

## FABP2

Dr\_Mahboob@hotmail.com :

PCR-RFLP ( ) PPAR $\alpha$  FABP2 :  
BMI ( Gas Chromatography )  
 $\omega$ -3  $\omega$ -6 ( PUFA ) ( SFA ) :  
 $\omega$ -3 (  $p < /$  ) FABP2  
PPAR $\alpha$  (  $p < /$  )  
Thr54 :  
PPAR $\alpha$  Lue162 Val162 FABP2 Ala54  
Lue162 Ala54 Val162 Thr54  
Thr54  $\omega$ -3  $\omega$ -6 PUFA SFA  
Ala54  
DNA :

(Lusis 2000)

Hokanson )

(1995; Bingham 2002; Arab 2003

(and Austin 1996

Steinberg et al. )

1997; Kooner et al. 1998; Carlsson et al.  
(2000; Lind et al. 2000  
(Jouven et al. 2001)

(Masson et al. 2003)  
(FABP)

Agostoni et al. 1994; )

(Scaglioni et al. 2006

(FABP2)

TG

HDL-C

(Wajchenberg 2000;Denke 2001)

(A54T)

A54T

FABP2

(Baier et al. 1996; Levy et al. 2001)

Garaulet et al. 2001; )

(Vessby 2003; Tremblay et al. 2004

(Georgopoulos et al. 2000; Ribalta et al. 2005)

FABP2

(Aro 2003)

Vessby )

FABP2

(2000; Riccardi et al. 2004

)

(

(

)

MUFA Saturated Fatty Acid SFA)

( Monounsaturated Fatty Acid

(Polyunsaturated Fatty Acid ( PUFA )

Ma et al. ) .

/

$$n = \left( \frac{[Z_{1-\alpha/2}] + [Z_{1-\beta}]}{d} \right)^2 \quad \text{where } d = \frac{|\bar{D}_1 - \bar{D}_2|}{\sqrt{2\sigma_d^2}}$$

$$d = \frac{|\bar{D}_1 - \bar{D}_2|}{\sqrt{2\sigma_d^2}} \quad \text{if } \bar{D}_1 - \bar{D}_2 = 2mm/l$$

$$d = \frac{2}{3.3} = 0.61 \quad n =$$

( Germany ) Seca

l ( ) BMI

Ala54Thr

%

FABP2

×g

μL

C

C

FABP 2

Thr 54 Ala/Ala

( )

)

HDL-CL LDL-CL

(

VLDL ( Roche, Germany)

Optima TL X (d<1.006 g / L)

rpm ( fixed-angle, BECKMAN, USA

16 °Cflnj 2

ApoB (Ordovas 1998)

( )

ApoCIII

(Randox, England)

Gas)

( chromatography

: (GasChoromatography)

Folch

Ala/Ala

Ala/Thr

Folch et al. )

$$(H_0 = \bar{D}_1 = \bar{D}_2)$$

$$1 - \beta = 0.80 \quad \alpha = 0.5$$

(1957

$$\alpha = / \quad \beta = /$$

Thr54 allele  
 Ala54 allele bp  
 bp bp  
 : PPAR $\alpha$  Lue162Val (BF3)  
 PPAR $\alpha$  Lue162Val  
 (C) (G) °C  
 Mismatch PCR ( / ) HCl  
 Forward : 5-GAC TCA AGC TGG TGT  
 Reverse – Misatch : 5- ATG ACA AGT -3  
 CGT TGT GTG ACA TCC CGA CAG AAT  
 Mismatch ) -3  
 Vohl et al. )( Reverse Primer  
 ( ) Hinf I .(2000  
 bp PCR  
 Allele bp  
 bp Allele  
 : PPAR $\alpha$   
 PCR – RFLP  
 DNA  
 ( Amplification)  
 Forward : 5-ACA ATC ACT  
 Reverse : CCT TAA ATA TGG TGG -3  
 TAG GGA CAG ACA GGA CCA 5-AAG  
 .(Jamshidi et al. 2002) GTA -3. )(24 l  
 Taq I  
 GG  
 CG bp  
 bp  
 :  
 One Sample Kolmogrove–Smirnov  
 Doc System  
 50 bp ladder

