

Evaluation of fetal status during KAATSU training[®] in the third trimester of pregnancy

N. Takano, M. Kusumi, H. Takano

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[Objective] We explored KAATSU training performed in a pregnant woman was safe for the fetus at the third trimester of pregnancy.

[Methods] A 36-year-old primigravida woman underwent non-stress tests (NST) at 29 weeks and 6 days (29w6d) and 30w4d of gestation in three states: resting (no exercise load), biceps curls using a 1 kg load without restricted blood flow, and biceps curls under a 1 kg load with arm blood flow restriction (BFR) with KAATSU belts, a specially designed elastic pressure cuffs. In addition, maternal hemodynamics using a Task Force Monitor and umbilical artery resistance index (UARI) using pulse wave Doppler duplex system were measured during femoral BFR with KAATSU belts at 31w1d.

[Results]

All of NST results showed that the fetal status was considered to be good and appropriate for the gestational age. Although femoral BFR caused a reduction in the maternal preload, the UARI did not change.

[Conclusion] Under the test conditions used in the present study, KAATSU training had no direct influence on the fetal status and utero-placental circulation. However, as the absence of fetal status influence of KAATSU training could not be confirmed, further investigation will be necessary.

Key words: non-stress test, umbilical artery waveform, maternal cardiovascular hemodynamics, KAATSU training

Correspondence to:
N. Takano, Takano Clinic,
4-6-38, Kamisaginomiya,
Nakano-ku, Tokyo, 165-0031
Japan
info@tanaka-cl.com

See end of article for
authors' affiliations

INTRODUCTION

Low-intensity resistance training combined with blood flow restriction (BFR), referred to as "KAATSU Training[®]", that is a method created by the inventor, Dr. Yoshiaki Sato, through his more than 45 years of research, elicits muscle hypertrophy and strength gains similar to those elicited during traditional high-intensity resistance training. Although several possibilities exist, the physiological mechanisms that promote muscle growth associated with "KAATSU Training" are poorly understood. (Yasuda et al., 2012, 2013) Furthermore, until now, no study has been published on the influence of KAATSU training on pregnant women and fetuses.

The American College of Obstetricians and Gynecologists has published new recommendations and guidelines for exercise during pregnancy and the postpartum period in 2002. (ACOG Committee, 2002) Pregnancy should not be a state of confinement, and pregnant women with uncomplicated pregnancies should be encouraged to continue and engage in physical activities. Despite the fact that pregnancy is associated with profound anatomical and physiological changes, exercise has minimal risks and confirmed benefits for most women. (Artal et al., 2003) However, specific methods of training, especially "KAATSU Training" are not mentioned in the guideline.

Therefore, we investigated effects of KAATSU training on the fetal status and utero-placental circulation at the third trimester of pregnancy

MATERIALS AND METHODS

Subject

A 36-year-old primigravida woman was volunteered for the study at 29 weeks and 6 days (29w6d), 30w4d, and 31w1d of gestation (BMI=22.2, body weight gain 5-6 kg, no complications, normal fetal development). The informed consent was obtained prior to the study. The subject had previously participated in KAATSU training, but she had not done any in the previous 2 years.

Blood Flow Restriction (BFR)

During KAATSU training session, a subject wore a specially designed elastic pressure cuff, KAATSU belts, (KAATSU Master[®], KAATSU JAPAN Co., Ltd., Tokyo, Japan) around the proximal portion of the upper arms (protocol 1) or thighs (protocol 2) to restrict venous blood flow and cause pooling of blood in capacitance vessels distal to the cuff. (Takano et al., 2005) The cuff mounting and setting pressure was 30 mmHg and 160 mmHg at the protocol 1, and 40 mmHg and 200 mmHg at the protocol 2.

Non-stress test (NST); protocol 1

The non-stress test (NST) is the most commonly performed non-invasive method of the fetal evaluation during pregnancy. The concept behind a non-stress test is that adequate oxygen is required for fetal activity and fetal heart rate (FHR) to be within normal ranges. The test involves attaching one belt to the mother's abdomen to measure FHR and another belt to measure contractions. Movement, heart rate and "reactivity" of heart rate to movement are usually measured for 20-30 minutes.

