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Review Article

The effects of two weeks of overfeeding with peanut butter modified with cylodextrins on body composition and metabolism: A double-blind, placebo-controlled, crossover, pilot trial

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ABSTRACT

The purpose of this pilot study was to examine the effects of a hypercaloric diet with regular peanut butter (HC + RPB) versus a hypercaloric diet with modified cyclodextrin based peanut butter (HC + MPB) on body composition and metabolism. The study was a crossover design using 6 healthy male subjects. Fat mass significantly increased from Pre- to Post-Test in the HC + RPB condition ($p<0.05$, $mean_{diff}$ = +1.00kg, 95% CI: 0.11 to 1.88kg) whereas no significant changes were demonstrated in the HC + MPB condition. Additionally, the relative Pre-Test to Post-Test percent change was significantly greater in HC + RPB ($p<0.05$, $mean_{diff}$ = 6.04%g) compared to HC+MPB. There were no significant changes in metabolism or lean mass. Here we demonstrate that adding modified cyclodextrins to peanut butter may prevent short-term fat gain with moderate overfeeding.

1. Introduction

Obesity is a condition of excess body fat and is defined as having a body mass index (weight in kg divided by the height squared in m) of $\geq$ 30 kg/m^2.[1] The prevalence of obesity in US adults has increased from 15% in 1980 to nearly 40% in 2016.[2,3] This steep rise in the number of obese individuals in the US has made the obesity epidemic one of the leading public health concerns of the century.[4]

Obesity is associated with type II diabetes, hypertension, coronary heart disease, gallstones, osteoarthritis, and many types of cancers.[5,6] As a result, for every 5-unit increase in BMI above 25 kg/m^2, mortality increases by 29%, cardiovascular mortality by 41%, and diabetes-related mortality by 21%.[7] Furthermore, obese compared to normal weight individuals incur greater healthcare (36%) and medication (77%) costs.[7] Chronic illnesses associated with obesity also have indirect impacts through lost job productivity and forgone earnings.[8]

Obesity occurs through multiple mechanisms. However, it is most notably manifested through sedentary lifestyle and excessive energy intake above daily needs.[5] Evidence suggest that degree of obesity is directly related to the amount of fat consumed, and some experts propose that of all potential factors influencing obesity, high fat (HF) diets may initiate the strongest effect.[9] High fat diets are defined as consuming >30% of total energy requirements from fats. Currently, the majority of US adults consume a HF diet and many cross-sectional studies reveal that people who are overweight typically consume a higher percent of energy from fat than do normal weight individuals.[10,11] Additionally, rodent models have found that HF diets may result in obesity independent of energy intake.[12–14] Furthermore, HF diets may have undesirable effects on appetite and food choice, creating another barrier to reversing the obesity epidemic. Studies have reported that overweight individuals have a greater tendency to choose high calorie, low nutrition foods, while obese individuals

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typically prefer HF foods.[15–17] These studies indicate that HF food preference may be directly related to body weight and may be more difficult to control as body weight increases.[17]

Because HF foods are so popular among Americans, introducing toppings that are high in fat, such as peanut butter, may accelerate fat gain. Peanut butter, a high-fat food item, is commonly consumed by many Americans. Antonio et al.[18] recently found that overfeeding of 24 ounces of peanut butter per week, or roughly 500 extra calories per day, for 4 weeks led to a nearly 1 kg increase in fat mass. One potential strategy to prevent fat gain may be to modify higher fat butters or foods to reduce fat digestion and absorption. Recently, a modified peanut butter has been marketed for consumption (Professor Nutz^{TM}). The product contains modified cyclodextrins (CD), a naturally occurring fiber.[19] Modified cyclodextrins, a soluble dietary fiber, has been shown to bind and eliminate nine times of its own weight in dietary fat.[19] Studies with different animal models have reported that CD preferentially binds fatty acids, reducing their levels in blood.[19] Clinical trials demonstrated that CD prevented weight gain in obese diabetic patients.[19] However, the combination of CD with peanut butter in healthy subjects remains to be examined.

The purpose of this pilot study was to examine the effects of a hypercaloric diet with regular peanut-butter (HC + RPB) versus a hypercaloric diet with modified peanut butter (HC + MPB) on body composition and metabolism in a crossover design using six healthy, non-obese male subjects.

2. Materials and Methods

2.1. Participants

For this trial, six healthy, non-obese males aged 25-35 years were recruited for the study (mean ± sem: age = 28.7 ± 1.5 years, height = 179.9 ± 2.3 cm, body mass = 91.24 ± 2.69 kg, BMI = 28.20 ± 0.76 kg/m^2). The exclusion criteria was having a BMI greater than or equal to 30 kg/m^2, currently trying to lose or gain weight; having cardiovascular, metabolic, or endocrine disease; undergone surgery that affects digestion and absorption, smoking, drinking heavily (> 7 and > 14 drinks per week for women and men, respectively), and taking medication to control blood pressure, lipids, and blood glucose or taking anabolic-androgenic steroids.

