早稲田大学審査学位論文
博士（スポーツ科学）

Physical activity and nutrition intake among Chinese pregnant women and effect of physical activity on pregnancy outcome: The research by using a new Chinese version of Pregnancy Physical Activity Questionnaire

中国人女性における妊娠期の身体活動量と栄養摂取および身体活動が妊娠アウトカムに与える影響
－新しい中国語版妊娠期身体活動尺度による検討－

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CHAPTER 1
INTRODUCTION

1.1 Pregnancy—an important period of life

Pregnancy is an important period for both maternal and their infant. It is a period associated with physical changes, environment for the development of the fetus have been created by these physical changes, and these changes produce long-term impacts on maternal and their fetal health (Hopkins et al., 2010). The developmental origin of health and disease hypothesis also suggested that development of the fetus, adult health and disease risk can be caused changes by the prenatal environments (Langley-Evans et al., 2010; Feinberg et al., 2007). In addition, previous studies have suggested that because women are concerned about their child's wellbeing during the pregnancy, pregnancy is an opportunity for promoting their positive health behaviors (Gillman et al., 2013).

1.2 Gestational weight gain (GWG) during pregnancy and birth weight (BW)

GWG is an important determinant of maternal and infant health. Women with inadequate GWG have an increased risk of low birth weight (<2500 g) infants, neonatal mortality (Branum, 2002), small-for-gestational age infants and preterm delivery (Han et al., 2011). On the other hand, women with excessive

GWG have an increased risk of gestational hypertension and preeclampsia (Chen et al., 2010), gestational diabetes mellitus (Carreno et al., 2012), postpartum weight retention (Knudsen et al., 2012), and fetal macrosomia (>4000 g) (Cnattingius et al., 1998). Birth weight is a predictor of fetal future health outcomes (Calkins et al., 2011). Both low birth weight and macrosomia are related with many deleterious health outcomes such as type 2 diabetes (Whincup et al., 2008), cardiovascular disease (Drake et al., 2004), obesity (Yu et al., 2011), and some cancers (McCormack et al., 2005) in adulthood. Therefore, in 2009, the Institute of Medicine (IOM) released guidelines for GWG (IOM, 2009). The guidelines recommend that women with a prepregnancy body mass index (BMI) less than 18.5 kg/m^2 should gain 28–40 pounds, those with a prepregnancy BMI of 18.5–24.9 kg/m^2 should gain 25–35 pounds, those with a prepregnancy BMI of 25.0–29.9 kg/m^2 should gain 15-25 pounds, and those with a prepregnancy BMI of more than 30 kg/m^2 should gain 11–20 pounds (IOM, 2009). The prevention of both inadequate and excessive GWG as well as extreme BW is necessary for maternal and child health.

1.3 Association of physical activity (PA) during pregnancy with GWG and BW

PA is a key highly modifiable factor associated with both maternal GWG

(Stuebe et al., 2009) and fetal BW (Leiferman et al., 2004). PA during pregnancy is beneficial for maternal and child health. Studies suggests that a lower incidence of gestational diabetes mellitus (GDM) (Tobias et al., 2011), preeclampsia (Aune et al., 2014), and excessive GWG (Streuling et al., 2011) have been related to PA performed during pregnancy. In addition, maternal PA during pregnancy is associated with a decreased incidence of preterm birth (Domingues et al., 2009), macrosomia (Owe et al., 2009), and obesity in adulthood (Tomic et al., 2013).

Despite advocate increasing PA during pregnancy for both the maternal and child health, PA becomes to decline during pregnancy, and as pregnancy progresses, both the intensity and the frequency of exercise be likely to decrease (Domingues et al., 2007, Coll et al., 2106). Additionally, many women continue to be inactive after pregnancy (Evenson et al., 2004). Therefore, guidelines for exercise during pregnancy has been released by the American College of Obstetricians and Gynecologists (ACOG) in the United States, which recommended 150 minutes or more of moderate- or higher-intensity activity per week (ACOG, 2002). Similar guidelines have been also released in Denmark (Madsen et al., 2007), Canada (Davies et al., 2003), and the United Kingdom

(Royal College of Obstetricians and Gynaecologists, 2012). However, despite some studies showed that the effect of PA during pregnancy on maternal and fetal health differed based on race (IOM, 2009, McCullough, 2015), most of the studies used to develop those guidelines involved Caucasian women (Gjestland, 2012; Smith, 2013); only a few involved Asian populations (Jiang, 2012).

