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Journal of Nutritional Biochemistry 22 (2011) 791–797
Journal of Nutritional Biochemistry

High dietary intake of medium-chain fatty acids during pregnancy in rats prevents later-life obesity in their offspring

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Received 28 October 2009; received in revised form 24 April 2010; accepted 2 July 2010

Abstract

We investigated the effects of dietary fatty acids of different chain lengths during pregnancy in the rat on the susceptibility of offspring to later-life obesity and the underlying mechanisms. Pregnant rats were fed three different diets: standard (STD), high medium-chain fatty acids (MCFA); and high long-chain fatty acids (LCFA). The male offspring were assigned to three groups: STD control, MCFA and LCFA according to the maternal diets and suckled by dams fed with STD during pregnancy and lactation. After weaning, the offspring were fed with STD from 3 to 8 weeks of age. At the age of 8 weeks, rats in three groups: high-fat diet (HFD) control, MCFA and LCFA were fed with HFD until 14 weeks of age in an attempt to induce obesity, and rats in the HFD control group were selected randomly from the STD control group. Body weight and body fat content were decreased in the MCFA group accompanied by down-regulated mRNA expression of fatty acid synthase and acetyl-coA carboxylase 1, and increased mRNA and protein expression of adenosine monophosphate (AMP)-activated protein kinase (AMPK), carnitine palmitoyltransferase 1 and uncoupling protein 3 compared with the corresponding controls at 3, 8 and 14 weeks of age. The results suggested that the MCFA diet during pregnancy prevented later-life obesity in the offspring when they were exposed to HFD in later life, which might be related to programming of the expression of genes involved in fatty acid metabolism.

Keywords: Medium-chain fatty acids; Metabolism programming; Offspring; Obesity; Fatty acid oxidation

1. Introduction

Obesity has become an important health problem in the 21st century [1] and nutrition is a critical influential factor of adult obesity. Earlier studies showed that the fetal nutritional environment was the key determinant of later-life obesity [2–5], which can be explained by "metabolism programming" [6–9].

Most conventional edible oils, including soybean (*Glycine max*), peanut (*Arachis hypogaea*), palm (*Elaeis guineensis*), corn (*Zea mays*), lard and butter, are composed primarily of long-chain triglycerides. There has been a great deal of research on the role of dietary medium-chain triglycerides [coconut oil (*Cocos nucifera*) and palm kernel oils contain a high proportion of medium-chain triglycerides] in weight control. Medium-chain triglycerides containing medium-chain fatty acids (MCFAs, 8–12 carbon atoms) can reduce body weight and body fat mass in animals and humans compared with long-chain triglycerides that contain long-chain fatty acids (LCFAs, ≥14 carbon atoms) [10,11]. In an animal study, Sprague-Dawley rats fed with medium-chain triglycerides for 6 weeks had lower body fat mass and gained less weight than those fed with long-chain triglycerides [10]. Tsuji et al. [11] found that overweight human subjects (with BMI ≥23 kg/m^2) fed with a diet containing medium-chain triglycerides had significantly lower body weight and body fat mass than overweight subjects fed with a long-chain triglyceride diet. Furthermore, earlier studies suggested that dietary medium-chain triglycerides would decrease the concentration of cholesterol in blood and liver, and the concentration of triglyceride (TG) in heart and skeletal muscle [12,13]. However, little research has been done to confirm whether dietary MCFA or LCFA during pregnancy can influence body weight, fat mass and change the serum lipid profile in the later life of the offspring. In this study, we asked whether dietary MCFA or LCFA fed to pregnant rats could affect body weight, fat mass and the serum lipid profile in the later life of the offspring. We also investigated the expression of genes involved in lipid metabolism.

2. Materials and methods

2.1. Experimental design and animal care

All procedures were approved by the Animal Experimentation Ethics Committee of Harbin Medical University. Rats were housed in a temperature-controlled room with a 12-h light/12-h dark cycle and water was available ad libitum.

Female (170±10 g body weight) and male (210±10 g body weight) Wistar rats were purchased from Shanghai SLAC Laboratory Animal (Shanghai, China). Female rats

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doi:10.1016/j.jnutbio.2010.07.006

Table 1
Diet compositions

Ingredients	STD	MCFA	LCFA	HFD
g/100 g diet				
Casein	20.00	20.00	20.00	20.00
L-Cystine	0.30	0.30	0.30	0.30
L-Methionine	0.16	0.16	0.16	0.16
Carbohydrates	66.84	52.54	53.84	55.84
Fat	7.00[a]	21.30[b]	20.00[a]	18.00[c]
Cellulose	1.00	1.00	1.00	1.00
Vitamin mix, AIN-93G	1.00	1.00	1.00	1.00
Mineral mix, AIN-93G	3.50	3.50	3.50	3.50
Choline bitartrate (50% choline)	0.20	0.20	0.20	0.20
Sources of energy (%)				
Protein	20	17	17	17
Carbohydrates	65	45	45	48
Fat	15	38[d]	38	35

