



## Acute Effects of a Multi-Ingredient Pre-Workout Supplement On 5-KM Running Performance in Recreationally-Trained Athletes

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### ABSTRACT

*International Journal of Exercise Science 12(2): 1045-1056, 2019.* The purpose of the present study was to examine the effects of an acute dose of a multi-ingredient pre-workout supplement on 5-km running performance and subjective measures of fatigue. Twenty aerobically-trained, males ( $n = 10$ , mean  $\pm$  SD =  $80.8 \pm 6.1$  kg) and females ( $n = 10$ ,  $64.5 \pm 6.6$  kg) completed two 5-km running races for time in a double-blind, cross-over fashion. During the first session, subjects were randomly assigned to ingest the supplement or placebo 30 minutes prior to running a 5-km race. The supplement contained multiple ingredients including caffeine anhydrous (150 mg), beta alanine (1.6 g), and arginine alpha-ketoglutarate (AKG) (1.0 g). Subjects also completed a 5-point Likert scale (1 = low, 5 = high) questionnaire to determine feelings of fatigue immediately prior to ingesting the substance (baseline), 30 minutes post-ingestion (immediately pre-race), and 5 minutes post-race. For the second session, subjects ingested the opposite substance (supplement or placebo) and underwent the same testing procedures (including time of day) as the first session. The results indicated there was no significant ( $p > 0.05$ ) difference in 5-km race time between the supplement ( $23.62 \pm 2.08$  min) and placebo ( $23.51 \pm 1.97$  min) conditions. For the feelings of fatigue, there were no significant condition  $\times$  time interactions or main effects for condition, but there were main effects for time. These findings indicated that the pre-workout supplement provided no ergogenic effect on 5-km race time or subjective feelings of fatigue when administered on an acute basis in aerobically-trained individuals.

KEY WORDS: Supplementation, thermogenic, caffeine

### INTRODUCTION

A specialized category of dietary supplements known as “pre-workouts” have become a popular nutritional strategy within the fitness and sport performance communities (19). These supplements are designed for ingestion 30 to 60 minutes prior to an exercise session or athletic event with the purpose of enhancing metabolic, physiological, and psychological function (7). Typically, pre-workout supplements consist of multiple ingredients that are often manufactured into “proprietary blends” with their specific quantities not provided on the “supplement facts”

label (26). The most common ingredients in pre-workout supplements include beta-alanine, caffeine, tyrosine, creatine, and arginine (26). Individually, many of these ingredients have been shown (1, 15, 44) to provide diverse ergogenic effects on performance and the inclusion of additional molecules (e.g. herbal extracts) may result in synergistic benefits. To this end, it has been suggested (7) that supplementation with pre-workouts may increase energy expenditure and substrate availability, enhance fatigue-resistance, and reduce perceived exertion.

The majority of previous investigations that have examined the effectiveness of pre-workout supplements have focused on measures of anaerobic performance. For example, the acute ingestion of pre-workouts has been shown to improve total resistance training volume (5, 9, 16, 24, 27), repetitions to failure for squat (22), leg press (9, 40) and bench press (7, 9, 27), as well as upper body peak and mean power (16), and bench press peak and mean velocity (29). In contrast, however, a number of other studies have shown no change in peak and mean power from the Wingate Anaerobic Test (17, 20), maximum push-ups or sit-ups completed in one minute (21), one repetition maximum bench press (6, 31), bench press throw (5), maximum voluntary contraction force during the squat (43) and isokinetic leg extension (5), vertical jump (7, 29, 31), or anaerobic running capacity and critical velocity (40). Collectively, the findings of these investigations (5-7, 9, 16, 17, 20, 21, 24, 27, 29, 31, 40, 43) suggest that acute supplementation with pre-workout may be more beneficial for sustaining repetitive movements associated with muscular endurance than improving measures of maximal effort anaerobic performance.