In addition, there is some debate with regard to the effect of PA on BW and GWG, because most previous studies only included one trimester, used tools that were not validated for pregnancy, and were limited to vigorous-intensity exercise only (Haakstad et al., 2007, McCullough et al., 2015, Stuebe et al., 2009). Therefore, a study with a detailed focus on PA during pregnancy by intensity, type, and timing of trimester in Asian women is needed.

1.4 GWG and BW statistics from China

China is the world's most populous country, with >10 million live births annually (China Statistical Year Book, 2010). In China, less than half of pregnant women have an appropriate GWG (Jiang et al., 2012). The rates of low birth weight have decreased very little, and the rates of macrosomia in China have increased significantly (Pei, 2016). For instance, in Shanghai, the proportion of newborn macrosomia increased by 50% from 1989 to 1999 (Zhu, 2001); in

Shaanxi Province, the rates of macrosomia increased by 14.3% from 2010 to 2013 (Pei, 2016). Inappropriate GWG and BW are common problems in China (Pei, 2016).

Therefore, the aim of this dissertation was to design effective interventions for promoting maternal and fetal health and influence GWG and BW of Chinese women and their infants, and examine the characteristics of lifestyle such as PA and nutrition during pregnancy and their effect on the GWG and BW among Chinese women. The following three studies were conducted:

Study 1 (chapter 2): Reliability and validity of a Chinese-translated version of a pregnancy physical activity questionnaire (PPAQ-C). This study aimed to explore a suitable and detailed PA questionnaire for pregnant Chinese women, because such a tool has not been developed.

Study 2 (chapter 3): PA and nutrient intake during pregnancy and their associated factors among Chinese women were evaluated with the PPAQ-C. This study prepared the stage for examining the effect of PA during pregnancy on

GWG and BW and for identifying the intensity and type of PA in Chinese women during pregnancy. This study not only investigated PA but also the factors related to nutrition intake in order to accurately examine the association between PA during pregnancy and GWG and BW while adjusting for nutrition intake.

Study 3 (chapter 4): Effects of PA during pregnancy on GWG and BW among Chinese women. Based on study 2, this prospective study followed up pregnant women who were investigated in study 2 until delivery and then examined the effect of PA during pregnancy in each trimester according to intensity, type, and amount on GWG and BW. This is the first study to examine the association between PA and GWG as well as BW according to intensity and type of PA among pregnant Chinese women. The information would be useful for guiding effective interventions that aim to improve maternal and child health among pregnant Chinese women.

CHAPTER 2
Reliability and validity of a Chinese-translated version of a pregnancy physical activity questionnaire (PPAQ-C)

—published in Maternal and child health journal

2.1 Background and Purpose

In order to examine the associations of PA during pregnancy with GWG and BW in Chinese women, PA in pregnant Chinese women needs to be measured. The measurements of PA are typically divided into objective assessment by accelerometer and self-report by questionnaires. Accelerometer, a wearable device, is depended on the correct wearing habit of participants and difficult to assess long-term PA patterns due to the inconvenient. Questionnaires can reduce participant burden and assess PA type (e.g., exercise, household). However, at present, there is no suitable questionnaire for pregnant Chinese women.

Recently, several questionnaires have been used to assess PA in pregnant women (Evenson et al., 2012). Determining changes in PA and whether women meet recommendations for PA during pregnancy are often of interest in epidemiological studies. The Kaiser Physical Activity Survey (KPAS) could be used to assess changes in PA from pre-pregnancy to pregnancy and post-partum (Ainsworth et al., 2000). It was designed specifically to assess PA in women using

a 5-point Likert scale (1, “never” to 5, “always”). However, it does not provide metabolic equivalents (METs) for hours/week of activity (Ainsworth et al., 2000); therefore, it cannot be used to determine whether women meet recommendations for PA during pregnancy. For this reason, the mode, frequency, duration, and intensity of PA must be obtained. The PPAQ assesses PA in pregnant patients by examining the relative contributions of different activities based on three 24-h recalls (Chasan-Taber et al., 2004, Evenson et al., 2012). To our knowledge, the PPAQ is the only validated instrument designed specifically to assess PA during pregnancy. In contrast to the KPAS, the PPAQ can quantify PA by providing information on MET-hours/week of activity. The PPAQ is also easily understood by respondents in a variety of settings. It has been translated and is widely used in the United States (Chasan-Taber et al., 2004) and Europe (Nadia et al., 2012). Thus, the PPAQ is widely available for assessing PA during pregnancy. However, there is no Chinese version of PPAQ.