In this study, NST was performed twice (29w6d and 30w4d of gestation) in a semi-Fowler's position using a childbirth monitoring apparatus (Actocardiograph MT-540 A®, TOITU Co., Ltd. Tokyo, Japan) as shown in Figure 1. First, ordinary NST (NST-pre) was performed for 40 minutes. Thereafter, a standard exercise load NST (NST-ex) without BFR was performed. The exercise protocol involved performing 2 sets (1 set of 30 repetitions followed by 20 repetitions, and then 15 repetitions with 20 sec of rest between sets) of biceps curls with a 1 kg load in the first half of 20 minutes, and followed by rest for the last half of 20 minutes. Subsequently, the KAATSU exercise load NST (NST-ka) with arm BFR was performed at the same exercise load and protocol as NST-ex. The speed of the movement during each repetition was held constant at approximately 1 repetition per 4 seconds.

Three times of NST were performed within the same day under an adequate resting period for each session. These NST results were interpretation by an obstetrician and gynecologist. NST-ex and NST-ka results were evaluated by two sessions: the first half (exercise time) and last half (observation time).

Maternal cardiovascular hemodynamic and utero-placental circulation; Protocol 2 Hemodynamics

Hemodynamic parameters were determined using the Task Force Monitor (CNSystemes Medizintechnik, Graz, Austria, Takano et al., 2005; Iida et al., 2007; Kubota et al., 2008). Data were obtained every beat with a 1.000 Hz sampling rate and used to calculate all hemodynamic parameters in real time. In this study, this system was used to measure the maternal hemodynamic data including heart rate (HR; bpm), systolic blood pressure (sBP; mmHg), diastolic blood pressure (dBp; mmHg), mean arterial blood pressure (MAP; mmHg), cardiac output (CO; l/min) and stroke volume (SV; ml).

Utero-placental circulation

Doppler velocimetry is a non-invasive method used to evaluate resistance to blood flow in the utero-placental and fetoplacental circulations. The umbilical artery is evaluated by measuring the blood flow velocity at peak systole (maximal contraction of the heart) and peak diastole (maximal relaxation of the heart). One of the most common ratio of these values used is the umbilical artery resistance index (UARI; (peak systolic velocity – diastolic velocity)/ peak systolic velocity). (Stuart et al., 1980; Maulik, 1995) UARI was automatically calculated by equipment. Doppler velocimetry was performed on a Voluson E8® (GE Healthcare Japan Corporation, Tokyo, Japan) ultrasound scanner, using a 3.5-MHz convex transducer. A minimum of six uniform Doppler waveforms were measured for calculating UARI during a period of minimum fetal movements. First, the subject was placed in the supine position with the Task Force

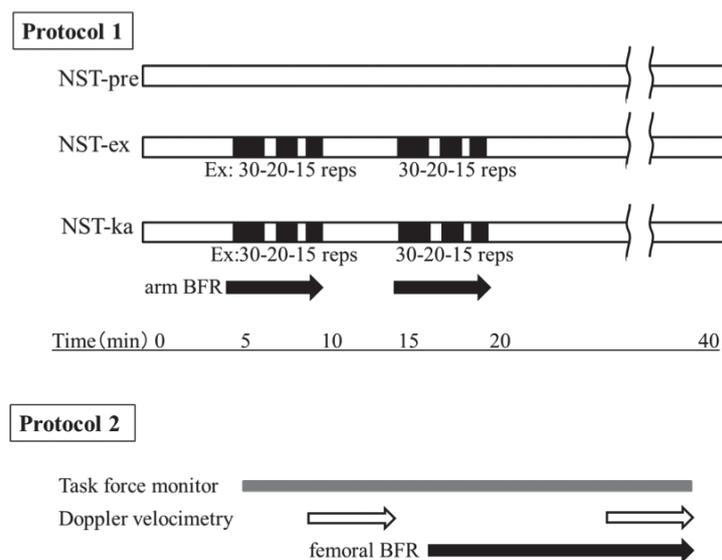


Figure 1. Examination design (see methods)

Time course is shown in the lowermost field.

Abbreviations: Ex=Number of exercise, reps=repetitions, BFR=blood flow restriction

Monitor[®], and maternal hemodynamic data and UARI were obtained at rest (baseline). Thereafter, at 5 min after femoral BFR by KAATSU belts applied to the proximal ends of both thighs, the same measurement was performed.

