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Psychological effects of energy gels: An investigation into runners' energy gel choice and consumption strategies in marathon running

ABSTRACT

Marathon running is a physical and mental activity. Runners consume high-energy food products to fill their glycogen stores for maintaining their marathon performance. This makes consuming carbohydrates, mainly in the form of energy gels, an essential part of marathon running. While previous research demonstrates significant physiological effects of these high-energy food products on performance, their psychological effects, which could benefit from and shed light on food design studies, have been underexplored. This article explores these effects with two participant studies, a narrative study (n = 10) and a survey (n = 39). The inquiries start with understanding the psychology of marathon runners and examining the psychological effects of energy gels on marathon running. The results showed that the marathon runners follow a self-identified energy gel consumption strategy during marathon running. Several qualities of energy gels influence these

KEYWORDS

energy gels
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psychological effects
gel consumption
strategy
marathon experience
high-energy food
products
sports nutrition

strategies and the meanings marathon runners attach to energy gel consumption. The findings elucidated a novel area of food design research by unveiling the nature of the non-nutritional interactions between runner and energy gels consumed in marathon running.

INTRODUCTION

In the last decade, the number of recreational marathon runners increased from 500,000 to 1.1 million people worldwide (Andersen 2019). One of the reasons for this increase is that running a marathon (i.e. 42.195 km) is no longer postulated to be a 'only for elite athletes' type of activity (Kruiger and Saayman 2013). While most marathon runners are motivated by the perceived benefits of running (Loughran et al. 2013), multiple reasons, such as being healthy, maintaining psychological well-being, feeling in competition and controlling mood, have all been identified as motivation to train for and complete a marathon (Ogles and Masters 2003; Zach et al. 2017). Not surprisingly, such a long performance involves evolving feelings and mood changes (Raglin 2007). The marathon world record holder Eliud Kipchoge once noted that 'pressure is a lot in the marathon because it's a long journey. There is a big pressure through the 42km' (ineos195challenge 2019: n.pag.), revealing how running a marathon can be psychologically demanding and stressful.

Runners employ various strategies to reduce the mental and physiological stress of marathon running. For instance, some runners use pacing strategies that suit their motivation and aerobic capacity (Nikolaidis and Knechtle 2017). In doing so, they frequently reflect on their performance through the physical comfort they feel, their pace and the distance left (Samson et al. 2017). Much of the rest of the time, marathon runners' thoughts dwell on their surroundings and the extreme discomfort they are enduring (Raglin 2007). These strategies can also be viewed as cognitive orientation in marathon running to physiologically and psychologically prevent increased fatigue and energy loss during a marathon (Stevinson and Biddle 1998).

Consuming high-energy food products (i.e. energy gels or bars) is another strategy many runners employ to reduce the physiological stress of marathon running (Wilson 2016). Research shows that these products contribute positively to performance optimization in distance running (Burke et al. 2019; Costa et al. 2019). Energy gel consumption can ease runners' psychological struggles of marathon running as well. It is because the body receives an instantaneous boost before consuming the gel (Phillips et al. 2012), and hence, the energy intake timing can transform a disassociation strategy (e.g. a distraction from bodily sensations) into an association (e.g. physical sensations) strategy (Stevinson and Biddle 1998). Food products like energy gels (an example collection is given in Figure 1) are likely to trigger runners' subconscious symbolic associations, valuations and engagement with complex multi-sensory experiences (Joutsela et al. 2017).

Hence, this article aims to investigate the psychological effects of energy gels in marathon running. In the following, I aim to answer two main questions: (1) What are the psychological roles of energy gels in marathon running experience? (2) How do the product qualities of energy gels affect the marathon running experience? By answering these questions, I aim to define opportunities for food design to support better marathon running and endurance sports performance.



Figure 1: A collection of energy gels available in the consumer market.

ROLES OF ENERGY GELS IN MARATHON PERFORMANCE

Healthily completing a marathon requires proper preparations and planning. Athletes need a certain amount and variety of training to improve their capacity to perform better (Bompa and Buzzichelli 2015; Mattocks et al. 2016) together with proper planning (Koehler 2016). Research shows that consuming carbohydrates is essential to restore and optimize the muscle glycogen stores to keep the energy levels of endurance athletes at the desired levels (Beck et al. 2015; Close et al. 2016; Peeling et al. 2019), while undertaking carbohydrates is likely to result in underperforming (Stevinson and Biddle 1998). As a result, nutrition intake becomes essential for athletes to adapt their training load and support their performance (Jeukendrup 2017; Pugh et al. 2018).