[a]Soybean oil; [b]coconut oil (17.8g) plus soybean oil (3.5g); [c]lard (14.0g) plus soybean oil (4.0g); [d]the energy yield of coconut oil is 8.3 kcal/g [36].

were mated overnight with male rats. The day of a sperm-positive vaginal smear was designated as day 0 of pregnancy. The pregnant rats were moved to individual cages and (n=30 for each diet) and fed with a purified American Institute of Nutrition (AIN-93G) diet as a standard diet (STD), an MCFA diet or an LCFA diet (Table 1). Food intake and body weight were measured every 3 days until the rats delivered on Day 21, which was considered as age 0 weeks for the offspring. A flowchart of the procedure is shown in Fig. 1.

Male offspring were selected and assigned to one of three groups, STD, MCFA or LCFA, according to the maternal diet. Then male offspring were standardized to 8 per litter within 6 hours of delivery and were suckled by dams fed STD during pregnancy and lactation. In order to further standardize the postnatal environment (from 3 to 8 weeks of age), male offspring were housed in individual cages and fed with STD ad libitum. At 8 weeks of age, 30 offspring were selected randomly from the STD control group to be the high-fat diet (HFD) control group. The other rats in the STD control group continued to be fed with STD. Rats in MCFA, LCFA and HFD control groups were fed HFD (Tables 1 and 2) until 14 weeks of age in an attempt to induce obesity.

Food intake was measured daily and body weight of the offspring was measured weekly. The weight-adjusted energy intake of mothers and offspring was calculated as:

kilocalorie intake × 100 / body weight

The obesity rate (n=30) at 14 weeks of age was calculated as:

(number of obese offspring rats) / (total number of offspring rats) × 100%

Table 2
Fatty acid composition of coconut oil, soybean oil and lard[a]

Fatty acid	Coconut oil	Soybean oil	Lard
% of total fatty acids			
C 8:0	4.3	–	–
C 10:0	5.0	–	–
C 12:0	39	–	–
C 14:0	18	Trace	2.3
C 16:0	11.3	11	26.3
C 16:1	1.0	0.4	2.9
C 18:0	3.2	3.8	15.1
C 18:1	8.9	22.2	41.2
C 18:2	8.5	54.2	7.2
C 18:3	-	7.7	0.5
Others	0.8	0.7	4.5

[a] All data are based on laboratory analysis.

Obesity was defined as: body weight>mean+2 S.D. Body fat content of the offspring was calculated as:

100(perirenal and epididymal fat pads) / body weight

To determine whether metabolism programming induced changes in the later life of the offspring, we chose dynamic observation points 0 (birth), 3 (weaning), 8 (near adulthood) and 14 (after 6 weeks obesity inducing) weeks of age. At these time points, 10 offspring were selected randomly from each group, fasted overnight and then anaesthetised with pentobarbital. Blood was collected by decapitation at 0 and 3 weeks and from the abdominal aorta at 8 and 14 weeks old. Liver and skeletal muscle were removed, weighed, snap-frozen in liquid nitrogen and stored at −80°C.

2.2. Fatty acid composition of oils

The fat in the diets was provided in the form of coconut and soybean oils (MCFA), soybean oil (LCFA), soybean oil (STD) and soybean and lard oils (HFD). The fatty acid composition of coconut, soybean and lard oils was analysed by gas chromatography coupled to an ion trap mass spectrometer (TRACE GC/PolarisQ MS; Thermo Finnigan, San Jose, CA, USA), and the results are given in Table 2.

2.3. Levels of serum TG, high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C)

Serum was obtained by centrifugation and stored at –80 °C. Serum contents of TG, HDL-C and LDL-C were assayed by standard enzymatic colorimetric methods with

