



Original Article

Preliminary validation of an exercise program suitable for pregnant women with abnormal glucose metabolism: inhibitory effects of Tai Chi Yuttari-exercise on plasma glucose elevation

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Abstract. [Purpose] There is insufficient evidence related to exercise programs that are safe and efficacious for pregnant women with abnormal glucose metabolism. Tai Chi Yuttari-exercise is an exercise program with validated safety and efficacy in improving physical function in the elderly. In this study, we investigated this program's inhibitory effects on plasma glucose elevation when it was adapted to a pregnancy model. [Subjects and Methods] Twelve 18- to 19-year-old females without a history of pregnancy were randomly assorted into two groups: an intervention group, for which six subjects were outfitted with mock-pregnancy suits and asked to perform Tai Chi Yuttari-exercise, and a control group who did not perform exercise. The intervention group had a mean Borg Scale score of 11.1 ± 0.9 during the exercise. [Results] No significant intragroup differences were observed in fasting, baseline, or post-intervention/observation plasma glucose levels. On the other hand, the intergroup change in plasma glucose levels after intervention/observation was significant when comparing the intervention and control groups: -1.66 ± 7.0 and 9.42 ± 6.57 mg/dl, respectively. [Conclusion] Tai Chi Yuttari-exercise appears to effectively inhibit plasma glucose elevation at intensity and movement levels that can be safely applied to pregnant women with abnormal glucose metabolism.

Key words: Glucose metabolism disorders, Pregnant women with abnormal glucose metabolism, Gestational diabetes mellitus

(This article was submitted Jun. 22, 2016, and was accepted Aug. 23, 2016)

INTRODUCTION

Exercise during pregnancy effectively enhances maternal and fetal health and physical fitness¹⁾. It also reduces the risks of pregnancy-induced hypertension and diabetes mellitus, which often complicate pregnancies²⁾. Exercise is therefore recommended throughout the pregnancy term for women without absolute contraindications to it³⁾. Diabetes is increasing in prevalence worldwide: one in 11 adults are currently affected, and this number is estimated to grow to one in 10 by 2040⁴⁾. Abnormal glucose metabolism discovered during pregnancy is defined as gestational diabetes mellitus, and is estimated to affect 15% of pregnant women worldwide⁵⁾. Along with dietary regimens, exercise therapy is a basic treatment for diabetes; its immediate effects include enhanced glucose and fatty acid utilization and decreased plasma glucose levels, while its long-term effects include decreased insulin resistance⁶⁾. Pregnant women with abnormal glucose metabolism have been reported to experience maternal complications including miscarriage and premature birth, as well as fetal complications including fetal

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distress and fetal demise.

Exercise is typically recommended for pregnant women. However, there is a lack of evidence to recommend exercise as a safe therapy for pregnant women with abnormal glucose metabolism⁷). Exercise programs adapted to pregnant women with abnormal glucose metabolism must avoid excessive contraction of abdominal muscles⁸), and performing such a program habitually may contribute to increased insulin sensitivity⁹). Therefore, selecting an exercise program for pregnant women with abnormal glucose metabolism is difficult due to the lack of evidence regarding safety.

Tai Chi Yuttari-exercise is an exercise program with validated safety and efficacy in improving physical function in the elderly. In this study, we investigated this program's inhibitory effects on plasma glucose elevation when it was adapted to a pregnancy model.

SUBJECTS AND METHODS

Twelve healthy, 18- to 19-year-old females were selected as the participants in this study. Participants had no regular exercise routine, no history of pregnancy, and were not currently pregnant. Candidates who were visiting a hospital regularly or taking medication for any kind of disease were excluded. Before the study began, its research objectives and methods were explained to participants verbally and in writing, and their written consent was obtained. Research data collection was conducted in November 2014. This study was conducted after obtaining the approval of the Research Ethics Committee of Kansai University of Welfare Sciences (Approval No. 14-41).

The exercise program used was Tai Chi Yuttari-exercise. This program consists of calisthenics (physical exercises) that incorporate elements of Tai Chi and was developed for frail elderly individuals to be able to perform the exercise program continuously, enjoyably, and safely¹⁰). Tai Chi Yuttari-exercises include two types of activities, and the subjects can perform them in either a standing or sitting position. Only the two sitting versions were used in this study. In order to prevent falls, a chair is placed in front of the participants in the sitting versions, so that even elderly individuals with diminished physical function can exercise safely. All movements in Tai Chi Yuttari-exercise are slow and use muscle groups throughout the body; no quick movements are required. In addition, participants imitate the movements while watching a video, removing the need for a special exercise instructor. Moreover, the program is not dependent on the weather, because it can be performed indoors. We have previously reported the regimen to be safe when we verified the cardiopulmonary dynamics of healthy females with an average age of 74 years performing Tai Chi Yuttari-exercise¹¹). A summary of our findings is as follows: the respiratory rate slightly increased, but no abnormal breathing patterns were exhibited; blood pressure tended to decrease following exercise; subjective exercise intensity (perceived at the heart and lungs) had a maximum Borg Scale score of 9 (very light) during exercise; exercise intensity ranged from 1.34–1.87 METs; and the respiratory quotient ranged from 0.82–0.90.

