University of Glasgow | College of Medical, Veterinary & Life Sciences

Head of College Scholars List Scheme

Summer Studentship

Report Form

This report should be completed by the student with his/her project supervisor. It should summarise the work undertaken during the project and, once completed, should be sent by email to: jill.morrison@glasgow.ac.uk within four weeks of the end of the studentship.

1. **Student**

   Surname: Lundberg **Forename:** Katrina

   E-mail address: Katrina.lundberg@gmail.com

2. **Supervisor:**

   Surname: Malkova **Forename:** Dalia

   E-mail address: Dalia.Malkova@glasgow.ac.uk

3. **Research Project Report**

   3.1 Project Title (maximum 20 words):

The effect of moderate intensity aerobic exercise programme on gastrointestinal appetite hormones and feeding behaviour in overweight women

   3.2 Project Lay Summary (copied from application):

Obesity in humans arises from excess energy consumption relative to expenditure over long periods. To great extend food intake is regulated by gut hormones. In obese individuals after-meal responses of these hormones are blunted. Limited evidence suggests that these blunted responses can be corrected by exercise. This causal relationship between participation in exercise and peripheral hormone alterations was not found in all studies. Therefore, the aim of this study is to examine the effect of aerobic exercise programme on the

appetite hormones originating from gut in overweight women and assessing role of these hormones in regulation of subjective appetite and food intake.

3.3 **Start Date**: 16.05.16 **Finish Date:** 24.06.16

3.4 Original project aims and objectives (100 words max):

- The main aim of this study is to examine the effect of four week aerobic exercise programme on appetite hormones originating from gut in overweight and obese women and assess the within individual relationship between gastrointestinal hormones and subjective appetite measures.
- The main hypotheses are that overweight women participating in physical activity will achieve improved satiety regulation and that changes induced in postprandial satiety will relate to changes in the gastrointestinal appetite hormones.
- The student will be involved in data collection during seven-hour metabolic trial, will measure gastrointestinal hormones, analyse appetite questionnaires and conduct statistical analyses on the obtained data. Student will work alongside the PhD student.

3.5 <u>Methodology: Summarise and include reference to training received in research methods etc. (250 words max):</u>

Recruitment and Group Assignment

Participants were overweight and obese (BMI> 25) women (N=17) between 18 and 45 years old. Upon recruitment, participants selected to be in either the Exercise group, which participated in a 4-week exercise intervention, or the control group, which continued their habitual life style for 4 weeks.

I learned the difficulty of participant recruitment as the selection criteria for this study was very specific.

Prior Measurements

Prior to the 4-week intervention participants performed a submaximal test in order to determine maximum heart rate. Participants were also asked to come in for 7-hour experimental trials on 3 occasions: before and after the intervention, and one-week after the intervention. Participants were asked not to exercise during the week post intervention. Participants reported to the New Lister building metabolic room in a fasted state. Body weight and fatness as well as waist circumference were measured. Resting metabolic measurements were taken for 20 minutes, after which a cannula was inserted and blood samples are taken. After the baseline measurement, participants were given a high-fat, high-carbohydrate breakfast. Lunch was given at the 4-hour time-mark. Blood samples were taken every hour along with gas samples. Appetite and satiety data was collected every hour.

I have participated in data collection during 7-hour experimental trials and was able to independently lead the 7-hour trial with one of the participants, although I did not perform the

blood sample collection. I learned how to make gas sample collections using Oxycon Pro which allowed to measure rate of oxygen consumption (VO_2) and rate of carbon dioxide production (VCO_2) and thus to calculate rate of fat and carbohydrate and thus, rate of energy expenditure during post-breakfast and post-lunch periods. I therein gained experience in dealing and interacting with participants and in learning how to apply indirect calorimetry for research studies.

Exercise Training

The intervention consisted of 4 weekly sessions of endurance-type exercise (cycling and running). In week one the sessions lasted 30 minutes and increased by 10 minutes (60 minutes in the final week). Participants were asked to exercise at 60% of maximum heart rate, which was monitored and recorded by investigators every 5 minutes.

