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Article

Impact of simple vs complex carbohydrates under time constraint before anaerobic and aerobic exercise

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SUMMARY

When a busy schedule only allows for a short window of time to eat before a workout or cardio session, it is crucial to eat proper, energizing foods that let one reap the most out of their exercise. To that end, we compared simple carbohydrates, complex carbohydrates, and a control group of no pre-workout meal to determine their effects on an athlete's overall performance when consumed 30 minutes before anaerobic and aerobic exercises. We measured several quantitative variables: heart rate, mile run time, and repetitions for the bench press, bicep curl, and abdominal crunch. Random assignment delegated one treatment to every other day during an 11-day data collection period. We hypothesized that there will be no difference in heart rates when simple carbohydrates, complex carbohydrates, or no food is consumed 30 minutes before exercise. However, the time it takes to run a mile and the number of repetitions successfully performed will see better results if simple carbohydrates are consumed 30 minutes before exercise, as opposed to no food or if complex carbohydrates are consumed. Ultimately, we found that, when one's schedule only allows for 30 minutes to eat before a workout, the best pre-workout meal for optimal glycogen levels to prompt muscle hypertrophy, strength increases, and better endurance is one that is simple carbohydrate-heavy. Thus, when the time between a meal and a workout falls under 30 minutes, this fast-digesting macromolecule will best fuel the workout and allow for prime performance.

INTRODUCTION

Research has conveyed that eating food before exercising, whether it be anaerobic or aerobic exercise, is beneficial to increase workout performance and intra-workout energy levels. These "pre-workout meals" are hypothesized to provide fuel for the body when undergoing a period of glycogen and sodium depletion, which makes workouts more efficient (1). However, there is not enough clarity in the literature about how long before a workout one should consume certain foods. Thus, we looked at a 30-minute time window before various exercises to determine the best type of macronutrient that will optimize one's performance in a time constrained situation. Furthermore, better "performance" in this pilot study was measured by whichever pre-workout meal resulted in the most repetitions for each anaerobic exercise, along with the shortest one mile run time. Workouts that result in better performance are conducive to greater muscle hypertrophy, strength, and endurance augmentation, so it is important to find the best foods to optimize performance.

We tested one macronutrient in this pilot study, carbohydrates, as the established literature concurs that carbohydrates are the most directly influential macromolecule on overall exercise performance because they provide bursts of energy through promoting blood-glucose levels in the body (2). There are two main subsets of carbohydrates: simple and complex carbohydrates. Many believe that a pre-workout meal consisting of complex carbohydrates (a slow-digesting carbohydrate) gives rise to the greatest energy levels and performance in most individuals during different types of exercise (3). However, research shows that simple carbohydrates (a fast-digesting carbohydrate) have a faster digestion rate that potentially allows an athlete to have an energy spike (4). As a result, we tested whether simple or complex carbohydrates are more beneficial for exercise specifically when consumed 30-minutes before a workout. We also tested consuming no food before exercise as a control treatment. The exercises chosen to test the pre-workout meals include bench presses, bicep curls, abdominal crunches, and a one-mile run. All but the one-mile run are considered anaerobic exercises, while the run is an aerobic exercise. We also measured heart rate to see if there was a correlation between the any of the pre-workout meals.

We hypothesized that there will be no difference in heart rates when simple carbohydrates, complex carbohydrates, or no food is consumed 30 minutes before exercise. However, we hypothesized that the one-mile run and anaerobic exercises will see better results in performance when the simple carbohydrate pre-workout meals are consumed 30 minutes before exercise, as opposed to no food or the complex carbohydrate meals. After performing the experiment, we found that, when one's schedule only allows for 30 minutes to eat before a workout, the best pre-workout meal for optimal glycogen levels to prompt muscle hypertrophy, strength increases, and better endurance is one that is simple carbohydrate-heavy. Thus, when the time between a meal and a workout falls under 30 minutes, this fastest digesting macromolecule will best fuel the workout and allow for prime performance.

Days	Pre-Workout Meal	Starting Heart Rate (bpm)	Ending Heart Rate (bpm)	Bench Press Repetitions	Bicep Curl Repetitions	Abdominal Crunch Repetitions	Mile Run Time (minutes and seconds)
Day 1	Simple	57	156	33	47	140	7:31
Day 3	Complex	60	162	33	45	138	7:42
Day 5	Simple	62	155	34	51	144	7:36
Day 7	None	60	152	27	45	135	8:14
Day 9	Complex	59	158	32	47	139	7:52
Day 11	None	55	154	29	44	136	8:03

Table 1: Overall Results from Data Collection Days. A table of results for all data collection days organized in appropriate rows and columns.

