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The Effect of Energy Gel Administration in Preventing Declining Running Performance of Healthy Recreational Runners

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ABSTRACT

A half-marathon is a type of endurance sport that is increasingly popular in Indonesia. During endurance activities, the body experiences a decrease in glycogen reserves and blood glucose levels, which can lead to reduced physical performance and increased fatigue. Energy gels are concentrated sources of carbohydrates to provide fast-absorbing energy during exercise. Consuming energy gels during running is considered beneficial for maintaining performance and preventing fatigue. Most research on energy gel consumption focused on trained athletes; the effect of energy gel consumption for recreational runners, however, is unclear. The objective of this study was to examine the impact of energy gel consumption on maintaining running performance in healthy, recreational Indonesian half-marathon runners. In this crossover study, sixteen recreational runners received energy gel (28 g/serving carbohydrate), konjac jelly (4 g/serving carbohydrate), and mineral water supplementation on three separate occasions during their running. Self-reported performance data (running duration, distance, elevation, rate of perceived exertion, and heart rate) were collected using a web-based questionnaire after each session, and assessed with the Friedman Test and the Wilcoxon Signed Ranks Test. In this study, energy gel consumption significantly reduced the rate of perceived exertion (RPE) compared to mineral water consumption ($p < 0.05$). However, no significant effect on running duration ($p>0.05$) nor heart rate ($p>0.05$) was observed.

Keywords: energy gel, half marathon, heart rate, RPE, running duration

INTRODUCTION

A half-marathon is a type of endurance sport that requires the aerobic energy system to function for a prolonged duration, accompanied by eccentric contractions and relatively high training intensity (Hill, J.A. et al., 2014; Wiewelhove, T. et al., 2018). During endurance activities, the body experiences a decrease in glycogen reserves and blood glucose levels, which, if left unaddressed, can compromise physical performance and exacerbate fatigue (Burke et al., 2011). Therefore, maintaining stable energy levels is crucial to prevent fatigue (Karahanoğlu, A., 2022).

Carbohydrates serve as the primary energy source for marathon runners, accounting for approximately 90% of their energy expenditure (Stellingwerff, T., 2013, as cited in Yan, L. et al., 2024). Carbohydrate consumption is also known to be associated with improved running performance (Yan, L. et al., 2024). In endurance sports, the availability of carbohydrates to the

muscles and central nervous system can be impaired due to their relatively limited supply, as the fuel needed for the activity exceeds the body's carbohydrate stores (Burke et al., 2011).
According to research by Rapoport, B.I. (2010), more than two-fifths of marathon runners reported hitting the wall, referring to a rapid onset of severe fatigue and inability to maintain high-intensity speed as a result of depleted carbohydrate reserves in the leg muscles and liver. Therefore, providing additional carbohydrates is necessary to improve marathon performance, as it enables runners to maintain optimal speeds for more extended periods before experiencing fatigue (Burke, L. M., 2007).

Based on guidelines published by ACSM, runners with exercise durations above 1 hour require additional carbohydrate intake of 30–60 grams/hour (Sawka et al., 2007 in Jeukendrup, A.E., 2011) or 0.7 g/kg BW/hour (Rodriguez, N. R., 2009 in Jeukendrup, A.E., 2011). Carbohydrate intake can increase blood sugar levels which ultimately stimulate the release of insulin from pancreatic β cells to transport liver glucose and exogenous glucose into muscle cells, stimulate lipolysis so that the breakdown of fatty acids can be used as an energy source, increase calcium release to support muscle contraction, rapid glucose absorption to provide energy supplies for working muscles, replenish lost electrolytes and increase fluid retention, protect against ongoing tissue inflammation, oxidative stress, and so on (Rocha, A., et al., 2016 in Ravindra, P.V. et al., 2020). Indeed, Tsintzas, K. et al. (1993) found that runners who consumed carbohydrates in the form of glucose completed the marathon faster (128.3 ± 19.9 minutes) compared to those who only drank water (131.2 ± 18.7 minutes).

Energy gels are concentrated sources of carbohydrates, widely used by long-distance runners due to their practical form and formulation. Energy gels provide fast-absorbing carbohydrates, which are considered advantageous for maintaining performance and preventing fatigue during intense physical activity. However, most research on energy gel consumption focused on trained athletes. Additionally, inconsistencies remain in research results, primarily due to variations in running distance. Therefore, the objective of this study was to examine the effect of energy gel consumption on maintaining running performance in healthy, recreational Indonesian half-marathon runners. With this understanding, the results of this study are expected to provide an effective method to maintain running performance in recreational runners.

