Blood Glucose Response During a 9-Hole Round of Golf for Collegiate Golfers

Original Research

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Abstract

Introduction: Competitive golf places substantial physical and cognitive demands on athletes. Prolonged walking, explosive movements, environmental stressors, and mental focus contribute to significant energy expenditure and fatigue during competition. Nutrition plays a critical role in supporting both physical performance and cognitive function. Maintaining stable blood glucose levels is especially important to performance, as fluctuations may impair endurance, decision making, and concentration. Therefore, the purpose of this study was to examine blood glucose responses in collegiate golfers during a 9-hole round of golf.
Methods: Age, height, and weight were collected using a scale and stadiometer. All participants played 9 holes of golf while walking. Prior to the round of golf, participants completed a modified 24-hour food recall and a baseline blood glucose measurement. During the round, the participants were instructed to only consume water; blood glucose was collected after the completion of every hole.
Results: Blood glucose levels declined progressively across the 9-hole round, with an average decrease of 9.2 mg/dL from baseline (91.6 ± 17.7 mg/dL) to post round (82.4 ± 9.1 mg/dL). Mean blood glucose decreased by approximately 0.95 mg/dL per hole ($p < 0.001$), with significant variation across holes and between individuals. Linear mixed effects modeling revealed a significant effect of hole on blood glucose ($p < 0.001$), with over half of the total variance attributable to between participant differences (ICC = 0.545).
Conclusions: These findings highlight the need for individualized nutritional strategies to support golf performance. Collaborative, athlete specific nutrition approaches aimed at maintaining stable blood glucose levels may be essential for sustaining physical and cognitive performance throughout competitive play.

Key Words: performance, nutrition

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Introduction

The physical demands of competitive golf (collegiate and professional) are often underestimated. Flexibility, strength, power, and coordination are essential components of competition that must be trained and optimized for success in the sport[1]. While golf is seen to have a lower intensity than other sports like football, soccer, or basketball, it has been recognized as one of the most technically and physically complex athletic endeavors[1]. The aerobic system predominates during walking, which constitutes most of the activity in golf, while the anaerobic system supports the explosive power required for each swing[1,2]. Moreover, golf presents significant mental challenges, requiring a high level of cognitive performance. Not only do elite golfers often rely on structured routines to enhance mental readiness, focus, and consistency throughout competition[1], they also rely on their nutrition impacting their cognition and decision making abilities[3].

Collegiate golfers specifically have demanding schedules that often include rigorous workouts, academic responsibilities, extensive practice sessions, qualifying rounds, and frequent travel. Most collegiate golfers walk their 18-hole rounds. Previous research analyzed energy expenditure for collegiate golfers across two, 18-hole rounds and reported average distanced covered between 7.3 and 7.6 miles and an average caloric expenditure between 1,559.3 and 1,657.7 calories[4]. In some competitions, athletes may play 36 holes on the first day, lasting 10 to 12 hours, followed by an additional 18 holes on the second day. Walking these distances while carrying a golf bag or using a push/pull cart can total more than 15 miles over a 48-hour period. While the distance traveled is similar for all, there is a difference in the energy expenditure between those walking and those using a pushcart.

Previous research analyzed the activity energy expenditure across three 18-hole rounds, one round the participants used a pushcart, one round they used an electric golf cart, and one round they carried their golf clubs[5]. The results showed that using a pushcart (manual trolley) elicits the highest energy expended (756 $\pm$ 210 kcal), followed by carrying clubs (688 $\pm$ 213 kcal), and lastly a golf cart (633 $\pm$ 218 kcal)[5]. It is important to note that variation in results is heavily influenced by individual heart rate response[5], furthering the need for golfers to be treated as individuals in terms of training and nutrition.