The physiological benefits of carbohydrate intake are extensively explored by sports nutrition science. For example, carbohydrate intake before (Hargreaves et al. 2004) and during endurance activities (Coyle 2004) was reported to increase the availability of carbohydrates to exercising muscles (Jeukendrup 2010). Still, athletes might experience severe gastrointestinal symptoms caused by these energy substitutes (Hansen et al. 2014). Therefore, it is advised that comfort in the digestibility of energy supplements must be tested before the actual performance, preferably during training, to eliminate the risks of unexpected gastrointestinal experiences during endurance

activities (Jeukendrup 2010). To overcome potential digestibility problems, most marathon runners carry those body-approved nutrition supplies in their pockets or attached to their belts (Koehler 2016). In contrast, elite runners can access the reserved areas during the race, saving them from carrying their food (Koehler 2016).

Several guidelines suggest the type, amount and timing of energy intake to promote optimal health and performance across endurance sports (Thomas et al. 2016). Specifically, to sustain high-intensity and long exercises over 90 minutes, athletes are recommended to take carbohydrate supplements in several forms like energy gels or beans (Campbell et al. 2008). Furthermore, ultra-endurance athletes are advised to take between 60 and 90 g of carbohydrates for every hour of exercise (Burke et al. 2011; Kimber et al. 2002) and delay the biochemical determinants of fatigue in order to compete effectively (Close et al. 2016). These guidelines also explain why most carbohydrate-containing energy gels in the consumer market are in a minimum of 45–55 g packages. Therefore, considering the recommendations (Burke et al. 2011; Kimber et al. 2002) and depending on personal marathon completion times (e.g. between 2 and 6 hours), it can be estimated that a marathon runner might consume between four and eight energy supplements in the form of energy gels in a marathon event.

Aligned with the articulation of Schifferstein et al. (2013), I believe it is vital to understand the experiences of these unique food products for long-distance runners. This knowledge could contribute to designing better food experiences and the psychological effects of high-energy products in endurance sports. Therefore, this article aims to provide insights into food design by taking the psychological effects into account to stimulate pleasurable marathon experiences.

To investigate these effects, I carried out two complementary studies with runners who completed at least one full marathon in the past. The goal and the contribution of the studies differ. In the first study ($n = 10$), I examined the psychology of marathon running, investigated the energy gel consumption strategies runners follow and the effects of gel consumption on the psychology of marathon running. Following this, I carried out a quantitative study ($n = 39$). I explored the relations between several aspects of energy gels, gel consumption strategies runners follow and the psychological effects of gel consumption in marathon running. In the following, I will explain each study's methodology, analysis and results and conclude with a general discussion.

STUDY 1: NARRATIVES OF GEL CONSUMPTION EXPERIENCES IN MARATHON RUNNING

In the first study, I conducted interviews accompanied by a narrative exercise (Chase 2003; Georgakopoulou 2006) to investigate the effects of gel consumption on marathon runners' psychology during marathon events and capture their food consumption stories. The narrative study was utilized to investigate the 'what and how' of exercisers' stories (Smith 2010). The narrative study helps to reveal the temporal, emotional and contextual qualities of experiences and relationships and allows an understanding of how athletes connect with bodies (McGannon and Smith 2015; Smith and Sparkes 2009). Furthermore, the method enables me to embrace the complexity of the self-motivational and psychological conditions connected to energy gel consumption experienced in marathon running. I aim to answer three sub-questions with the

first study: (1) How do the runners experience running a marathon? (2) What are the energy gel consumption strategies runners employ? (3) What are the effects of energy gel consumption on the psychology of marathon runners?

Sample and participant selection

To reach out to the participants, I followed purposeful sampling (Coyne 1997). First, I recruited participants via social media and individual e-mails. I was not interested in runners' marathon performance or finishing times but in their momentary marathon running experience and the perceived psychological effects of energy gels on their marathon experience. Therefore, the goal was to reach out to the runners who completed a marathon in the past three years, possibly within the past year. Unfortunately, due to the global pandemic in 2020, most runners faced the challenge that almost all worldwide marathon events were cancelled after March 2020. Still, nineteen marathon runners were interested in the study, and I interviewed ten runners between the ages of 24 and 52 ($M = 37.90$) who completed at least one marathon within the past three years (Table 1).

Data collection and analysis

All interviews were conducted on online platforms (e.g. Skype, Teams or Zoom). Each participant was invited to join a secure online meeting. Before the interview, each participant was informed about the goal and flow of the interview. Each participant's consent was collected before the sessions. The

Table 1: Participant profile of narrative study (n = 10).

P#	Age	Gender	Number of marathons completed	Frequency of gel consumption	Last marathon completed in	Finishing time (hh:mm)
P01	24	Male	>10	Before the start and 1 g of carbohydrate per minute (did not specify)	2020	02:27
P02	39	Male	3	At 7–14–21–28–36 km	2020	03:35
P03	44	Female	6	At 9–18–26–32–38 km	2020	03:57
P04	30	Male	2	At 6–13–19–24–30–36 km	2017	04:00
P05	40	Male	3	Before start: at 7–16–25–30–36 km	2020	02:45
P06	30	Female	2	At 8–15–23–30–36 km	2020	03:24
P07	48	Male	7	At 9–18–25–35 km	2020	03:39
P08	45	Female	2	Gel consumption at 12–25 km and other nutrition supplies before the start and at 5th, 19th and 34th km	2020	04:42
P09	52	Male	7	Gel 5 minutes before the start; afterwards at 10th, 20th and 30th km	2020	03:45
P10	27	Female	1	At 9–20.5–29–37 km	2020	03:58

interviews were voice-recorded and the data collected from the participants were kept anonymous. Each interview took between 45 and 67 minutes, and all the interviews were held in the participant's native language.