METHOD

Respondents

Participants were 30 young male adults, aged 20–40 years, with a normal body mass index (BMI) of 18.5–22.9 kg/m², who were recreational runners. However, fourteen people did not complete the entire series of studies (did not finish/DNF), so only sixteen people were eligible for data analysis. Before the study began, all respondents were asked to complete an informed consent form that explained the procedures and potential risks associated with participating in the study. This has been submitted to the ethics commission with approval number: 010K/III/PPPE.PM.10.05/11/2024

Design Study

This study used a crossover design. All participants ran three half-marathon sessions, with a minimum of one week's washout period between each session. In each session, participants consumed three different samples in random order: energy gel, konjac jelly, or mineral water. All participants tested the samples beforehand to assess whether they experienced any adverse reactions or sensitivities to the samples. Participants were asked to maintain their regular eating habits from the previous dinner until the last meal before the half-marathon session, including the type of food, portion size, and meal schedule. They were also asked to sleep at least eight hours the night before each run, maintain their warm-up and cool-down habits, use the same running track and follow the same schedule for all sessions, follow the instructions for product use, and consume one product every 30 minutes by setting their own alarm.

Physical Performance Measurement

Physical performance data were collected using a fitness tracker (device or application) owned by each participant. Self-reported performance data were collected using a web-based questionnaire after each session, including running duration, distance, elevation, rate of perceived exertion, and heart rate.

The rate of perceived exertion was measured as running fatigue using a Likert scale:

1 = Extremely easy
2 = Very easy
3 = Easy
4 = Moderate
5 = Somewhat hard
6 = Moderately heard
7 = Hard
8 = Very hard
9 = Very, very hard
10 = Extremely hard

Sample Preference Measurement

Self-reported sample preference data were collected using a web-based questionnaire after each session. Participants were asked to scale their product experience, including taste, texture, the product's effect on performance, and likelihood to finish the product in one use, using a Likert scale:

1 = Strongly disagree
2 = Disagree
3 = Somewhat disagree
4 = Somewhat agree

5 = Agree
6 = Strongly agree

Statistical Analysis

Statistical analysis was performed using SPSS Statistics version 27 with a p-value of <0.05. The variables analyzed included running duration, fatigue (RPE), and heart rate (HR), which were not normally distributed; therefore, non-parametric tests were performed using the Friedman Test and Wilcoxon Signed-Rank Test. For acceptability variables (effects on performance, taste, texture, and ability to finish the product), which were not normally distributed, a non-parametric test of the difference between two paired means with the Wilcoxon Signed Ranks Test was performed to determine the average difference between variables. The hypothesis in this study is that the use of energy gel can prevent a decline in running performance when consumed during a half-marathon compared to konjac jelly.

Materials

The products used in this study were energy gel (L-Men), commercial konjac jelly, and mineral water. Each serving of energy gel (35g) contained 28g of carbohydrates, 40mg of caffeine, and 500mg of BCAAs (including 125g of valine, 125mg of isoleucine, and 250mg of leucine). Meanwhile, commercial konjac jelly was used as a comparison, with a lower carbohydrate content of 4g total carbohydrates, and no added caffeine or BCAAs per serving (20g). Mineral water, used as a non-caloric control group, did not contain macronutrients.

RESULTS AND DISCUSSION

Table 1. Results of the Three Products towards All Variables

Variable	Konjac Jelly	Energy gel	Mineral water	p-value
Running duration (min)	131,63± 17,06	129,31± 15,48	132,31± 17,5	0,709
Rate of perceived exertion	3,47± 1,13 (a)	3,56± 0,96 (a)	4,63± 1,67 (b)	0,006*
Minimum heart rate (bpm)	102,81± 17,49	108,56± 21,58	104,5± 18,25	0,062
Average heart rate (bpm)	157,5± 10,74	157,69± 10,1	154,81± 11,18	0,160
Maximum heart rate (bpm)	177,87± 9,5	178,69± 11,97	174,56± 10,28	0,06

*Significantly different (p<0,01), where (a) is different from (b)

Running Duration

The average running duration was calculated as the leading performance indicator for each session. The average running times when participants consumed mineral water, konjac jelly, and energy gel were 132.31 ± 17.5 minutes, 131.63 ± 17.06 minutes, and 129.31 ± 15.48 minutes, respectively. Although a slightly faster running duration was observed with energy gel consumption, statistical analysis showed no significant difference between all treatments (p = 0.709). Overall, energy gel consumption did not significantly affect running time for the half-marathon in healthy recreational runners.