Therefore, to accurately assess PA during pregnancy and examine the effect of PA on pregnancy outcomes in China, the aims of chapter 2 were to translate the English version of the PPAQ into Chinese and examine its reliability and validity for using in pregnant Chinese women.

2.2 Methods

2.2.1 Participants

We recruited study participants through the Maternal and Child Health Hospital of Chengdu Wuhou, in the Sichuan province of western China, which handles approximately 6,000 deliveries per year. Pregnant women were eligible if they were >20 years of age with a singleton pregnancy, were of Han Chinese nationality, and had no disease, including diabetes mellitus, hypertension, heart disease, chronic renal disease, or other diseases that would restrict physical activity, before pregnancy. From June 2013 to January 2015, 224 women during their first (<16 weeks), second (16–28 weeks), and third trimesters (>28 weeks) of pregnancy were recruited. Of these, we excluded 42 participants with missing demographic information or who did not complete the PPAQ-C. Of the remaining 182 participants, 160 wore an accelerometer for ≥3 valid days week following questionnaire completion. Of these, 125 completed the PPAQ-C again 1 week after completing it the first time. There were no differences in age, pre-pregnancy body mass index (BMI), exercise habits, education, income, weeks of pregnancy, employment status, or parity between the remaining subjects and those excluded. Chengdu is a second-tier city, which combines rural and urban areas. Although

there were different education levels among participants, all participants were literate. Even so, to ensure accurate understanding of the questionnaires, all eligible participants who consented to participate were informed about the study's purpose and procedures, and be instructed on how to complete the survey. Investigators were waiting to receive the participants' completed questionnaires. After patients completed the questionnaires, they were provided detailed guidance for using the accelerometers and asked to note daily the hours they participated in activities not detectable by accelerometers, such as stationary bicycle exercising and swimming.

2.2.2 Ethics statement

This study was approved by the committee on human subjects research of the Waseda University and by the Maternal and Child Health Hospital of Chengdu Wuhou. All subjects provided written informed consent.

2.2.3 The PPAQ

The original PPAQ was designed to assess the duration, frequency, and intensity of total physical activity during the current trimester of pregnancy. For each of 32 activities, respondents select the category best estimating the amount

of time spent in that activity (e.g., “none,” “less than 1/2 hour per day,” “1/2 to almost 1 hour per day,” “1 to almost 2 hours per day,” “2 to almost 3 hours per day,” or “3 or more hours per day”). Activities are classified by type: household/caregiving (13 activities), occupational (5 activities), sports/exercise (8 activities), transportation (3 activities), and inactivity (3 activities). At the end of the “Sports and Exercises” section (questions 30 and 31), an open-ended section allows the respondent to add activities not already listed. Activities are also classified by intensity: sedentary (<1.5 METs), light (1.5–<3.0 METs), moderate (3.0–6.0 METs), or vigorous (>6.0 METs).

Significant changes between the original PPAQ and the Chinese version (PPAQ-C) involved conversion from English measurements (gallons, pounds) to the metric equivalents (liters, kg) for item 33 and the addition of item 20-2, “riding a bicycle for transportation,” since Chinese women often use a bicycle for basic transportation. Items 18 and 19 in the original PPAQ referred to the use of a lawnmower, which is not commonly used in China. However, these items were not deleted or altered in the PPAQ-C, because there are times when a lawnmower is used, such as in local regions or in luxury housing.

The average energy expenditure per week (MET-h·wk-1) for each activity

was calculated from the weekly number of hours multiplied by each activity intensity (where 1 MET is the metabolic equivalent of the energy expended at rest), and activities of at least light intensity were summed to derive average MET·hours per week for total activity. The average hours per week spent in each activity type were also calculated (Chasan-Taber et al., 2004). Participants were required to record the sleeping hours. We found that women slept >4 hours and <20 hours. To avoid significant underestimation or overestimation of daily activity, data reporting ≥20 hours and <4 hours of average daily physical activity were excluded. Twenty participants were excluded, but there were no significant differences between the excluded and included participants.