A recent survey (25) on the common practices of pre-workout supplementation found the majority of users ( $n = 872$ ) listed "resistance training" as their primary mode of exercise. It was also indicated, however, that over 16% of pre-workout users are primarily involved in aerobic training, group exercise classes, and recreational activities (e.g. hiking, biking, etc.) (25). Although there are limited data regarding the effectiveness of pre-workout supplements on aerobic exercise performance, it is possible that supplementation would be beneficial based on their typical ingredient profile (26). For example, Walsh et al. (47) examined the influence of a caffeine-based pre-workout supplement on time to exhaustion and subjective feelings during constant-intensity treadmill running. The authors (47) reported that compared to the placebo, the pre-workout supplement led to increased time to exhaustion (+12.5%) at 70%  $\dot{V}O_{2max}$ , while improving feelings of energy and focus. These findings may be attributable to caffeine, beta-alanine, and arginine found within the investigated product and many other pre-workouts that have been shown to delay the onset of fatigue and reduce feelings of exertion (4, 11, 15, 28, 30, 39, 41, 42, 48). Consistent with many pre-workouts on the market, however, the product of Walsh et al. (47) contained proprietary blends with the majority of ingredients (including caffeine) listed at unknown quantities. Walsh et al. (47) proposed the inclusion of these additional ingredients may enhance the stimulatory effect of caffeine and provide synergistic benefits. Given that a recent study (26) has illustrated the majority of pre-workout supplements contain ingredients at quantities lower than the demonstrated effective dose, the potential for synergistic mechanisms provide a plausible explanation for ergogenic findings. Caffeine, beta-alanine, and arginine and other ingredients (tyrosine, L-carnitine, green coffee bean extract, capsicum, *Mucuna pruriens*, and *Coleus forskohlii*) that are combined in a popular pre-workout supplement (Cellucor, Bryan, TX) also have purported physiological effects related to

metabolism including increased energy expenditure, lipolysis, and the transportation and utilization of fatty acids. Based on these mechanisms, is it possible that this pre-workout supplement (Cellucor, Bryan, TX) would enhance performance in aerobic activities on an acute basis. Therefore, the purpose of the present study was to examine the influence of an acute dose of a multi-ingredient pre-workout supplement on 5,000-m running performance and subjective measures of fatigue in aerobically-trained individuals. Based on the findings of Walsh et al. (47), we hypothesized that the current product would result in improved 5,000-m race time while reducing overall feelings of exertion.

## METHODS

### *Participants*

Twenty aerobically-trained, college-aged males ( $n = 10$ , mean  $\pm$  SD =  $80.8 \pm 6.1$  kg) and females ( $n = 10$ ,  $64.5 \pm 6.6$  kg) who ran  $\geq 24.1$  km  $\cdot$  wk<sup>-1</sup> volunteered to participate in the current study. An *a priori* power analysis using G\*Power 3.1 (Universität Düsseldorf, Germany) indicated a sample size of 19 was required to achieve power ( $1-\beta$ ) of 0.80 with an effect size of 0.6 and alpha of 0.05. The subjects did not report or exhibit any of the following that could significantly affect the outcome of the study: 1) medical history of cardiovascular disease, chest pain, loss of balance due to dizziness, unconsciousness, bone or joint injury, taking medications for blood pressure or a heart condition, or any other reason why they should not participate in physical activity; 2) use of nutritional supplements; 3) habitual use of caffeine; or 4) participation in another clinical trial of an investigational product within the last 30 days. Subjects were asked to maintain their current dietary and exercise habits for the duration of the study but were encouraged to avoid strenuous workouts and alcohol 48 hours prior to each visit. In addition, the subjects were instructed to avoid caffeine for at least two weeks prior to the beginning of the study. The study adhered to the ethical policies set by the Editorial Board (32) and was approved by the University Institutional Review Board for Human Subjects (IRB Title: Effects of a multi-ingredient thermogenic pre-workout supplement on 5K running performance in college-aged males and females; Approval Date: October 18, 2016). All subjects completed a health history questionnaire and signed a written informed consent prior to any testing.

### *Protocol*

**Study Design:** This study utilized a randomized, double-blind, placebo-controlled, within-subjects crossover design. The double-blind was completed by a third party not involved in the data analysis. Subjects were required to visit the laboratory on three occasions. The first visit was structured as an orientation session to familiarize the subjects with the testing procedures associated with the study. For the second visit, the subjects were randomly assigned (through computerized random number generator) to ingest one dose of the pre-workout supplement (Cellucor, Bryan, TX) or placebo 30 minutes prior to running a 5,000-m race as fast as possible. Subjects also completed a 5-point Likert scale questionnaire (1 = very low, 5 = very high) to determine feelings of fatigue, alertness, energy, and focus immediately prior to ingesting the supplement or placebo (baseline), 30 minutes post-ingestion (immediately pre-race), and five minutes post-race. For the third visit seven days later, the subjects ingested the opposite substance (supplement or placebo) and completed another 5,000-m race with the same testing

procedures as the second visit. Two-day food logs were recorded prior to the second and third visits.