In addition, the modality used to carry an individual's club impacting the strain of the sport, there are other factors that play a role in a golfer's performance and the metabolic demands. Environmental factors such as heat, humidity, or cold further increase the sport's energy demands. For example, when playing in hotter conditions, which is not uncommon in college golf, there is a shift in energy metabolism and an impact on energy expenditure[6]. If in a high humid environment, an athlete's ability to thermoregulate will also be impacted; therefore, impacting energy expenditure[7]. One of the other factors that could impact performance and energy expenditure is the terrain of the golf course. Previous research reported that terrain and elevation changes can play a large role in total energy expenditure during a round of golf[8]. The combination of prolonged walking and sustained mental concentration can lead to both physical and cognitive fatigue, increasing the risk of injury and poor decision making[1]. Therefore, it is imperative that competitive golfers implement strategies to delay fatigue and sustain optimal performance throughout competition.

Nutrition plays a crucial role in supporting both physical performance and cognitive function, making it an essential factor in golf performance[9]. Elite athletes typically follow well balanced diets to optimize energy levels and recovery, yet many amateur golfers overlook this component[10]. Educating developing golfers about the role of nutrition is critical, as proper fueling supports focus, endurance, and decision-making during competition. Maintaining stable glucose levels through balanced nutrition helps combat fatigue, enhances cognitive clarity, and sustains consistent performance over long durations[11].

For golfers, maintaining stable blood glucose levels is essential, as the sport often involves extended periods of play. Given the length of a typical round, athletes must consume food, specifically carbohydrates, periodically to sustain energy and concentration. Proper nutrition helps prevent fatigue, allowing players to remain both mentally sharp and physically engaged[11]. Maintenance of appropriate levels of blood glucose is a crucial factor when considering cognitive function and performance during a round of golf[12]. The timing of meals and snacks relative to performance is therefore a critical factor in delaying fatigue[13]. The macronutrient composition of these foods is equally important. Carbohydrates provide a steady source of energy during long rounds and directly impact blood glucose, protein supports muscle repair and recovery; and healthy fats, as well as vitamins and minerals, aid in reducing inflammation and promoting overall recovery[14]. Hydration also plays a vital role in both physical endurance and cognitive function. Even mild dehydration can impair focus, slow reaction times, and increase the perception of fatigue, all of which can negatively affect performance[10]. In sum, maintaining adequate nutrition and hydration during play enhances both physical performance and mental resilience on the course.

Historically, nutrition received little attention in golf, as the sport was traditionally viewed more as a game of skill and leisure than as a physically demanding athletic endeavor. In the 19th and early 20th centuries, golf was often regarded as a pastime focused on enjoyment rather than physical preparation[15]. During this era, dietary habits were rarely considered in relation to athletic performance. However, as golf's popularity grew throughout the mid-20th century, the role of physical fitness and nutrition began to gain recognition[10]. The NCAA officially added men's golf as an intercollegiate sport in 1939 and women's golf in 1982[16], marking a turning point in the sport's competitive evolution.

A major catalyst for change came with modern golfers who began to revolutionize the sport by integrating fitness, strength training, and nutrition into their regimen. This holistic approach has emphasized that physical conditioning and diet have been integral to peak performance in golf. Modern professional golfers such as Brooks Koepka have adopted advanced technologies such as percussion massagers and wearable tracking devices like the WHOOP band and routinely consult sports nutritionists to optimize recovery and energy management. The recognition of nutrition's impact on golf performance has now extended beyond professionals to the amateur ranks. Increasingly, golfers at all levels focus on dietary strategies and evidence-based supplement use to enhance performance, recovery, and overall wellbeing on and off the course.

Overwhelmingly, publications on golf performance emphasize the need for further research to better understand the factors that influence success in the sport. Nutrition remains one of the most underexplored yet potentially impactful areas, warranting deeper investigation. Appropriate levels of blood glucose are a crucial factor, therefore, the aim of this study was to observe blood glucose response for collegiate golfers during a 9-hole round of golf.

Methods

Participants

Twelve NCAA Division II golfers from Catawba College (19.4±1.3 yrs, 69.3±3.6 in, 164.6±26.8 lbs), eight males (19.8±1.2 yrs, 71.2±2.3 in, 176.4±22.9 lbs) and four females (18.8±1.5 yrs, 65.4±1.9 in, 141.0±17.3 lbs) participated. The informed consent document was read aloud to each participant and they each voluntarily agreed to participate. The study was approved by the Catawba College Institutional Review Board.