KOH  
 ( 0.5 N)  
 (BF3)  
 °C  
 ( / ) HCl  
 Genamic DNA : DNA ( Qiagene , ) Flexi Gene DNA Kit ( GmbM, Germany DNA  
 : FABP2 Ala54Thr  
 Polymerase )  
 Chain Reaction –Restriction Fragment Length Polymerase ) PCR-RFLP  
 PCR DNA Amplification ..  
 Forward : .  
 5-ACA GGT GTT AAT ATA GTG AAA  
 Reverse : 5-TAC CCT GAG AG -3  
 Vimalleswaran ) TTC AGT TCC GTC -3  
 $\mu$ L .(et al. 2006  
 $\mu$ L hin61 /  $\mu$ L PCR  
 $\mu$ L X Tango  
 °C (overnight)  
 °C  
 % PCR

Kunesova et al. 2002; ) ( t .  
(Dwyer et al. 2004 -

) n-16 ( ) n-14 FABP2  
Thr54 ( ) n-18 ( ) PCR-RFLP  
Ala54 % / .  
Ala54 Thr54 % / Val162  
Thr54 ( AA ) ,FABP2 . GC  
Ala54 Thr54  
) Thr54  
(  
Thr54 Ala54

Finn EPA ( $p < /$  )  $\alpha$  ( $p < /$  )  
( $p < /$  )PUFA ( $p < /$  ) SFA ( $p < /$  )  
 $\omega - 3$  ( $p < /$  )  $\omega - 6$  ( $p < /$  ) MUFA  
Ala54 Thr54 ( $p < /$  )  
( )  
Val162 Lue162) PPAR $\alpha$   
(GC GG

Rossner et al. 1989; ) .  
(Tremblay et al. 2004

in-vivo FABP2

Finns de novo  
Pima (Vidgren et al. 1997) Ma et al. 1995; Salo )  
Thr54 Ala54 Vessby ;et al. 2000; Warensjo et al. 2006  
(2003

(AA) .(Pratley et al. 2000) )  
Ala54 Thr54

(SFA)

$\omega$ -3  $\omega$ -6 (PUFA)

Ala54 Thr54 Decsi et al. 1996; Samuelson et al. )

FABP2-Thr54 (2001)

FABP2-Ala

(Marin et al. 2005) (LCPUFA)

Decsi

(Decsi et al. 1996)

SFA

PUFA /SFA TG ( AA/ LA )

( PUFA)

TG ( AA/DGLA)

(Klein-Platat et al. 2005)

Thr54 n-6

n-3 PUFA SFA Ala54

Klein-Platat ). n-6

(et al. 2005) (Decsi et al. 1996)

PUFA n-3

(Rossner et al. 1989)

PUFA n-3 (Phinney et al. 1994)

(Klein-Platat et al. 2005)

PUFA n-3

(Klein-Platat et al. 2005) (Nakamura et al. 2001)