I was able to attend exercise sessions and supervise my own participants and opportunity which I enjoyed as I was able to interact more with the participants while getting to experience another central component of the investigation.

Hormone Measurement

Glucagon Like Peptide-1 and PYY hormone levels were measured using ELISA.

Prior to this studentship, I had not worked completely independently in a lab setting. I learned how to perform ELISA tests and how to obtain measurements using the plate reader.

Dietary Analysis

Subjects were asked to complete a food diary for the 3 days prior to the first 7-hour experimental trial. Diet was then assessed for energy intake and macronutrient content using the dietary software Windiets 2005.

I had never before performed dietary analysis and now feel comfortable using Windiets to calculate macronutrient and energy intake. .

Statistics

Total Areas Under the Curve (AUC) was calculated using the trapezium rule. Paired t-tests were used to compare time-averaged concentrations of hormones and time-averaged scores of appetite measures between the two trials (prior to and after 4-week exercise intervention). The strength of within subject relations for changes in hormone and VAS appetite measurements (fullness and satiety) were measured using regression slopes and R^2 correlational values of the relationship between the two variables for each time point. One sample t-tests were used to determine the significance of the relationships between hormone concentrations and appetite measures. Microsoft Excel 2010 ® (USA) was used to calculate AUC and regression. Secondary analysis was performed using Minitab 17 (USA) and Miscrosoft Excel 2010 ® (USA) (Lemmens et al 2011)(Fatima et al 2015).

I had never before calculated AUC, and although I cannot say I completely understand it, I understand enough to be able to comprehend my results. I also learned the importance of an organised database.

3.6 Results: Summarise key findings (300 words max). Please include any relevant tables or images as an appendix to this report:

VAS scores (mm), "satiety" and "fullness", changed over time in parallel with GLP-1 and PYY (pg/mL), both pre and post exercise intervention (Figure 1and Figure 2). Within subject relations between changes in appetite scores and changes in hormone regression R^2 values demonstrated weak correlations between the two measures (table 1). Relations between PYY and appetite scores showed significant correlations pre exercise intervention (Satiety: R^2= 0.33 ± 0.06, 95% CI (0.54, 1.31) and fullness: R^2=0.38 ± 0.05, 95% CI (0.61, 1.31). Correlations remained significant post intervention (Satiety: R^2= 0.56 ± 0.15, 95% CI (0.55, 1.43) and fullness: R^2 = 0.4 ± 0.06, 95% CI (0.61, 1.51)). Relations between GLP-1 and appetite scores demonstrated significant correlations pre exercise intervention for fullness (R^2= 0.29± 0.06, 95% CI (0.025, 0.31)). The relationship between GLP-1 and satiety was insignificant pre intervention (R^2= 0.25 ± 0.05, 95% CI (-0.093, 0.366)). The correlation between GLP-1 and fullness remained significant while that between GLP-1 and Satiety became significant post exercise intervention (R^2 = 0.27 ± 0.05, 95% CI (0.29, 0.29). Mean time averaged AUC for satiety increased significantly from pre to post intervention ($P<0.05$). Mean time average AUC for fullness did not change significantly from pre to post intervention ($P>0.05$) (table 2). There was no significant difference in mean time averaged AUC for GLP-1 and PYY concentrations after a 4-week exercise intervention ($P>0.05$) (table 3).

3.7 Discussion (500 words max):

The aims of the investigation were two-fold: First, to demonstrate that hormone concentration and subjective appetite follow parallel trends, and second, to determine whether hormone, or appetite responses, or both change with a 4-week exercise intervention in overweight and obese women.

Results indicate that subjective appetite measures (satiety and fullness) parallel hormone responses after food ingestion (figure 2). The relationship between subjective appetite measures and hormone concentrations are all, significant for PYY pre and post intervention while only fullness significantly correlated with GLP-1 pre intervention. The relationship between GLP-1 and satiety became significant post intervention (table 1). The associations between hormone concentrations and subjective appetite generally align with research consensus. Several studies demonstrate that hormone concentration and subjective appetite are indeed linked (though whether or not hormones are a biomarker for appetite is undetermined)(Wynne et al 2005) (Lean and Malkova et al 2015)(de Graaf et al 2004)(Lemmers et al 2011). The improvement seen in the relationship between GLP-1 and satiety after the intervention suggests that exercise acts to improve the anorexigenic effect of GLP-1.