Protocol

Age, height, and weight were collected using a scale and stadiometer. All participants played 9 holes of golf (male: 3,270 yds; female: 2,763 yds), while walking and carrying their golf bag (11 participants) or using a pushcart (1 participant). Prior to the round of golf, participants completed a modified 24-hour food recall and a baseline blood glucose measurement. During the round, the participants were instructed to only consume water; blood glucose was collected after the completion of every hole. All blood glucose measurements were collected using a FreeStyle Neo device by Abbott (Chicago, IL).

Statistical Analysis

Descriptive statistics are presented as mean ± standard deviation for all variables using Microsoft Excel (Microsoft, Redmond, Washington). To evaluate changes in blood glucose across the round while accounting for repeated measurements within participants, a linear mixed effects model was conducted using Jamovi (version 2.6) (Sydney, Australia). Hole was included as a fixed effect, and participant was included as a random intercept. Model fit was assessed using marginal and conditional R^2 values, and the intraclass correlation coefficient was calculated to quantify between participant variability. Statistical significance was set at $p \leq 0.05$.

As a secondary analysis, a paired samples t test was performed using Jamovi to compare baseline blood glucose values with values obtained following completion of the ninth hole. Effect size was calculated using Cohen's d, and 95% confidence intervals were reported. All statistical tests were two tailed.

Results

Notable variation in blood glucose levels was observed throughout the round of golf. The average baseline blood glucose concentration was 91.6 ± 17.7 mg/dL, which decreased immediately after the first hole to 86.1 ± 13.8 mg/dL. Following the second hole, blood glucose levels stabilized slightly (87.9 ± 11.2 mg/dL); however, a gradual decline was observed as play continued, reaching a low point of 80.6 ± 8.6 mg/dL after the eighth hole. By the end of the round, the average blood glucose level was 82.4 ± 9.1 mg/dL. Across all participants, this represented an average decrease of 9.2 mg/dL from baseline to post round (Figure 1). Additionally, it is important to note that there were individual differences in blood glucose responses per hole (Table 1).

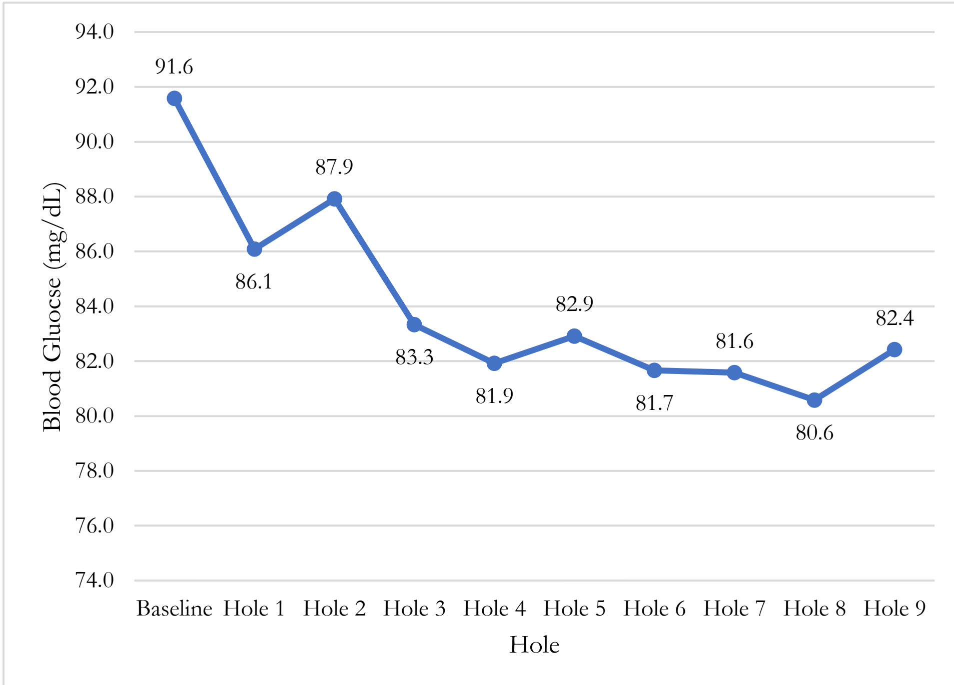

Figure 1. Average of All Participant's Blood Glucose Response. Blood glucose (mg/dL) was measured at baseline and after each hole, 1 through 9. A linear mixed effects model demonstrated significant linear decrease across the round (p<0.001), with an average decline of 0.95 mg/dL per hole. The decrease from baseline to hole 9 was not statistically significant (p = 0.075). *Note:* The significant effect reflects the overall linear trend across holes rather than differences between holes.