n-3

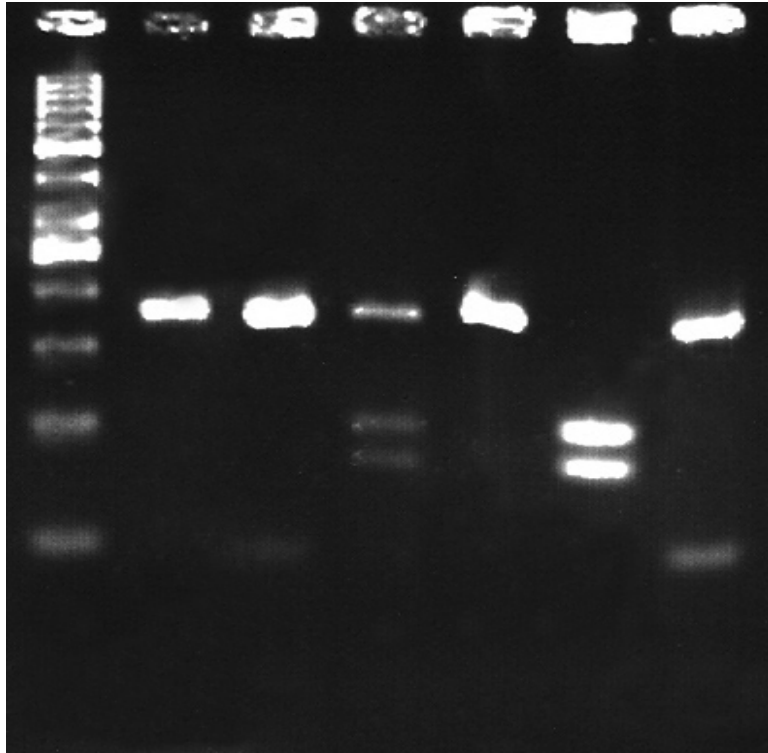
Thr54 EPA (AA)

Ala54

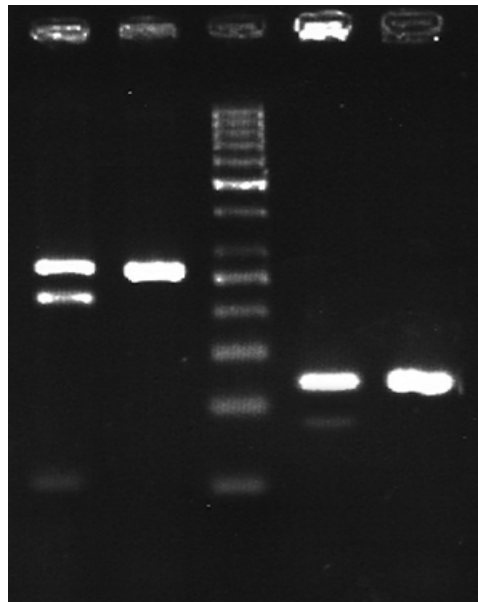
Gasperiikova et al. ) (AA)

(2002)

Lue162Val Thr54  
 Baier et al. ) Ala54  
 val162 Lue162 . (1995  
 Val162 Thr54  
 PUFA n-3 22-6n-3  
 .(Couet et al. 1997)  
 Finn  
 (Urban et al. 1989).  
 PUFA  
 Garaulet et al. ) . SFA  
 (2001  
 Thr54  
 FABP2 Ala54  
 PPAR $\alpha$  Lue162 Val162  
 Ala54 Val162 Thr54 . (Garaulet et al. 2001)  
 Lue162  
 PUFA SFA Thr54  
 $\omega$ -3  $\omega$ -6  
 Ala54 Thr54 TG PUFA n-3  
 Vessby ) . HDL-CL  
 .(2003; Riccardi et al. 2004  
 Lue162Val PPAR $\alpha$   
 ) FABP2  
 ( ) ( )  
 Val162 Lue162  
 FABP2  
 PPAR $\alpha$  Lue162Val



(A) FABP2 PCR-RFLP – (B) PPARα  
 Ala54 / Ala ( bp ) Thr54/Thr ( bp ) Ladder : ( A  
 Ala54 / Thr ( bp ) Thr54/Thr ( bp ) Ala54/Ala ( bp ) bp)



(B) Lue162/Val ( bp ) Lue162/Lue : ( B  
 GC ( bp ) GG ( bp ) Ladder ( bp )  
 Lue162/Val ( bp ) Lue162/Lue ( bp )



