

# Low glucose relates to greater aggression in married couples

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**Intimate partner violence affects millions of people globally. One possible contributing factor is poor self-control. Self-control requires energy, part of which is provided by glucose. For 21 days, glucose levels were measured in 107 married couples. To measure aggressive impulses, each evening participants stuck between 0 and 51 pins into a voodoo doll that represented their spouse, depending how angry they were with their spouse. To measure aggression, participants competed against their spouse on a 25-trial task in which the winner blasted the loser with loud noise through headphones. As expected, the lower the level of glucose in the blood, the greater number of pins participants stuck into the voodoo doll, and the higher intensity and longer duration of noise participants set for their spouse.**

self-regulation | hungry | ego-depletion

Quarrel not at all. No man resolved to make the most of himself can spare time for personal contention. Still less can he afford to take all the consequences, including the vitiating of his temper and loss of self control.

Abraham Lincoln

As former US President Abraham Lincoln notes, quarrels and contentions not only waste time, they can also produce harmful consequences, such as damaging relationships. It is somewhat ironic that such quarrels and contentions often occur between people who are closest to each other: intimate partners. Sometimes these “lovers’ quarrels” can escalate beyond hurtful words to physical acts of aggression and violence. Intimate partner violence refers to physical, sexual, or psychological harm caused by a partner or spouse (1). Intimate partner violence affects millions of people around the world (2). As Lincoln suggests, loss of self-control may help explain why people quarrel and contend with others, even their intimate partners.

## Self-Control

Self-control refers to the ability to override an urge, desire, impulse, or habitual tendency (3). In intimate relationships, it is especially important to keep angry feelings in check. The need to vent one’s anger is one of the most frequently cited motivations for intimate partner violence among male and female perpetrators (4). Unfortunately, people have fewer and less effective techniques for controlling anger than for controlling any other emotion (5). To override an aggressive urge, self-control is needed.

However, self-control is not an unlimited resource. When people use self-control energy, it becomes depleted, an effect called “ego depletion” (6). Numerous studies have shown that when people engage in one act of self-control, they have less self-control for subsequent tasks (3). Of particular relevance to the present study is research showing that when people engage in an initial act of self-control, they are less able to subsequently control their aggressive impulses (7). Overriding aggressive impulses requires self-control energy, and, when some of that energy is depleted, people become more aggressive.

Self-control requires energy, and that energy is provided in part by glucose. Glucose is made from nutritious intake that becomes converted into neurotransmitters that provide energy for brain processes. Low glucose levels can undermine self-control because people have insufficient energy to overcome challenges and unwanted impulses. Numerous studies have found a relationship between low glucose levels and poor self-control (8). For example, when glucose levels are low, people have more difficulty controlling their attention (9), regulating their emotions (10, 11), and overriding their aggressive impulses (12). Some evidence suggests that low glucose levels might even increase the risk of violent criminal behavior, including spousal abuse (13). To our knowledge, our study is the first systematic investigation that tests the hypothesis that low glucose levels relate to greater intimate partner violent tendencies.

## Overview

The present study tests the hypothesis that evening glucose levels will predict aggressive impulses and also aggressive behavior in married couples. For 21 consecutive days, glucose levels were measured each morning before breakfast and each evening before bedtime. Our prediction was based on evening glucose levels because previous research has shown that self-control becomes more and more depleted as the day wears on, such that it is easier to exercise self-control early in the day than later in the day (14). Glucose also breaks down into energy less effectively as the day progresses (15), which offers further evidence that self-control energy may be compromised later in the day. To measure aggressive impulses, each participant was given a voodoo doll and was told to stick between 0 and 51 pins in the doll each evening, depending how angry they were with their spouse. After the 21 days, participants came into the laboratory and completed

## Significance

**People are often the most aggressive against the people to whom they are closest—intimate partners. Intimate partner violence might be partly a result of poor self-control. Self-control of aggressive impulses requires energy, and much of this energy is provided by glucose derived from the food we eat. We measured glucose levels in 107 married couples over 21 days. To measure aggressive impulses, participants stuck 0–51 pins into a voodoo doll that represented their spouse each night, depending how angry they were with their spouse. To measure aggression, participants blasted their spouse with loud noise through headphones. Participants who had lower glucose levels stuck more pins into the voodoo doll and blasted their spouse with louder and longer noise blasts.**

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a measure of aggressive behavior. They competed with their spouse on a task in which the winner got to blast the loser with loud noise through headphones. The intensity and duration of noise participants set for their spouse on the 25 trials was used to measure aggression. We predicted that evening glucose levels would be negatively related to aggressive impulses (i.e., the number of pins stuck into the voodoo doll) and to aggressive behaviors (i.e., the intensity and duration of noise participants set for their spouse).

