participants as "yes" which indicated a change or "no" which indicated no change. Participants who were categorized as "yes" received a numerical value of 1. Participants who were categorized as "no" received a numerical value of 0. A third variable was calculated for raw change in knowledge. This was calculated by subtracting the pre-test raw score from the posttest raw score. The dependent variables were differences in the change from pre- to post-intervention survey scores and dietary habits. The independent variable was participation in the weekly newsletters. Logistic regression was used to analyze if a positive change in eating habits or behaviors was associated with a change in nutrition knowledge and participation in the weekly newsletters. A $p < .05$ indicated significance The statistical analysis was done was done using SPSS (version 26, SPSS, Inc., Chicago, IL, 2008). The level of determining statistical significance was $P < .05$ for all comparisons.

RESULTS

Pre and post surveys included 19 multiple choice questions, 2 Likert scaled questions and 2 short response questions related to general and sports related nutrition knowledge and eating habits.

Demographics

A demographic profile of the RED-S newsletter intervention group participants is summarized in **Table 1.** Of the 6 participants, 67% were 13-14 years of age and 33% were 15-16 years of age. The majority were female (67%) and involved in track and field (50%).

Table 1. Demographic Profile of Participants in the RED-S Newsletter Intervention Group (n = 6)	
	Intervention Group n (%)
Age (y)	
13-14	4 (67)
15-16	2 (33)
Sex	
Female	4 (67)
Male	2 (33)
Sport	
Track and Field	3 (50)
Dance	1 (17)
Cross-Country	1 (17)
Soccer	1 (17)
Swimming	1 (17)
Note: Percentages may not total 100 because multiple participants reported involvement in multiple sports	

Table 1. Demographic characteristics of RED-S Newsletter Intervention Participants

Change in Knowledge

Knowledge relating to RED-S, general nutrition and sports nutrition significantly increased from the pre- to post-test scores ($p < .05$). 83% of participants showed an increase in nutrition knowledge test scores from pre- to post- intervention (**Figure 1**).

The mean for summed nutrition knowledge scores before the newsletter intervention was 46% $\pm$ 24.16%. The mean for the summed nutrition knowledge scores after the newsletter intervention was 61% $\pm$ 18.22%. Total participants mean summed scores were 15% higher in the post-test than in the pre-test. (**Figure 2**).

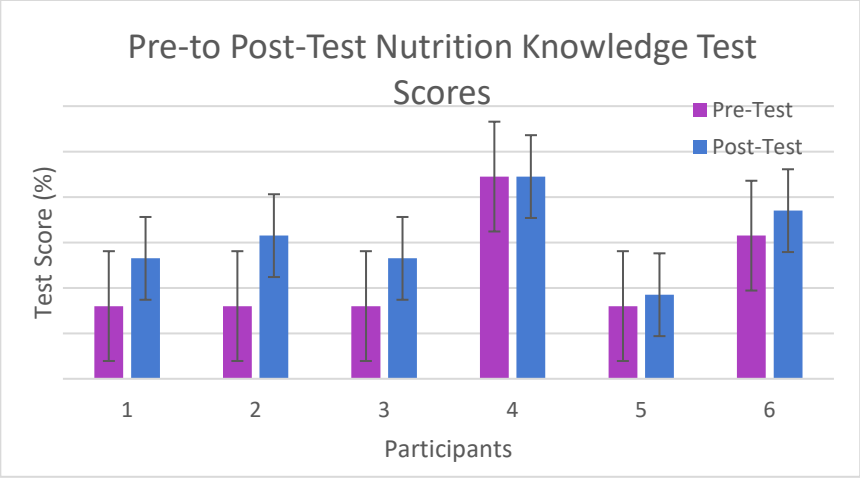

Figure 1: Individual participant nutrition knowledge change from pre- to post intervention; total score (%) and standard deviation, Wilcoxon rank tests * $p < 0.05$