P value*				
	( )	( )	( )	
-	( )	( / )	( / )	
/	( )	( / )	( / )	Thr54 carriers(%)
/	( / )	( / )	( / )	V162 carriers (%)
/	( / )	( / )	( / )	C7 carriers (%)
/	/ ± /	/ ± /	/ ± /	Age
/	/ ± /	/ ± /	/ ± /	BMI
/	/ ± /	/ ± /	/ ± /	TG (mg/dL)
/	/ ± /	/ ± /	/ ± /	Total CL (mg/dL)
/	/ ± /	/ ± /	/ ± /	LDL-CL (mg/dL)
/	/ ± /	/ ± /	/ ± /	HDL-CL (mg/dL)
/	/ ± /	/ ± /	/ ± /	VLDL (mg/dL)
/	/ ± /	/ ± /	/ ± /	FBS (mg/dl )
/	/ ± /	/ ± /	/ ± /	APOB (mg/dL)
/	/ ± /	/ ± /	/ ± /	APOCIII (mg/dL)

Mean±SD t \*

## FABP2

P valve***	(µg/ml)		Fatty acids
	Ala/Thr Thr/Thr	= = *	
/	/ ± /	/ ± /	(C14:0)
/	/ ± /	/ ± /	(C16:0)
/	/ ± /	/ ± /	(C18:0)
/	/ ± /	/ ± /	(C18:1, n-9)
/	/ ± /	/ ± /	(C18:2n-6) LA
/	/ ± /	/ ± /	(C20:0)
/	/ ± /	/ ± /	(C18:3, n-6) GLA
/	/ ± /	/ ± /	(C20-1)
/	/ ± /	/ ± /	(C18:3, n-3)
/	/ ± /	/ ± /	(C20:2, n-6)
/	/ ± /	/ ± /	(C22:0)
/	/ ± /	/ ± /	(C20:3, n-6) DGLA

/	/ ± /	/ ± /	(C20:3, n-3)		
/	/ ± /	/ ± /	(C20:4, n-6) AA		
/	/ ± /	/ ± /	(DDA, C22:2, n-6)		
/	/ ± /	/ ± /	(C20:5, n-3) EPA		
/	/ ± /	/ ± /	(C24:1)		
/	/ ± /	/ ± /	(C22:6, n-3) DHA		
/	/ ± /	/ ± /			
/	/ ± /	/ ± /	MUFA		
/	/ ± /	/ ± /	PUFA		
/	/ ± /	/ ± /	n-6		
/	/ ± /	/ ± /	n-3		
/	/ ± /	/ ± /			
/	/ ± /	/ ± /	EPA	DGLA	AA
/	/ ± /	/ ± /		n3	n6
Mean±SE					
	Ala54Thr54	Thr54/Thr		Thr54 /Thr	*
			Ala54/Thr +Thr54/Thr	Ala54/Ala	**
	Ala54/Ala		Ala54/Thr+Thr54/Thr	t	***

## (GC GG Lue/Val Lue/Lue)PPARα

μg/ml						Fatty acids
P value*	GC	GG	P value*	Lue/Va	Lue/Lue	
/	/ ± /	/ ± /	/	/ ± /	/ ± /	(C14:0)
/	/ ± /	/ ± /	/	/ ± /	/ ± /	(C16:0)
/	/ ± /	/ ± /	/	/ ± /	/ ± /	(C18:0)
/	/ ± /	/ ± /	/	/ ± /	/ ± /	(C18:1, n-9)
/	/ ± /	/ ± /	/	/ ± /	/ ± /	(C18:2n-6) LA
/	/ ± /	/ ± /	/	/ ± /	/ ± /	(C20:0)
/	/ ± /	/ ± /	/	/ ± /	/ ± /	(C18:3, n-6) GLA
/	/ ± /	/ ± /	/	/ ± /	/ ± /	(C20-1)
/	/ ± /	/ ± /	/	/ ± /	/ ±21/1	n-3)
/	/ ± /	/ ± /	/	/ ± /	/ ± /	(C18:3,
/	/ ± /	/ ± /	/	/ ± /	/ ± /	(C20:2, n-6)
/	/ ± /	/ ± /	/	/ ± /	/ ± /	(C22:0)
/	/ ± /	/ ± /	/	/ ± /	/ ± /	(C20:3, n-6) DGLA
/	/ ± /	/ ± /	/	/ ± /	/ ± /	(C20:3, n-3)