**Supplementation Protocol:** During the second and third visits, the subjects consumed one serving of the supplement (Cellucor, Bryan, TX) or placebo (Kraft Foods, Chicago, IL) with six ounces of water 30 minutes prior to the 5,000-m race in a double-blind manner. One serving of the supplement (Cellucor, Bryan, TX) contained beta alanine (1.6 g), arginine alpha-ketoglutarate (AKG) (1.0 g), a proprietary “energy” blend [371 mg of tyrosine, caffeine anhydrous (150 mg), and velvet bean (*Mucuna pruriens*) seed extract], a proprietary “ripped” blend [1.0 g of L-carnitine tartrate, green coffee bean extract, Capsimax® cayenne (*Capsicum annuum*) fruit extract, and *Coleus forskohlii* root extract], vitamin C (250 mg), niacin (30 mg), vitamin B6 (500 µg), folic acid (250 µg), vitamin B12 (35 µg), and calcium (16 mg). The placebo was non-caloric Crystal Light (Kraft Foods, Chicago, IL) and matched with the supplement for similar appearance, taste, and consistency.

**5,000-m Races:** The 5,000-m races took place seven days apart on an indoor, temperature and humidity controlled, four-lane, 200-m track. Males and females completed separate races to promote competition and ensure that the track was not overly crowded. All subjects were verbally encouraged to complete the fastest time possible before and during the races. Laps on the track for each subject were counted by research assistants to ensure a total of 25 laps (25 laps x 200 meters per lap = 5,000 meters) were completed. Previous studies (12, 23) have shown high test-retest reliability measures in 5,000-m running time trials in competitive runners.

**Likert Scale Questionnaire:** Each subject completed a 5-point Likert scale questionnaire (1 = very low, 2 = low, 3 = average, 4 = high, 5 = very high) at three different time points during both the second and third visits. These three time points included: 1) immediately prior to ingesting the supplement or placebo (baseline), 2) 30 minutes post-ingestion (immediately pre-race), and 3) five minutes after they completed the race (post-race). The questionnaire included four questions in which the subjects were asked to rate their: 1) energy level, 2) fatigue level, 3) feelings of alertness, and 4) feelings of focus for task (27).

**Food Logs:** Two-day dietary history was recorded prior to each testing session using a commercially available nutritional analysis program (*MyFitnessPal, Inc.*) (33) to assess differences in total caloric and macronutrient (carbohydrates, fat, and protein) intake and to ensure the outcomes of the study were not influenced by dietary intake.

#### *Statistical Analysis*

Race times were compared between the supplement and placebo conditions using a paired-samples *t*-test. Model assumptions for the paired-samples *t*-test were met as indicated by normal distribution (skewness:  $-0.22 \pm 0.51$ ; kurtosis:  $1.36 \pm 0.99$ ) and no identification of outliers using the box plot method ( $< 3$  IQR). Four separate two-way ANOVAs with repeated measures were used to compare the Likert scale questionnaire variables between the conditions (supplement vs. placebo) at the common time points (baseline, pre-race, post-race) (34). In addition, four separate paired-samples *t*-tests were used to compare differences in total caloric and

macronutrient intake between conditions. An alpha of 0.05 was considered statistically significant for all comparisons.

**Table 1.** Two-day averages (mean ± SD) for total calories and macronutrients consumed during the supplement and placebo conditions.

	Supplement	Placebo	<i>p</i> value
Total calories (kcal·d <sup>-1</sup> )	2043 ± 837	1964 ± 707	0.564
Carbohydrates (g·d <sup>-1</sup> )	251 ± 101	236 ± 69	0.506
Fat (g·d <sup>-1</sup> )	81 ± 41	79 ± 41	0.851
Protein (g·d <sup>-1</sup> )	109 ± 63	95 ± 55	0.184

Note: There were no significant (*p* > 0.05) differences among conditions for kcals or macronutrients.