At the beginning of the interviews, the participants were asked about their marathon preparation routines and the role of their daily eating practices in this preparation. They were also asked about their gel choice, their consumption strategy in marathon running and whether their strategy changed during the marathon. Following, I introduced the narrative exercise. In the narrative exercise, I asked the participants to imagine themselves on the day of the marathon they had completed recently or the one in which they had the most memories. With this, I aimed to discover the thoughts that pushed them to start and keep running and explored possible links between the psychology of runners and the use of energy gels.

For the narrative exercise, I prepared visual materials to facilitate the narrative exercise. First, I provided the participants with an online 'distance-line' using the online collaboration tool 'Miro' (Miro 2020). I asked them to imagine the line was the marathon. The line was divided into smaller distances of 5 km each. Next, the participants were asked to mention what best described their feelings and thoughts during each stage of the race. Finally, they were encouraged to tell what they would say to themselves and speak about the moments they struggled the most during marathon running.

I shared my screen with the participants during the narrative exercise and used the Miro board 'post-its' to type in all the narratives participants talked about. I asked questions, where necessary, to probe the participants and inquire more about their stories. The participants were also asked the timing of their gel consumption during the marathon and how they felt after consuming it. At the end of this exercise, the participants were asked to think aloud about their psychology during the marathon and illustrate a line representing the change over time. This line was shaped together until the participant was happy with the curvature. The exercise ended when there was nothing left to speak about the participants' experiences. After collecting data from ten participants, I completed this qualitative study as saturation in data was achieved (Bowen 2008).

After collecting the data, I transcribed all interviews into Excel sheets. To not lose the sequence of narratives, I put the stories of each participant in Excel sheets in separate columns in the original order. Then, I transcribed the narrative stories of participants into storylines by arraying the kilometre marks. I first read up the results and then thematically analysed them (Vaismoradi et al. 2013) to illustrate (1) the psychology of marathon running, (2) gel choice and consumption strategy and (3) the psychological effects of energy gel consumption in marathon running.

Results

Psychology of marathon running

Through self-talk, the participants described a broad spectrum of feelings about their marathon experience during the narrative exercise. The results showed a fluctuating pattern among excitement, anxiety, doubt, boredom, happiness, confidence, disappointment and pride. Excitement and anxiety were the most commonly experienced feelings just before or at the start of the marathon. One participant described his excitement before starting as: 'This is my day; I only think about the moment I start' (P5). Two participants explicitly

mentioned feeling responsible to their followers (e.g. on social platforms such as Instagram and Strava) as the cause of their stress before the start.

Self-control in the beginning: Immediately after the start, runners focus on keeping themselves under control. While some runners kept checking their heart rate (e.g. P3), others concentrate on their pace (e.g. P9) to ensure that they save energy to the end of the race. After around the 3rd km, most runners felt relieved and started thinking about the finish line (e.g. P8). Joy after the finish line was what motivates the runner: 'My family is waiting for me there. [Seeing them will be] a great joy' (P8, between 10 and 15 km). After around the 4th km, runners start drinking water or consuming gels.

Mood fluctuations through the race: Runners' moods fluctuate from the 10th km until the end of the race's first half. A considerable number of participants ($n = 6$) indicated that they recognized the cheer-zones, friends or people they knew between the 10th and 20th km of the race, which helped them feel comfortable, supported and motivated. Self-judgement of the performance was what most runners kept doing. Reflecting on the distance covered, one of the participants exemplified a judgement they make about the remaining kilometres by indicating:

I compare my performance with my training performance. When I ran 15 km two weeks ago, I felt just like this, but I try to figure out how I would be feeling between 30–40 kms.

(P9)

P1 indicated that around the 21st km, he started losing his consciousness of running in a race:

The half is over, and I wish the race were over here! I am beginning to be unaware of what I am doing.

After half of the race till the 35th km, the amount of self-talk and self-control increases. From the 30th km on, narratives evidenced a noticeable decrease in physical vitality and a struggle between body and mind. Interestingly, P4 named this phase as 'accounting', meaning that he starts making calculations to motivate himself, while P9 indicated the serious part of the race begins.

Fear of failure was mentioned by several participants, especially after the 25th km. This is exemplified by P7:

I noticed that two people behind me speeded up and passed me. My speed is running low; the energy is going down.