/...						
/	/ ± /	/ ± /	/	/ ± /	/ ± /	(C20:4, n-6) AA
/	/ ± /	/ ± /	/	/ ± /	/ ± /	(DDA, C22:2, n-6)
/	/ ± /	/ ± /	/	/ ± /	/ ± /	(C20:5, n-3) EPA
/	/ ± /	/ ± /	/	/ ± /	/ ± /	(C24:1)
/	/ ± /	/ ± /	/	/ ± /	/ ± /	(C22:6, n-3) DHA
/	/ ± /	/ ± /	/	/ ± /	/ ± /	
/	/ ± /	/ ± /	/	/ ± /	/ ± /	MUFA
/	/ ± /	/ ± /	/	/ ± /	/ ± /	PUFA
/	/ ± /	/ ± /	/	/ ± /	/ ± /	n-6
/	/ ± /	/ ± /	/	/ ± /	/ ± /	n-3
/	/ ± /	/ ± /	/	/ ± /	/ ± /	
/	/ ± /	/ ± /	/	/ ± /	/ ± /	AA
/	/ ± /	/ ± /	/	/ ± /	/ ± /	EPA DGLA
/	/ ± /	/ ± /	/	/ ± /	/ ± /	n3 n6
.	**	.	t	*	.	Mean±SE

C. and Prochazka, M., 1995. An amino acid substitution in the human intestinal fatty acid binding protein is associated with increased fatty acid binding, increased fat oxidation, and insulin resistance. *J Clin Invest*, **95**, pp. 1281-1287.

Bingham, S.A., 2002. Biomarkers in nutritional epidemiology. *Public Health Nutr*, **5**, pp. 821-827.

Carlsson, M., Wessman, Y., Almgren, P. and Groop, L., 2000. High levels of nonesterified fatty acids are associated with increased familial risk of cardiovascular disease. *Arterioscler Thromb Vasc Biol*, **20**, pp. 1588-1594.

Couet, C., Delarue, J., Ritz, P., Antoine, J.M. and Lamisse, F., 1997. Effect of dietary fish oil on body fat mass and basal fat oxidation in healthy adults. *Int J Obes Relat Metab Disord*, **21**, pp. 637-643.

Decsi, T., Molnar, D. and Koletzko, B., 1996. Long-chain polyunsaturated fatty acids in

Agostoni, C., Riva, E., Bellu, R., Vincenzo, S.S., Grazia, B.M. and Giovannini, M., 1994. Relationships between the fatty acid status and insulinemic indexes in obese children. *Prostaglandins Leukot Essent Fatty Acids*, **51**, pp. 317-321.

Arab, L., 2003. Biomarkers of fat and fatty acid intake. *J Nutr*, **133** Suppl 3, pp. 925S-932S.

Aro, A., 2003. Fatty acid composition of serum lipids: is this marker of fat intake still relevant for identifying metabolic and cardiovascular disorders? *Nutr Metab Cardiovasc Dis*, **13**, pp. 253-255.

Baier, L.J., Bogardus, C. and Sacchettini, J.C., 1996. A polymorphism in the human intestinal fatty acid binding protein alters fatty acid transport across Caco-2 cells. *J Biol Chem*, **271**, pp. 10892-10896.

Baier, L.J., Sacchettini, J.C., Knowler, W.C., Eads, J., Paolisso, G., Tataranni, P.A., Mochizuki, H., Bennett, P.H., Bogardus,