Our study is relevant as long-term improvement in aerobic exercise endurance, strength gains, muscle hypertrophy, footspeed, etc., all require a consistent training routine and well-designed pre-workout meals to reap the most out of the time invested into improving one's shape and fitness. On another note, one study, when looking at the effects of simple versus complex carbohydrates on 20 athletes' aerobic performances, concluded that there was no difference in performance between the two groups (5). However, it is important to consider the different variables that can affect exercise, such as the time between consuming a meal and the workout. Therefore, we tested a time window of 30 minutes between exercising and consuming a pre-workout meal, which includes simple carbohydrates, complex carbohydrates, and a control group of no food.

RESULTS

To record the effects of simple and complex carbohydrates during a workout, each pre-workout meal was randomly assigned to specific workout sessions using a random number generator. We observed the time to complete a one-mile run and the number of repetitions for the bench press, bicep curls, and abdominal crunches, until the participant could no longer perform the exercise. We decided on testing the aforementioned exercises for many reasons. First, we landed on the anaerobic exercises—bench press, bicep curl, abdominal crunch-–because none of these movements have a direct overlap in terms of the targeted muscle, therefore minimizing the effects of muscle fatigue. Furthermore, we chose to record a one-mile run for the aerobic exercise because it would be the most convenient and accurate way to test a cardio-like activity.

Once pre-workout meals were randomly assigned, we began testing on Day 1. Our process for testing was as follows: consume the meal exactly 30 minutes prior to starting the workout, which remained the same throughout our study: bench press, bicep curl, abdominal crunch, one-mile run (**Table 1**). We made sure to control for several variables, expanded on in later sections.

Our results demonstrate a favor towards simple carbohydrates being the optimal pre-workout meal out of all treatments ever so slightly (**Table 1**). For both simple carbohydrate days, the mean of the bench press repetitions is 34 repetitions, while that of the complex carbohydrate days is 33 repetitions (**Figure 1**). The bicep curls exercise for simple carbohydrates averaged to 49 repetitions compared to the 46 repetitions for the complex carbohydrates (**Figure 2**), and the abdominal crunches for simple carbohydrates averaged to 142 repetitions compared to the 139 repetitions for the complex carbohydrates (**Figure 3**). Finally, the one-mile run average time for the simple carbohydrate meal was roughly 14 seconds faster than the complex carbohydrate one-mile run (**Figure 4**).

Moreover, the control group of no pre-workout meal exhibited a more extreme result from the other meals, eliciting

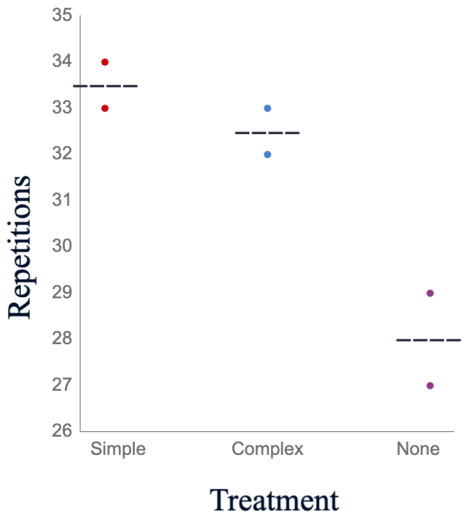

Figure 1: Bench press repetitions until failure for each pre-workout meal. Number of repetitions of bench presses performed until failure for each pre-workout meal of simple carbohydrates (red), complex carbohydrates (blue), and no pre-workout meal (purple). Subject ate each meal 30 minutes before exercise, n = 2 per meal type.

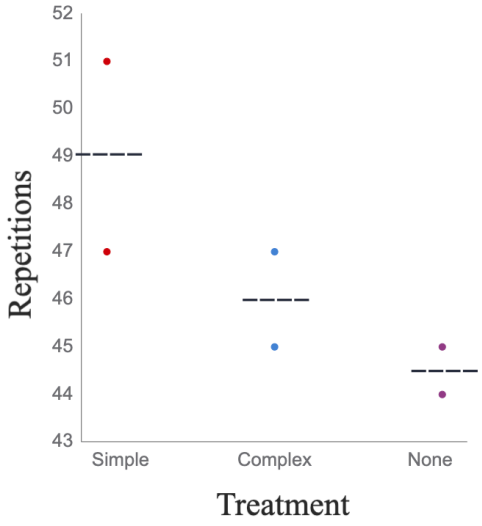

Figure 2: Bicep curl repetitions until failure for each pre-workout meal. Average number of repetitions of bicep curls performed until failure for each pre-workout meal of simple carbohydrates (red), complex carbohydrates (blue), and no pre-workout meal (purple). Subject ate each meal 30 minutes before exercise, n = 2 per meal type.