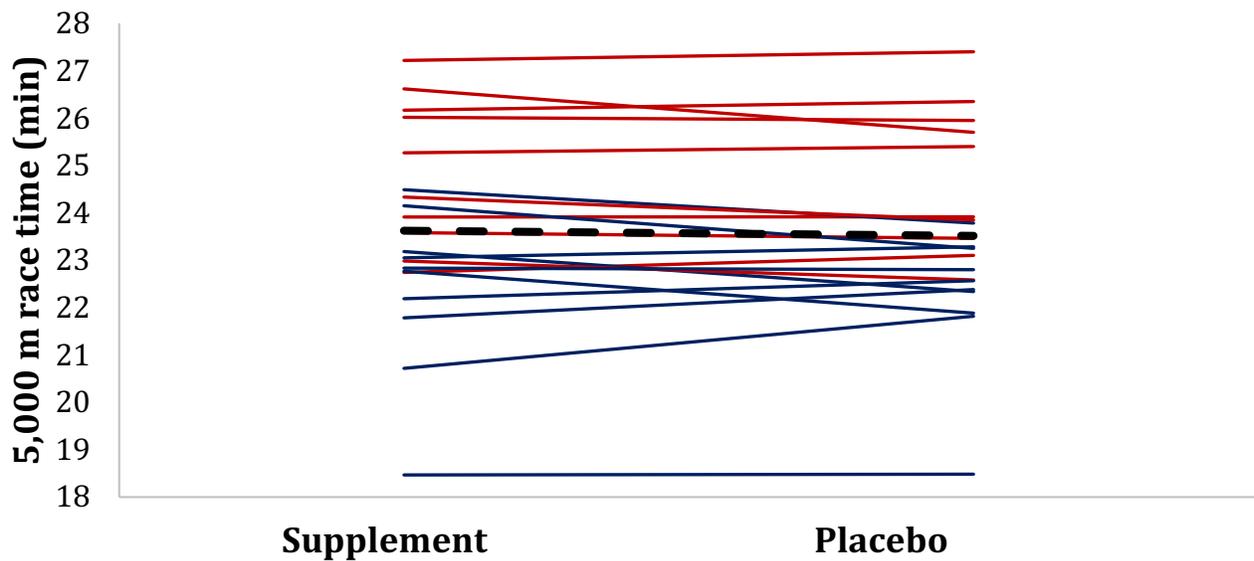
**Table 2.** Likert scale values (mean ± SD) for the psychological variables between conditions at baseline, 30-minutes post-ingestion, and post-race (*n* = 20).

Variable	Supplement	Placebo
<b><u>Energy</u></b>		
Baseline	3.0 ± 0.5	2.7 ± 0.7
30-min Post-Ingestion	3.8 ± 0.7	3.3 ± 0.7
Post-Race	2.8 ± 0.9	2.8 ± 1.0
<b><u>Fatigue</u></b>		
Baseline	2.3 ± 0.8	2.4 ± 0.8
30-min Post-Ingestion	2.3 ± 0.7	2.5 ± 0.7
Post-Race	3.3 ± 1.0	3.3 ± 1.1
<b><u>Alertness</u></b>		
Baseline	3.1 ± 0.7	3.2 ± 0.6
30-min Post-Ingestion	3.9 ± 0.6	3.5 ± 0.6
Post-Race	3.7 ± 0.8	3.5 ± 0.8
<b><u>Focus</u></b>		
Baseline	3.5 ± 0.6	3.3 ± 0.6
30-min Post-Ingestion	3.9 ± 0.7	3.5 ± 0.6
Post-Race	3.4 ± 0.9	3.6 ± 1.0

Note: There were no significant (*p* > 0.05) condition × time interactions or main effects for condition for energy, fatigue, alertness, and focus. Likert scale (1 = very low, 3 = average, 5 = very high).

## RESULTS

For the dietary analyses, there were no significant differences between conditions for total caloric ( $p = 0.564$ ; partial  $\eta^2 = 0.020$ ), carbohydrate ( $p = 0.506$ ; partial  $\eta^2 = 0.026$ ), fat ( $p = 0.851$ ; partial  $\eta^2 = 0.002$ ), and protein ( $p = 0.184$ ; partial  $\eta^2 = 0.101$ ) intake (Table 1). Our results also indicated there was no significant ( $p = 0.392$ ; partial  $\eta^2 = 0.039$ ) difference in 5-km race time between the supplement ( $23.62 \pm 2.08$  min) and placebo ( $23.51 \pm 1.97$  min) conditions (Figure 1). The two-way repeated measures ANOVAs for the psychological variables (energy, fatigue, alertness, and focus) indicated there were no significant condition  $\times$  time interactions or main effects for condition, but there were main effects for time (Table 2).