Later, she related her low energy with the bad timing of the latest gel consumption:

I could have consumed the gel earlier, but when I realised, I was late. With the effect of gel [taken at 25th km], I recovered between 30-35 kilometres.

Mental war towards the end: Thoughts related to external mood boosters such as music, seeing family members or water stations after around the 32nd km were mentioned by multiple participants. According to P4, seeing friends

around the 34th km cheering him was the signal of the end of the race for him. P7 framed this part of the race as the start of the mental war: 'I feel tired. Why does a man do to this and suffer this torture?' Another participant expressed the mental war he experienced between 30 and 36 km:

My body is starting not to bear the fatigue of the marathon anymore. I wish this will be over as soon as possible!
(P1)

Two participants (P5 and P6) stated that they consumed gels at the 36th km, which boosted their self-belief about achieving their self-set marathon-finishing time goals. Another one mentioned that he started thinking of speeding up after the 36th km:

I thought that after 36 kms, I could speed up if there are no signs of tiredness, but I couldn't do that.
(P2)

P8 stated that she did not want to be miserable at the end of the race. Therefore, she focused on keeping herself motivated and concentrated on her pace. What P9 stated was interesting in that sense:

You think you are doing great things, but for an outsider, you do not perform outstandingly.

Light at the end of the tunnel: Participants indicated that around the 40th km, they start to acquire the awareness of being closer to the finish line. Some of the comments gained an optimistic perspective: 'I saw the finish sign – suddenly I got faster! I'm not depressed' (P5). P7 stated that seeing the 40th-km sign was the end of the race: 'All this pain will end. The first signal to finish. Twelve minutes to go!' This positive self-talk motivated P1 to run a faster last 2 km. On the other hand, at that phase, two participants (P3 and P4) stated that they were still in doubt whether they would finish the race healthy, such that P4 once asked for medical help after crossing the finish line.

Mixed feelings after the finish line: Crossing the finish line involved mixed feelings for many participants. These included positive ones like excitement and pride to have completed the marathon course that goes beyond the very noticeable physical pain, as P7 expressed:

An incredible combination of pain and happiness. I was so exhausted. That was what it should have been.

For most runners, after the marathon it became clear that they have accomplished something difficult. Eight out of ten participants indicated that after completing the race, they asked themselves: 'Where is the next marathon?'

Energy gel choice and gel consumption strategy

I recognized several repeating reasons behind runners' gel choice and gel consumption strategy. They categorized these under relying on knowledge, reducing unpleasant surprises and self-experience.

Relying on knowledge: The participants indicated that they define their marathon gel consumption strategy based on the knowledge they gain from more experienced runners ($n = 4$) and scientific resources ($n = 3$). Two participants indicated that their trainers advise them to have a specific strategy. P2 stated that he researched sports nutrition and found that consuming around 60 mg/hour is scientifically proven to affect performance, which helped him define his gel consumption strategy based on this evidence.

Some participants ($n = 4$) mentioned that they followed other runners' advice that the body's energy stores must be filled up before getting completely depleted. That is why these participants define and follow a specific gel consumption strategy based on their expected marathon completion time. They all believed that 30–45 minutes is the best time interval for them to consume gels in a marathon to get the most physiological effects (i.e. energy) out of the gels.

Reducing unpleasant surprises: All participants except P1 mentioned that they carried their gels with them during marathon, while P1 indicated leaving the gels in the athletes zone. For P1, not carrying gels ensured that he did not take additional weight during the performance. For others, carrying gels is a way to avoid consuming the gels of an unexperimented brand or taste during the marathon. This was also important for them to ensure that gel consumption does not result in severe gastrointestinal symptoms. Still, the way the gels were secured (e.g. in a waist belt) can result in unpleasant surprises. For instance, P9 expressed how frustrated he felt when he noticed that one gel he carried had fallen from his belt.

While most participants indicated that they rarely change their gel consumption strategy, it might vary based on how the runner feel about their needs. For example, P6 stated that he carried an additional gel with him, just in case, to feel confident and safe. P7 noted that he had five gels with him as his strategy was to consume all during the race. However, his stomach did not feel good after the fourth one, and he had to skip consuming the fifth.

Self-experience: A vast majority of participants ($n = 9$) consumed gels available in the sports nutrition market. All participants indicated that they assure (or prefer) only to consume gels they have tested before, either in a previous race or during training. Experimenting with a gel during prior training is a common strategy for gel choice ($n = 6$). This included self-experimenting the taste and ingredients of gels before deciding about the gel choice. For instance, P5 stated that his gel choice was mainly based on the gels' content (e.g. caffeine or high sugar) and a particular brand, which does not require drinking water after consumption. He stated that he prefers the gels of the Hi5 brand as those gels contain 23 g of carbs in 40 g of gel package. Due to similar reasons, P6 stated that she prefers the gels of the SIS brand, and P7 prefers the gels of the GU brand. An advantage of these particular gels was that the runner does not depend on the marathon organizations' water stations for setting the gel consumption strategy.