- Jamshidi, Y., Montgomery, H.E., Hense, H.W., Myerson, S.G., Torra, I.P., Staels, B., World, M.J., Doering, A., Erdmann, J., Hengstenberg, C., Humphries, S.E., Schunkert, H. and Flavell, D.M., 2002. Peroxisome proliferator--activated receptor alpha gene regulates left ventricular growth in response to exercise and hypertension. *Circulation*, **105**, pp. 950-955.
- Jouven, X., Charles, M.A., Desnos, M. and Ducimetiere, P., 2001. Circulating nonesterified fatty acid level as a predictive risk factor for sudden death in the population. *Circulation*, **104**, pp. 761-756.
- Klein-Platat, C., Drai, J., Oujaa, M., Schlienger, J.L. and Simon, C., 2005. Plasma fatty acid composition is associated with the metabolic syndrome and low-grade inflammation in overweight adolescents. *Am J Clin Nutr*, **82**, pp. 1178-1184.
- Kooner, J.S., Baliga, R.R., Wilding, J., Crook, D., Packard, C.J., Banks, L.M., Peart, S., Aitman, T.J. and Scott, J., 1998. Abdominal obesity, impaired nonesterified fatty acid suppression, and insulin-mediated glucose disposal are early metabolic abnormalities in families with premature myocardial infarction. *Arterioscler Thromb Vasc Biol*, **18**, pp. 1021-1026.
- Kunesova, M., Hainer, V., Tvrzicka, E., Phinney, S.D., Stich, V., Parizkova, J., Zak, A. and Stunkard, A.J., 2002. Assessment of dietary and genetic factors influencing serum and adipose fatty acid composition in obese female identical twins. *Lipids*, **37**, pp. 27-32.
- Levy, E., Menard, D., Delvin, E., Stan, S., Mitchell, G., Lambert, M., Ziv, E., Feoli-Fonseca, J.C., Seidman, E., 2001. The polymorphism at codon 54 of the FABP2 gene increases fat absorption in human intestinal explants. *J Biol Chem*, **276**, pp. 39679-39684.
- Lind, L., Fugmann, A., Branth, S., Vessby, B., Millgard, J., Berne, C. and Lithell, H., 2000. The impairment in endothelial function induced by non-esterified fatty acids can be plasma lipids of obese children. *Lipids*, **31**, pp. 305-311.
- Denke, M.A., 2001. Connections between obesity and dyslipidaemia. *Curr Opin Lipidol*, **12**, pp. 625-628.
- Dwyer, J.H., Allayee, H., Dwyer, K.M., Fan, J., Wu, H., Mar, R., Lusi, A.J. and Mehrabian, M., 2004. Arachidonate 5-lipoxygenase promoter genotype, dietary arachidonic acid, and atherosclerosis. *N Engl J Med*, **350**, pp. 29-37.
- Folch, J., Lees, M. and Sloane Stanley, G.H., 1957. A simple method for the isolation and purification of total lipides from animal tissues. *J Biol Chem*, **226**, pp. 497-509.
- Garaulet, M., Perez-Llamas, F., Perez-Ayala, M., Martinez, P., de Medina, F.S., Tebar, F.J. and Zamora, S., 2001. Site-specific differences in the fatty acid composition of abdominal adipose tissue in an obese population from a Mediterranean area: relation with dietary fatty acids, plasma lipid profile, serum insulin, and central obesity. *Am J Clin Nutr*, **74**, pp. 585-591.
- Gasperiakova, D., Demcakova, E., Ukropec, J., Klimes, I. and Sebokova, E., 2002. Insulin resistance in the hereditary hypertriglyceridemic rat is associated with an impairment of delta-6 desaturase expression in liver. *Ann N Y Acad Sci*, **967**, pp. 446-453.
- Georgopoulos, A., Aras, O. and Tsai, M.Y., 2000. Codon-54 polymorphism of the fatty acid-binding protein 2 gene is associated with elevation of fasting and postprandial triglyceride in type 2 diabetes. *J Clin Endocrinol Metab*, **85**, pp. 3155-3160.
- Hokanson, J.E. and Austin, A., 1996. Plasma triglyceride level is a risk factor for cardiovascular disease independent of high-density lipoprotein cholesterol level: a meta-analysis of population-based prospective studies. *J Cardiovasc Risk*, **3**, pp. 213-219.