**Figure 1.** Individual results of 5,000-meter race time for the supplement and placebo conditions ( $n = 20$ ). Male and female subjects are indicated by blue and red lines, respectively. Dashed bold line represents the mean.

## DISCUSSION

The findings of the present investigation indicated that ingestion of the current pre-workout supplement had no effect on 5,000-m race time performance or subjective feelings of fatigue. The majority of previous studies that have examined the influence of acute supplementation with pre-workouts have shown beneficial effects for anaerobic performance, but there are limited data concerning the efficacy in aerobic measures. Walsh et al. (47), however, examined the acute effects of a pre-workout supplement on constant-intensity treadmill running to volitional exhaustion. The authors (47) reported that the pre-workout supplement increased the time to exhaustion (+12.5%) at 70%  $\dot{V}O_{2max}$ , and improved subjective feelings of energy and focus during the work bout. Based on these findings, we hypothesized that acute ingestion of pre-workout would result in improved 5,000-m run time. It is possible that the discrepancy in results between the present study and those of Walsh et al. (47) can be explained by differences in subject training level, intensity of the exercise bouts, or ingredient profile of the pre-workout supplement. Although both groups of subjects were defined as “recreationally active”, our

sample had a minimum running requirement of  $>24.1 \text{ km} \cdot \text{wk}^{-1}$ . In addition, the classic work of Daniels and colleagues (10) suggested that 5,000-m race pace in a motivated athlete is maintained at a higher intensity (i.e.  $> 90\% \dot{V}O_2\text{max}$ ) than the intensity ( $70\% \dot{V}O_2\text{max}$ ) of Walsh et al. (47). The inclusion of proprietary blends in the both supplements also makes comparisons difficult, even though the some of the same ingredients (caffeine, beta-alanine, and arginine) were utilized. Consistent with the present findings, Collins et al. (9) reported no improvement in 4,000-m cycling time trials in recreationally-active males and females following acute supplementation with a pre-workout containing caffeine (200 mg), beta-alanine (2.1 g), and arginine (1.3 g). Collectively, the results of the current study as well as those of Walsh et al. (47) and Collins et al. (9) indicated that pre-workout supplementation may be beneficial for aerobic exercise at a constant-intensity to volitional fatigue, but not for time trials of pre-determined distances. The present findings, however, should be considered in light of the study limitations that included running indoors and under artificial conditions that may not be consistent with recreational or competitive 5,000-m races with larger entry numbers and spectators. In addition, the present study did not examine blood or urine markers of ingredient metabolites or conduct any third-party testing of the supplement contents.

The current pre-workout supplement contained a total of nine ingredients (excluding vitamins and minerals) with six of these ingredients included in proprietary blends at undisclosed quantities. The three ingredients with the quantity provided were caffeine (150 mg), beta-alanine (1.6 g), and arginine (1.0 g). Each of these ingredients possess physiological mechanisms that have been shown to improve a number of measures associated with aerobic performance (1, 15, 44). For example, caffeine is a mild central nervous system stimulant that primarily functions as an ergogenic aid by blocking adenosine receptors, thereby increasing feelings of energy and alertness (15). Acute caffeine supplementation of  $5 \text{ mg} \cdot \text{kg}^{-1}$  has also been shown to increase free fatty acid mobilization and time to exhaustion at  $80\% \dot{V}O_2\text{max}$  (41), and improve mental effort as well as cognitive function during high intensity exercise (13). Other beneficial effects of caffeine ( $6 \text{ mg} \cdot \text{kg}^{-1}$ ) on exercise performance include increased release of  $\beta$ -endorphins during two hours of cycle ergometry at  $65\% \dot{V}O_2\text{max}$  (30). The findings of these studies (30, 41) demonstrated that caffeine can be an effective ergogenic aid on metabolic, physiological, and psychological factors when administered in acute doses of 5-6  $\text{mg} \cdot \text{kg}^{-1}$ . In the current supplement, however, the absolute caffeine content was 150 mg. This translated to average relative doses of 1.9 and  $2.3 \text{ mg} \cdot \text{kg}^{-1}$  in our sample of males ( $n = 10$ ;  $80.8 \pm 6.1 \text{ kg}$ ) and females ( $n = 10$ ;  $64.5 \pm 6.6 \text{ kg}$ ), respectively. Therefore, it is likely that the caffeine content (150 mg) included in the present pre-workout supplement was too low to have any measurable effect on 5,000-meter race time or subjective feelings of fatigue, focus, alertness, or energy. In support, O'Rourke and colleagues (35) demonstrated that acute supplementation with  $5 \text{ mg} \cdot \text{kg}^{-1}$  of caffeine significantly improved 5,000-m race time in both recreational (1.0%) and well-trained (1.1%) runners.