Self-experience stands out as an interesting reason for gel choice and consumption and a way of preventing unpleasant surprises. For instance, P10 indicated that she never trusts the marathon organizations in their premises for providing gels during the event, even if the brand of the provided gels is the one she is used to. This was because the flavour of the gel provided during the event would be different than the ones her stomach can digest.

Another participant (P6) indicated that she could not consume the content of the whole gel package if she does not squeeze the package properly. Based on her experience, she has to press hard and push the gel with her fingers in a certain way to finish up the gels. Another interesting example was P5, who stated that to prevent breaking the opening of the package, he opens the gel package with his mouth and only from one side. He indicated that it could be challenging for him to open the package with his mouth at a relatively higher speed than his marathon training.

Roles of gel consumption in marathon running

The narrative exercise showed three psychological roles of gel consumption in marathon running. Through the analysis, I categorized these under being *saviour*, *stimuli* and a *milestone*. An example of self-talk (see section 'Psychology of marathon running') and the roles of gel consumption are illustrated in Figure 2.

Saviour: Energy gels function as an impulse that contains perceived energy needs and results in several psychological outcomes ($n = 5$). For some runners, energy gels work as a saviour. For instance, the frequency of gel intake makes P4 feel confident and safe against cramps and hunger. Similarly, P2 thinks that the consumption of the first gel did not correspond to energy deprivation. Still, he feels good after the first gel, which makes him believe that he would run the race more comfortably. Running in a considerably hilly marathon course, P10 considered consuming the first gel around the 9th km as an early replacement of energy: "There will be a hill coming up, let's consume a gel!" P8 exemplified a similar need as the body's need of morale: 'I replaced what was lost, and I had confidence'. On the other hand, for P1, gel consumption was already part of the experience, but he did not experience an immediate energy increase due to gel consumption.

Milestone: Narrative results showed that the timing of gels becomes an important milestone for some runners ($n = 4$). For instance, P5 indicated that

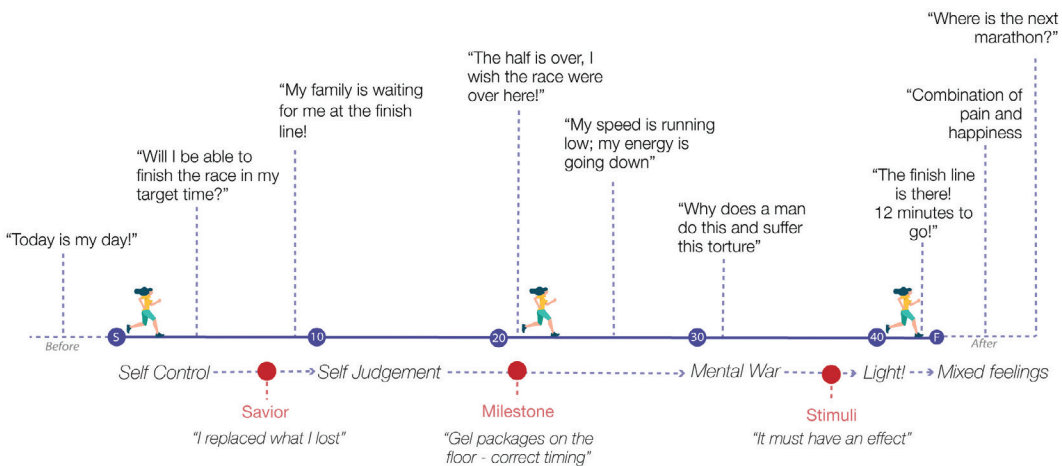


Figure 2: An example of self-talk and the role of energy gel consumption in marathon running.

'every gel closes a chapter of the race', and he builds his running motivation based on his gel consumption timing. Interestingly, P10 self-confirmed that her timing of gel consumption around the 21st km was the right choice: 'Lots of empty gel packs on the floor, apparently others consumed gel around here too!'

Stimuli: Once the runner complies with the need to get the functional support, the stimulus effect of gels is experienced, and the emotional push becomes more evident ($n = 4$). Thus, a stimulus can be considered an action by which the runner fulfils their energy needs by connecting the consumption to a perceived consequence. The resulting experience can be immediate functional or emotional support. For instance, P5 stated that

it must have an effect [on performance]. Too often during training, I experienced that I was exhausted when I didn't consume gels. Carb deficiency is also psychologically challenging. You feel even more exhausted.

Supporting this view, P3 stated that she consumed a gel after the 38th km, needing a psychological impulse, though she believed there would be no physiological effects. Apart from these results, the participants of the narrative study declared that the psychological effect of energy gels on their performance is indirect, while the physiological effects are more distinct.

