

Research article

The effects of a carbohydrate-protein gel supplement on alpine slalom ski performance

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Abstract

Alpine slalom ski racing is a high intensity, complex sport in which racers execute turns every second. Acute fatigue can make the difference in not finishing a run (DNF) or finishing out of contention. The quantity and quality of training often dictates racing success. It is not known if nutritional supplementation can improve performance in this high intensity, short duration activity. The objective of this study was to determine if ingesting a carbohydrate-protein energy gel (GEL) improves finishing success and number of gates completed during 2 hr slalom sessions on two consecutive days of training. Twenty-four racers were matched; one group ingested the GEL, the second group received a liquid placebo (PLA). Total carbohydrate, protein, and water ingested by the GEL group were 60g, 15g, and 450 mL, while the PLA group ingested 450 mL of PLA. The GEL group had significantly fewer DNF's (7/48 vs. 18/48; $p = 0.02$) on both days, completed a greater number of training gates on Day 2 (260.3 ± 20.1 vs. 246.3 ± 17.5 gates; $p = 0.03$), and had a lower RPE (3.9 ± 1.2 vs. 5.3 ± 1.2 on Day 2 ($p = 0.004$) vs. PLA. The statistical analysis of combined finishing times was not possible due to the high number of DNF's in the PLA group. High intensity slalom performance can be improved by the ingestion of an energy gel. The GEL allowed the athletes to improve training quantity and quality and their perception of effort was less than skiers who ingested a placebo.

Key words: Alpine ski racing, nutritional supplementation, performance.

Introduction

Alpine slalom ski racing is a sport where hundredths of a second can separate racers. The average time separation between each of the top 10 finishers was 0.14 ± 0.05 sec out of an average finishing time of 103.3 ± 5.1 sec/race over 10 races during the 2009 World Cup men's slalom season (FISa, 2010). A slalom race consists of two runs with 53 to 70 turning gates per run. With the combination of a complex movement activity and high velocities, it is no surprise that many racers do not finish a course. In 2010, about 30% of women did not finish (DNF) and about 35% of men recorded a DNF in World Cup slalom races (FISb, 2010).

A DNF is the recorded result when a skier straddles a gate or loses control and skis off the course in a manner as to not finish the run. Slalom skiers, in search of more speed, make their turns as close to the gates as possible. Mistakes in fine motor movements, such as balance and body position, pressure application to the ski, and ski

orientation (attack angle) may cost a racer valuable time at the finish line or to not finish the run (Reid et al., 2009). Having the ski at an optimal attack angle is a very precise motor control mechanism and the ski tips orientation, in relation to the turning gate, may be the difference between recording a faster time and recording a DNF.

Fine motor control movements required for racing are impaired through fatigue and muscle stress induced by the amount of eccentric work, stretch shortening contractions and occlusion of blood flow due to the high muscular forces generated during training, or even within a run (Berg and Eiken, 1999; Szmedra, et al., 2001; Tomazin et al., 2008). Tomazin et al., (2008) noted that high frequency fatigue in elite slalom racers occurred following one run in a 45 gate slalom course (about 42 sec in duration). The factors related to fatigue in that study appear to be related to central fatigue mechanisms. Additionally, Twist et al. (2008) reported that a high intensity stretch shortening exercise impaired post exercise balance and peak torque. If skiers experience impaired balance or a loss of torque, they could be prone to more mistakes within a race training course.

Not only is there a motor component to the skier's success, but muscle metabolism may also affect performance. Elite collegiate racers have been reported to race and train at high intensities in excess of 95% HRmax (Seifert et al., 2000), while junior racers have been reported to train in excess of 90% of VO_{2max} during one run of slalom (Bacharach and Bacharach, 2007). The high intensities associated with racing are thought to be the combination of eccentric contractions and stretch shortening contractions needed to counter the high ground reaction forces and vibrations (Babiel et al., 1997; Berg and Eiken, 1999; Hintermeister et al., 1995; Nachbauer, 1987; Tomazin et al., 2008). With high muscle forces required to ski through a slalom course, acute fatigue may occur during training (Tomazin et al., 2008). Additionally, Tesch (1995) observed glycogen depletion in racers following their giant slalom training. The question then arises whether these issues can be mitigated through a nutritional intervention.

