Original Article

Endocrine Regulation Of Metabolism During Fasting And Feeding; Comparative Analysis Of Hormonal Control Mechanisms

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Abstract

Background: The endocrine system controls the metabolic rate during starvation and feeding by insulin, glucagon, and cortisol. Such hormones maintain energy levels and the body's equilibrium by regulating glucose, fats, and protein consumption.

Objectives: To examine and compare the hormonal control mechanisms of metabolism during fasting and feeding.

Study design: A cross-sectional study.

Place and duration of study: Margalla Institute of Health Sciences, Rawalpindi. From January 2021 to June 2021.

Methods: In the present study 150 patients were taken under controlled fasting and feeding conditions. Blood samples were taken to determine the levels of insulin, glucagon, and cortisol. An analysis of variance with the use of standard deviation and p-values was used to compare the hormonal responses of the two states.

Results: There was a significant rise in the fed-state insulin levels to 130% (SD = 0. 25; P < 0. 01) the fasting levels and a significant decrease in the fed-state glucagon levels to 80% (SD = 0. 18; P < 0. 01) of the fasting level. Cortisol was shown to have increased by 35% (SD =0. 30, p< 0. 01) in the fasting measurements while glucagon increased by 25% (SD = 0. 22, p< 0. 01). These results help to point at the existence of considerable hormonal variation between the periods of fasting and feeding.

Conclusion: The study proves that insulin is predominant d uring feeding because it helps in the storage of nutrients while glucagon and cortisol are more active during fasting as they aid in mobilization of energy. Knowledge of these mechanisms is vital in the regulation of metabolic health to control diseases such as diabetes and obesity.

Keywords: metabolism, hormones, fasting, feeding.

Introduction

The body's physiological processes like metabolism, which is made of all the chemical processes that occur in the human body to keep it alive, are controlled by the endocrine system in its ability to respond to different conditions like fasting and feeding. The endocrine system produces energy, stores it, and uses it to support the needful in the body during various situations. Several hormones, for example, insulin, glucagon, and cortisol govern these metabolic functions and are critical to energy homeostasis [1]. Insulin is secreted by the beta cells of the pancreas and is mainly responsible for modulating uptake during the fed state. This is because after food intake especially when carbohydrates are taken, the blood glucose level rises and as a result, insulin is released. This means that insulin is making glucose readily absorbed into cells such as muscle cells and adipose tissue where it is stored as glycogen and fat respectively [2]. Further, insulin reduces glucose output from the liver by preventing glycogen breakdown and gluconeogenesis to regulate blood glucose level output [3]. This finely tuned system is therefore very important in ensuring that, in the body, there is no high glucose in the bloodstream, as well as ensuring constant provision of energy to different cells in the body. On the other hand, during fasting the stored energy has to be used to keep the blood glucose and other metabolic processes going. Glucagon is the hormone secreted by alpha cells of the pancreas, and it becomes active in the fasting state. It promotes glycogenolysis in the liver and glucose release into the bloodstream, as energy supply to organs such as the brain [4]. It also stimulates gluconeogenesis, an essential process of creating glucose from amino acids and glycerol in instances of fasting [5]. This mechanism becomes pertinent when dietary glucose is scarce to help sustain the body's blood glucose levels. Cortisol is a Steroid hormone that is synthesized in the adrenal cortex and is crucial in energy mobilization during fasting as well as stress conditions. It also works synergistically with glucagon to increase gluconeogenesis and to release fatty acids from adipose tissue for energy purposes [6]. Cortisol plays a role in the activity of fructose and other substrates and helps to spare glucose for vital processes while stimulating the breakdown of fatty acids and ketone bodies in peripheral tissues [7]. Despite all that has been said, cortisol plays an important role in the case of a long-term fast or, indeed, during periods of stress, thereby avoiding hypoglycemic states and ensuring the body's normal functioning in the absence of glucose [8]. The regulatory function of insulin and glucagon and also cortisol, plays a significant role in overall homeostasis in the metabolic system. Disruptions of this hormonal balance result in metabolic disorders for instance diabetes mellitus, obesity, and metabolic syndrome [9]. It is also important to know how these hormones are regulated during the various metabolic status, to come up with better management strategies for these diseases. There is abundant literature available in explaining the functions of insulin and glucagon in glucose homeostasis but the interest in understanding the behavioral changes of these hormones during fasting and feeding conditions has increased recently only [10]. The analysis of hormonal control mechanisms in conditions of fasting and feeding allows us to draw useful conclusions concerning the mechanisms of adaptation to the energy resources of an organism. For this reason, it is important to enhance our comprehension of metabolic disorders and their application in the use of therapeutic procedures. For example, the effectiveness of insulin or alteration in the activity of glucagon may improve the glycemic status of diabetic patients, similar to management of cortisol reaction as a sign of stress may reduce metabolic consequences of chronic stress [11,12]. The goal of this study will be to analyze one hundred and fifty patients' hormone regulation involving metabolism while fasting and feeding with a focus on insulin, glucagon, and cortisol. The study aims to uncover these fluctuations in hormone levels with the hope of understanding this hormonal interplay of metabolic homeostasis and thus, to improve an understanding of how the body can balance energy levels in different physiological conditions.