Prior to engaging in any study procedures, subjects signed a written informed consent for participation that was approved by an Institutional Review Board (IntegReview, Austin, TX) and in agreement with the Declaration of Helsinki.

2.2. Study Design

This study was a randomized, double-blind, placebo-controlled, crossover trial. Subjects were randomly assigned to either a HC + RPB or a HC + MPB diet for 2 weeks each. Body composition and metabolism were assessed following an overnight fast (~10 hr) at baseline and at the end of the 2 week treatment period. Then, subjects washed out for four weeks and crossed over into opposite conditions, repeating the same testing procedures.

2.3. Diet Intervention

Subjects were asked to meet their usual daily energy needs, as determined by metabolic cart testing (described below), plus an additional 5 servings (160 g) of their respective peanut butter condition. All subjects had prior experience tracking dietary intake, and were familiarized with tracking intakes using the MyFitnessPal moblie app (MyFitnessPal, Inc; San Francisco, CA). Subjects tracked their dietary intake 3 d/wk during the 2 week intervention periods and emailed the weekly dietary report to a researcher at the end of the week. The consumption of both the modified and regular peanut butter were supervised by the investigators to enhance adherence.

2.4. Measurements

2.4.1. Dual-energy X-ray absorptiometry

Body composition was determined by a whole-body scan on a dual-energy x-ray absorptiometry device (Horizon DXA System, Hologic Inc, Marlborough, MA). Fat-Free Mass (FFM), Fat Mass (FM), and Body Fat Percentage (BF%) was determined for the total body with the subject lying in a supine position with knees and elbows extended and instructed not to move for the entire duration of the scan (approximately 5 minutes). Results from each scan were uploaded and accessed on a computer that was directly linked to the DXA device. Calibration of the DXA device was done against a phantom provided by the manufacturing company prior to testing.

2.4.2. Resting Metabolic Rate

Subjects were instructed to avoid consuming caffeine and stimulants that could alter resting metabolic rate (RMR) and respiratory exchange ratio (RER). Before testing, subjects will be positioned in a chair and instructed to avoid unnecessary ovement to achieve a resting state (approximately 2-3 minutes). Metabolic testing was conducted on an indirect calorimeter (CardioCoach; KORR Medical Technologies, Inc, Salt Lake City, Utah) for approximately 12 to 15 minutes in a quiet, lit room while subjects breathed normally into a mouthpiece with a nose clip in place. Calibration took place prior to each individual test; this process is automated as the device contains barometric, temperature, and humidity sensors in addition to the oxygen and flowmeter sensors. The reathing hose came from the factory with a bacterial/viral filter inserted between the mouthpiece and gas analyzer for sanitary purposes.

2.5. Statistical analysis

Prior to carrying out inferential statistics, data was assessed for normality via the Shapiro-Wilk test. All data passed normality testing ($p>0.05$) and there were no outliers detected according to visual inspections of box blots. The means and relative percent change values ([Time2 – Time1/Time1)*100]) were analyzed by two-tailed, paired t-test for dependent variables. Statistical significance was accepted a $p<0.05$. Data are reported as mean and standard error. Statistical analysis was performed using GraphPad Prism 8 software (GraphPad Software; San Diego, CA, USA).

3. Results

3.1. Total Body Mass (TM)

There were no significant between or within-group differences for TM ($p>0.05$). The raw data expressed as mean and standard error is displayed in Table 1.

Table 1: Total Body Mass (kg) Raw Data.

Sample	Pre	Post	Delta	% Change
HC + MPB	91.88 ± 2.92	92.28 ± 2.96	0.40	0.44
HC + RPB	91.34 ± 3.01	92.49 ± 3.01	1.15	1.21

3.2. Fat Mass (FM)

Fat mass significantly increased from Pre- to Post-Test in the HC + MPB condition ($p<0.05$, $mean_{diff}$ = +1.00kg, 95% CI: 0.11 to 1.88kg) whereas no significant changes were demonstrated in the HC + MPB condition. Additionally, the relative Pre-Test to Post-Test percent change was significantly greater in HC + RPB ($p<0.05$, $mean_{diff}$ = 6.04%g, 95% CI: 0.43 to 12.50%) compared to HC+MPB. The raw data expressed as mean and standard error is displayed in Table 2.

Table 2: Fat Mass (kg) Raw Data.