It has been widely demonstrated that nutrient supplementation, in both carbohydrate (CHO) and CHO-protein forms, improves endurance performance (Fritzsche et al., 2000; Ivy et al., 2003; Murray et al., 1991; Saunders et al., 2007). Ingesting 600 mL/hr of a CHO-protein sports drink during recreational skiing has been shown to reduce muscular stress and maintain runs

completed during 3 hrs of free skiing (Seifert et al., 2005). However, due to the high intensity training nature of alpine ski racing, it is debatable whether racers would be able to tolerate ingesting sports drinks, in volumes thought to improve performance, during training. Energy gels, however, are formulated to provide a concentrated source of substrate while eliminating the need to ingest large volumes of fluid. This option may be particularly beneficial to the ski racer who is attempting to increase training volume and improving performance.

Whether it is metabolically induced fatigue or an error in motor control, the racer has interrupted training which results in less training or diminished training quality. The quality of racing is largely dependent upon training quality and quantity (Bompa, 1999). It is, however, still unknown if training quality and performance can be improved through nutritional intervention during a high intensity, short duration activity.

The purpose of this study was to determine if ingesting a carbohydrate-protein gel results in improved finishing success (training quantity), run time differences, number of gates completed (training quality), and Rating of Perceived Exertion (RPE) during slalom training in elite junior racers.

Methods

This study was approved by the university's institutional review board. All subjects provided written informed consent and ascent forms.

Subjects

Twelve female and 12 male elite junior club ski racers volunteered to participate. Average age, height, and weight were 16.2 ± 1.9 y, 1.71 ± 0.07 m, and 66.3 ± 9.5 kg, respectively. Skiers were matched by sex, age, and United States Ski & Snowboard Association (USSA) slalom points. Average USSA points were 97.9 ± 47.4 .

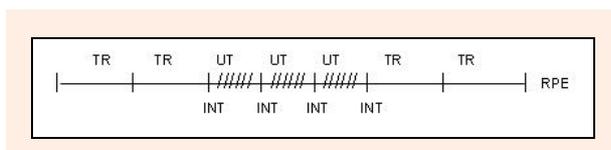


Figure 1. Schematic of the skiing protocol. TR: 48 gate timed run; UT: 42 gate untimed training run; INT: Intervention and drink; RPE: Rating of Perceived Exertion (5 min after the last TR run). Young skiers (14-16 y) completed two UT while the older skiers (16-18 y) completed three UT.

Design and methodology

One group ($n = 12$) of skiers received an energy gel (GEL; Accel Gel, PacificHealth Laboratories, Matawan, NJ) while the other group ($n = 12$) received a liquid non-caloric flavored placebo (PLA) following each training run (see Figure 1). Each GEL packet contains 20g of CHO (similar content of sucrose, fructose, and maltodextrin), 5g whey protein, 115 mg sodium, and 20 mg potassium. Skiers in the GEL group ingested the GEL with 150 mL of water after the second timed run and again after each of the training runs. The matched skier ingested 150 mL of the PLA in the same sequence as the GEL group.

Due to possible residual effects of training on Day 1, all subjects received the same treatment on the second day of training as they did on the first day. To further blind skiers and to eliminate preconceived group benefits, subjects were told this study was only comparing preferences to a sports gel or a sports drink. Skiers were instructed to maintain their typical dietary habits by eating breakfast before their school lessons and lunch before each training test day.

Skiers completed two consecutive days of slalom training. Training took place from 13:00 to 15:00 each day. All courses were set according to International Ski Federation (FIS) and USSA standards. The on-snow duration of each training day was their customary two hour training session (see Figure 1). Skiers completed a standardized warm up run followed by performing two timed runs of 48 gates per run, two or three untimed training runs of 42 gates per run, followed by two more timed runs on the original timed course (48 gates per run). The older skiers (16 - 18 y of age) skied three untimed training runs while the younger skiers (14 - 16 y of age) skied two untimed training runs. The combining of two timed runs was used to simulate race conditions where combined run time determines finishing placement. The ski run, on which the courses were set, was groomed the night prior to training. Coaches and assistants periodically side slipped the courses during training to minimize rut development as is normal in a training session. Side slipping is a technique in which the skiers place their skis perpendicular to the fall line (across the hill) and slide down the hill to minimize the severity of ruts and holes in the snow. Coaches instructed the racers to approach each day as a racing day and to ski with the intensity that they would for a race.

Performance was assessed by the number of DNF runs, comparing finishing times between treatments for the combined times of the two post-training runs, and the number of gates completed during training. Rating of perceived exertion (RPE) was collected from each racer independently approximately five minutes following the final run using the Borg 10 pt. scale

Statistical analysis

The DNF, finishing time, and RPE data were analyzed with a 2x2 ANOVA with independent t-test used to differentiate means upon an interaction (Statistica; Tulsa, OK). Alpha level of significance was set at 0.05. All data are listed as mean \pm SD. The hypotheses for this study were that the GEL would confer a greater performance level than the placebo and that training quality (faster times) and quantity (more gates skied) would be enhanced when a GEL is ingested during training.