Table 1. Individual Participant Blood Glucose Response.

Participant	Baseline	Hole 1	Hole 2	Hole 3	Hole 4	Hole 5	Hole 6	Hole 7	Hole 8	Hole 9
1	88	97	87	68	79	94	86	78	86	87
2	93	93	97	92	90	92	73	73	81	81
3	76	78	75	76	79	72	70	74	79	83
4	80	80	78	70	68	70	71	81	74	60
5	96	90	86	87	81	76	84	84	77	93
6	120	88	96	89	78	68	83	78	80	80
7	74	75	84	67	77	88	87	69	73	87
8	108	64	92	94	91	81	85	87	81	91
9	75	80	75	86	76	84	79	81	76	73
10	96	86	86	82	80	86	83	93	81	83
11	71	82	84	80	74	79	81	83	74	80
12	122	120	115	109	110	105	98	98	105	91

Individual blood glucose responses across a 9-hole round of golf (n = 12). Blood glucose (mg/dL) was assessed at baseline and after each hole, 1 through 9. Data are presented as individual values to illustrate participant variability in glycemic responses throughout the round.

A linear mixed effects model was used to examine changes in blood glucose across a 9-hole round of golf. Hole number was treated as a continuous fixed effect to assess the linear trend in blood glucose across the round, while participant was included as a random intercept to account for repeated measurements within individuals. Modeling hole number as a continuous predictor allowed estimation of the average rate of change in blood glucose per hole. Although individual hole to hole responses may vary, the primary aim of the model was to evaluate the overall directional trend across the round. This approach was chosen to estimate the overall change in blood glucose across the round while accounting for repeated measures within participants. The model demonstrated a significant effect of the hole on blood glucose values ($F(1, 107) = 15.2$, $p < 0.001$). Blood glucose decreased by an average of 0.95 mg/dL per hole ($\beta = -0.949$, SE = 0.244, 95% CI [−1.43, −0.47], $p < 0.001$).

The marginal R^2 indicated that the fixed effect explained 5.5% of the variance in blood glucose, while the conditional R^2 indicated that 57.0% of the variance was explained by the combined fixed and random effects. The intraclass correlation coefficient (ICC = 0.545) suggested that approximately 54.5% of the variance in blood glucose was attributable to between participant differences. A total of 120 observations from 12 participants were included in the analysis.

A paired samples *t* test compared baseline blood glucose with values measured after completion of the ninth hole. Blood glucose decreased by an average of 9.2 mg/dL (post to baseline), but this difference did not reach statistical significance ($t(11) = 1.97$, $p = .075$). The effect size was moderate (Cohen's $d = 0.57$; 95% CI −0.06 to 1.17), suggesting a meaningful but variable decline in blood glucose across participants.

Discussion

Collectively, these results indicate a significant progressive decline in blood glucose across the round of golf, as identified by the linear mixed effects model. Although the paired samples t test compared only baseline and end of round values, the difference did not reach statistical significance, and the observed moderate effect size suggests a potentially meaningful reduction that may not have been detected due to limited statistical power. Overall, blood glucose levels decreased progressively as participants continued to play. Previous research has reported that blood glucose may decrease by up to 30% without appropriate nutritional intervention[12], which can lead to measurable declines in both physical and cognitive performance[17]. In the current study, the average decrease from beginning to end was 10.04%, however the extent of blood glucose fluctuation varied substantially within each participant, and between participants, as indicated by the large standard deviations. These findings suggest that individual physiological and nutritional differences may play a key role.