Neither time averaged AUC for fullness measures, nor for satiety measures were significantly different ($P>0.05$) after the 4-week exercise intervention. Satiety did see a larger increase in VAS score, (based off of difference in mean values), however this difference did not reach significance (table 2). Additionally looking at figure 1 it is evident that exercise inspired higher satiety and fullness later after a meal, though this relationship too is insignificant. In recent research by King et al (2009), researchers found an improvement in postprandial satiety in response to a 12-week exercise program. It is possible that the disagreement between this study and that by King et al (2009) lies in study power (their study included 58 participants). The fact that an exercise intervention did not significantly change subjective appetite measures could also be a result of inter-individual variability, whereby some individuals respond to exercise and some do not. Evaluating purely mean values could have masked positive individual appetite responses to the exercise intervention (King et al 2008).

In terms of hormone responses, most commonly observed is an increase in the concentration of GLP-1 in response to exercise. Most research on the regulatory functions of anorexigenic hormones focuses on acute responses to exercise and not long-term adaptations. Such studies most often report increased fasting concentrations of GLP-1 (O'Connor et al 1995)(O'Connor et al 2006), although increases have also been noted post-prandially (Chanoine et al 2008). In one of the first studies to investigate longer-term impacts of exercise on appetite hormones, Martins et al (2009) found that a 12-week exercise intervention resulted in increased post-prandial GLP-1 levels. Thus it is plausible to expect a similar response on the current investigation. However, neither PYY nor GLP-1 concentrations were significantly different post exercise intervention ($P<0.05$). It is possible that this is a result of the low power in the study as a result of the small sample size ($N=17$). However we can't exclude the possibility that the exercise intervention produced modifications, which improved the coupling of appetite hormones and appetite sensations, resulting in increased sensitivity to the hormone. The mechanisms of this adaptation however are not yet clear.

Limitations to the investigation included the small sample size ($N=17$), where additional participants might allow for increased study power. Secondly, although four weeks appear sufficient to produce an advantageous effect, an intervention of longer duration might provide additional insights. In future experiments, an investigation of longer duration should be carried out with additional trials within the intervention time period, in order to potentially identify whether adaptations to exercise involve both components of hormone appetite linkage and hormone concentration increases.

In conclusion, participation in 4-week exercise programme has no impact on appetite hormones and subjective appetite measures but the relationship between hormone concentrations and satiety are stronger following exercise programme. This suggests that participation in physical activity may be expected enhance sensitivity to appetite hormone action.

References

Chanoine J-P, Mackelvie KJ, Barr SI, Wong ACK, Meneilly GS, Elahi DH. GLP-1 and appetite responses to a meal in lean and overweight adolescents following exercise. Obesity Res 2008; 16: 202–204.

Fatima, S., Gerasimidis, K., Wright, C., Tsiountsioura, M., Arvanitidou, E.-I. and Malkova, D. (2015) 'Response of appetite and potential appetite regulators following intake of high energy nutritional supplements', *Appetite*, 95, pp. 36–43. doi: 10.1016/j.appet.2015.06.010.

de Graaf, C., Blom, W.A., Smeets, P.A., Stafleu, A. and Hendriks, H.F. (2004) 'Biomarkers of satiation and satiety', *The American Journal of Clinical Nutrition*, 79(6), pp. 946–961.

King, N.A., Hopkins, M., Caudwell, P., Stubbs, R.J. and Blundell, J.E. (2007) 'Individual variability following 12 weeks of supervised exercise: Identification and characterization of compensation for exercise-induced weight loss', *International Journal of Obesity*, 32(1), pp. 177–184. doi: 10.1038/sj.ijo.0803712.

