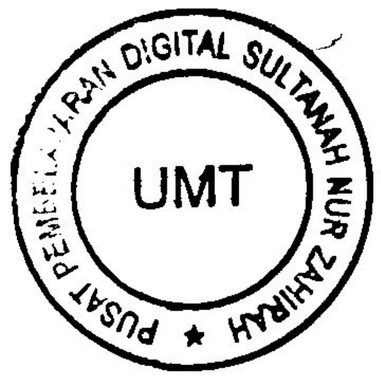
MODIFIED MINIMAL MODEL FOR EFFECT OF EXERCISE ON INSULIN SENSITIVITY AND GLUCOSE EFFECTIVENESS IN TYPE 2 DIABETIC PATIENTS

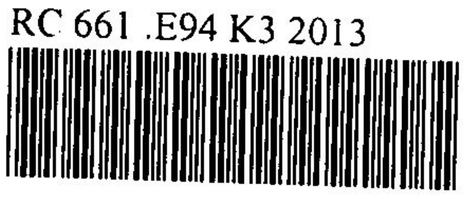
KAMARIAH NOOR AB KAHAR

MASTER OF SCIENCE

UNIVERSITI MALAYSIA TERENGGANU
MALAYSIA

2013





1100091955		

Lihat Sebelah

MODIFIED MINIMAL MODEL FOR EFFECT OF EXERCISE ON INSULIN SENSITIVITY AND GLUCOSE EFFECTIVENESS IN TYPE 2 DIABETIC PATIENTS

KAMARIAH NOOR AB KAHAR

Thesis Submitted in Fulfillment of the Requirement for the Degree of Master of Science in the Faculty of Science and Technology Universiti Malaysia Terengganu

December 2013

DEDICATION

Specially dedicated to:

My husband Mohd Afandi Marzuki and my daughter Nurul Najwa Mohd Afandi

Abstract of thesis presented to the Senate of Universiti Malaysia Terengganu in fulfillment of the requirement for the degree of Master of Science

MODIFIED MINIMAL MODEL FOR EFFECT OF EXERCISE ON INSULIN SENSITIVITY AND GLUCOSE EFFECTIVENESS IN TYPE 2 DIABETIC PATIENTS

Kamariah Noor Ab Kahar

December 2013

Chairperson : Prof. Mustafa bin Mamat, Ph.D.

Member : Agus Kartono, Ph.D.

Prof. Ismail bin Mohd, Ph.D.

School : Informatics and Applied Mathematics

The classical minimal model with single compartment is modified by the assumption that the insulin decay rate is not always a first-order process, and a mathematical function for describing the insulin infusion rate is introduced. The modified model is used to study the two sets of published data including healthy human and Type 2 diabetes with different types of insulin infusion rates. The single- step fitting process took the glucose-insulin system as a dynamic integrated physiological system and generated the real optimized model parameters from the experimental data using the modified model. It also avoided the errors from the interpolation or extrapolation for taking measured insulin points as inputs, which were mostly published when using the single or multi-compartments minimal model.

The classical minimal model of glucose and insulin plasma levels is commonly used to analyse the results of glucose tolerance tests in humans. In the modified minimal model, the first equation represents the physiological factors that determine the restoration of plasma glucose compartment ($G(t)$) after injection, the second equation represents the flux of insulin leaves or enters the interstitial tissue compartment and the third equation represents insulin enters the plasma insulin compartment. The modified minimal model with plasma insulin compartment is presented by the assumption that if the plasma glucose compartment drops below the basal glucose levels, the rate of insulin entering the plasma glucose compartment is zero. Insulin is cleared from the plasma insulin compartment at a rate proportional to the amount of insulin in the plasma insulin compartment. A mathematical function for describing the insulin infusion rate is also introduced in this study. The modified minimal model is used to study the effect of physical exercise via parameters of a mathematical model to qualitative the magnitude of changes in insulin sensitivity (S_I) and glucose effectiveness (S_G) in response to exercise in Type 2 diabetes (T2D) and healthy human. Insulin sensitivity (S_I) and glucose effectiveness (S_G) are the two main factors controlling glucose tolerance. Physical exercise indicated either to prevent or delay the onset of Type 2 diabetes or to assure a good control of Type 2 diabetes by increasing insulin sensitivity and ameliorating the metabolism of glucose disappearance.