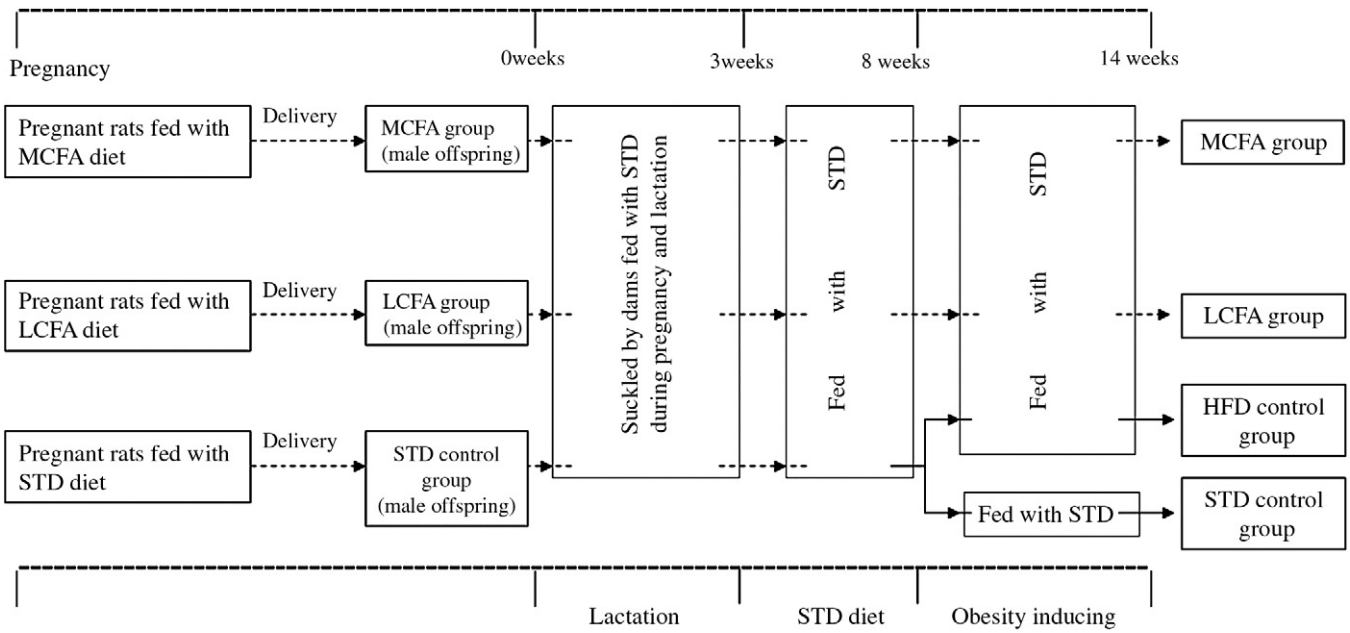

Fig. 1. The study design and the flow of treatment groups and times.

Table 3
Primer and probe sequence of quantitative real-time PCR

Gene		Sequence	Product Length (bp)
CPT1	Forward	5′-GCCCATGTTGTACAGCTTCCA-3′	113
	Reverse	5′-AGTCTTCTTCCTTCATCAGTGGC-3′	
	Probe	5′-(FAM) TCTCTGCCACGCCTGCCTGTCC (TAMRA)-3′	
AMPK	Forward	5′-ATGGCCGAGAAGCAGAAGCA-3′	122
	Reverse	5′-TTATGTCCAGTCAACTCGTGCTT-3′	
	Probe	5′-(FAM) ACTTTCCCGAAGGTGCCGACGCC (TAMRA)-3′	
UCP3	Forward	5′-TTTGCTGATCTCCTCACCTTCC-3′	79
	Reverse	5′-TCTGCACTCCTGGGTTCTCC-3′	
	Probe	5′- (FAM) ACACCGCCAAGGTCCGCCTGC (TAMRA)-3′	
ACC1	Forward	5′-TTTTCGATGTCCTCCCAAACTTTT -3′	99
	Reverse	5′-GCTCATAGGCGATATAAGCTCTTC -3′	
	Probe	5′-(FAM) ACCTCCAGAGCCGCCATCCTCACC (TAMRA) -3′	
FAS	Forward	5′-TCTCTGGTGGTGTCTACATTTCG -3′	141
	Reverse	5′-GCAGGATAGCACTCTCAGACAG -3′	
	Probe	5′-(FAM) ACAACAGCAACCTCACGGCGGCAG (TAMRA)-3′	
β-Actin	Forward	5′-AGGGAAATCGTGCGTGAC-3′	146
	Reverse	5′-CGCTCATTGCCGATAGTG-3′	
	Probe	5′-(FAM) CTGTGCTATGTTGCCCTAGACTTC (TAMRA)-3′	

commercial kits (Biosino Biotechnology, Beijing, China) and with an auto-analyser (Autolab, PM 4000, AMS, Rome, Italy).

2.4. Extraction of total RNA

Total RNA was isolated from liver and skeletal muscle using TRIzol reagent (Invitrogen, Carlsbad, CA, USA) in accordance with the manufacturer's protocol. Total RNA was measured by a nucleic acid and protein auto-analyser (Du 600 series, Beckman, Fullerton, CA, USA) at A_{260}.