RESULTS

NST results are shown in Table 1. No deceleration of FHR or abnormal uterine contractions were observed; the fetal status was judged to be good and appropriate for the gestational age. NST-ex and NST-ka tended to show greater both FHR baseline and FHR baseline variability than NST-pre, and many of accelerations (≥ 15 bpm, 15sec) were observed. The second NST at 30w4d of gestation showed no abnormalities.

The maternal hemodynamic using Task Force

Monitor[®] revealed reduced CO and SV due to femoral BFR with KAATSU belts demonstrating a decreased preload (Table 2). Doppler velocimetry revealed increases in systolic maximum blood flow rate and diastolic blood flow rate, but it did not detect any change in UARI (Fig. 2, Table 2).

DISCUSSION

The umbilical artery, a very important vessel of the fetus, was the first vessel to be assessed, which has become the most widely investigated component of the fetal circulation. The umbilical artery waveform can easily be detected by real time ultrasound associated with pulse wave Doppler duplex system. The umbilical arterial resistance is increased in the fetus with utero-placental insufficiency secondary to various causes. And, the umbilical artery waveforms,

Table 1. NST results

	NST-pre		NST-ex (exercise/observation)		NST-ka (exercise/observation)	
	29-6	30-4	29-6	30-4	29-6	30-4
Gestational age (week-day)	29-6	30-4	29-6	30-4	29-6	30-4
Fetal heartrate baseline (bpm)	140	145	140/ 145	140/ 160	145/ 150	140/ 140
FHR baseline variability (bpm)	5-10	5-15	5-15/ 5-15	5-15/ 5-20	5-15/ 3-15	5-15/5-15
Accelerations (no)	1	2	2 / 3	3 / 8	1 / 3	6 / 2
Decelerations (no)	0	0	0	0	0	0
Uterine contractions (no)	0	0	0	0	0	0

Abbreviations: FHR = fetal heart rate, no = number of

Table 2.

Maternal hemodynamic parameter	baseline	during BFR
sBP / dBP (MAP) (mmHg)	116/79 (90)	115/78 (93)
Heart rate (bpm)	82.9 \pm 2.6	88.1 \pm 29
Cardiac output (l/min)	5.2 \pm 0.32	4.5 \pm 0.16
Stroke volume (ml)	62.5 \pm 3.5	50.6 \pm 2.5
Doppler velocimetry of UA	baseline	during BFR
Fetal heart rate (bpm)	146	144
Peak systolic velocity(cm/s)	64.14	72.05
End-diastolic velocity (cm/s)	20.18	22.03
Resistance index	0.69	0.69

Abbreviations: UA=umbilical artery, sBP=systolic blood pressure, dBP=diastolic blood pressure, MAP=mean arterial blood, BFR=blood flow restriction