- Ribalta, J., Halkes, C.J., Salazar, J., Masana, L. and Cabezas, M.C., 2005. Additive effects of the PPARgamma, APOE, and FABP-2 genes in increasing daylong triglycerides of normolipidemic women to concentrations comparable to those in men. *Clin Chem*, **51**, pp. 864-871.
- Riccardi, G., Giacco, R. and Rivellese, A.A., 2004. Dietary fat, insulin sensitivity and the metabolic syndrome. *Clin Nutr*, **23**, pp. 447-456.
- Rossner, S., Walldius, G. and Bjorvell, H., 1989. Fatty acid composition in serum lipids and adipose tissue in severe obesity before and after six weeks of weight loss. *Int J Obes*, **13**, pp. 603-612.
- Salo, P., Viikari, J., Hamalainen, M., Lapinleimu, H., Routi, T., Niinikoski, H., Rask-Nissila, L., Tammi, A., Ronnema, T., Seppanen, R., Jokinen, E., Valimaki, I. and Simell, O., 2000. Fatty acid composition of serum cholesterol esters as a reflector of low-saturated-fat, low-cholesterol diet in young children: the STRIP project. The Special Turku coronary Risk factor Intervention Project. *Acta Paediatr*, **89**, pp. 399-405.
- Samuelson, G., Bratteby, L.E., Mohsen, R. and Vessby, B., 2001. Dietary fat intake in healthy adolescents: inverse relationships between the estimated intake of saturated fatty acids and serum cholesterol. *Br J Nutr*, **85**, pp. 333-341.
- Sarkkinen, E.S., Agren, J.J., Ahola, I., Ovaskainen, M.L. and Uusitupa, M.I., 1994. Fatty acid composition of serum cholesterol esters, and erythrocyte and platelet membranes as indicators of long-term adherence to fat-modified diets. *Am J Clin Nutr*, **59**, pp. 364-370.
- Scaglioni, S., Verduci, E., Salvioni, M., Bruzzese, M.G., Radaelli, G., Zetterstrom, R., Riva, E. and Agostoni, C., 2006. Plasma long-chain fatty acids and the degree of obesity in Italian children. *Acta Paediatr*, **95**, pp. 964-969.
- Smedman, A.E., Gustafsson, I.B., Berglund, L.G. and Vessby, B.O., 1999. Pentadecanoic reversed by insulin. *Clin Sci (Lond)*, **99**, pp. 169-174.
- Lusis, A.J., 2000. Atherosclerosis. *Nature*, **407**, pp. 233-241.
- Ma, J., Folsom, A.R., Shahar, E. and Eckfeldt, J.H., 1995. Plasma fatty acid composition as an indicator of habitual dietary fat intake in middle aged adults. The Atherosclerosis Risk in Communities (ARIC) Study Investigators. *Am J Clin Nutr*, **62**, pp. 564-571.
- Marin, C., Perez-Jimenez, F., Gomez, P., Delgado, J., Paniagua, J.A., Lozano, A., Cortes, B., Jimenez-Gomez, Y., Gomez, M.J. and Lopez-Miranda, J., 2005. The Ala54Thr polymorphism of the fatty acid-binding protein 2 gene is associated with a change in insulin sensitivity after a change in the type of dietary fat. *Am J Clin Nutr*, **82**, pp. 196-200.
- Masson, L.F., McNeill, G. and Avenell, A., 2003. Genetic variation and the lipid response to dietary intervention: a systematic review. *Am J Clin Nutr*, **77**, pp. 1098-1111.
- Nakamura, M.T., Cho, H.P., Xu, J., Tang, Z. and Clarke, S.D., 2001. Metabolism and functions of highly unsaturated fatty acids: an update. *Lipids*, **36**, pp. 961-964.
- Ordoas, J., M., 1998. Fast ultracentrifugation Methods for the Separation of Plasma Lipoproteins springer-verlag Boston MA.
- Phinney, S.D., Fislser, J.S., Tang, A.B. and Warden, C.H., 1994. Liver fatty acid composition correlates with body fat and sex in a multigenic mouse model of obesity. *Am J Clin Nutr*, **60**, pp. 61-67.
- Pratley, R.E., Baier, L., Pan, D.A., Salbe, A.D., Storlien, L., Ravussin, E. and Bogardus, C., 2000. Effects of an Ala54Thr polymorphism in the intestinal fatty acid-binding protein on responses to dietary fat in humans. *J Lipid Res*, **41**, pp. 2002-2008.