2.5. Quantitative real-time polymerase chain reaction (PCR)

The mRNA expression of fatty acid synthase (FAS), acetyl-coA carboxylase 1 (ACC1) and carnitine palmitoyltransferase 1 (CPT1) in liver, and uncoupling protein 3 (UCP3) and adenosine monophosphate (AMP)-activated protein kinase (AMPK) in skeletal muscle was determined by quantitative real-time PCR. All primers, probes and reagents (TaqMan Reverse Transcriptase reagents and TaqMan Universal PCR Master Mix) for real-time PCR analysis were purchased from TaKaRa Biotech (Dalian, China) and used according to the manufacturer's instructions.

Table 4
Average body weight, body fat content, obesity rate and metabolic parameters of offspring

Parameter	STD control	HFD control	MCFA	LCFA
Body weight, g				
0 weeks[a]	6.3±0.3		5.9±0.4*	6.1±0.7
3 weeks[a]	39.0±2.5		34.8±3.9	40.4±4.5
8 weeks[a]	180.9±10.0	179.2±11.0	169.2±11.6	176.9±16.5
14 weeks[b]	304.5±6.7†	325.2±14.0	306.7±16.9†	326.2±24.2
Body fat content 100 (perirenal+epididymal fat pads) g/(body weight) g				
3 weeks[a]	0.64±0.26		0.44±0.22*	0.54±0.26
8 weeks[a]	1.58±0.64		1.50±0.56	1.61±0.31
14 weeks[b]	3.54±0.77†	4.22±0.69	3.77±0.46†	4.38±0.97
Obesity rate (the number of obese rats[c] in a group / the sum total of rats in the group) × 100%				
14 weeks[b]		70.00	30.00†	63.33
Serum TG , mmol/L				
3 weeks[a]	1.50±0.40		1.15±0.35*	1.20±0.27*
8 weeks[a]	0.95±0.26		0.75±0.14*	0.87±0.16
14 weeks[b]	1.00±0.21†	1.40±0.21	1.10±0.32†	1.35±0.40
Serum HDL-C, mmol/L				
3 weeks[a]	0.70±0.35		0.87±0.29*	0.75±0.32
8 weeks[a]	0.87±0.36		0.92±0.30	0.85±0.32
14 weeks[b]	0.82±0.36†	0.61±0.35	0.79±0.40†	0.67±0.26
Serum LDL-C, mmol/L				
3 weeks[a]	0.69±0.21		0.73±0.26	0.77±0.31
8 weeks[a]	0.52±0.21		0.38±0.24	0.49±0.23
14 weeks[b]	0.48±0.25†	0.80±0.35	0.57±0.27†	0.70±0.33

[a]n=10 per group; [b]MCFA, LCFA and HFD control: n=30 per group; [b]STD control: n=10; data are mean±SD; [c]Body weight>mean (STD control group rats) + 2 S.D.; *P<.05 vs. STD control; †P<.05 vs. HFD control.

Real-time PCR is a two-step manner. cDNA was synthesized by reverse transcription from 500 ng of total RNA in a total reaction volume of 10 μl. cDNA corresponding to 50 ng of RNA per reaction was used for real-time PCR amplification after reverse transcription reactions. Specific products were amplified and detected with the ABI Prism 7500 Fast Real-Time PCR system (Applied Biosystems) according to the manufacturer's protocol. The amplification procedure was as follows. Samples were denatured at 95°C for 10 s and then subjected to 40 cycles of amplification. The amplification consisted of 5 s at 95°C, 30 s at 58°C for AMPK and ACC1 (60°C for UCP3, CPT1 and FAS; 54°C for β-actin, which was used