Results

Temperatures at 12:00 for the two days of training were -8°C and -5°C , respectively. There were no reports of gastrointestinal side effects from either treatment. Subjective responses indicated that the fluid volume of 450 mL for the younger skiers or 600 mL for the older skiers was a tolerable volume during high intensity training.

Table 1. Daily responses to slalom training. Data are means (\pm SD).

	Day 1			Day 2		
	DNF	Gates	RPE	DNF	Gates	RPE
Gel	2	231.5 (16.3)	4.6 (1.7)	5	260.3 (20.1)	3.9 (1.2)
Placebo	10 *	240.3 (19.2)	5.0 (1.5)	8 *	246.3 (17.5) *	5.3 (1.2) *

DNF: did not finish (total out of 24 runs/day). Gates: training gates completed; RPE: rating of perceived exertion. * = significantly different from Gel

A significant difference between treatments was observed for DNF's in the post training timed runs ($p = 0.015$). The GEL group recorded 7 DNF's out of 48 of the final two timed runs (15%) while the PLA group recorded 18 DNF's out of 48 of the final timed runs (38%). When separated by day, 8% of the 24 runs final timed runs were DNF's for the GEL group while 42% of the timed runs were DNF's in the PLA group on Day 1 (Table 1). On Day 2, 21% of the final timed runs were DNF's for the GEL group while 33% of the runs were DNF's for the PLA group.

No difference between treatments for the number of completed gates on Day 1 was observed between GEL and PLA (Table 1). However, the GEL group completed significantly more gates on Day 2 than PLA ($p = 0.03$).

Due to the high number of DNF's for the PLA condition, the use of combined times for the post-training run comparison, as what normally occurs in ski racing, was not possible. Therefore, only the fastest time was used for statistical comparison. No difference was observed between treatments for the single fastest post-training timed runs.

No significant difference was observed for RPE on Day 1 between GEL and PLA (Table 1). However, RPE for the GEL group was significantly lower than PLA ($p = 0.004$). In terms of untimed training runs, skiers in the GEL group maintained the number of untimed training runs from Day 1 to Day 2 at $2.3 \text{ runs} \pm 0.5/\text{day}$. The PLA group, however, experienced a significant decrease from 2.5 ± 0.5 training runs on Day 1 to 2.0 ± 0.4 runs on Day 2.

Discussion

The goal of this study was to investigate the efficacy of ingesting a CHO-protein GEL on alpine slalom race training quality and quantity under high intensity training conditions. Based on the number of DNF's and the number of gates completed, skiers improved performance and training quality and quantity when they ingested a CHO + protein GEL during their 2-hr slalom training bout. These high level junior ski racers mimicked an average slalom training session at high intensities for about five minutes in total over the two hour training period each day.

It is well established that nutrient ingestion may improve endurance exercise performance, but the finding that supplementation can improve high intensity; short duration performance is relatively new, especially in a complex activity such as alpine slalom racing. Interestingly, no differences were observed between the GEL and PLA groups in single run finish time. However, the PLA group did not finish enough post training timed runs to use combined times for statistical analysis.

Slalom racing is a complex movement activity

where any loss of time can result in the loss of a race, placing far down the list, or not finishing the run (Seifert et al., 2009). One can only speculate as to why training quantity and finishing performance was improved for the GEL group during this intermittent activity. Ingesting the GEL may have maintained the neurological recruitment patterns of muscle during the runs, minimized muscle metabolism disruption, or delayed the change in the frequency spectra with the onset of acute fatigue (Kröll et al., 2010).

Acute fatigue can be manifested through two primary paths, peripheral and central. Peripheral fatigue occurs when there is a reduction in the force generating capacity of the muscle (Gandevia, 2001; Taylor and Gandevia, 2008) whereas central fatigue is observed when there is a neurological reduction in muscle activation (Tomazin et al., 2008; Gandevia, 2001; Rattey et al., 2007). In complex movement activities, such as alpine slalom racing, crossover between the peripheral and central fatigue factors may occur, but this crossover phenomenon appears to occur primarily in the lower limbs (Rattey et al., 2007). Tomazin et al. (2008) reported that high frequency fatigue occurred after only one run through a 45 gate slalom course. These authors defined high frequency fatigue as a change in the generation, delivery, or sarcolemmal processing of the action potential. Tomazin et al.'s (2008) results point to central fatigue as an important component in fatigue during high intensity slalom racing.