Abstrak thesis yang dikemukakan kepada Senat Universiti Malaysia Terengganu
sebagai memenuhi keperluan untuk ijazah Master Sains

PENGUBAHSUAIAN MODEL MINIMUM UNTUK KESAN SENAMAN PADA KEPEKAAN INSULIN DAN KEBERKESANAN GLUKOSA KEPADA PESAKIT DIABETES JENIS 2

Kamariah Noor Ab Kahar

Disember 2013

Pengerusi : Prof. Mustafa bin Mamat, Ph.D.

Ahli : Agus Kartono, Ph.D.

Prof. Ismail bin Mohd, Ph.D.

Pusat Pengajian : Informatik dan Matematik Gunaan

Model klasik minimum dengan petak tunggal telah diubahsuai dengan andaian bahawa kadar pereputan insulin tidak selalunya proses tertib pertama, dan fungsi matematik untuk menerangkan kadar infusi insulin diperkenalkan. Model yang diubahsuai telah digunakan untuk mengkaji dua set data melibatkan manusia yang sihat dan pesakit diabetes jenis dua dengan perbezaan kadar infusi insulin. Proses pemadanan satu-langkah mengambil sistem glukosa-insulin sebagai suatu sistem fisiologi bersepadu dinamik dan menjana parameter model sebenar yang dioptimumkan daripada data eksperimen menggunakan model yang diubahsuai. Ini dapat mengelakkan berlaku ralat dari penentudalaman atau penentuluar untuk mengambil data insulin yang diukur sebagai input, yang kebanyakannya telah diterbitkan apabila menggunakan model minimum tunggal atau multi-petak.

Model klasik minimum tahap plasma glukosa dan insulin biasanya digunakan untuk menganalisis keputusan ujian toleransi glukosa pada manusia. Dalam model minimum diubahsuai, persamaan pertama mewakili faktor-faktor fisiologi yang menentukan pemulihan petak glukosa plasma *(G(t))* selepas suntikan, persamaan kedua mewakili fluks insulin yang keluar atau memasuki petak tisu celahan dan persamaan ketiga mewakili insulin memasuki petak plasma insulin. Model minimum yang diubahsuai dengan petak insulin plasma telah dibentangkan dengan andaian bahawa jika petak plasma glukosa jatuh di bawah paras glukosa basal, kadar insulin memasuki petak glukosa plasma adalah sifar. Insulin dibersihkan dari petak insulin plasma pada kadar yang berkadar langsung dengan jumlah insulin dalam petak insulin plasma. Fungsi matematik untuk menerangkan kadar infusi insulin juga diperkenalkan dalam kajian ini. Model minimum yang diubahsuai telah digunakan untuk mengkaji kesan senaman fizikal melalui parameter model matematik untuk mengira magnitud perubahan dalam kepekaan insulin (S_I) dan keberkesanan glukosa (S_G) sebagai tindak balas terhadap latihan bagi penyakit diabetes Jenis 2 (T2D) dan manusia sihat. Sensitiviti insulin (S_I) dan keberkesanan glukosa (S_G) adalah dua faktor utama yang mengawal toleransi glukosa. Senaman fizikal menunjukkan bahawa sama ada untuk menghalang atau melambatkan berlakunya kejadian diabetes Jenis 2 atau untuk memastikan kawalan yang baik diabetes Jenis 2 dengan meningkatkan kepekaan insulin dan menambahbaik metabolisme kehilangan glukosa.