Rate of Perceived Exertion

The rate of perceived exertion (RPE) was measured using a 1–10 Likert scale immediately after respondents completed the run. The highest fatigue score (4.63 ± 1.67) was observed when participants consumed only mineral water, followed by energy gel (3.56 ± 0.96) and konjac jelly (3.47 ± 1.13). The Friedman test conducted showed a significant difference in fatigue levels between treatments (p = 0.001). Further analysis using the Wilcoxon Rank Test revealed that a significantly higher RPE scale was observed during mineral water treatment compared to konjac jelly (p = 0.042) and energy gel (p = 0.013) treatments. This suggests that additional carbohydrate intake, whether from energy gel or konjac jelly consumption, may have the potential to reduce the perception of fatigue during a half-marathon.

Heart Rate

Heart rate was measured as an indicator of physiological response to exercise and analyzed based on three parameters: average, minimum, and maximum heart rates during the running phase. No significant difference between treatments for the parameters, including minimum heart rate (HRmin) (p = 0.062), maximum heart rate (HRmax) (p = 0.06), and average heart rate (HRavg) (p = 0.160).

Acceptance

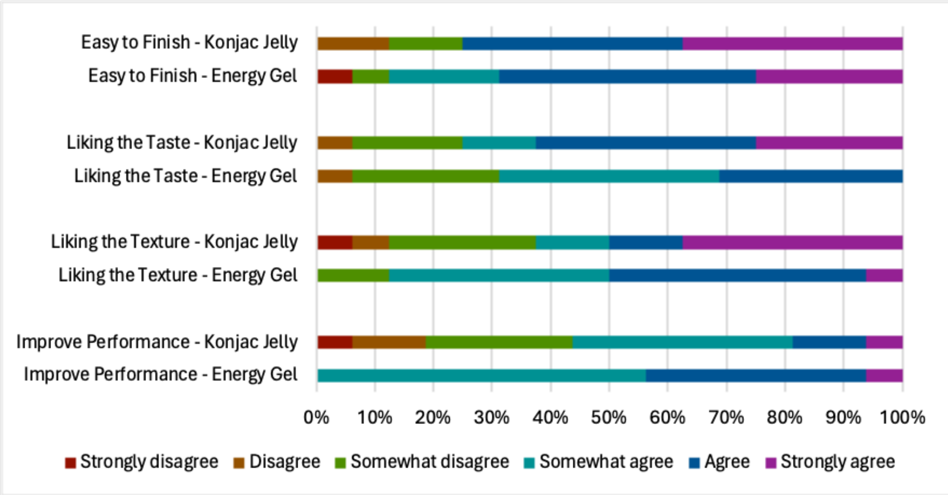

Fig. 1. Comparison of the acceptability results between konjac jelly and energy gel products in recreational runners.

Subjective aspects related to product experience were evaluated through four perceptual indicators: effectiveness in improving performance, taste preference, texture preference, and ease of consuming the product in one sitting. Participants rated the energy gel as having a higher perceived performance improvement after consumption compared to the konjac jelly, with an average score of 4.50 ± 0.63 for the energy gel and 3.56 ± 1.26 for the konjac jelly. This difference was statistically significant ($p = 0.013$), indicating that participants subjectively perceived energy gel consumption as contributing to an improvement in their running performance.

Overall, energy gels demonstrated good acceptability and positive perceptions of performance enhancement, although preferences for taste and texture varied among individuals. No significant difference was observed in taste preference ($p=0.093$), texture preference ($p=0.694$), and ease of using the product ($p=0.791$) between energy gel and commercial konjac jelly.

Discussion

The objective of this study was to investigate the effect of energy gel consumption on maintaining running performance in healthy, recreational half-marathon runners. This study aimed to determine whether consuming carbohydrates in the form of energy gels during training would affect performance or alter whole-body physiological responses during a half-marathon.

Relationship between Product Consumption and Running Duration

This study found no significant difference in running duration between the three treatment groups ($p = 0.709$). However, a shorter average running time was observed with energy gel consumption compared to konjac jelly and mineral water consumption. This suggests that consuming energy gel during a half-marathon does not directly increase speed or significantly reduce running time in recreational runners.

Research on the effect of carbohydrate consumption on running duration is still inconclusive. This is likely related to differences in the target audiences of athletes and non-athletes. Burke et al. (2005) found no significant difference ($p = 0.520$) between the running durations of the carbohydrate-consumed group (73.35 min) and the placebo group (73.56 min). This suggests that carbohydrate consumption during endurance activities does not always significantly impact running duration, particularly in non-athletes at submaximal intensity.