Lean, M.E.J. and Malkova, D. (2015) 'Altered gut and adipose tissue hormones in overweight and obese individuals: Cause or consequence?', *International Journal of Obesity*, 40(4), pp. 622–632. doi: 10.1038/ijo.2015.220.

Lemmens, S.G., Martens, E.A., Kester, A.D. and Westerterp-Plantenga, M.S. (2011) 'Changes in gut hormone and glucose concentrations in relation to hunger and fullness', *American Journal of Clinical Nutrition*, 94(3), pp. 717–725. doi: 10.3945/ajcn.110.008631.

Martins, C., Kulseng, B., King, N.A., Holst, J.J. and Blundell, J.E. (2010) 'The effects of exercise-induced weight loss on appetite-related peptides and motivation to eat', *The Journal of Clinical Endocrinology & Metabolism*, 95(4), pp. 1609–1616. doi: 10.1210/jc.2009-2082.

O'Connor AM, Johnston CF, Buchanan KD, Boreham C, Trinick TR, Riddoch CJ. Circulating gastrointestinal hormone changes in marathon running. Int J Sports Med 1995; 16: 283–287.

O'Connor AM, Pola S, Ward BM, Fillmore D, Buchanan KD, Kirwan JP. The gastroenteroinsular response to glucose ingestion during postexercise recovery. Am J Physiol Endocrinol Metab 2006; 290: E1155–E1161.

Wynne K, Stanley S, McGowan B, Bloom S. Appetite control. J Endocrinol 2005; 184: 291–318.

4. **Reflection by the student on the experience and value of the studentship (300 words max):**

I have always been interested in nutrition and its role in health maintenance. Although I knew that research in this field is central to the provision of better and more conceptualised health care, I had not previously had the opportunity to myself experience, beyond lectures and labs, what research was like. I was, therefore, happy to have been given the opportunity this summer to experience all aspects of research, from recruitment, to data collection, and analysis.

I enjoyed the opportunity to independently carry out data collection. It was interesting to be placed in the role of researcher in regards to my interactions with participants. I found it quite easy to interact with participants and quickly got the hang of taking gas measurements. I however did find dietary analysis to be slightly challenging, as it often required me to interpret portion sizes and find suitable replacements for foods not in the database or in cases where product nutritional information was not provided.

I especially enjoyed data analysis in the lab. Though I had previous lab experience with ELISA and PCR etc, I had never been able to independently use ELISA kits and from start to finish take measurements and readings using the plate reader. I particularly appreciated the independence given to me in this part of the investigation, though it did make me especially anxious about obtaining good quality results. I think the lab skills that I gained in this investigation will prove useful in my future studies and career. I found statistical analysis interesting as it put meaning to the raw results that I had obtained, however, I did find it quite difficult.

One of the biggest lessons came at the start of my studentship. As a student, often the labs we perform for our courses are already well-investigated topics where expected outcomes are fairly strongly supported. Thus it was an adjustment for me to realize that results that we got weren't necessarily right or wrong because the answer is not yet fully understood. Thus all we can do is interpret based on what we already know. I found this challenging at first, but as I continued with the studentship, I found myself coming in to the lab excited and intrigued by what this additional data would contribute to the developing conclusion.

Ultimately this experience was of great benefit to me as it has given me insight into the research field and has further given me insight into prospective career directions, which I can pursue upon graduation.

5. Dissemination: (note any presentations/publications submitted/planned from the work):

The results obtain during summer studentship will contribute to the results of the bigger study and will be presented at leading national and international conferences and published in leading scientific journals.