Sample	Pre	Post	Delta	% Change
HC + MPB	20.08 ± 2.65	20.14 ± 2.70	0.06	0.26
HC + RPB	19.50 ± 2.78	20.50 ± 2.56*	1.00	6.30**

*=significantly greater than Pre ($p<0.05$). **=significantly greater than HC + MPB ($p<0.05$)

3.3. Fat-Free Mass (FFM)

There were no significant between or within-group differences for FFM ($p>0.05$,). The raw data expressed as mean and standard error is displayed in Table 3.

Table 3: Fat-Free Mass (kg) Raw Data.

Sample	Pre	Post	Delta	% Change
HC + MPB	71.8 ± 2.63	72.15 ± 2.70	0.35	0.45
HC + RPB	71.87 ± 2.78	71.92 ± 2.56	0.05	-0.16

3.4. Metabolism

There were no significant between- or within-condition differences for resting metabolic rate ($p>0.05$, Figure 1) or respiratory exchange ratio ($p>0.05$,Figure 2).

3.5. Dietary Intake

There were no significant between-group differences ($p>0.05$) for percentage of calories consumed from fat, carbohydrate (CHO), or protein (PRO). Additionally, no significant differences for total calorie intake (kcal) occurred between groups ($p>0.05$, Table 4). The data reported in Table 3 does not include the consumption of 5 servings of the respective condition.

Table 4: Dietary Intake Including Total Calories (Kcal) and Percentage of Calorie Distribution.

Sample	FAT (%)	CHO (%)	PRO (%)	Kcal	Pre-RMR (kcal)
HC + MPB	44 ± 8	31 ± 6	33 ± 4	2299 ± 65	2270±80
HC + RPB	47 ± 9	27 ± 6	35 ± 5	2108 ± 49	2191±134

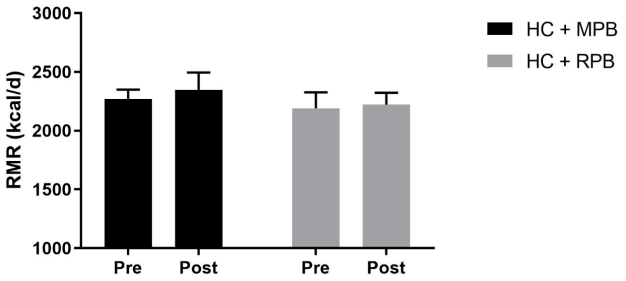

Fig. 1: Resting Metabolic Rate (kcal/d).

4. Discussion and Conclusions

The purpose of this pilot study was to examine the effects of a hypercaloric diet with regular peanut butter (HC + RPB)

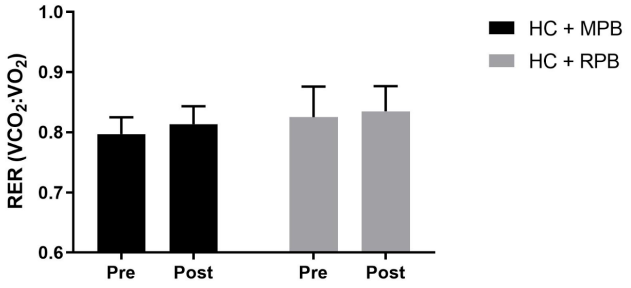

Fig. 2: Respiratory Exchange Ratio (VCO_2:VO_2).

versus a hypercaloric diet with modified peanut butter (HC + MPB), consumed over 2 weeks each, on body composition and metabolism in a crossover design using 6 healthy, non-obese male subjects. The primary findings of the study were that 2 weeks of overfeeding of regular peanut butter resulted in an approximately 1 kg or a 6.3% increase in fat mass. However, when consuming peanut butter treated with modified CD, subjects did not increase FM despite similar dietary intakes and identical consumption between conditions (160 g).

These findings agreed with Antonio et al.[18] who found that overfeeding with regular peanut butter over 4 weeks also increased FM. However, in the current study, when peanut butter was treated with modified CD, fat gain was prevented. Our results also agreed with previous research in obese individuals that demonstrated that CD were able to prevent fat gain when overfeeding on a high-fat diet.[19] While we did not investigate the exact mechanism of action, previous research has. Specifically, CD are cyclic oligosaccharides derived from corn that have been shown to form a stable complex with dietary fat. Once formed, the complex is resistant to normal lipolytic hydrolysis by lipases, thereby reducing the absorption and bioavailability of dietary fat. Thus, it is likely that the fiber source prevented over assimilation of calories into fat by inhibiting their absorption.

In conclusion, the alteration of peanut butter with CD was able to prevent fat gain. These results have implications for the prevention of fat gain in numerous populations. Our research has extended previous findings in obese populations to healthy, non-obese populations.

5. Source of Funding

This study was funded by AD-TPS Ltd.

6. Conflict of Interest

None.

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