In contrast, Tsintzas, K. et al. (1993) found a significant difference ($p < 0.01$) in the group of athletes who consumed carbohydrates during running, resulting in faster running durations (128.3 ± 19.9 min) compared to those who only consumed mineral water (131.2 ± 18.7 min). This difference in results is likely related to the characteristics of the respondents. Athletes would generally have more optimal physiological adaptations than non-athletes because they are accustomed to undergoing structured and intensive training. These adaptations include increased aerobic capacity (VO_2max), energy metabolism efficiency, and the ability to absorb and utilize nutrients during physical activity (Cermak et al., 2013). Additionally, the body composition of athletes, which typically features higher muscle mass and a lower percentage of fat, can also contribute to improved performance. Therefore, the benefits of carbohydrate supplementation on physical performance during exercise are likely more pronounced in athletes than in recreational runners.

Differences in carbohydrate dosages in products can also affect the effectiveness of energy gel consumption on running duration. According to research by Cermak et al. (2013), consuming high doses of carbohydrates (60-90 grams per hour) during endurance exercise can improve performance by an average of 2-6% for durations >90 minutes. In the context of this study, the energy gel used contained 28 grams of carbohydrate per sachet and was consumed every 30 minutes. Therefore, the total carbohydrate intake per hour likely did not reach the optimal dose as suggested in previous studies, so its effect on running duration may be less than optimal.

Although this study did not directly demonstrate that consuming an energy gel during running significantly increased speed or reduced running time, there was a trend toward shorter running times with energy gel consumption compared to consuming konjac jelly or mineral water. This is consistent with the mechanism of action of fast-digesting carbohydrates used in energy gel, which function to maintain blood glucose levels and provide additional energy substrate during endurance activities (Thomas et al., 2016).

Relationship between Product Consumption and Rate of Perceived Exertion

This study found a significant difference in fatigue levels between treatments ($p = 0.001$). The highest fatigue score (4.63 ± 1.67) was observed when only mineral water was consumed, followed by energy gel (3.56 ± 0.96) and konjac jelly (3.47 ± 1.13) consumption. Significant differences were observed between mineral water and konjac jelly consumption ($p = 0.042$) and between mineral water and energy gel consumption ($p = 0.013$). However, there was no significant difference between the consumption of konjac jelly and energy gel, indicating that both have the potential to reduce the perception of fatigue during running compared to consuming only mineral water.

Carbohydrate consumption during endurance activity plays a role in maintaining blood glucose levels, which not only provide energy for muscles but also for the central nervous system. According to Meeusen et al. (2006), brain glucose plays a crucial role in the perception of fatigue and motivation during physical activity. Consequently, decreased blood glucose levels can increase the sensation of fatigue even before a decline in physical performance occurs.

These results are in line with research by Seifert, et al. (2012) which found that there was a significant difference ($p = 0.004$) between the RPE in group consuming energy gel (3.9 ± 1.2) and placebo (5.3 ± 1.2) which indicates that group consuming carbohydrates in the form of energy gel had lower fatigue than the group consuming the placebo. Backhouse, S.H. et al. (2005) and Faulkner, J., & Eston, R.G. (2008) also reported that participants who consumed carbohydrates had significantly lower RPE values compared to participants who only drank water (placebo) after completing 63% of the activity. This indicates that carbohydrate intake not only provides physical energy but also reduces the mental perception of difficulty in performing endurance sports, such as marathons (Faulkner, J., & Eston, R. G., 2008).

The results also showed that consuming konjac jelly was related to a lower RPE compared to consuming mineral water. This suggests the possibility of physiological effects from consuming extra product during exercise, as discussed by Munnangi S et al. (2023) regarding placebos that can alter participants' perceptions of a product's effects even though it does not contain any active ingredients.

Relationship between Product Consumption and Heart Rate (HR)

It was observed that there were no significant differences between the three treatments in all heart rates, including HRmin ($p = 0.062$), HRmax ($p = 0.06$), and HRavg ($p = 0.106$). Relatively similar heart rate responses were observed during the half-marathon activity when consuming energy gel, konjac jelly, and mineral water. The results of this study are consistent with research by Suna and Türkay (2020), which found that there was no significant difference between the average heart rate (HRavg) in people who consumed carbohydrates (148.3 ± 7.3 bpm) and isotonic (152.9 ± 9.7 bpm), with a p-value of 0.249 during running activities.