The 12 participants were randomly assigned to one of two groups: six to an intervention group that performed the Tai Chi Yuttari-exercise and six to a control group that did not. The total duration of the Tai Chi Yuttari-exercise was 30 minutes; one set consisted of two types of activities in a sitting position with a rest break between. Participants performed two sets over a 60 minute timeframe. For the pregnancy model, women in the intervention group wore a front-sided ~300 g backpack containing 1.8 kg of weights and newspaper (height: 34 cm, width: 18 cm, and total weight ~2.1 kg) (Fig. 1). During the Tai Chi Yuttari-exercises, participants were instructed to restrict their movements so that their abdominal region would not be compressed in the resulting range of motion. The intervention group was asked to rate their perceived exercise intensity using the Borg Scale as well as their ability to converse during exercise¹²) while they performed the exercises.

The measurement procedure was as follows. First, participants were instructed to avoid strenuous exercise and to fast (except for drinking water) from 8 p.m. the day prior to the exercise session. Fasting plasma glucose was then measured on the day of the session using a plasma glucose meter (Medisafe Fit: Thermo Co., Ltd., Japan). Participants in both groups were fed one pack of a cookie-type test meal (glucose load) containing 75 g of sugar and 28.5 g of fat (Meal Test C: Saraya Co., Ltd., Japan) for precision testing of glucose tolerance¹³). Participants were instructed to consume their test meal within 20 minutes, with up to 200 ml of drinking water permitted during feeding. Plasma glucose was measured after one hour of rest in a sitting position. Baseline indicates measurements taken 1 hour after test meal consumption. During the next hour, the intervention group performed the Tai Chi Yuttari-exercise, while the control group continued to rest in a sitting position; plasma glucose was then rechecked (Fig. 2). All measurements were performed in the morning by the same investigator.

According to the results of Shapiro-Wilk normality tests, paired or unpaired t-tests were used for intervention versus control group comparisons and for baseline versus post-intervention/observation comparisons. The IBM SPSS Statistics for Windows version 19.0 software program (IBM Corporation, Armonk, NY, USA) was used for all analysis with a 5% significance level.

RESULTS

No significant differences between the intervention and control groups were observed in terms of height, weight, fasting plasma glucose, plasma glucose 1 hour after test meal consumption, or plasma glucose after intervention/observation (Table 1). On the other hand, the intergroup change in plasma glucose levels after intervention/observation was significant when comparing the intervention and control groups: -1.66 ± 7.0 and 9.42 ± 6.57 mg/dl, respectively ($p < 0.05$). Table 2 shows



Fig. 1. The pregnancy model in present study

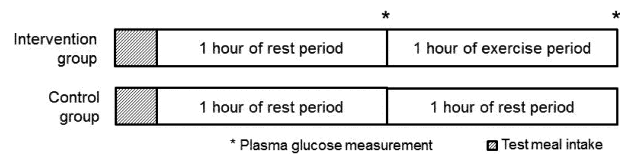


Fig. 2. The test meal was consumed within a 20-minute time-frame, and plasma glucose was then measured

Table 1. Subject characteristics and changes in plasma glucose values

Parameters	Units	Intervention group n=6	Control group n=6
Height	cm	154.1 ± 3.3	157.6 ± 4.7
Weight	kg	47.6 ± 4.8	51.9 ± 6.9
Fasting plasma glucose	mg/dl	95.3 ± 4.8	87.8 ± 8.0
Plasma glucose 1 hour after test meal	mg/dl	106.3 ± 12.8	101.5 ± 6.8
Plasma glucose after intervention or observation	mg/dl	104.6 ± 7.3	109.1 ± 8.7
Change in plasma glucose*	mg/dl	-1.6 ± 7.0	7.6 ± 5.0 [†]

*Quantity of change of plasma glucose is the difference in plasma glucose 1 hour after test meal and plasma glucose after intervention or observation. [†]p<0.05 comparing intervention group with control group.