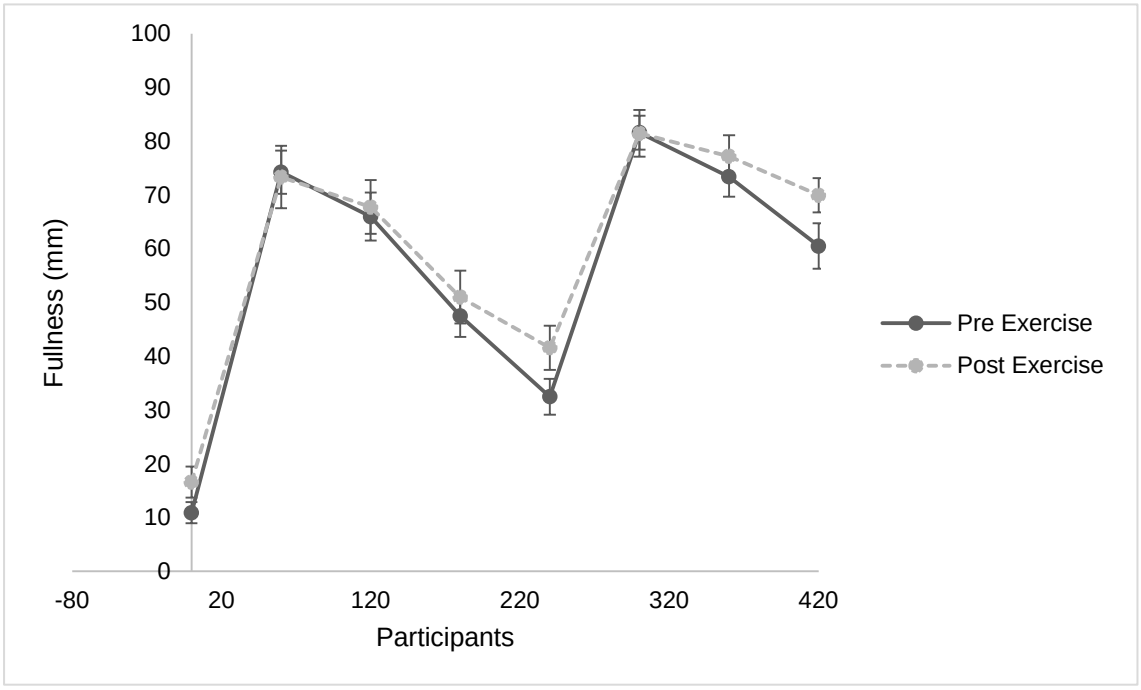
6. Signatures:

Supervisor **Date** **27.07.2016**

Student Katrina Lundberg

Date 22.07.16

Appendix



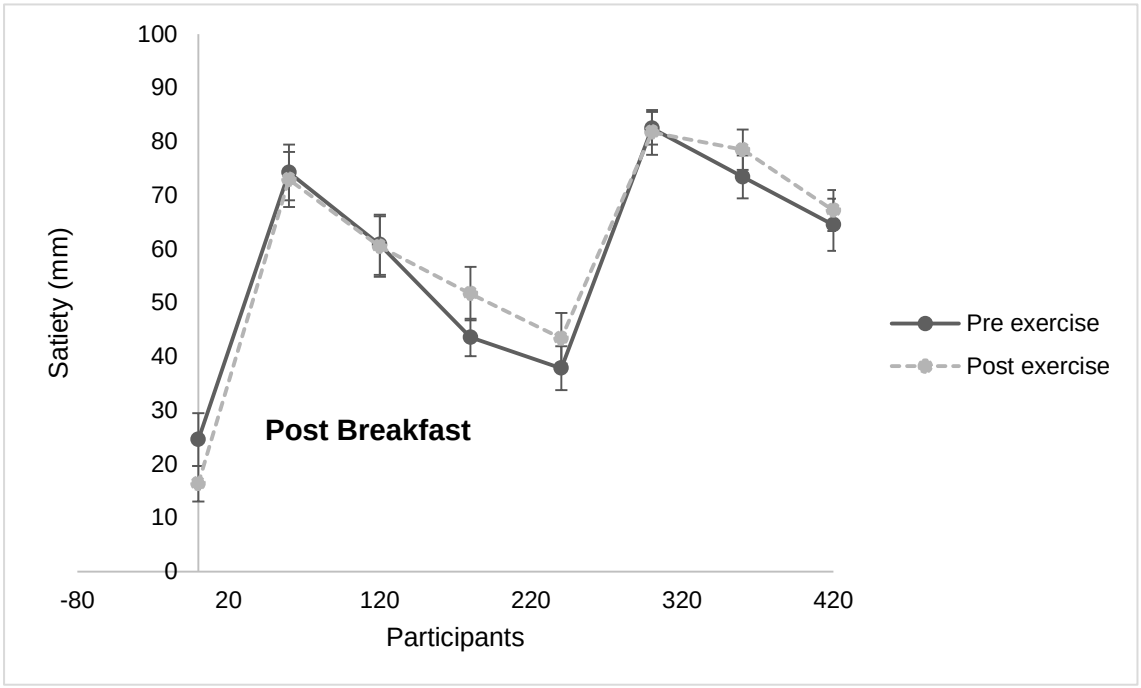
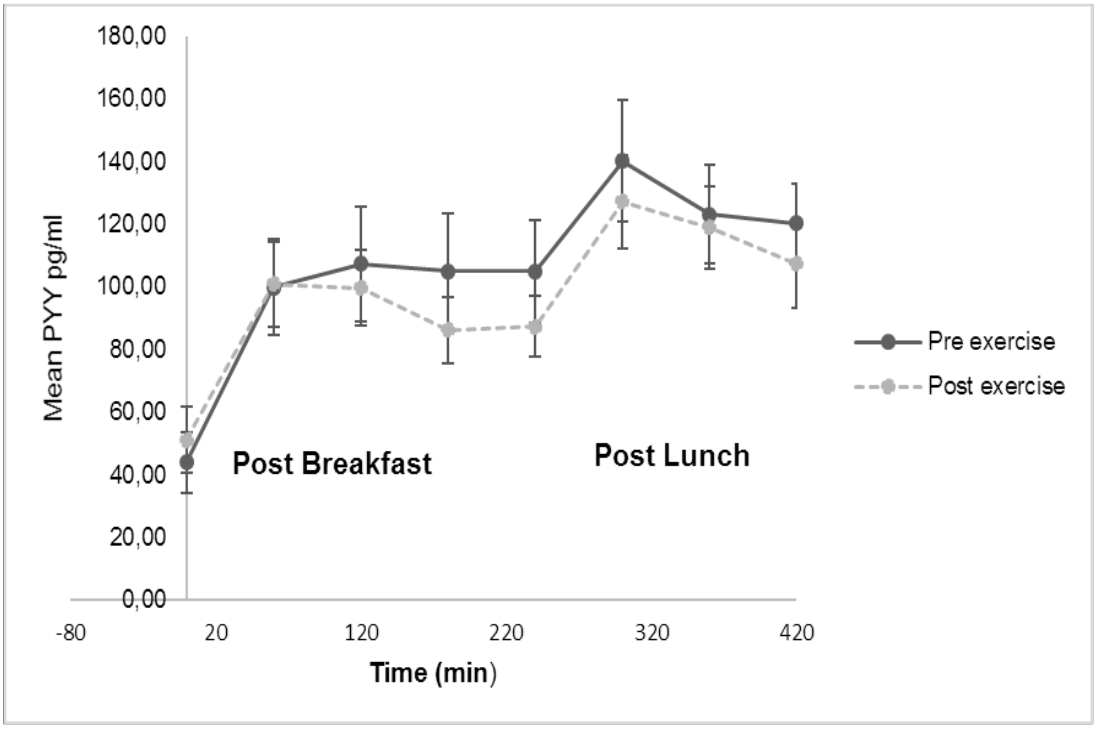
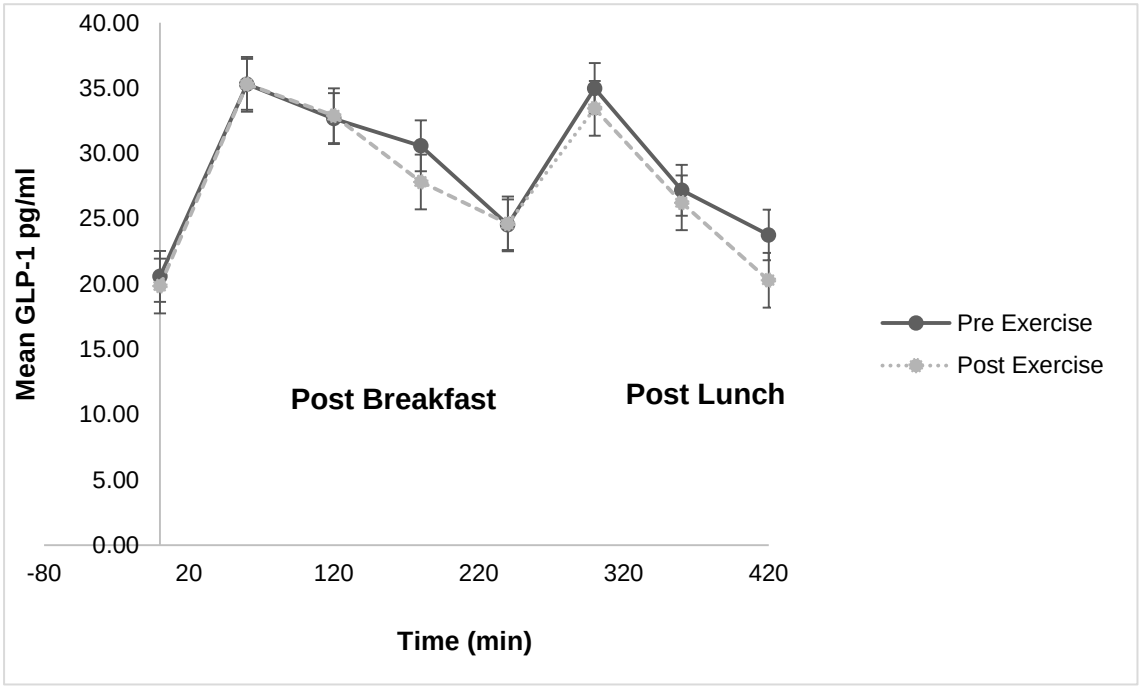