2.2.4 PPAQ translation

Lisa Chasan-Taber, one of the original authors of the PPAQ, granted permission for the development and use of a Chinese version (PPAQ-C). Forward- and back-translation were performed to confirm accuracy, which is a minimum requirement for the cross-cultural adaptation of established scales (Brislin et al., 1970). Forward-translation was done by this paper's first author. Translations were reviewed and discussed with the third author and another Ph.D. student. A revised version was back-translated by two Ph.D. students at Waseda

University. All individuals involved in the translation are fluent in English and Chinese and majoring in sports sciences. The PPAQ was translated into Chinese and tested for wording acceptability. The original and back-translated English versions were compared, and inconsistencies were resolved through consensus meetings. The Chinese version was finalized when there was no dispute or new suggestions.

2.2.5 The accelerometer

PPAQ-C measures of current trimester activity were compared with data obtained from a uniaxial accelerometer with confirmed reliability and validity (Kenz Lifecorder [KL]; Suzuken Co. Ltd., Nagoya, Japan; weight, 60 g; width, 72.5 mm; length, 41.5 mm; thickness, 27.5 mm), which served as an objective measure of physical activity. Women were asked to wear an accelerometer on the front of the hip for 7 consecutive days. To assess accurately the time that respondents wore the accelerometer, they were given a daily reminder to note the hours of sleep and whether they removed the accelerometer at any time (e.g., for swimming, convenience, or resting/napping) or whether they participated in activities not detectable by accelerometers, such as stationary bicycle exercise. A valid day was defined as a day in which the accelerometer was worn for ≥10 hours.

Data for participants with ≥3 valid days are described throughout the paper.

Abel et al. validated use of KL accelerometers in adults. At the slowest treadmill walking speed, the accelerometer counted 92 ± 6% of observed steps. It accurately estimated step count and energy expenditure at most other walking and running speeds (Abel et al., 2008). Kumahara et al. also investigated the accuracy of the KL accelerometer for assessing total energy expenditure and physical-activity-related energy expenditure over a 24-hour period in a respiratory chamber. There was a strong correlation between total energy expenditure and physical activity-related energy expenditure measured by the KL and by the respiratory chamber (Kumahara et al., 2004). The KL records step count, energy expenditure, and physical activity duration. Activity data were categorized into 11 activity levels (0, 0.5, and 1–9). In our study, light-intensity activity was categorized as 1–3, moderate as 4–6, and vigorous as 7–9 (Kumahara et al., 2004). These levels were also classified into MET categories. The corresponding MET values validated the manufacturer's default intensity levels. Finally, we compared accelerometer data with the ACOG guidelines (7) to assess physical activity in pregnant Chinese women.

2.2.6 PPAQ-C reliability and validity

Participants completed the PPAQ-C twice (1 week apart) to assess its reliability. Data from the PPAQ-C completed at the second visit and average accelerometer data were used to assess the PPAQ-C's validity.

2.2.7 Covariate assessment/other measurements

Demographic information was recorded for each participant, including date of birth, height, pre-pregnancy weight and exercise habits, current exercise habits and weight, life habits (e.g., smoking, alcohol consumption), education, income, week of pregnancy, employment status, gestational compliance (e.g., gestational diabetes mellitus, gestational hypertension), parity, due date, and obstetrical history.

2.2.8 Statistical analyses

All analyses were conducted using SPSS version 21 (IBM Corp., Armonk, NY). Socio-demographic characteristics, activity values from both administrations of the PPAQ-C, and accelerometer data (averaged over 7 days of measurement) were expressed as medians (25th and 75th quartiles) and means. Significant differences for continuous and categorical variables among women within each trimester were determined by a one-way ANOVA and the chi-

squared test, respectively.

Intraclass correlation coefficients (ICCs) were used to evaluate the PPAQ-C's reliability for total activity and sub-activities according to type and intensity. Spearman correlation coefficients (SCCs) were used to evaluate the validity of the PPAQ-C between the PPAQ-C completed at the second visit and average accelerometer data.