- Vidgren, H.M., Sipilainen, R.H., Heikkinen, S., Laakso, M. and Uusitupa, M.I., 1997. Threonine allele in codon 54 of the fatty acid binding protein 2 gene does not modify the fatty acid composition of serum lipids in obese subjects. *Eur J Clin Invest*, **27**, pp. 405-408.
- Vimaleswaran, K.S., Radha, V. and Mohan, V., 2006. Thr54 allele carriers of the Ala54Thr variant of FABP2 gene have associations with metabolic syndrome and hypertriglyceridemia in urban South Indians. *Metabolism*, **55**, pp. 1222-1226.
- Vohl, M.C., Lepage, P., Gaudet, D., Brewer, C.G., Betard, C., Perron, P., Houde, G., Cellier, C., Faith, J.M., Despres, J.P., Morgan, K. and Hudson, T.J., 2000. Molecular scanning of the human PPAR $\alpha$  gene: association of the L162v mutation with hyperapobetalipoproteinemia. *J Lipid Res*, **41**, pp. 945-952.
- Von Houwelingen, A.C., Kester, A.D. and Kromhout, D., Hornstra, G., 1989. Comparison between habitual intake of polyunsaturated fatty acids and their concentrations in serum lipid fractions. *Eur J Clin Nutr*, **43**, pp. 11-20.
- Wajchenberg, B.L., 2000. Subcutaneous and visceral adipose tissue: their relation to the metabolic syndrome. *Endocr Rev*, **21**, pp. 697-738.
- Warensjo, E., Sundstrom, J., Lind, L. and Vessby, B., 2006. Factor analysis of fatty acids in serum lipids as a measure of dietary fat quality in relation to the metabolic syndrome in men. *Am J Clin Nutr*, **84**, pp. 442-448.
- Wolk, A., Furuheim, M., Vessby, B., 2001. Fatty acid composition of adipose tissue and serum lipids are valid biological markers of dairy fat intake in men. *J Nutr*, **131**, pp. 828-833.
- acid in serum as a marker for intake of milk fat: relations between intake of milk fat and metabolic risk factors. *Am J Clin Nutr*, **69**, pp. 22-29.
- Steinberg, H.O., Tarshoby, M., Monestel, R., Hook, G., Cronin, J., Johnson, A., Bayazeed, B. and Baron, A.D., 1997. Elevated circulating free fatty acid levels impair endothelium-dependent vasodilation. *J Clin Invest*, **100**, pp. 1230-1239.
- Tremblay, A.J., Despres, J.P., Piche, M.E., Nadeau, A., Bergeron, J., Almeras, N., Tremblay, A. and Lemieux, S., 2004. Associations between the fatty acid content of triglyceride, visceral adipose tissue accumulation, and components of the insulin resistance syndrome. *Metabolism*, **53**, pp. 310-317.
- Urban, M., Wojtowicz, J., Pedzinski, W. and Grojec, M., 1989. [Tests evaluating the influence of plasma fatty acid composition on the dynamics of contractions of the left heart ventricle in children with simple obesity. Part I. Influence of plasma fatty acid composition in children with simple obesity]. *Pediatr Pol*, **64**, pp. 9-16.
- van Staveren, W.A., Deurenberg, P., Katan, M.B., Burema, J., de Groot, L.C. and Hoffmans, M.D., 1986. Validity of the fatty acid composition of subcutaneous fat tissue microbiopsies as an estimate of the long-term average fatty acid composition of the diet of separate individuals. *Am J Epidemiol*, **123**, pp. 455-463.
- Vessby, B., 2000. Dietary fat and insulin action in humans. *Br J Nutr*, **83** Suppl 1, pp. S91-96.
- Vessby, B., 2003. Dietary fat, fatty acid composition in plasma and the metabolic syndrome. *Curr Opin Lipidol*, **14**, pp. 15-19.