Figure 1: VAS scores for fullness and satiety measured during the 7-hour trials conducted pre- and post- exercise intervention. Values are means + SE, n=17





\

Figure 2: Plasma concentrations of PYY and GLP-1 measured during the 7-hour trials conducted pre- and post- exercise intervention. Values are means + SE, n=17

	Slope	95% CI	R
Pre Exercise			
PYY vs. Satiety *	0.88 ± 0.16	(0.539, 1.309)	0.33 ± 0.06
PYY vs. Fullness*	0.95 ± 0.17	(0.614, 1.307)	0.38 ± 0.05
GLP-1 vs. Satiety	0.14 ± 0.06	(-0.093, 0.366)	0.25 ± 0.05
GLP-1 vs. Fullness *	0.15 ± 0.06	(0.0251, 0.3119)	0.29 ± 0.06
Post Exercise			
PYY vs. Satiety*	0.94 ± 0.21	(0.554, 1.430)	0.56 ± 0.15
PYY vs. Fullness*	0.86 ± 0.17	(0.607, 1.507)	0.4 ± 0.06
GLP-1 vs. Satiety*	0.17 ± 0.06	(0.0286, 0.2680)	0.27 ± 0.05
GLP-1 vs. Fullness*	0.17 ±0.05	(0.0903, 0.2976)	0.27 ± 0.05

Table 1: Within Subject Relations between Appetite Hormones and Subjective Appetite Measures (fullness and satiety) pre and post intervention

Table 1. The mean ± slopes, mean R^2 values and 95% confidence intervals of the relationship between hormone concentrations and subjective appetite measures.

. Identifies significance*

	Pre	Post	P-value
Satiety	72.97 ± 3.55	90.86 ± 5.35	P=0.83
Fullness	88.12 ± 4.44	90.56 ± 5.73	P=0.65
PYY	104.02 ± 13.04	95.55 ± 10.55	P=0.25
GLP-1	28.51 ± 3.65	27.81 ± 4.23	P=0.75

Table 2: Time averaged AUC for satiety and fullness, and GLP-1 and PYY measured pre and post- intervention. Values are mean ± SE, n=17