Because the goal of using this questionnaire is to examine associations between physical activity and gestational weight gain and pregnancy outcomes the in future, measuring relative activity levels would be important. The Jonckheere-Terpstra test can analyze ordinal data and assess trends. We grouped participants into tertiles of total energy expenditure (low, middle, and high) according to PPAQ-C data. For each tertile, we calculated the mean accelerometer values. Using the Jonckheere-Terpstra test, we evaluated whether grouping participants into tertiles yielded groups with different "true" activity levels. Significance was set at $P < 0.05$.

2.3 Results

Of the 224 women recruited, 182 completed the first PPAQ-C questionnaire, and 125 of those completed it again after accelerometer measurement. The

PPAQ-C took 5–15 minutes to complete. Most respondents reported that it was easy to complete. Participants socio-demographic characteristics are presented in Table 1. Participants ranged in age from 20 to 41 yr (mean, 27.5 yr) and represented all three trimesters of pregnancy; 32.4% were in the first trimester, 42.3% were in the second trimester, and 25.3% were in the third trimester. Based on pre-pregnancy BMI values, 19% of women were classified as underweight (BMI ≤18.5 kg/m^2) and 8.4% of women were classified as overweight or obese (BMI >25 kg/m^2). Regarding educational background, 44.5% of women had a high school education or less. Regarding income, 68.7% of women reported monthly household incomes of ≥4,000 RMB (about US$570, middle income in China). Age, pre-pregnancy BMI, marital status, employment status, education, household income, family form, pre-pregnancy exercise habits, smoking, and alcohol habits were similar among the trimesters. Proportions of participants reporting greater physical activity and with gestational complications increased across trimesters.

Median values obtained from the first PPAQ-C administration were comparable to those obtained from the second administration for total activity and across activity intensities and types (Table 2). Median total activity from the first PPAQ-C administration was slightly higher than that from the second

administration (62.9 vs. 56.3 MET-h·wk^{-1}). Similar trends were observed for the median index values of each intensity level, household/caregiving activities, and occupational activities. Within each administration, median values for each activity were fairly comparable. The mean number of steps, minutes involved in activities, and total energy expenditure spent at moderate-intensity and higher activities were calculated (Table 3). Pregnant Chinese women walked an average of 7,478 ± 2,759 steps·d-1 during pregnancy. The average total weekly minutes and total number of activities spent in at least moderate-intensity activities were 98 mins·week^{-1} and 6.8 MET-h·week^{-1}, respectively. Only 21.9% of participants met the physical activity level recommended by ACOG, and low-intensity activities accounted for 73.1% of total physical activities.

Reliability as indicated by the ICC between the two administrations of the questionnaire was generally strong (0.77 for total physical activity) (Table 4). Reliability was higher for sedentary (0.76) and light-intensity (0.75) activities than for moderate-intensity and higher activities (0.59). Reliability was lowest for sports/exercise (0.34) and highest for household/caregiving (0.74) and occupational (0.75) activities.

The questionnaire's validity at different intensities was also assessed. As

no major difference was observed among the trimesters, results are reported for all participants pooled together. Although there were no significant correlations for moderate (0.19; $P > 0.05$) or vigorous activity (0.15; $P > 0.05$), there were significant correlations for total activity (light intensity and above) (0.35; $P < 0.01$) and light activity (0.33; $P < 0.01$) (Table 6).

Finally, to evaluate whether grouping women into tertiles based on the PPAQ-C total activity score would result in groups with different "true" activity levels, we calculated the average total activity and each intensity activity per week as measured by accelerometer within each tertile (Table 5). There was a significant linear trend for increasing total activity and steps based on accelerometer data across tertiles for activity based on the PPAQ-C score.

2.4 Discussion

Our results indicated that the PPAQ-C has good reliability (0.77) and validity (0.35; $p < 0.01$) for assessing total activity among pregnant Chinese women that was comparable to the validity of the original PPAQ (Chasan-Taber et al., 2004).

Participants varied widely by age, pregnancy trimester, working status, income, education, exercise habits, pre-pregnancy BMI, and parity and were thus

appropriate for demonstrating the criterion validity of the PPAQ-C. As shown in table 1, 19% of women were classified as underweight (BMI ≤18.5 kg/m^2), and 8.4% of women were classified as overweight or obese (BMI >25 kg/m^2) based on their pre-pregnancy weight. Almost half had a high school education or less, and 68.7% reported monthly household incomes of ≥4000 RMB (about US$570, middle income). These data are similar to those of typical Chinese women in second-tier cities (Wei et al., 2015, Zhang et al., 2014). Therefore, this study is a true reflection of second-tier cities, which combine rural and urban areas.