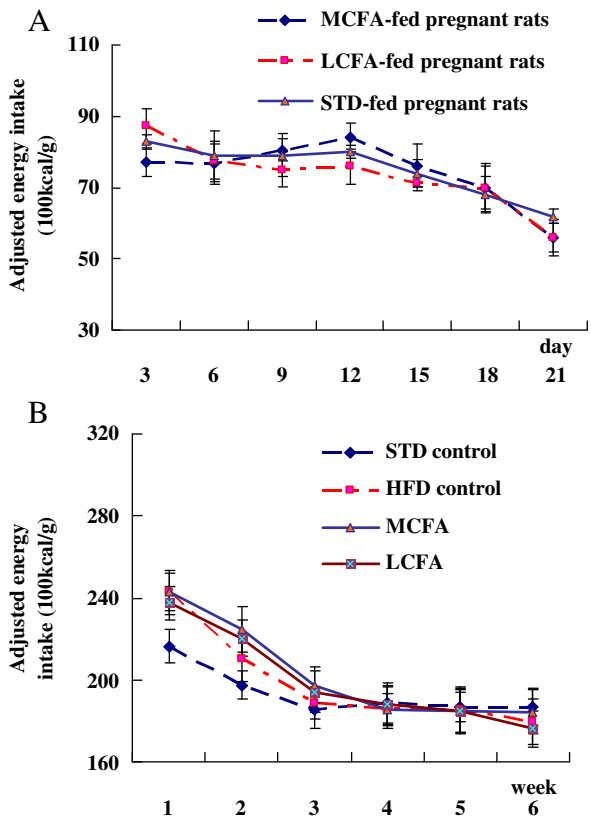

Fig. 2. The adjusted energy intake of pregnant rats fed with different diets (A) and offspring during the HFD (B). The data are mean±SD, n=30. STD control, standard diet control group; MCFA, medium-chain fatty acid group; LCFA, long-chain fatty acid group; HFD control, high-fat diet control group. No significant difference of adjusted energy intake was found among the pregnant rats fed with different diets and among offspring groups MCFA, LCFA and HFD control during the obesity-inducing period.

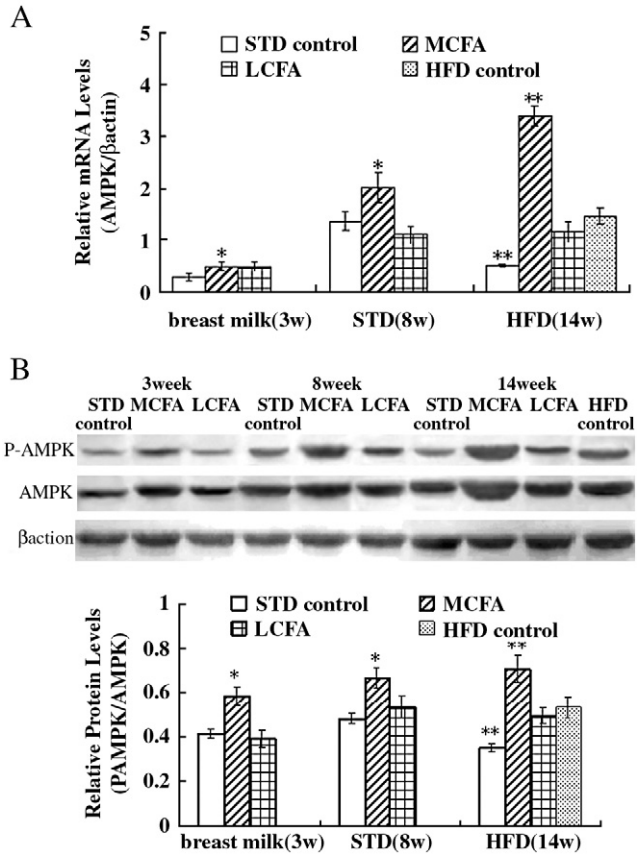

Fig. 3. Effects of different diets during pregnancy on offspring AMPK mRNA expression (A) and AMPK activity (B) in skeletal muscle. Each bar represents mean±SD. *P<.05 vs. STD control; **P<.05 vs. HFD control (n=6).

as the control). A standard curve was plotted for each primer–probe set with a series of dilution pooled cDNA. All real-time PCR was done in triplicate. The sequences of the primers and probes are given in Table 3.

2.6. Western blot analysis

The protein expression of CPT1, UCP3 and AMPK and phosphorylation of the AMPK protein (P-AMPK) in skeletal muscle were determined by Western blot. Tissue samples (100 mg) of skeletal muscle were lysed for 2 hours on ice. Lysates were centrifuged at 12,000g for 10 min at 4°C. The supernatants were transferred to Eppendorf vials. Equal amounts of total protein (80 μg) for each sample were mixed with 5× sodium dodecyl sulfate polyacrylamide gel electrophoresis loading buffer (Beyotime Institute of Biotechnology), and heated at 95–100°C for 3 min. Samples were then loaded onto 8% or 10% polyacrylamide gels and subjected to electrophoresis. The gels were transferred onto nitrocellulose membranes (Millipore, Bedford, MA, USA), which were blocked and incubated for 2 h with primary antibodies rabbit polyclonal anti-P-AMPK, anti-AMPK IgG (Cell Signaling Technology, Danvers, MA, USA), goat polyclonal anti-CPT (sc-20514) and anti-UCP3 IgG (sc-31387) (Santa Cruz Biotechnology, Santa Cruz, CA, USA), or mouse polyclonal anti-β-actin IgG (Boster Biotechnology, no.BA0410). The membranes were washed and then incubated for 1 hr with secondary antibodies conjugated to alkaline phosphatase (Promega, no. W3960). The membranes were washed again and then specific protein bands were analysed with a Chemi ImagerTM 4000 (Alpha Innotech, San Leandro, CA, USA). Values are presented as the relative intensity of the protein bands and all samples were analysed in triplicate.