There appears to be a significant interaction between central and peripheral fatigue, however. McLean and Samorezov (2009) reported that changes in muscle metabolism altered the sensitivity of the central motor drive involving the alpha motor neurons and Group III and IV afferent neurons. With minute changes in muscle metabolism, there is the possibility of altered motor control during the activity. In ski racing, for example, there may be a loss in precise motor control of the foot and ankle thereby diminishing the pressure adjustments to the ski edge or loss of edge control. There may be slower reaction/response time to an undesired movement, or greater hip or knee extension in the turning phase. Any such change in body position would then have a negative impact on force production, slowing of response time, maintaining balance, or regaining lost balance (Twist et al., 2008). If metabolic homeostasis can be maintained with nutrient ingestion, muscle and central nervous system functions can be sustained during high intensity work. This is certainly plausible since Gant et al. (2010) reported that CHO ingestion facilitates corticomotor outputs to both fatigued and unfatigued muscle.

Providing nutrient supplementation during exercise appears to be an important component in minimizing

muscle stress and improving output. In previous work with recreational skiers, Seifert et al. (2005) reported significant differences in creatine kinase and myoglobin concentrations when skiers ingested a CHO-protein sports drink during three hours of free skiing. Those authors reported that creatine kinase and myoglobin concentrations remained unchanged from baseline and were significantly less when the CHO-protein sports drink was ingested compared to a water placebo, which was also lower than the no fluid ingesting group. The skiers in the sports drink group also maintained the number of runs during the final hour of skiing (3.8 runs) compared to the no fluid group who experienced a significant decrease in the number of runs during the final hour of skiing completing an average of 2.9 runs.

It is also possible that the carbohydrates and amino acids provided by the GEL may have aided in the delay of central fatigue. Blomstrand (2006) reported that amino acid ingestion reduced central fatigue following endurance exercise. The presumed mechanism is that 5-hydroxytryptophan (5-HT) levels are attenuated by amino acid ingestion. It is thought that brain 5-HT levels may play a role in fatigue during and after training. This explanation may be plausible as Tomazin et al. (2008) noted that acute fatigue during slalom training was probably centrally located.

Training volume, measured by the number of untimed runs and training quantity (number of gates completed), was maintained at 2.3 runs/day/racer (a group total of 28 runs/day) from Day 1 to Day 2 by the GEL group in the present study. Training volume, however, decreased significantly for PLA group. The PLA group experienced a significant decrease from an average of 2.5 training runs/day/racer (a group total of 30 runs/day) on Day 1 to an average of 2.0 runs/racer (total of 24/day) on Day 2. The change in the number of training runs for PLA happened to also coincide with a significant difference between groups in RPE. This decrease in training run numbers on Day 2 may also be indicative of residual fatigue from Day 1. A possible confounding variable to the results may be nutrition recommendations given to the skiers. They were instructed to maintain their typical dietary habits during the study. There may have been perturbations in their dietary intake. One of the goals of this study was to allow the skiers to maintain their normal behaviors during the training as this is what happens in real life training situations. When asked, skiers did indicate verbally that they followed their usual dietary patterns on the training days.

It can be argued that racers in the PLA group were going faster in the runs in which they recorded a DNF, which, in theory, could help their racing. However, there are sections within a course where racers must demonstrate a strategy in order to finish the course to gain a second run or record a finishing result. Skiing fast, but being unable to complete the course has little merit in racing. When fluid homeostasis is not an issue, the CHO-protein GEL allowed racers to not only maintain their training quantity, but to improve their training quality while their perception of effort was less than when skiers ingested a PLA. Future research in this area may be

needed to separate the influence of substrate availability on central and peripheral factors. Although the racers used in this study were top level junior racers, they were young and skied technically at the junior level. How older, more technically developed racers would respond to an intervention is unknown. Future research should include the developed racer who is at the national/international level.

Conclusion

This study was completed in a field setting that mimicked race conditions from course setting to snow preparation. Success rate in the slalom course completion, assessed by DNF's, was improved with ingesting the sports GEL. A simple nutritional intervention allowed the racers to increase their training volume. Racers' perception of effort was significantly lower on the second day of training with the GEL compared to the PLA group.

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Key points

- Nutritional supplementation with a carbohydrate/protein sports gel during high intensity ski training improved training volume as measured by the number gates completed.
- Supplementation also reduced the number of DNF's during training.
- Racers' perception of effort was significantly lower with the supplement ingestion compared to a non-caloric placebo.
- This applied study was conducted under real life field conditions and training environments.