## Methods

**Participants.** Participants were 107 heterosexual couples [mean age,  $35.6 \pm 10.9$  y (SD); 78% white] who had been married 12 y on average (SD 9.9) and were recruited via advertisements and paid \$100 (\$50 each).

**Procedure.** Although participants were tested in couples, responses were collected individually. After giving informed consent, participants completed the 10-item relationship satisfaction subscale of the Investment Model Scale (16) (e.g., "I feel satisfied with our relationship;" with 1 indicating "strongly disagree" and 7 indicating "strongly agree"; Cronbach  $\alpha = 0.95$  for men and 0.94 for women) in the laboratory. The experimenter also showed couples how to take glucose samples by using an Accu-Chek Aviva blood glucose meter, which they did every morning before breakfast and every evening before bed for 21 consecutive days.

To obtain daily measures of aggressive inclinations toward their partner, each participant received a voodoo doll along with 51 pins, and was told: "This doll represents your spouse. At the end of each day, for 21 consecutive days, insert between 0 and 51 pins in the doll, depending how angry you are with your spouse. You will do this alone, without your spouse being present." Participants recorded the number of pins they stuck into the voodoo doll. Previous research has shown that this procedure is a valid way to measure aggressive inclinations in couples (17).

After 21 days, participants returned to the laboratory to complete a behavioral measure of aggression. Participants were told that they would compete with their spouse to see who could press a button faster when a target square turned red on the computer, and that the winner on each trial could blast the loser with loud noise through headphones. The noise was a mixture of sounds that most people hate (e.g., fingernails scratching on a chalkboard, dentist drills, ambulance sirens). The noise levels ranged from level 1 (60 dB) to level 10 (105 dB; approximately the same level as a fire alarm). The winner could also determine the duration of the loser's suffering by controlling the noise duration [from level 1 (0.5 s) to level 10 (5 s)]. A nonaggressive no-noise option (level 0) was also provided. The participants actually competed against a computer rather than their spouse. Participants lost 13 of the 25 trials (randomly determined) and heard noise on each of those 13 trials. (If participants waited more than 0.5 s to respond, they automatically lost the trial; we added this option so participants would not become suspicious if they were slow but still won the trial.) The computer chose random noise intensity and duration levels for the spouse across the 25 trials. Basically, within the ethical limits of the laboratory, participants controlled a weapon that could be used to blast their spouse with unpleasant noise. This is a well-validated measure of laboratory aggression (18) that has been used for decades (19). A debriefing followed. Only three participants of 214 (1%) suspected that their partner during the aggression task was not their spouse, but these concerns were only expressed after they were told that they were playing against a computer. The results did not differ when these suspicious participants were excluded, so we kept them in the data set.

## Results

**Association Between Glucose and Aggressive Impulses.** We predicted that daily evening glucose levels would be negatively associated with daily aggressive inclinations, as measured by the number of daily pins participants stuck into the voodoo doll that represented their spouse. Our data exhibited a nested structure, such that daily pins were nested (i.e., clustered) within participants, and participants were nested within couples. Thus, our data violated the assumption of independence in ordinary least squares regression. For instance, a participant's aggressive inclinations are likely to be similar over days. In addition, aggressive inclinations are more likely to be similar for couples than for strangers. To account for the nested structure of our data, we used multilevel modeling procedures (20). A total of 4,051 days of data were provided by 214