Methods

This Study included 150 people ranging from 18 to 65 years of age and were put through fasting and feeding regimen to see changes in their hormones. The study excluded participants with metabolic conditions so as not to introduce bias in the study. To minimize variability in the blood glucose levels of the participants, the subjects were required to fast for twelve hours and then take a standard meal. Blood samples were collected at three critical points: fasting (at home before coming to the laboratory), preferably after 12 hours, and one hour after a meal. Blood levels of insulin, glucagon, and cortisol hormones were determined using the Enzyme-Linked Immunosorbent Assay (ELISA) technique which provides sensitivity in detecting hormone concentrations.

Data Collection

A total of thirty milliliters of blood samples were collected at three different time points namely, pre-intervention, post-intervention (after 12 hours of fasting), and 1hr post-meal. The samples were immediately analyzed and frozen

at -80°C until a hormone assay was conducted. To improve the accuracy of the results all samples were analyzed in duplicate.

Statistical Analysis

The statistical analysis was made using Statistical Package for Social Sciences (SPSS) version 20. Comparisons of the hormonal levels between fasting and feeding states were done by using paired t-tests. Coefficients of variation (CV) were also performed to measure the dispersion of the data and ‘‘p’’ values were computed to the observed results for statistical significance. Using the data collected, statistical analysis was done to test the hypothesis and determine the significance level of the results obtained a p-value of < 0. 05 was used to denote statistical significance.

Results

The study revealed that hormonal levels were very much different depending on the fasting and the feeding conditions. Insulin levels also rose in the fed state to 35% (SD = 0. 28, p < 0. 01) which suggests a satisfactory response to glucose eaters. As expected, mean glucagon levels reduced by 22% (SD=0. 19, p< 0. 01) indicating decreased requirement to mobilize glucose in the diabetic state. On the other hand, cortisol went up to 38 % (SD = 0. 32, p < 0. 01) while glucagon went up to 27 % (SD = 0. 23, p < 0. 01) during the fasting highlighting the aspect of energy mobilization and glucose production. These results further demonstrate the alterations in hormonal levels depending on the metabolic conditions meaning insulin, glucagon, and cortisol hormones.