Conclusions

The narrative study provided the details of the psychology of marathon running, the reasons behind runners' gel choice and consumption strategy and the roles that energy gels play in marathon completion. I found that runners tend to choose the gels they consume based on advice from people, mostly the marathon runners they trust. This sometimes results in self-experiments with different brands and gel contents (e.g. caffeine, high sugar, etc.). It became clear that most runners carry their gels with them in a running belt. While there were many insights hidden between the lines, I believe it is worth investigating the relations between product qualities, gel consumption and runners' psychology in marathon running. This could provide us with new directions for discovering the effects of food design in endurance sports. With this aim, I carried out a second study, which I present in the next section.

STUDY 2: PRODUCT QUALITIES, GEL CONSUMPTION AND PSYCHOLOGY OF RUNNERS

Combining the results of the narrative study with literature findings, I hypothesized that several food product qualities of energy gels have a significant positive relation with the gel consumption strategy the runners follow and the perceived psychological effects of energy gels. Based on these findings, in the second study, the following hypotheses were tested:

- H1:* Product qualities of energy gels are related to marathon runners' gel consumption strategy.
- H2:* Product qualities of energy gels positively correlate with the perceived psychological effects of energy gel consumption in marathon running.

Participants

To test the hypotheses, an online survey was employed. The link to the online survey was shared on social platforms and via personal e-mails. In total, 45 runners filled in the survey. Six of the respondents were removed from the sample for several reasons (e.g. participant did not run a marathon, there was no variation observed in the responses). Finally, 39 participants (11 female and 28 male), ages ranging from 31 to 58 ($M = 39.87$), were included in the analyses. The participants' average experience in running was $m = 6.87$ years, and the average marathon experience was $M = 4.16$ times. Runners consumed at least two gels during marathon running (41 per cent). Of the participants, 46 per cent indicated that they consumed at least four gels, while 8 per cent consumed more than five gels.

Survey

In the survey, first demographics and the participants' experiences in marathon running were collected. Subsequently, the participants rated the importance of seven food product qualities that could play a role in runners' energy gel choice (e.g. prior experience, the brand of the gel and other packaging-related aspects). The participants were then asked to indicate their agreement with several statements regarding (1) their energy gel consumption strategy and (2) the psychological effects of energy gel consumption during marathon running. All responses were collected on a five-point rating scale. The survey questions were obtained from the narrative study and several literature sources. The items and their literature sources are given in the Results section. At the end of the survey, there was a text box for the participants to add comments or thoughts about their experiences. All the collected data were anonymized.

Data analysis plan

The mean and standard deviations of the survey questions were calculated to start with our data analysis. Next, three univariate analyses of variance tests were run to compare the mean scores of comparable questions using the Tukey test for multiple comparisons. Then, the Cronbach's alpha values of the two constructs of the survey (i.e. runners' energy gel consumption strategy and the perceived psychological effects of energy gel consumption in marathon running) were calculated to estimate the reliability of the constructs. Subsequently, to test the hypotheses and determine whether the gel choice reasons are correlated with the gel consumption strategy runners follow and the psychological effects of gel consumption in marathon running, Pearson's correlation coefficients were calculated. All statistical analyses were performed using SPSS software.

Results

Results of survey questions

When the participants were asked about the importance of the *qualities of the gels* for their gel choice (Table 2), it was found that the runners pay attention to the gel content (caffeine, high sugar, etc.) the most ($M = 4.05$, $SD = 1.38$). The least essential criterium was the advice from the marathon runners they trust ($M = 3.41$, $SD = 1.52$). The univariate analysis of variance

Table 2: Importance of gel selection criteria (N = 39).

Criteria for gel selection	M	SD
Gel content (caffeine, high sugar, etc.)	4.05	1.38
Brand of the gel	3.59	1.39
Suitability of the package to consume the gel during running	3.59	1.33
Suitability of the package design to open with the mouth during running	3.56	1.25
Suitability of the package design to open manually while running	3.46	1.35
Easy portability of the package	3.46	1.35
Advice from marathon runners I trust	3.41	1.52

Table 3: Construct 1: Gel consumption strategy in marathon running (N = 39).

	M	SD
S1. I carry my gels during the marathon	4.49	1.07
S2. I think the gel consumption strategy contributes positively to my performance	4.36	0.74
S3. I determine my gel consumption strategy before the marathon	4.28	1.10
S4. I never consume the gels that marathon organizations provide	4.13	1.36
S5. During the marathon, I pay attention to consume gels regularly	4.05	1.21
S6. My gel consumption strategy does not change during the marathon	3.39	1.29
S7. I adopt my gel consumption according to the condition of my stomach during the marathon	3.10	1.41
S8. I listen to my body to determine if I need gel consumption	2.72	1.28

Statements were partly derived from Burke et al. (2011) (S5), Campbell et al. (2008) (S5), Coyle (2004) (S2), Jeukendrup (2017) (S2, S3, S7), Kimber et al. (2002) (S5), Koehler (2016) (S1, S4) and Pugh et al. (2018) (S3, S7, S8).

test was conducted to compare the mean scores of the importance of the gel selection criteria. The results showed that none of the reasons listed in Table 2 is significantly more important than the others (all values were $p > 0.05$).