participants (mean 18.93 days). Because the distribution of the number of pins stuck in the voodoo doll each day (mean,  $1.35 \pm 4.13$ ) was positively skewed, we used a Poisson distribution. Data were analyzed in Hierarchical Linear Modeling version 6.08 by using a three-level hierarchical model (with daily observations nested within participants, and participants nested within couples). Because glucose measurements were assessed daily, we used a within-participant centering approach (i.e., group mean-centered or participant-centered). That is, daily glucose was standardized around each participant's mean glucose level. Within-person centering eliminates the influence of individual differences between daily predictors and daily outcomes. In so doing, we were able to examine whether within-participant fluctuations in glucose across days significantly predicted aggressive inclinations above and beyond the influence of a participant's average glucose level. We included as covariates participant sex and relationship satisfaction (which was standardized around its mean in our sample, i.e., grand mean-centered). The outcome variable was the number of daily pins stuck into the voodoo doll that represented the participant's spouse.

As predicted, daily evening glucose levels predicted sticking fewer pins into the voodoo doll representing one's partner [ $b = -0.007$ ,  $t(213) = -2.43$ ,  $P < 0.02$ ] before controlling for any covariates. Daily evening glucose continued to predict fewer pin sticks even after controlling for relationship satisfaction and participant sex [ $b = -0.008$ ,  $t(213) = -2.82$ ,  $P = 0.006$ ]. Relationship satisfaction was also negatively related to the number of daily pin sticks [ $b = -0.63$ ,  $t(212) = -5.19$ ,  $P < 0.0001$ ]. Women also tended to stick more pins into the voodoo doll than men did, although the difference was not quite significant [ $b = -0.37$ ,  $t(213) = -1.92$ ,  $P = 0.056$ ]. Thus, having lower evening glucose levels related to stabbing a voodoo doll that represented one's spouse with more pins. People with lower glucose levels had higher aggressive impulses.

**Association Between Glucose and Aggressive Behavior.** Because noise intensity and duration were significantly correlated across the 25 trials ( $r = 0.88$ ), noise intensity and duration levels were averaged to obtain a more reliable aggression measure (Cronbach  $\alpha = 0.96$ ). We predicted that average evening glucose levels would be negatively associated with behavioral aggression at the end of the study. We, again, used multilevel modeling procedures to account for the dyadic nature of our data. We analyzed our data by using a two-level hierarchical model (with participants nested within couples), with average evening glucose (grand mean-centered) as our main predictor of interest, participant sex and relationship satisfaction (grand mean-centered) entered as covariates, and aggression on the noise-blast task as the outcome variable. We used average evening glucose levels for two reasons. First, it was not possible to compare daily evening glucose levels to aggression levels on the noise-blast task because participants did not complete the noise-blast task each day. Second, the average evening glucose index provided a good estimate of metabolic energy levels, which should provide a guide regarding how well participants could overcome their aggressive urges.

As predicted, average evening glucose levels predicted lower noise intensity and duration levels given to one's spouse [ $b = -0.003$ ,  $t(211) = -5.79$ ,  $P < 0.0001$ ] before controlling for any covariates. Average evening glucose continued to predict less aggression even after controlling for relationship satisfaction and participant sex [ $b = -0.003$ ,  $t(206) = -5.63$ ,  $P < 0.0001$ ]. No significant effects were obtained for relationship satisfaction or participant sex [ $b = -0.05$ ,  $t(206) = -0.28$ ,  $P = 0.78$ ; and  $b = 0.12$ ,  $t(206) = 0.53$ ,  $P = 0.60$ , respectively]. Thus, having lower evening glucose levels related to blasting one's spouse with more intense and prolonged noise. People with lower glucose levels had higher aggression levels. These findings for aggressive behavior replicate and extend the previous daily diary results for aggressive impulses.

**Mediation Analysis.** The correlation  $r$  between aggressive impulses (i.e., average number of pins stuck in the voodoo doll across the 21 days) and aggressive behavior (i.e., average of noise intensity and duration across the 25 trials) 0.24 ( $P = 0.001$ ). Next, we investigated whether aggressive impulses (i.e., average number of pins stuck into the voodoo doll across the 21 days) mediated the association between evening glucose and aggressive behavior. Having shown significant relationships between glucose and aggressive impulses and between glucose and aggressive behavior, we next tested whether aggressive impulses predicted aggressive behavior, controlling for average evening glucose, participant sex, and relationship satisfaction. We again used multilevel modeling procedures to account for the dyadic nature of our data. As predicted, the association between average daily aggressive impulses and aggressive behavior was significant [ $b = 0.17$ ,  $t(205) = 2.51$ ,  $P = 0.01$ ], such that people who stuck more pins into the voodoo doll across the 21 days also selected louder and longer noise blasts for their spouse.