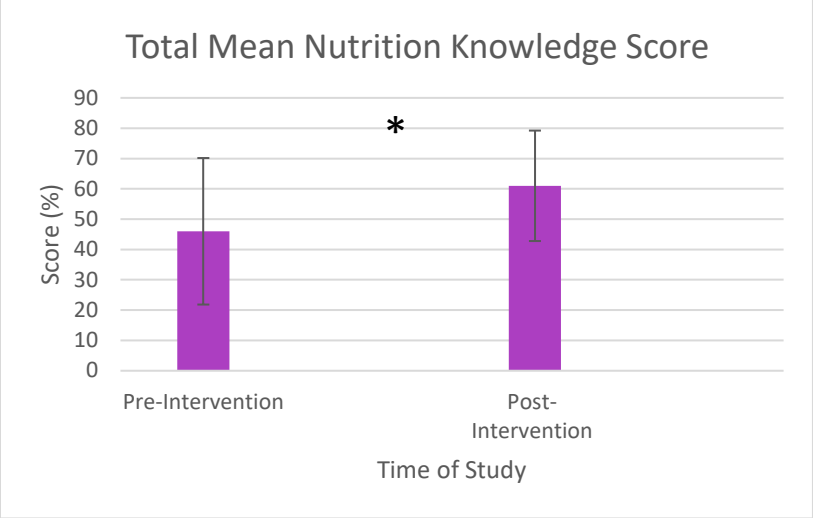

Figure 2. Total summed mean scores of participants from pre- to post- intervention; total summed score (%) and standard deviation, Wilcoxon rank tests * $p < 0.05$

Change in Eating Behaviors and Patterns

Two participants (33%) demonstrated an overall positive change in their eating habits from pre- to post-intervention after data was analyzed from the open ended and Likert scaled questions. The RED-S newsletter intervention group participants' common eating behaviors surrounding sports activity prior to the intervention and following the intervention are summarized in **Table 2.** Qualitative data was thematically examined to identify common dietary habits and coding designs were discussed by 2

members of the research team and revised until an agreement was reached.

Prior to participation in the RED-S newsletter intervention, the majority of participants (83%) reported either not changing their eating habits or were unaware of any eating behavior changes before sporting events. Participants seemed to select snacks based on 1 of 3 common intervention.

macronutrient compositions found in **Table 2**. Following participation in the RED-S newsletter intervention, there was an increase from 17% to 33% in participants who changed their intake before sporting events. One participant who reported not eating a snack before sporting events pre-intervention, reported bringing a carbohydrate-based snack following the

Table 2. RED-S Intervention Group Eating Habits Surrounding Sporting Events

Question/Response	Number of Participants (n)
Pre-Test	
Do you change your intake before sporting events?	
Yes	1
No	3
Not Sure	2
How do you change your intake?	
Eat more carbohydrates	1
Do you eat a snack before sporting events?	
Yes	5
No	1
What snacks do you typically eat?	
Carbohydrate based	2
Carbohydrate and Protein based	2
Carbohydrate, Protein, and Fat based	1
Post-Test	
Do you change your intake before sporting events?	
Yes	2
No	3
Not Sure	1
How do you change your intake?	
Eat Less Dairy	1
Eat more carbohydrates	1
Do you eat a snack before sporting events?	
Yes	5
No	1
What snacks do you typically eat?	

Table 2. RED-S Intervention Group Eating Habits Surrounding Sporting Events	
Carbohydrate based	2
Carbohydrate and Protein based	2
Carbohydrate, and Fat based	1

Table 2. Common themes of answers for open-ended questions from pre- to post-intervention

Intervention group participants had significant increases ($p < .05$) from pre-to post-newsletter intervention scores for Likert scale data measuring food group consumption frequency. However, there was not a significant difference in the meal consumption frequency in participants as evidenced by a p-value of .285. Two participants had an increased frequency in consumption of meals and food groups overall (**Table 3, Table 4, Table 5, and Table 6**). The total mean score representing meal frequency was 0.7 points higher in the post-intervention responses (**Figure 3)**. The total mean score representing food frequency was 2.4 points higher in the post intervention responses **(Figure 4**). Pre- to post-questionnaire responses indicating frequency of food groups consumed each week and frequency of meals eaten each day were analyzed and compared. Point values were assigned to each response (1-5), totaled for each participant, and then changes were compared between pre- and post-intervention habits for each participant. **Table 3** and **Table 4** show pre-questionnaire meal and food frequency breakdown. **Table 5** and **Table 6** show post-questionnaire meal and food frequency breakdown.