The results of runners' *gel consumption strategy* questions yielded interesting results (Table 3). The univariate analysis of variance test showed several significant differences between the strategy questions. For example, the responses to questions S7 and S8 (see Table 3 for the complete list of questions) were significantly lower than to questions S1, S2, S3, S4 and S5 ($p < 0.05$). Similarly, the results of question S6 were significantly lower than that of S1, S2 and S3 ($p < 0.05$). Accordingly, marathon runners are least likely to listen to their bodies and to adopt their gel consumption strategy.

The mean scores of the questions asked to measure the psychological effects of energy gel *consumption in marathon running* ranged between $M = 3.74$ and $M = 3.33$ (Table 4). The univariate analysis of variance test results showed no statistical significance between the mean scores of the questions ($p > 0.05$).

Table 4: Construct 2: Psychological effects of energy gel consumption in marathon running (N = 39).

Questions	M	SD
PS1. I think my gel consumption strategy has an impact on my motivation for marathon running	3.74	1.14
PS2. I feel stronger after consuming the last gel	3.62	1.11
PS3. I feel better after consuming the gel than before	3.59	1.09
PS4. I feel less stressed after consuming the gel	3.41	1.29
PS5. After consuming each gel, I feel more confident that I will reach my goal	3.36	1.11
PS6. I feel happy after consuming every gel	3.33	1.18

Statements were partly derived from Wilson (2016) and from participants (P2, P3, P4, P9).

Reliability analysis of the constructs

The Cronbach's alpha coefficient estimated the internal consistency of the constructs (see Tables 3 and 4). The coefficients are relatively high for both constructs. A coefficient of 0.85 was calculated for strategy (eight items), and 0.93 for psychological effects (six items). Both constructs showed an internal consistency estimate higher than 0.70 (Nunnally and Bernstein 1994). Item-total correlations (Nunnally and Bernstein 1994) were also run to understand if all the items contribute positively to the reliability of each construct. The results showed that the item-total correlations ranged from 0.81 to 0.86 for the *strategy* construct and from 0.91 to 0.92 for the *psychological effects* construct.

Overall, it can be concluded that the survey questions satisfactorily measured the two constructs: (1) the *strategy* that recreational runners follow to consume energy gels and (2) the *psychological effects* of these products. No significant correlation was found between the gel consumption strategy and the psychological effects of these food products $r(39) = 0.1, p > 0.05$.

Relations between gel choice reasons, consumption strategy and runners' marathon psychology

The results of Pearson's correlation coefficients between the scores of the two constructs and the importance runners attach to the different product aspects also yielded interesting results. It was found that there was a significant correlation between the runners' adoption of a personal gel consumption strategy and the importance they attach to the advice they get from other marathon runners they entrust ($r[39] = 0.34, p < 0.005$). For the psychological effects of gel consumption in marathon running, positive correlations with the ease of portability of the package ($r[39] = 0.46, p < 0.005$), advice from marathoners they entrust ($r[39] = 0.44, p < 0.005$), the brand of the energy gels ($r[39] = 0.43, p < 0.005$) and the suitability of the package to consume the gel during running ($r[39] = 0.33, p < 0.005$) were also found. No other significant correlations were observed between gel choice reasons, consumption strategy and runners' marathon psychology ($p > 0.05$).

DISCUSSION

The two participant studies reported in this article illustrated several psychological effects of gel consumption in marathon running. The first study

unravelling the details of the psychology of marathon running. Supporting Raglin's (2007) findings, the shift in the feelings, starting from anxiety to excitement and pride, became evident along the distance covered by the runner. After the start, the marathon event's thrill gets low, while the fatigue starts to be felt deeper. Interestingly, crossing the finish line, runners start thinking about running the next marathon. The results showed that even though marathon running is mentally and physically destructive, many runners enjoy and are motivated to participate in marathons (Ogles and Masters 2003).

The studies showed that runners consume approximately four to seven gels in marathon running, depending on the runners' marathon completion time. Relatively, the timing of the first gel consumption of the participants falls around the first hour of the activity (i.e. 30–60 minutes). These results align with the sports scientists' suggestions that athletes should take between 60 and 90 g of gels for every hour of the exercise (Burke et al. 2011; Kimber et al. 2002). This evidence also explains why runners do not tend to change their gel consumption strategy.

As illustrated by survey results, other runners' advice is significantly correlated with the runners' gel consumption strategy and the perceived psychological effects of energy gels. Similar results are evident from the narrative analysis showing that runners trust other runners' advice and sports nutrition knowledge. The narrative study showed that the content (e.g. caffeine, high sugar, etc.) and the brand of gels are important gel selection parameters. Accordingly, some runners believe that the gels of a particular brand are more advantageous against others due to the gels' ingredients not requiring drinking water after consumption (as explained in section 'Energy gel choice and gel consumption strategy'). Therefore, the gel's content might be why a significant positive correlation between the gel brands and the psychological effects of gel consumption in the second study was found. However, this hypothesis must be tested further to arrive at better conclusions.