2.7. Statistical analysis

Statistical analysis was done with SPSS software (version 13.01S; Beijing Stats Data Mining, Beijing, China). Continuous variables and categorical variables are expressed as mean±SD and frequencies. The STD control group and the HFD control group served as controls at 3 and 8 weeks of age and at 14 weeks of age, respectively; One-way ANOVA analysis was used to analyse continuous variables. If P<.05, Dunnett's t test was used to compare experimental groups with the corresponding control groups. The χ^2 test was used to analyse categorical variables. The level of statistical significance was set at P<.05.

3. Results

3.1. Body weight, body fat content, obesity rate and adjusted energy intake

There was no statistical difference among the birth weights of MCFA, LCFA and STD groups. The body weight and body fat content were decreased significantly in the MCFA group when compared to corresponding controls at 3 and 14 weeks of age. There was a tendency for decreased body weight and body fat content in the MCFA group when compared with STD controls at 8 weeks of age. In addition, the obesity rate in the MCFA group (30.00%, P<.05) was 40.0% less than that in the HFD controls at 14 weeks of age (70.0%). However, there was no significant difference of body weight or body fat content at 14 weeks of age between the LCFA group and the HFD control. Body weight, body fat content and obesity rate are given in Table 4.

There was no significant difference of adjusted energy intake among the pregnant rats fed with different diets or among the offspring MCFA, LCFA and HFD control groups during the obesity-inducing period (Fig. 2A and B).

3.2. Serum levels of TG, HDL-C and LDL-C

There was no significant difference of serum levels of TG, HDL-C or LDL-C between the MCFA, LCFA and STD control groups at 0 weeks of age (data not shown). The concentration of TG in the

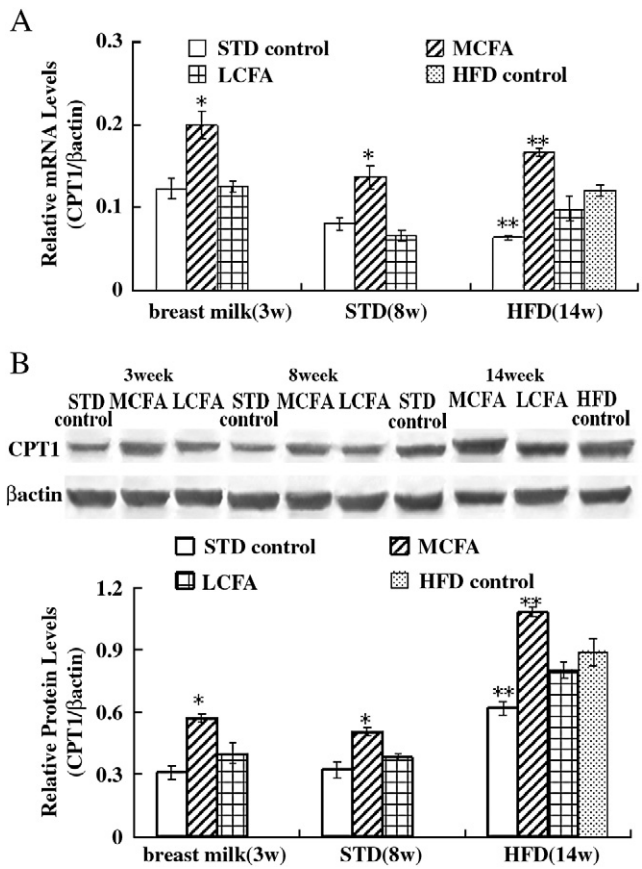

Fig. 4. Effects of different diets during pregnancy on offspring CPT1 mRNA (A) and protein (B) expression in skeletal muscle. Each bar represents mean±SD. *P<.05 vs. STD control; **P<.05 vs. HFD control (n=6). STD control, standard diet control group; MCFA, medium-chain fatty acid group; LCFA, long-chain fatty acid group; HFD control, high-fat diet control group.