We tested for statistical mediation by estimating the 95% CI of the indirect effect (i.e., mediated effect) by using the Product Confidence Limits for Indirect Effects (PRODCLIN) computer program, which generates a 95% CI for the indirect effect by empirically simulating a series of distributions for the product of coefficients that compose the indirect effect (21). Compared with traditional approaches for testing mediation, which are inappropriate for nested data (22), the PRODCLIN method provides more power and more accurate type I error rates for single-level and multilevel designs (23–25). As predicted, the indirect path through aggressive impulses was statistically significant because the 95% CI (−0.003 to −0.0002) excluded the value zero. Thus, participants with lower levels of evening glucose were more aggressive in part because they also had greater aggressive impulses.

## Discussion

This study attempted to find a link between glucose levels and aggressive impulses and behaviors in a 21-day diary study of married spouses. Numerous previous laboratory experiments have linked low glucose levels to poor self-control. Our study found that low glucose levels predicted higher aggressive impulses in the form of stabbing pins in a voodoo doll that represented a spouse. This study also found that low glucose levels predicted future aggressive behavior in the form of giving louder unpleasant noise blasts for longer durations to a spouse. There also was a link between aggressive impulses and aggressive behavior. Lower levels of glucose predicted aggressive impulses, which, in turn, predicted aggressive behavior. These findings remained significant even after controlling for relationship satisfaction and participant sex. Thus, low glucose levels might be one factor that contributes to intimate partner violence.

Numerous studies have shown that self-control becomes depleted after people use it. However, many of these studies have

been conducted under controlled laboratory settings. Our work tests the effects of self-control on aggression in the natural setting of one's own home and demonstrates that, even away from the laboratory, low glucose levels relate to greater aggressive impulses. Further, lower glucose levels over time predict future aggressive behavior outside of the home.

The results of this study demonstrate another important physiological variable that influences aggressive tendencies and behaviors, namely glucose. Glucose levels are an important influence on self-control and aggression, and glucose levels stand as a physiological factor that can be actively targeted and influenced. The current results suggest that interventions designed to provide individuals with metabolic energy might foster more harmonious couple interactions. Interventions that increase brain glycogen, for instance, might help provide additional metabolic energy that can be used for the self-controlled restraint of aggressive urges (26). This may be an effective intervention beyond couples; giving individuals more access to food could be a potential tool for curbing aggression by bolstering resources for effective self-control. This intervention might be especially important in stressful settings in which aggression might erupt, such as in prisons, psychiatric hospitals, and schools.

We focused on daily fluctuations in glucose levels, but future research may explore whether our effect would be strongest among populations that have compromised glucose levels. Dieters, for example, restrict their caloric intake in a manner that might place them at risk for aggression. Although we did not measure whether participants were dieting, hunger can increase feelings irritability. If dieters have not eaten enough, they will have lower glucose levels. As a result, they may have less energy to override their irritable feelings and aggressive impulses. The term “hangry” comes from the combination of the words “hungry” and “angry,” indicating that hungry people are often angry.

Relatedly, our emphasis on glucose levels neglected the possible importance of glucose tolerance—how effectively glucose is broken down into energy—in modulating our effects. Poor glucose tolerance is a core feature of some conditions, such as diabetes. Other research has also shown that elevated diabetic symptoms relate to greater aggressiveness (12). Future work may explore whether poor glucose tolerance represents a risk factor for intimate partner violence.

Intimate partner violence is a serious problem worldwide, and low self-control is likely a contributing factor. Self-control requires a lot of brain food in the form of glucose. The healthy metabolism of glucose may contribute to more peaceful homes by providing couples a boost to their self-control energy. Abraham Lincoln was correct about the relationship between self-control and quarreling. Aggression and violence often start when self-control stops, and glucose can help increase self-control.

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