Runners want to ensure the comfort in digestibility of energy gels (Jeukendrup 2010). To this aim, the participants had made self-experiments with gels (e.g. in their training) to eliminate negative surprises caused by consuming arbitrarily chosen gels. Hence, most runners carry their gels with them (Koehler 2016) and rarely consume the gels provided by the marathon events. This might be why a significant correlation between the psychological effects of gel consumption in marathon running and the ease of portability of the package was found. Still, there can be cases that the runners do not feel comfortable with their stomach after a gel consumption. Therefore, some runners might change their gel consumption strategy to avoid severe gastrointestinal symptoms caused by these energy substitutes (Hansen et al. 2014). However, further evidence of the reasons for changing their gel consumption strategy was found.

Not surprisingly, gel consumption becomes part of the race when the interaction with the first food product occurs. The results of the narrative study strengthen the thought that the role of gel consumption is not solely functional (e.g. keeping the energy expenditure balanced), but it goes beyond the nutritional roles and embraces a natural psychological role. Some runners regard energy gels as a hidden encouragement and achievement reward. These products are regarded as a saviour from energy depletion, a stimulus for emotional support and a milestone to keep track of the covered distance. Saviour and stimuli are connected by consequence, in the sense that when a functional or emotional need is detected, the runner seeks certain kinds of triggers (in this

case, gels) to help them fulfil the experienced urge. The milestone indirectly influences the runners' psychology by intruding upon the sensory systems of the runner.

The survey results illustrated no significant correlation between the psychological effects of gel consumption and the strategy runners follow. Nutritional assessments remark that the performance benefits from consuming gels are not necessarily about using sugar as a carbohydrate but about sensing that something boosts the energy level (Phillips et al. 2012). This perception matches the psychological effects illustrated in the narrative exercise and is supported by the survey results showing that runners feel happy or less stressed after a gel consumption. According to the narrative exercise, the consumption of the last gel falls into the most destructive portion of the marathon. This portion is where runners are somewhere between 'the mental war' and 'see the light at the end of the tunnel' phases of the race.

According to the findings, runners consume energy gels to feel safe and confident and sometimes keep track of the distance covered. Energy gels can also be part of the strategies that marathon runners adapt to cope with the stress of running a marathon. The three roles of energy gels that were arrived at from the narrative analysis can be regarded as the strategies that runners use to overcome the stress of marathon running (Phillips et al. 2012). The results showed that gel consumption in marathon running could ease runners' struggle to keep running. It is not only because the body receives an instantaneous boost before consuming the gel (Phillips et al. 2012), but the timing of the intake can transform the disassociation strategy (e.g. consuming the gel at a particular kilometre of the race) into an association strategy (e.g. consuming the gel as the body needs it).

Three packaging-related aspects of energy gels (i.e. ease of portability of the package, the suitability of the package to consume the gel during running and the suitability of the package design to open manually while running) were found to be positively correlated with the psychology of marathon running. Based on these results, it can be suggested that designing food products directed at marathon runners (and endurance sports) should incorporate physical cues (e.g. design of the opening of the gel package) that enhance motivation through a sensory stimulus and engage runners in multisensory energy gel consumption experiences.

The motivational roles of food products can involve actions with gel packages, such as opening, squeezing, holding and disposing of the package. This way, material qualities and sensory interactions with the food products can enhance marathon running experience. Matching runners' physiological and psychological needs might open refreshing innovations in sports nutrition packaging. The development of new energy gel packaging solutions can involve a great opportunity for sensory food experiences.

CONCLUSION

In this article, the psychological effects of energy gels in marathon running were investigated. The aim of the studies reported in this article was to provide insights for food design considering these effects (Wrigley and Ramsey 2016). The findings elucidated a novel area of food design research by unveiling the nature of the non-nutritional interactions between runners and energy gels consumed in marathon running. Several psychological roles and impacts

of these products in marathon running were discovered. I believe that the knowledge provided in this article goes beyond food design and connects it to sport psychology and sports nutrition practices.

The results presented in this article can be further tested to confirm a derived hypothesis. For instance, it would be interesting to investigate the effects of food design on mood shift in other endurance sports like cycling and triathlon. Specifically, the effects of the ease of use and usability of gel packages (e.g. opening and dosing of energy gels) on sporters' mood can yield new areas of research in food design for endurance sports. A further study can also look into how the branding of energy gel products and the gels' taste affect the psychology of marathon running. The studies reported in this article did not consider the environmental impact or gender differences in gel choice and consumption. Future studies can take these factors into account. Hence, the findings presented in this article provide baseline guidance for the food design studies for targeting the psychological needs of endurance sporters.

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