Table 3. Pre-Intervention Meal Consumption Frequency				
Participant #	Breakfast Consumption	Lunch Consumption	Dinner Consumption	Total
1	5	5	5	15
2	5	5	5	15
4	5	4	3	12
6	5	5	5	15
7	4	5	5	14
8	5	5	5	15

Table 3. Participant meal consumption frequency each week and total sum of pattern scores prior to the newsletter intervention. *A score of 1= rarely, 2 = once a week, 3 = 2-3 times a week, 4 =4-5 times a week, 5 = daily.*

Table 4. Pre-Intervention Food Group Frequency Consumption									
Participant #	Dairy	Fruit	Vegetable	Carbohydrate	Protein	Fat	Dessert Items	Sweets – Cookies, cake, candy	Total
1	4	5	5	5	5	5	5	2	36
2	5	4	4	5	4	4	5	5	36
4	3	2	2	4	4	3	4	3	25
6	5	5	5	5	5	5	1	1	32
7	5	4	4	5	5	4	5	5	37
8	5	5	5	5	5	4	5	3	27

Table 4. Participant food group consumption frequency each week and total sum of pattern scores prior to the newsletter intervention. *A score of 1= rarely, 2 = once a week, 3 = 2-3 times a week, 4 =4-5 times a week, 5 = daily.*

Table 5. Post-Intervention Meal Consumption Frequency				
Participant #	Breakfast Consumption	Lunch Consumption	Dinner Consumption	Total
1	5	5	5	15
2	5	5	5	15
4	5	5	5	15
6	5	5	5	15
7	5	5	5	15
8	5	5	5	15

Table 5. Participant meal consumption frequency each week and total sum of pattern scores following the newsletter intervention. *A score of 1= rarely, 2 = once a week, 3 = 2-3 times a week, 4 =4-5 times a week, 5 = daily.*

Table 6. Post-Intervention Food Group Frequency Consumption									
Participant #	Dairy	Fruit	Vegetable	Carbohydrate	Protein	Fat	Dessert Items	Sweets – Cookies, cake, candy	Total
1	5	5	5	5	5	5	5	1	36
2	5	4	4	5	4	4	4	4	34
4	5	1	3	5	3	5	5	5	32
6	5	5	5	5	5	5	1	1	32
7	5	5	4	5	5	5	4	4	37
8	5	5	5	4	5	3	5	5	37

Table 6. Participant food group consumption frequency each week and total sum of pattern scores following the newsletter intervention. *A score of 1= rarely, 2 = once a week, 3 = 2-3 times a week, 4 =4-5 times a week, 5 = daily.*

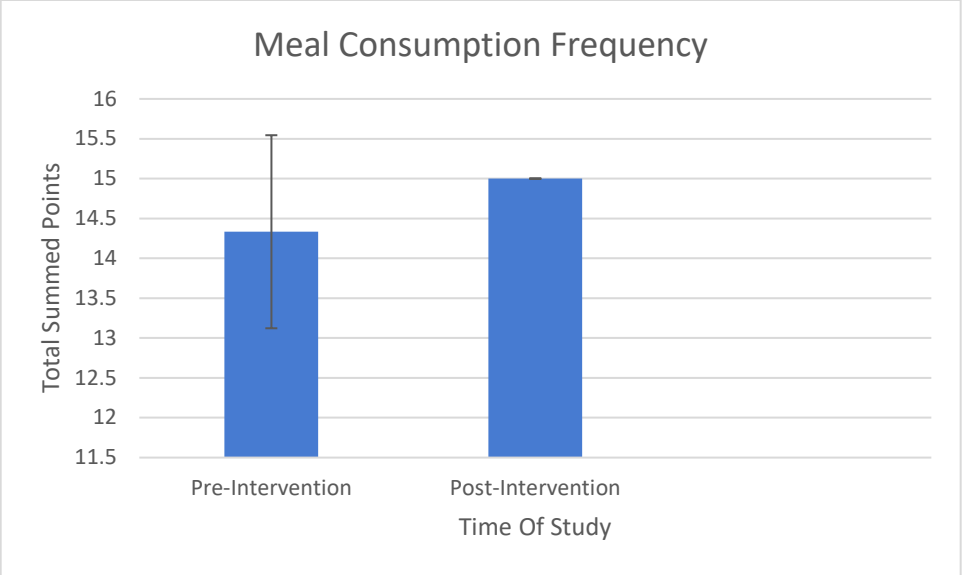

Figure 3. Participants mean total score of meal frequency consumption did not significantly increase from pre-intervention to post-intervention total points; means and standard deviation. ($p = .285$)