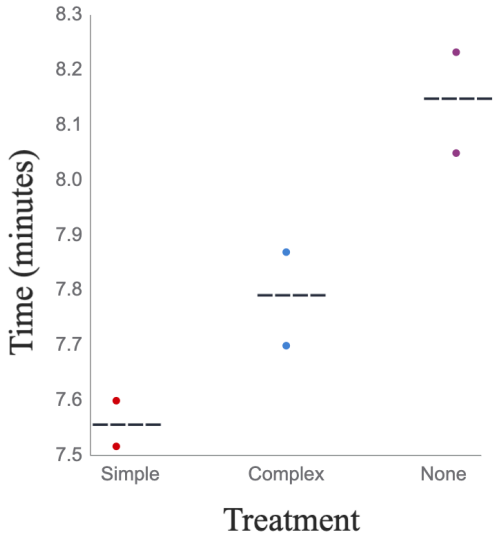

Figure 4: One-mile run time for each pre-workout meal. Average time elapsed for a one-mile run for each pre-workout meal of simple carbohydrates (red), complex carbohydrates (blue), and no pre-workout meal (purple).

a mean of 28 repetitions for the bench press (**Figure 1**), 45 repetitions for the bicep curl (**Figure 2**), and 136 repetitions for the abdominal crunches (**Figure 3**). The one-mile run average time for the simple carbohydrate meal was roughly 35 seconds faster than the no pre-workout one-mile run (**Figure 4**). As observed, the two carbohydrate treatments had much less variability when compared to no food consumed. The subject was able to perform more repetitions and run a mile much faster with carbohydrate pre-workout meals (**Table 1**). Thus, our data shows that eating some form of carbohydrates before working out, whether it be anaerobic or aerobic exercise, is more performance-enhancing.

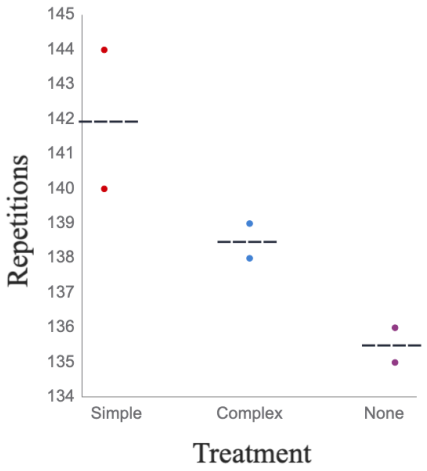

Figure 3: Abdominal crunch repetitions until failure for each pre-workout meal. Average number of repetitions of abdominal crunches performed until failure for each pre-workout meal of simple carbohydrates (red), complex carbohydrates (blue), and no pre-workout meal (purple). Subject ate each meal 30 minutes before exercise, n = 2 per meal type.

Moreover, we measured heart rate before and after each workout to see if there was a correlation between the simple and complex carbohydrate meals and found that there was little difference between the starting and ending heart rate for each workout. The heart rates range from 55 beats per minute to 62 beats per minute for each testing session (**Table 1**). Thus, we assume that the type of pre-workout meal consumed 30 minutes before exercising does not play an immediate, direct role on heartbeat. Contrarily, we saw a small pattern with the ending heart rates and corresponding treatments. Both control group trials with no pre-workout meals recorded the lowest ending heart rates of all the 6 testing days, albeit only a couple beats off (**Table 1**). The complex carbohydrate trials, however, have exhibited the highest ending heart rates, while the simple carbohydrate treatments linger in the middle (**Table 1**). It is not clear whether this is due to the actual treatment, a control inconsistency, or the lack of blindness in the study. Nonetheless, the control treatment data is supported by the science of lower blood sugar levels, or glucose, that result from not consuming carbohydrates or any food at all (6). Therefore, heart rate will be lower because no carbohydrates or glucose are readily passing throughout the body (17).