Table 2. Change of plasma glucose value of both groups

	Intervention group		Control group	
	Baseline	Post exercise	Baseline	Post observation
Case 1	96	102	98	99
Case 2	95	95	94	108
Case 3	106	109	99	103
Case 4	119	112	111	117
Case 5	97	98	109	122
Case 6	125	112	98	106

Units: mg/dl. Baseline indicates measurements taken 1 hour after test meal consumption. The second value represents plasma glucose for each subject measured after 1 hour of exercise in the intervention group or resting in a sitting position for the control group.

plasma glucose changes from before to after intervention/observation at the individual level for both groups. Individuals in the intervention group were observed to exhibit decreases in plasma glucose levels following exercise, whereas individuals in the control group exhibited increased or unchanged levels following observation only. The intervention group had a mean Borg Scale score of 11.1 ± 0.9 during the Tai Chi Yuttari-exercise and was able to maintain a conversation during exercise.

DISCUSSION

This study examined the inhibitory effects on plasma glucose elevation of Tai Chi Yuttari-exercise, an exercise program deemed feasible for pregnant women with abnormal glucose metabolism to perform safely, using healthy females under a

provisional pregnancy model.

The resting heart rate increases by about 10 bpm in pregnant women¹⁴), circulating blood volume increases from the first trimester with an average increase of 40–45% in late pregnancy from pre-pregnancy levels (although individual variations are large)¹⁵), and blood pressure slightly decreases in the second trimester but increases thereafter¹⁶). The supine position increases compression of the uterus, resulting in impeded venous return from the lower body and reduced cardiac output, which in turn causes a drop in arterial blood pressure. If this position is maintained, arterial compression causes blood pressure of the uterine artery to drop below the arterial pressure of the upper limbs¹⁷). The American Congress of Obstetricians and Gynecologists (ACOG), while cautioning against exercise in pregnant patients with absolute contraindications, recommends dynamic physical exercise using major muscle groups at an exercise intensity ranging from 12–14 on the Borg Scale, which corresponds to a range where individuals can still hold a conversation as they exercise³). Tai Chi Yuttari-exercise may be performed in either a sitting or standing position and consists of slow movements using muscle groups throughout the body. The forms of Tai Chi Yuttari-exercise adopted for our pregnancy model avoided leg positions contraindicated for pregnant women. Under these conditions, participants had a mean Borg Scale score of 11 and were able to hold a conversation during the exercise session. Given that this exercise regimen conforms to ACOG recommendations, we believe it would have minimal effects on the cardiopulmonary dynamics that accompany pregnancy.

Exercises adapted for pregnant women should avoid Valsalva maneuver-like movements and should be conducted in an environment with good humidity that avoids heat stress³). In addition, pregnant women's ability to balance is reduced, and their risk of falling is elevated¹⁸). Since falling can lead to maternal and fetal complications, selection of an exercise program must take into account fall prevention. Walking—a representative exercise program for all ages and genders—has been reported to increase the risk of falling in seniors who perform the exercise habitually¹⁹). Cardiopulmonary dynamics are stable during Tai Chi Yuttari-exercise even for elderly individuals¹¹). This finding, along with its ability to be conducted indoors, led us to consider this exercise program suitable for pregnant women. This program also addresses the increased fall risk of pregnant women, as it can be performed while sitting.

In this study, significant differences within each of the two groups in terms of plasma glucose levels were not observed during fasting nor before or after intervention/observation. However, mean plasma glucose was significantly decreased in the intervention group following exercise when compared with levels prior to exercise, while plasma glucose increased or remained unchanged for all subjects in the control group during the observation period. Maintaining satisfactory blood glucose control is critical for preventing maternal and fetal complications in pregnant women with abnormal glucose metabolism. Exercise intensities that result in a 40–60% peak oxygen uptake (or even higher) have been recommended in order to gain the maximal benefit from exercise²⁰); however, these intensities are inappropriate for pregnant women. In addition to fulfilling the major premise of ensuring the safety of the mother and infant, the Tai Chi Yuttari-exercise program should allow pregnant women with abnormal glucose metabolism to effectively control their plasma glucose.

The first limitation of the present study is the poor reliability of the pregnancy model. In addition, our data related to the inhibitory effects on plasma glucose elevation were obtained from healthy women who were not pregnant. Accordingly, caution is necessary when interpreting our results, including those concerning safety, and when adapting them to pregnant women with abnormal glucose metabolism. Finally, the data supporting the recommendation for exercise therapy for pregnant women with abnormal glucose metabolism are weak²¹), and there is no consensus on how to adapt exercise in this context. Thus, currently, prudent judgment is necessary when adapting exercise for pregnant women with abnormal glucose metabolism.

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