Beta-alanine is the most prevalent ingredient included in pre-workout supplements (26) and has been shown to increase intramuscular carnosine levels (18), reduce lactate concentration during aerobic performance (37), attenuate exercise-induced metabolic acidosis (2), improve time to exhaustion during graded exercise (39, 42), and boost cognitive function (46). It has been well-

established that supplementation with beta-alanine, however, requires chronic doses of 4-6 g · d<sup>-1</sup> typically for 2-4 weeks to achieve these benefits (3). Thus, the inclusion of beta-alanine in the current supplement would likely not contribute to any acute effect and also contains an insufficient dose (1.6 g) to be effective if administered long-term.

Arginine is a semi-essential amino acid that serves as the biological precursor for nitric oxide synthesis (1). This mechanism has been shown to promote blood flow to skeletal muscle (36), thereby increasing the delivery of oxygen and other nutrients while reducing metabolite production (38). Although acute supplementation with arginine has significant effects in the elderly and diseased populations (8, 36), there are conflicting data in healthy individuals. For example, it has been demonstrated that an acute dose of arginine can reduce the oxygen cost of moderate-intensity exercise and improve time to exhaustion during severe-intensity exercise in healthy samples (4), whereas other studies (14, 45) have shown no effects. Similar to caffeine and beta-alanine, the amount of arginine (1.0 g) in the current pre-workout supplement is well below the clinically-supported recommended dose (1) of at least 3-6 g for improving performance. Therefore, the absolute doses for the three main ingredients (caffeine, 150 mg; beta-alanine, 1.6 g; and arginine, 1.0 g) with listed quantities appear to be insufficient for eliciting ergogenic benefits associated with 5,000-m running performance or general feelings of exertion.

A recent study by Jagim et al. (26) has highlighted concern over the common practice of supplement companies under-dosing many of the ingredients in pre-workouts or including these ingredients in “proprietary blends” at undisclosed quantities. Out of the 100 best-selling pre-workout supplements on the market, the prevalence of these products containing at least the minimum ergogenic levels was only above 50% for caffeine (77%) with lower rates for beta-alanine (1.4%), arginine (4.0%), creatine (29.0%), and citrulline (37.5%). In addition, 58 out of these 100 products contained at least one proprietary blend with the quantities of 64% of all ingredients not provided. As suggested by Jagim et al. (26), pre-workout supplements with proprietary blends should be a concern for consumers due to the lack of necessary information to make decisions about efficacy and safety. The absence of any performance benefit in the present study supports this suggestion (26) and indicates that pre-workout supplement users should consider avoiding products with proprietary blends or ingest the desired ingredients at the known amounts individually to achieve the intended responses.

In summary, the results of the present study demonstrated that the acute single-dose ingestion of a multi-ingredient pre-workout supplement had no effect on 5,000 m run times or subjective measures of fatigue, energy, focus or alertness in an aerobically-trained population. It is likely that these findings could be attributed to the insufficient dosage of the three ingredients (caffeine, beta-alanine, and arginine) not included in the proprietary blends that were provided at quantities lower than the minimum ergogenic levels. Thus, these findings do not support the use of the current pre-workout supplement for improving 5,000-m running performance or associated subjective feelings of exertion on an acute single-dose basis. Future studies should examine the efficacy of individual ingredients common to pre-workout supplements on the metabolic, physiological, and psychological factors related to aerobic performance.

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