DISCUSSION

We tested the pre-workout meals before various exercises to find the optimal meal to increase exercise performance. The anaerobic exercises include the bench presses, bicep curls, and abdominal crunches, and the aerobic exercise was a one-mile run (**Table 1**). Upon testing, we found that simple carbohydrates provided the best enhancement of workout performance and efficiency when consumed 30 minutes before both anaerobic and aerobic exercise.

Better "performance" in this pilot study was measured and determined by whichever treatment resulted in the most repetitions of each anaerobic exercise, along with the shortest one mile run time. We tested the flat bench press first due to its nature as a main compound movement, meaning it works several muscle groups simultaneously. It predominantly targets the anterior deltoids, pectoralis major, and triceps brachii, while the second and third movements, the bicep curl and abdominal crunches, targets mostly the biceps brachii and abdominal muscles respectively (7-9). Since none of these exercises overlap directly with their respective targeted muscle groups, we decided on this sequence with the more demanding exercises in the beginning.

To ensure the pre-workout meals caused their respective results, we choose extreme versions of each meal. For instance, the first pre-workout meal of 390 calories of sugary-cereal bars serves as the treatment of simple carbohydrates, while the old-fashioned oats and whole wheat bread constitute the complex carbohydrates meal (10, 11).

After analyzing the results, we found that the difference was less substantial as the complex carbohydrates pre-workout meal did demonstrate overall inferior performance compared to each of the simple carbohydrate days. The simple carbohydrate treatment resulted in the greatest repetition counts for every anaerobic movement, and the one-mile runs were completed in a shorter amount of time on the trackfield (weather remained constant) (**Table 1**). All things considered, the data implicate that consuming simple carbohydrates 30 minutes before carrying out any form of aerobic or anaerobic exercise is the superior pre-workout meal for overall performance as opposed to complex carbohydrates or not eating at all. This does support the established literature that fast-digesting, simple carbohydrates will provide a faster spike in blood glucose (12). However, this is assuming that the workout does not extend past 90 minutes, where the results may be different due to body glycogen stores become more depleted as the total time of each exercise session increases (13). In that case, complex carbohydrates would likely have an edge because it provides a longer lasting fuel source by virtue of its slow-digesting nature (12, 14).

Nevertheless, we found that, under a time-constrained circumstance of 30 minutes before a workout, the best pre-workout meal for optimal glycogen levels to prompt muscle hypertrophy, strength increases, and endurance is one in which constituents are simple carbohydrate-heavy. Thus, whether the exercise performed is anaerobic or aerobic-based, such as weightlifting or running/sprinting, a fast-digesting carbohydrate will best energize the body to perform most optimally. It will be the most quickly absorbed macronutrient into one's bloodstream, contributing to the replenishment of glycogen stores that fuel workouts (12). When looking at long-term growth in aerobic exercise endurance, strength gains, muscle hypertrophy, footspeed, etc., a consistent training regimen must be paired with a thoroughly considered amount of intensity and volume during each workout to gain the most benefits out of the time spent improving one's shape and fitness (14). Consequently, a well-designed meal plan with pre-workout foods must be integrated deliberately in order for performance and exertion to be at one's maximum potential. Between the timing aspect of eating and the components of the pre-workout meal, many subtle variables can constitute drastic responses in physical shape and exercise performance (14, 15).

Time of Day	Meals	Calories
7 AM	Two whole eggs One large bagel 100 grams of avocado	380
1 PM	One chocolate protein bar (Kirkland) Fourty-two grams of ham Fifty grams of turkey One slice of whole-grain bread	410
3:30 PM	Pre-workout meal	390
6 PM	100 grams of cooked white rice 200 grams of 85% lean ground beef Three savings of vegetables 130 grams of strawberries ⅕ cup of granola One serving of greek yogurt	920 Total: 2,100

Table 2: Meals consumed each day not including the tested pre-workout meals.

In addition, since this pilot study emphasizes the time between the pre-workout meal and workout session, soluble fiber intake is crucial to control every day because it inhibits digestion, thus altering the absorption rates of both carbohydrate treatments (16). To avert this issue, the subject consumed the exact same meals to the gram each day except the pre-workout meal. At 7 o'clock in the morning, the subject ate 2 whole eggs, one large bagel, and 100 grams of avocado. At 1 o'clock midday, the subject ate one chocolate protein bar and one ham and turkey sandwich, which consisted of 50 grams of sliced turkey, one slice of bread, and 42 grams of sliced ham. At 6 o'clock in the afternoon, the subject ate 100 grams of cooked white rice, 200 grams of 85% lean ground beef, 3 servings of vegetables, 130 grams of strawberries, one-fifth cup of granola, and one serving of greek yogurt. This amounted to a daily total of exactly 2,100 calories every day for 11 days (**Table 2**).