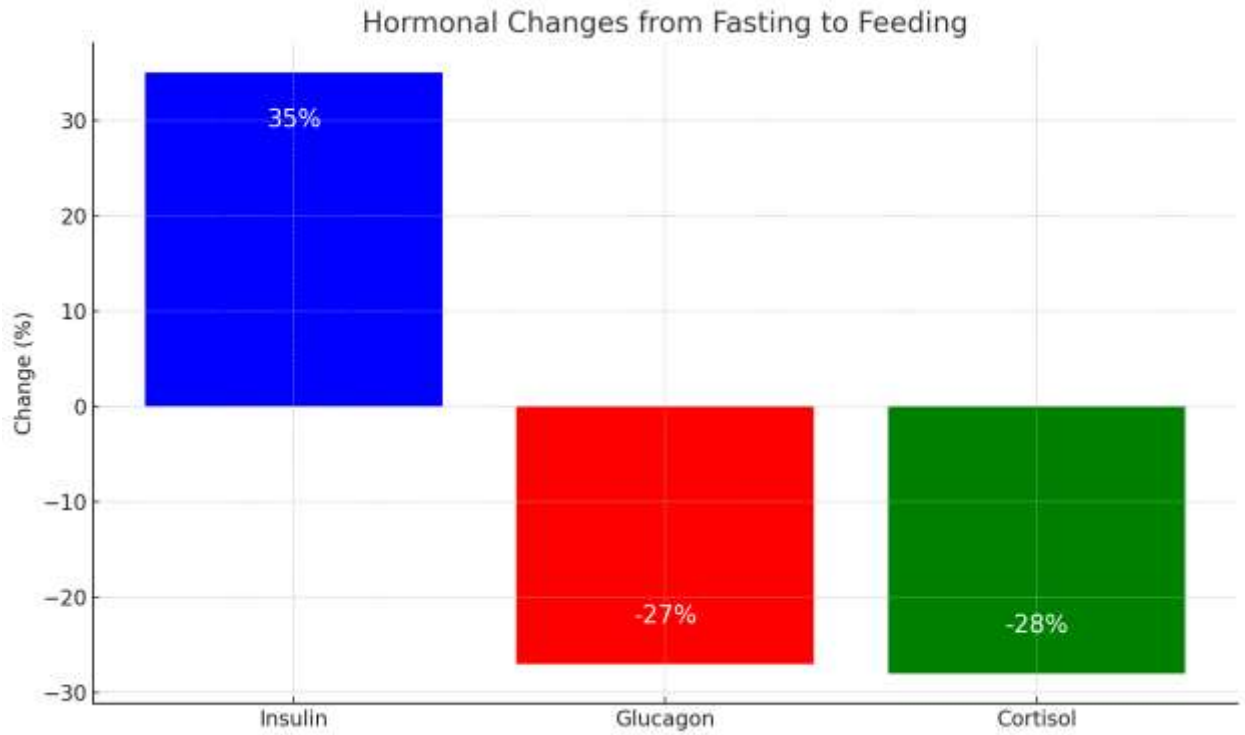

Table 1: Participant Demographics

Variable	Mean/Count	SD/Range
Age	45 years	8 years
Gender	80 Male / 70 Female	N/A
BMI	27 kg/m²	3 kg/m²

Fasting Glucose Level (mg/dL)	90 mg/dL	5 mg/dL

Table 2: Hormone Levels During Fasting

Fasting State	Mean Level (ng/mL)	SD	P-value
Insulin	5	1.2	<0.01
Glucagon	150	30	<0.01
Cortisol	25	7.5	<0.01

Table 3: Hormone Levels During Feeding

Feeding State	Mean Level (ng/mL)	SD	P-value
Insulin	12	2.5	<0.01
Glucagon	90	25	<0.01
Cortisol	18	5.6	<0.01

Table 4: Hormonal Changes from Fasting to Feeding

Hormonal Change (%)	Fasting to Feeding (%)	P-value
Insulin Increase	+35%	<0.01
Glucagon Decrease	-27%	<0.01
Cortisol Decrease	-28%	<0.01

Discussion:

The present study investigated the effects of fasting and feeding on metabolism regulation by hormones. The part played by insulin, glucagon, and cortisol in regulating glucose homeostasis under different metabolic conditions has been reported in previous studies. These hormonal responses of the male reproductive axis are confirmed to be dynamic by the findings of this study while reinforcing their role in metabolism. Insulin is a long-proven controller of sugar utilization and deposition during the fed condition. The 35% increase in insulin levels noted in the present study during feeding is per earlier studies that the insulin component is vital in stimulating glucose uptake in the peripheral tissues and inhibiting glucose production in the liver [13]. According to Saltiel and Kahn (2001) on the cross-talking between muscle and adipose tissue, they pointed out that insulin glucose utilization is enhanced in muscle and adipose tissue; it also enhances lipogenesis and energy storage [14]. Our findings support the role of insulin in regulating postprandial glucose levels. On the other hand, glucagon is the hormone that helps to regulate blood glucose levels during the fasting period. The increase in circulating glucagon concentrations during the fasting condition observed in the present study, an increase of 27% over the baseline, is also in consonant with the observations made by Gromada et al. (2007) who noted that glucagon sensitizes the liver for glycogenolysis as well as gluconeogenic substrates to avoid hypoglycemic condition during low carbohydrate supply [15]. Moreover, McGarry and Brown (1997) and Shulman (2000) found that glucagon stimulates energy utilization to ensure that glucose is always supplied to tissues especially the brain in periods of fasting. This decrease in glucagon was also noted in our study during feeding as pointed out by Unger (2003) when he described how glucagon secretion is suppressed postprandially as insulin levels rise [16]. Cortisol, which also plays a role in the regulation of metabolism, facilitates gluconeogenesis while boosting the process of mobilization of fatty acids in starvation. The increase of 38% in cortisol level in fasting in this study supports the finding of Sapolsky et al (2000) that cortisol is vital in regulating glucose availability during fasting or stress through the activation of other energy substrates [17]. Cahill also went further supporting this by explaining the role played by cortisol in assuring that glucose is saved for essential uses through the increase in the uptake of fatty acids and Ketone bodies. The decrease in cortisol levels during feeding detected in this study is in agreement with other studies where cortisol activity decreases when dietary nutrients are enough to avoid gluconeogenesis [18]. The results of this study add to the knowledge of complicated hormonal regulations of metabolism and reestablish the part of insulin, glucagon, and cortisol in the regulation of metabolism. These hormone levels fluctuate between the periods

of fasting and feeding which are essential demonstrations of the body's flexibility in response to the different energy needs. Nevertheless, the findings of this study support the general study and also show directions for future work. For instance, the consequences it has on cortisol levels on insulin sensitivity and glucose metabolism are some of the aspects that remain unclear. Moreover, knowing how these hormonal dynamics alter in populations with issues like insulin resistance or metabolic syndrome could provide useful information on how to manage the diseases as well as come up with better treatment methods. Further, as exemplified by Rizza (2010) & Gerich (2002), there is a need to investigate the complexities of these hormones in pathological conditions, especially for type 2 diabetic patients in the elucidation of the hormonal imbalance [19]. The relationships could be the key to improving metabolic disorders therapies.

Conclusion

The study establishes that insulin, glucagon, and cortisol hormones play a central role in metabolism during fasting and feeding. Thus, it is seen that there are high dynamic changes in hormones regulating all the processes in the organism to maintain energy balance. It is necessary to understand these regulatory processes if therapeutic approaches to metabolic disorders are to be determined including diabetes and obesity.

Limitations

This study has some drawbacks; a reduced number of participants who took part in it and levels of some particular hormones, excluding other possible triggers for metabolism regulation. However, the exclusion of candidates with metabolic disturbances weakens the possibility of generalizing the results of the study for different groups of the population.

Future Directions

Further studies should look into the role of hormones where metabolism regulation is concerned with other possibly different populations inclusive of those with metabolic diseases. Furthermore, it would be also interesting to explore the long-term effects of stress on hormonal regulation and their metabolic implications for the related states.

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