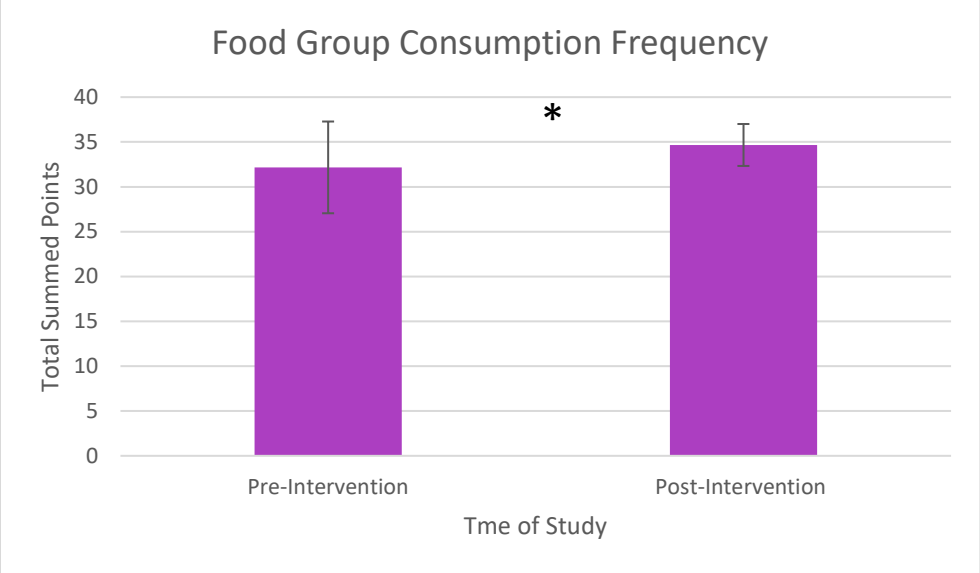

Figure 4. Participants mean total scores of food group frequency consumption were significantly increased from pre-intervention to post-intervention total points; means and standard deviation. T-test * $p < 0.05$

Association of Knowledge Change on Eating Habits/Patterns

Logistic regression analysis indicated that positive eating habits and patterns and change in knowledge were not significantly associated with participation in the weekly newsletters ($p = .423$) Positive changes in eating habits were not directly associated with a change in knowledge, evidenced by a p-value of 0.778. The dependent variables were change from pre-to post-intervention survey scores and dietary habits, and the independent variable was participation in weekly newsletters (Yes = 1 if they had a positive change, 0 = No, if they did not have a positive change, yes = 1 if they participated in the weekly newsletters, 0 = No if they did not participate in the weekly newsletters).

DISCUSSION

This main finding of the present study is that an online educational nutrition newsletter utilizing the social cognitive theory was effective at improving general and sports related nutrition knowledge and knowledge surrounding RED-S. An improvement in nutrition knowledge relating to general and sports nutrition was supported by statistically significant improvements in pre- to post- multiple choice survey scores. ($p < 0.05$), supporting the primary hypothesis. Additionally, 33% of participants demonstrated improved dietary habits from pre- to post-intervention (**Table 2, Table 3, Table 4, Table 5, and Table 6**), however contrary to our hypothesis, participation in weekly educational newsletters is not significantly associated with a change in knowledge and improved eating behaviors ($p = 0.423$). This finding cannot be attributed to a nutrition-related knowledge deficit since there was an overall statistically significant increase in nutrition knowledge from pre- to post-intervention. Rather, it appears that uncontrolled factors may have been an aspect in the insignificant results such as education level, gender, age, and type of sport played. Overall, online educational nutrition newsletters can be effective at increasing nutrition related knowledge in high school aged athletes.