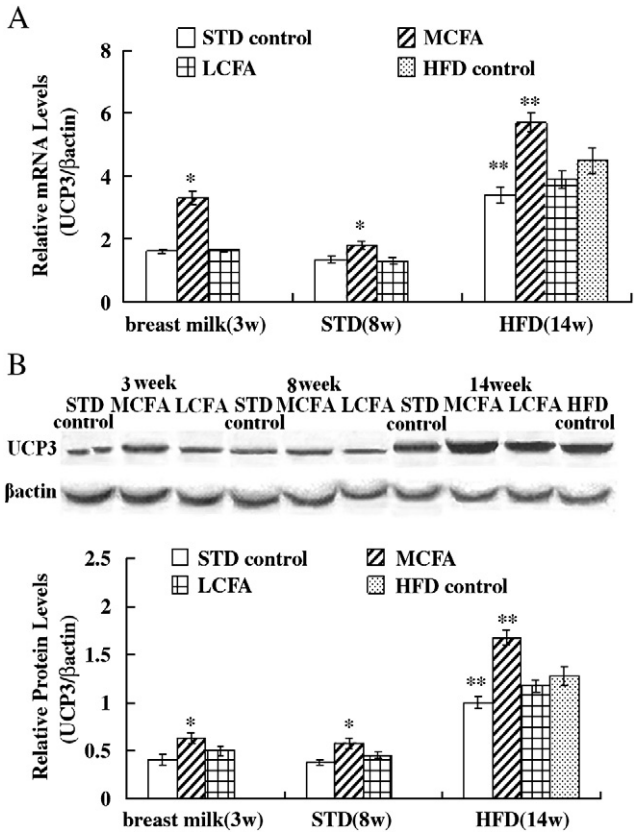

Fig. 5. Effect of different diets during pregnancy on offspring UCP3 mRNA (A) and protein (B) expression in skeletal muscle. Each bar represents mean±S.D. *P<.05 vs. STD control; **P<.05 vs. HFD control (n=6).

MCFA group was significantly lower than that in the corresponding controls at 3, 8 and 14 weeks of age (P<.05); the concentration of HDL-C was significantly higher than that in the corresponding controls at 3 and 14 weeks of age and the concentration of LDL-C was significantly lower than that in the HFD controls at 14 weeks of age. However, only the concentration of TG in the LCFA group was significantly lower in comparison with that in the STD controls at 3 weeks of age. The serum levels of TG, HDL-C and LDL-C are given in Table 4.

3.3. AMPK at mRNA level, AMPK activity in skeletal muscle

The expression of AMPK mRNA was significantly up-regulated in the MCFA group compared with the corresponding controls at 3, 8 and 14 weeks of age (Fig. 3A). This up-regulated expression of AMPK mRNA was accompanied by significantly increased AMPK protein and AMPK activity (the quotient of P-AMPK/AMPK, Fig. 3B). In contrast, there was no significant difference between the LCFA groups and the corresponding control at 3, 8 or 14 weeks of age in AMPK (Fig. 3A) expression or AMPK activity (Fig. 3B).

3.4. CPT1 and UCP3 at both mRNA and protein levels in skeletal muscle

The expression of CPT1 (Fig. 4A and B) and UCP3 (Fig. 5A and B) in the MCFA group was significantly higher than that in the corresponding controls at 3, 8 and 14 weeks of age. However, there was no significant difference between the LCFA groups and the corresponding control at 3, 8 or 14 weeks of age with respect to CPT1 (Fig. 4A and B) and UCP3 (Fig. 5A and B) expression.

3.5. ACC1 and FAS at mRNA level in liver

The mRNA expression of ACC1 (Fig. 6A) and FAS (Fig. 6B) in the MCFA group was significantly lower than that of the corresponding controls at 3, 8 and 14 weeks of age. However, the mRNA expression of ACC1 (Fig. 6A) and FAS (Fig. 6B) in the LCFA group was significantly lower than that of the STD controls only at 3 weeks of age.

4. Discussion

MCFAs can lead to a reduction of body weight and body fat content compared with LCFAs in both animal and human studies [10,11,14,15]. So far, little attention has been paid to whether an MCFA diet during pregnancy can reduce body weight and fat content and improve lipid metabolism in the offspring. Excess energy intake is a main factor contributing to obesity. To avoid the interference of this confounding factor, we adjusted energy intake with the body weight of pregnant rats and offspring. The results showed that there was no significant difference of adjusted energy intake among pregnant rats fed different diets or among the offspring MCFA, LCFA and HFD control groups during the obesity-inducing period. Hence, the changes in body weight, body fat content and serum levels of TG in the offspring in this study can be explained by the intake of different fatty acids during pregnancy. This study found that the MCFA diet during pregnancy significantly reduced the body weight, body fat content and concentration of TG in the serum of the offspring compared with the corresponding controls when the offspring were exposed to high fatty acid diets (lactation, Week 3; obesity inducing, Week 14). There was a trend of decreased body weight and body fat content in the MCFA group in comparison with the corresponding controls when the offspring were fed with the STD diet. Taken together, the data suggest that the MCFA diet during pregnancy prevented diet-induced obesity in the later life of their offspring and changed the lipid metabolism of their offspring. Furthermore, earlier studies reported that decreased