Heart rate is a physiological indicator of work intensity, cardiovascular stress, and cardiac efficiency during physical activity. Average HR (HRavg) reflects the heart's steady state during activity, while HRmax indicates the heart's maximum workload. Heart rate during moderate physical activity is approximately 50-69% of the maximum heart rate, while heart rate during vigorous physical activity can increase to 70-85% of the maximum heart rate (Pure et al., 2021).

In this study, no significant differences were found in any of the heart rate parameters between treatments. Although the energy gel product contains caffeine, a stimulant that can theoretically increase central nervous system (CNS) and peripheral nervous system (PNS) activity, as well as heart contractions (Goldstein et al., 2010), this effect was not significantly observed in the heart rate measurements. This may occur because caffeine content in the energy gel is relatively low (40 mg) and may not be high enough to provide significant physiological effects on the cardiovascular system, especially in individuals with established caffeine tolerance. This supports the statement of Spriet, L.L. (2014), who stated that the effect of caffeine on heart rate is more visible at caffeine doses >3 mg/kg BW, while the dose in this study was below that threshold.

On the other hand, the results of this study are inconsistent with those of Utter et al. (2002), who found significant differences in %HRmax and HRavg between the carbohydrate and placebo groups. The study used a 6% carbohydrate solution with a total consumption volume of approximately 1650 mL per hour, equivalent to approximately 99 grams of carbohydrate per hour. Meanwhile, participants in this study consumed only one sachet of energy gel (28 grams of carbohydrate) every 30 minutes, equivalent to approximately 56 grams of carbohydrate per hour in concentrated form, without additional fluid. This difference in carbohydrate form and dosage may be the reason for the lack of significant differences found in this study. In particular, the consumption of a large amount of carbohydrate solution in the study by Utter et al. (2022) not only provides energy but also contributes to optimal hydration and nutrient absorption during activity, which can improve physiological parameters such as HRavg and %HRmax.

Consideration of Confounding Variables (Distance, Sleep Time, Elevation)

In this study, sleep duration, track elevation, and distance were considered confounding variables that could potentially influence participants' physical performance and subjective perceptions of fatigue. However, the analysis revealed no significant differences between treatment conditions ($p > 0.05$), indicating that these variables were not the primary contributing factors to the outcome.

Inter-individual sleep variability can affect performance and fatigue. A minimum sleep time of 8 hours the day before running showed that the average sleep duration was relatively equivalent between treatments, at around 397 to 401 minutes. Similarly, the distance covered by runners varied slightly, from 21 to 23 km in each running session. However, the average difference was not statistically significant and was within the tolerance margin of field research. The track elevation, which is considered to affect physiological workload and heart rate, was also controlled (44 to 50 meters) by choosing the same route for each run, and analysis showed no significant differences.

This supports the validity of the main finding that differences in fatigue levels are more likely due to energy gel consumption, rather than differences in other external or physiological conditions.

Limitations

Limitations of this study include the lack of standardization of the fitness tracker devices used by participants to record heart rate, distance, duration, elevation, and other data. Different brands may have varying standards and levels of accuracy. To mitigate this bias, all participants were asked to use the same device across all three running sessions to maintain consistent measurements, despite individual differences.

The data collected in this study consisted of self-reports, which can increase the risk of error. To address this, participants were provided with explicit written and verbal guidance and were regularly monitored through a group to ensure the protocol was followed consistently and correctly.

Furthermore, there was a limitation in the product packaging design. The commercial konjac jelly used had packaging that was relatively more difficult to open compared to energy gels, potentially disrupting running rhythm or causing a decrease in pace when consumed mid-run. Although the packaging had been slightly modified to ease the opening process, potential interference from this factor remains a variable that can impact performance, such as run duration.

Therefore, for further research, it is recommended to use the same measuring tools for all participants to minimize variability, conduct direct field monitoring, and use the same packaging for all samples.

CONCLUSION

This study found that energy gel consumption did not significantly impact the objective performance of healthy recreational runners, as measured by running duration or physiological responses, including heart rate (HRmin, HRmax, HRavg). However, energy gel consumption significantly reduced subjective fatigue levels (as measured by the rate of perceived exertion) compared to mineral water consumption, indicating a benefit in improving participants' comfort and physical perception during the half-marathon. Thus, energy gel can be considered a nutritional strategy to improve subjective comfort and endurance during endurance activities in recreational runners; however, its effect on physiological parameters still requires further research with a more controlled design and a more homogeneous population.

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