Numerous confounding factors influence the variability observed in blood glucose measurements. While the meal immediately prior to performance is a primary determinant, cumulative dietary intake throughout the preceding 24 hours significantly impacts baseline blood glucose levels and subsequent metabolic responses[18]. Even when dietary protocols are standardized, significant between participant variation persists due to a complex interplay of physiological and lifestyle variables. These include biological sex, anthropometric dimensions, gut microbiota composition, hydration status, and recent alcohol consumption[19].

Furthermore, in diverse athletic cohorts, sociocultural factors and geographical origins, ranging from international backgrounds to regional domestic differences introduce additional layers of metabolic complexity[20]. Because these variables are inherently difficult to isolate in human nutrition research, blood glucose data must be interpreted through a lens of individualization. Consequently, broad nutritional guidelines must be carefully tailored to the specific physiological and cultural profile of the athlete to ensure efficacy and adherence[21].

Beyond the physiological variables previously identified, identifying an athlete's optimal glycemic window is essential for maintaining peak performance[22]. While a range of 90 to 120 mg/dL is generally accepted as the target for metabolic stability during activity, certain athletes may require higher concentrations to sustain "maximum effort" bouts or prolonged aerobic demand[14]. For the golfer, the specific positioning within this range is dictated by a combination of baseline metabolic rate, personal preference, and the unique cognitive demands of different stages of play.

In the present cohort, the average starting blood glucose measurement was 91 mg/dL, the lower threshold of the recommended performance range. A 10.04% decrease from this baseline, as observed in our data, carries significant implications for performance. Athletes initiating play at or below 90 mg/dL are at an immediate disadvantage; even minor glycemic dips can impair the executive functions required for course management and technical precision in the golf swing.

The mean decrease illustrated in Figure 1 together with the information available from previous research suggests that several of the participants operated at a suboptimal blood glucose concentration for the duration of the round. Admittedly, the substantial difference between participant variability for blood glucose outcome as well as for individual needs cannot provide conclusive evidence that all participants were operating less than optimally. However, such a deficit is known to induce central fatigue, manifesting as reduced mental clarity and compromised motor control[9,2,12].

While outside of the scope of this study, several previous studies agree that carbohydrate intake is a critical determinant of golf performance. Nagashima, Ito et al.[23] demonstrated that a delivery of 44 g/hr is necessary to maintain euglycemia and delay fatigue in golfers. This specific requirement aligns with broader sports nutrition guidelines, which suggest 30 to 60 g/hr for events lasting longer than 2.5 hours[24]. While high intensity endurance events may necessitate up to 90 g/hr, the lower metabolic intensity of golf suggests that 44 to 60 g/hr represents an effective ceiling for most players.

Following data collection, personalized consultations were conducted with a Registered Dietitian (RD) to translate these metabolic trends into actionable nutrition strategies. However, the study faced inherent limitations; primarily, the "water only" restriction following baseline measurements limited our observations to fasted glycemic trends rather than postprandial responses to active fueling.

Future investigations should involve a dynamic intervention where golfers follow prescribed nutritional protocols while providing subjective data on perceived fatigue and concentration levels. Furthermore, as modern course architecture continues to increase total yardage, hole specific recommendations (e.g., eating at the 3rd and 6th holes) are becoming less reliable. Time based analysis (hour by hour) fueling strategies may offer superior accuracy regardless of course length or pace of play. An important consideration regarding the intake of food or drink is gastrointestinal distress associated with anxiety before or during competition. This is a primary reason some golfers avoid carbohydrate intake; however, education and guidance from qualified staff, including strategies to train the gut for these and other competitive situations, can be highly valuable.

Conclusions

These findings underscore the importance of individualized nutritional strategies to optimize golf performance. Sport coaches, strength and conditioning professionals, athletic trainers and sport dietitians should collaborate to design tailored nutrition programs that address each golfer's unique energy demands. Maintaining optimal blood glucose levels is a multifactorial process influenced by nutrition timing, macronutrient balance, hydration, and supplementation. Nonetheless, the observed glucose decline suggests golfers may benefit from individualized fueling strategies, and controlled interventions studies are needed to determine whether carbohydrate intake during the round stabilizes glucose and improves performance or cognitive outcomes.

Conflict of Interest

The authors declare no conflicts of interest.

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