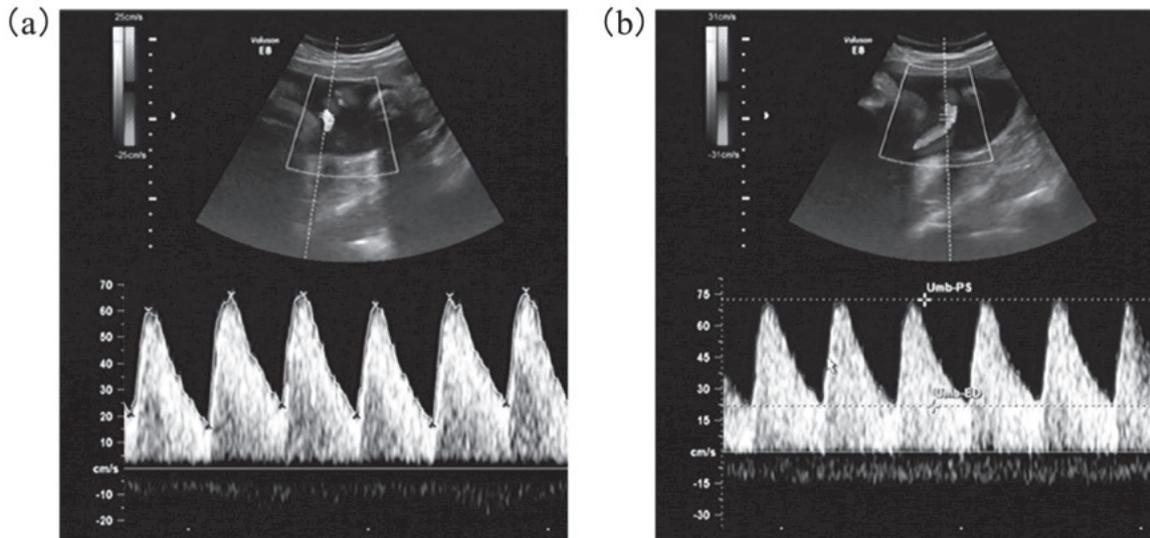


Figure 2. Doppler velocimetry of umbilical artery. (a) depicts a umbilical artery flow waveform without blood flow restriction as baseline. (b) depicts a umbilical artery flow waveform with femoral blood flow restriction. Abbreviations: Umb PS=umbilical artery peak systolic velocity, Umb ED=umbilical artery end-diastolic velocity

reflecting the resistance in fetoplacental circulation, have been used extensively for fetal surveillance, especially in high-risk pregnancy. An increase in umbilical resistance expressed by Doppler indices is well established to be associated with fetal hypoxia and acidosis, especially in fetus with growth restriction. (Stuart et al., 1980; Maulik, 1995). In this study, the effect of KAATSU training or only BFR with KAATSU belts on a primigravida mother and her fetus was evaluated on the basis of comprehensive assessment of the following parameters: (1) maternal hemodynamics using Task Force Monitor®, (2) FHR, fetal movement, and uterine contractions as assessed by NST, and (3) uteroplacental circulation status using UARI. In addition to the acute effect, the second NST was performed 5 days after KAATSU training. The NST results have indicated generally increased fetal heartbeat activity due to exercise load.

Many studies have reported FHR responses to exercise in a pregnant woman, including increases in FHR of 10-30 bpm observed during and after exercise. There are several proposed factors for this increase in FHR such as fetal hypoxia due to the decreased uteroplacental blood flow volume and the transplacental action of maternal catecholamine that increases with exercise. (Artal R et al., 2003) Nakai et al. suggested that the increase in fetal cardiac output with maternal exercise depends on FHR change. (Nakai et al., 1998) In contrast, a unique feature of KAATSU training not found in other types of exercises is decrease of CO and SV due to a reduction in preload. In addition, application of BFR also affects autonomic nervous activities, where an increase in the sympathetic nervous activity was observed. (Iida et al., 2007;

Kubota et al., 2008) In this study, fetal movement seemed to have increased within the normal range during BFR. This suggests a possible effect of maternal sympathetic nervous activation action on the fetus. Despite of decrease of CO and SV on maternal cardiovascular hemodynamic with femoral BFR, though the UARI did not change, the systolic maximum blood flow rate and diastolic blood flow rate increased. If assuming a lack of change in placental vascular resistance, an increase in blood flow rate means improvement of blood flow. Therefore, it was considered that at least there was no influence of acute, short-time reduction in the maternal preload.

Because the present findings were obtained from a pregnant woman (the only one) with a stable course in the third trimester of pregnancy, the results cannot be interpreted as being conclusive that KAATSU training does not influence fetal growth. Nakajima et al. reported that KAATSU training does not affect the haemostasis in healthy males. (Nakajima et al., 2007) But, normal pregnancy is well known to be accompanied by changes in the coagulation and fibrinolytic systems. (Bremme, 2003) Therefore, the further studies are needed to clarify whether KAATSU training may affect the coagulation system in a pregnant woman.

CONCLUSION

The present study is the first report showing the influence of KAATSU training on the fetus statement and uteroplacental circulation in a pregnant woman at the third trimester of pregnancy. No evidence was obtained for the direct influence of KAATSU training. However, this should not be interpreted as

demonstrating the absence of fetal influence from KAATSU training; further investigation will be necessary.

ACKNOWLEDGMENTS

The representation of KAATSU and “KAATSU training” mentioned herein are registered trademarks of KAATSU JAPAN Co., Ltd.

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Authors’ affiliations

N. Takano, H. Takano, Takano Clinic

M. Kusumi, Department of Obstetrics and Gynecology, Faculty of Medicine, The University of Tokyo

N. Takano, Department of Cardiovascular Medicine, The University of Tokyo Hospital

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