This conclusion is further supported by similar findings in a study conducted by Heikkila et al. This study found that nutrition knowledge improved following at least three education sessions.[11] Seventy-nine young athletes (18.0 years SD: 1.4) participated in the randomized, controlled intervention. Participants attended three 90-minute education sessions fortnightly, completed a validated nutrition knowledge questionnaire 3 separate times (0 weeks, 5 weeks, and 17 weeks) and completed a three-day food diary 2 different times (0 weeks and 17 weeks).[11] Results showed that at the conclusion of the 3 education sessions, participants had a significant increase in nutrition knowledge ($p < 0.001$), yet dietary habits and behaviors did not significantly improve ($p > 0.05$).[10] Heikkila et al. concluded that nutrition education interventions were not enough to change dietary intakes alone.[11]

Furthermore, an exploratory study by Dunne et al, examined the use of media for nutrition service extension and provision. Forty-four sports nutritionists completed an online survey indicating their personal and professional use of media, and sixteen participants took part in follow-up interviews.[12] 89% of sports nutritionists utilized a form of social media to support practice and 97% perceived media use to be beneficial. Delivering information, resources and messaging via online media was found to improve communication between a practitioner and athlete by facilitating

mobile and visual learning.[12] Dunne et al. concluded that professional education should consider supporting nutritionists' in developing digital professionalism.[12]

To produce significant results regarding positive eating habits, future studies should engage both the high school athlete and the parent or caregiver in the educational newsletters. Requiring a parent or caregiver to take part in the newsletter interventions could allow for better translation of the information into improved eating habits and patterns. Parents play an important and large role in shaping eating behaviors in their children. They provide either genes, the environment, or both, which can all have an influence.[13] The current study allowed for parent participation, but it was not necessary as the main focus was on the high school athlete. The previously mentioned studies also did not require parental participation. Allowing parents or caregivers to learn alongside their high school aged child could increase family support and shape healthier and more positive eating behaviors.

Strengths

A major strength of this study included the use of online platforms for ease of outreach. Using weekly newsletters sent via email allowed for participants to have flexibility with when participants chose to review the newsletter. The intervention length and timeframe allowed for more in-depth and thorough topic concepts to be presented each week. Focusing on one nutrition topic each week allowed for more detailed information to be presented as well as more time to learn the weekly information before a new topic was introduced, resulting in statistically significant findings. Participants were able to remain anonymous throughout the study to help limit bias. Lastly, the majority of participants who participated in the intervention in the Spring of 2022 were not the same participants who in the needs assessment that took place in the Fall of 2021.

Limitations

Limitations of this study included the small sample size (n=6) and uncontrolled variables. Additionally, diversity was limited with the majority of the participants being female (67%) and in the age group of 13-14 years of age (67%). No participants were in the age group of 17-18 years of age. Lastly, due to the online format of the intervention it is assumed that all participants were consistently involved and participated in the weekly newsletters, yet this was not able to be measured due to the online format. In future programs, it would be beneficial to include a way to measure participation in each weekly newsletter for improved understanding of results.

IMPLICATIONS FOR RESEARCH AND PRACTICE

The results of this study can serve as a model for how online nutrition education programs utilizing the social cognitive theory can be used to improve general and sports related nutrition knowledge in high-school aged athletes. The results of this study have implications for how nutrition education surrounding both general and sports related knowledge may be used to help prevent relative energy deficiency in sport in young athletes. Further research is needed to evaluate what other nutrition programs may aid in the prevention and/or treatment of RED-S in this population group as well as lead to positive dietary changes.

CONCLUSION

This study examined the use of an online educational newsletter to improve nutrition related knowledge for prevention of RED-S in high school athletes. The findings show that improvements in general nutrition knowledge and sports nutrition knowledge is significant following the conclusion of a weekly online educational newsletter. Knowledge improvements did not result in significant positive eating habits for RED-S prevention. Parental influence on eating behaviors, habits and meals may play a role in high school athletes' diets. Future studies should look to include participation from both the high school athlete and the caregiver in the intervention in an attempt to increase positive eating habits and behaviors for effective strategies to combat RED-S.

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Appendix A: Pre/Post-Test Tool