Finally, there are potential limitations to our pilot study, namely due to the nature of there being only one test subject. The 18-year-old female is a basketball athlete and does workouts such as those tested in this pilot study on a regular basis. She is familiar with performing bench presses, abdominal crunches, and bicep curls, and runs a mile at least once a month. When not partaking in the study, the subject does hypertrophy-focused weightlifting five times a week, and 30 minutes of various cardio seven times a week. Thus, our conclusion cannot be inferred to the population necessarily, but can provide some ideas for a larger scale experiment. For instance, a more robust approach would be with a larger sample size testing the same treatments and performing the same anaerobic and aerobic movements. This would be conducive to a more precise and applicable study, as the variability of the results-–repetitions, mile-run time, and heart

rate—would be smaller. Besides increasing the sample size, the single subject could try testing for a longer period of time so that each pre-workout meal could be run multiple times. This pilot study suggests that when the time between the pre-workout meal and the workout lengthens past the 30 minute mark, different rates of carbohydrate absorption may alter the performance advantage that simple carbohydrates permit. Further investigation may look at the true discrepancy between the rates of glucose absorption into the bloodstream with complex carbohydrates compared to simple carbohydrates when a longer window of time is available before working out. It may be worthwhile to parse when the digestion rates overlap and whether simple carbohydrates ultimately still have an edge in fueling the body in such a scenario.

MATERIALS AND METHODS

One 18-year-old female underwent two trials of three pre-workout meals, complex carbohydrates, simple carbohydrates, and no food intake, over the span of 11 days. The pre-workout meals were tested twice each in total and were randomly assigned on each day using a random number generator (TI-84 Calculator, Texas Instruments). Throughout the study, the total steps per day, hours of sleep, extra exercise, total daily energy expenditure (TDEE), daily meals, caloric consumption, and the time of day when the experiments were performed were controlled. To control for TDEE, the subject walked 10,000 steps every day and solely performed the workout that the experiment called for, which was tracked on two Apple Watches (Apple, Chengdu, China) during the data collection period. Furthermore, between each testing day was a "rest day" where the subject maintained all control variables but did not exercise for data collection. Each day the participant maintained 10,000 steps, 7.5 hours of sleep, performed no additional exercise, consumed 2,100 calories, and performed each task at 4:00 pm.

Moreover, the simple carbohydrate pre-workout meal consisted of two 24-gram Lucky Charms Cereal Bars (General Mills, Minneapolis, Minnesota), one 17-gram Rice Krispy Treat (Kellogg Company, Battle Creek, Michigan), and one 24-gram Cinnamon Toast Crunch Bar (General Mills, Minneapolis, Minnesota). The complex carbohydrates pre-workout meal included one bowl of 80 grams of Quaker old-fashioned oats microwaved with water, and one 45-gram slice of whole wheat bread. Each pre-workout was consumed 30 minutes prior to starting the exercise trials. The control treatment was no pre-workout meal 30 minutes before working out.

Each testing session consisted of the same anaerobic and aerobic exercise sequence and movements. The anaerobic exercise was weightlifting, and the aerobic exercise was a one-mile run; the weight lifting session was always carried out first each day. To measure the effect of each treatment on workout performance, the weightlifting session involved the subject recording the number of repetitions of flat bench presses (45lbs) she performed until failure, meaning until she could no longer do any more repetitions. A bench press is performed by lying squarely on a flat bench and lifting the bar off the rack with both arms, then moving the bar downwards until it touches your chest, and finally pushing it back up. We followed this with bicep curl repetitions (10lbs) until failure, then abdominal crunches (bodyweight) until failure; after each movement was a 3-minute rest period. A bicep curl is performed with a dumbbell in hand, elbow supinating, then going back down to the initial position. An abdominal crunch is performed lying on the ground, hands tucked behind the head, and raising the upper torso off the ground before returning to the initial position. Immediately after the last rest period, the subject ran one mile on a flat track field. We tracked this with a digital stopwatch by the subjects' sister. We also recorded the subjects' heart rate before and after every workout session.

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