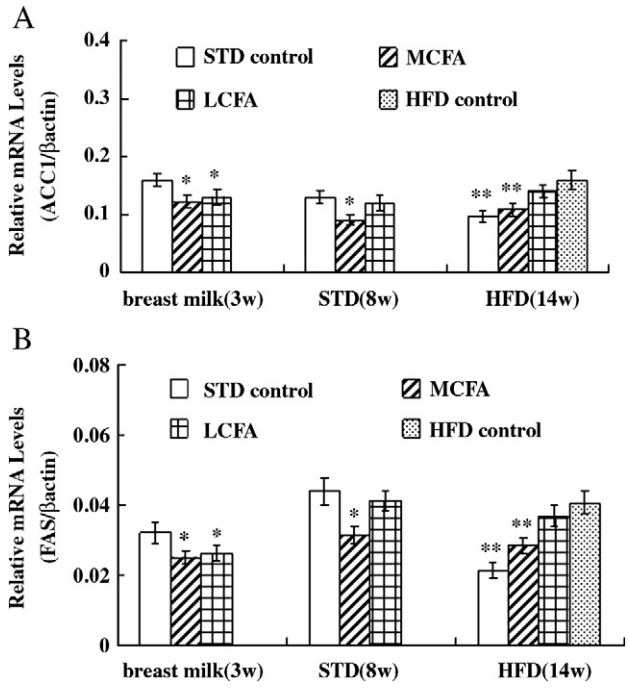

Fig. 6. Effect of different diets during pregnancy on offspring ACC (A) and FAS mRNA (B) expression in liver. Each bar represents mean±SD. *P<.05 vs. STD control, **P<.05 vs. HFD control (n=6).

fatty acid synthesis and increased fatty acid oxidation were associated with improved lipid profiles and the prevention of obesity [16–18].

Liver is a major organ for de novo lipogenesis [19], and ACC1 and FAS in liver are rate-limiting enzymes for de novo fatty acid synthesis. Reduced gene expression of ACC1 and FAS contributes to the prevention of obesity and decreased concentration of TG in plasma [20,21] and we detected lipogenic gene expression of ACC1 and FAS in the liver of the offspring. The results showed that the MCFA diet intake during pregnancy persistently down-regulated the expression of ACC1 and FAS in the liver of their offspring. Therefore, the MCFA diet intake during pregnancy programmed the prevention of obesity and improvement of serum TG in the offspring, which might be related to the programmed decrease in the expression of ACC1 and FAS in the liver of the offspring.

CPT1 is a rate-limiting enzyme in mitochondrial fatty acid oxidation and increased CPT1 expression in skeletal muscle can decrease the intracellular concentration of TG, fat content and body weight [22–27]. UCP3 is associated directly with fatty acid oxidation in skeletal muscle and the over-expression of UCP3 can increase fatty acid transport at the plasma and mitochondrial membranes, decrease skeletal muscle storage of TG and increase mitochondrial fatty acid oxidation [28]. In addition, TG are synthesized in liver, secreted into blood and transported to peripheral organs, such as skeletal muscle [29,30], which suggests that the utilization of TG in skeletal muscle might contribute to the decrease in concentration of serum TG. Therefore, in this study, we explored CPT1 and UCP3 in the skeletal muscle of the offspring.

Activation of AMPK, a key regulator of fatty acid metabolism, can be achieved by phosphorylation. Activated AMPK up-regulates the expression of both CPT1 [25,26,31,32] and UCP3 [33–35]. Hence, we determined the protein expression of P-AMPK, AMPK and mRNA expression of AMPK in the skeletal muscle of the offspring. The results showed that the MCFA diet during pregnancy persistently up-regulated the expression of CPT1, UCP3, AMPK and P-AMPK in the offspring. The up-regulated expression of AMPK and P-AMPK contributed to increased activity of AMPK in the offspring. Hence, the MCFA diet during pregnancy programmed the prevention of obesity and the improvement of serum TG of the offspring, which might be due to the programmed increase of AMPK, AMPK activity and the AMPK-responsive genes CPT1 and UCP3.

The MCFA diet-induced programming changed the gene expression of fatty acid metabolism, which persisted during the whole experiment. Meanwhile, the effect of the MCFA diet on the prevention of obesity was more obvious when the offspring were fed high fatty acid diets. A possible explanation is that maternal blood MCFAs might alter epigenetic regulation of fetal fatty acid metabolism-related genes. The regulation of fetal genes involved in fatty acid metabolism was programmed to be triggered when the offspring were exposed to high fatty acid diets. However, in contrast to the MCFA diet, the LCFA diet during pregnancy showed no effect on protecting the offspring from obesity.

In conclusion, the MCFA diet intake during pregnancy might protect the offspring from obesity in later life. Furthermore, the improvement of obesity might be associated with programmed changes in expression of the genes involved in fatty acid oxidation and synthesis.

Acknowledgments

This work was supported by Grant-in-Aid 30671756 from the Nature Science Foundation of China, by Postgraduate Innovation Grants of Harbin Medical University, and by Grant-in-Aid D200801 from Nature Science Foundation of Heilongjiang province and the Department of Education of Heilongjiang province. There are no conflicts of interest in this manuscript.

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