The test–retest ICC indicated good reliability for total activity and for activities varying by intensity and type, excluding sport/exercise and vigorous activity (Table 3). This phenomenon, whereby a questionnaire is more sensitive to measuring lower-level activity, has also been reported for other studies (Matsuzaki et al., 2014, Nadia et al., 2012). The median value for vigorous activity was 0 for the two administrations of the PPAQ-C (Table 2), similar to results of previous studies in the United States and Japan (Chasan-Taber et al., 2004, Matsuzaki et al., 2014), although the validation result is not consistent with that of the original PPAQ, which found an ICC of 0.81 for vigorous-intensity activity and 0.83 for sports activities. In addition, few pregnant women reported

performing vigorous activities or sport/exercise in the PPAQ-C. Therefore, the reason for the low reliability for vigorous activity and sport/exercise was that most women in this population did not engage in these activities. However, the reliability for measuring other activity intensities and types, as well as total activity, was not limited, so these aspects can be used to evaluate activity level of pregnant Chinese women.

Although the PPAQ-C was shown to be sensitive for measuring lower-level activity, a high SCC for total activity was observed, similar to results of previous studies, in which high SCCs were reported, excluding those for vigorous and sports/exercise activities (Matsuzaki et al., 2014, Nadia et al., 2012). It may be that pregnant women spend a large proportion of time involved in sedentary or low-intensity activities. Zhang et al. reported that walking slowly was the most popular exercise among pregnant Chinese women and that sedentary or low-intensity activities accounted for >80% of their total energy expenditure (Zhang et al., 2014). Therefore, although there were no significant correlations for moderate and vigorous activity, the PPAQ-C is a valid instrument for measuring physical activity in pregnant Chinese women.

An important purpose of physical activity assessment is to understand

participants' relative physical activity. The significant linear correlation in total activity across tertiles for PPAQ-C score and accelerometer data suggests that the questionnaire reflects the true ranking of physical activity levels (Table 5), consistent with results reported in previous research with the original PPAQ (Chasan-Taber et al., 2004, Matsuzaki et al., 2014, Nadia et al., 2012). Thus, the PPAQ-C is a valid tool for exploring associations between physical activity and pregnancy outcomes and for determining which level of physical activity might improve pregnancy outcomes.

2.5 Conclusion

Our data indicate that PPAQ-C is reliable and suitable for estimating physical activity among pregnant Chinese women.

Table 1. Women' characteristics. (n = 182)

	All participants	1st trimester	2nd trimester	3nd trimester
Pregnancy (n, %)	182	59 (32.4)	77 (42.3)	46 (25.3)
Age,year	27.5 ± 4.1	27.4 ± 4.1	27 ± 4.2	27.2 ± 3.9
Grestational age, week	22.4 ±8.6	11.7 ± 2.7	24.3 ± 3.7	32.7 ± 2.5
Pre-pregnancy BMI, $kg.m^{-2}$	21.1 ± 2.9	21.2 ± 3.27	21.1 ± 3.1	21.0 ± 2.7
Pre-pregnancy BMI, $kg.m^{-2}$ (%)				
< 18.5	19	20.5	18.8	20.7
18.5 - 25	72.6	69.9	70.6	74.1
> 25	8.4	9.6	10.6	5.2
Education (%)				
High school or less	44.5	41.9	45.3	45.8
College/graduate or more	55.5	58.1	54.7	54.2
Income per month (yuan, %)				
<4000	31.3	31.5	27.4	39.7
4000 - 8000	43.6	43.8	45.2	41.4
> 8000	25.1	24.7	27.4	19.0
Employed (%)				
yes	49.7	54.1	45.3	57.6
no	50.3	45.9	53.5	42.4
Grestational complance (%)*				
yes	49.3	73.2	40.9	41.2
no	50.7	26.8	59.1	58.8
pregnancy exercise habits(%)*				
yes	77.8	43.2	12.2	12.8
no	22.2	56.8	87.8	87.2
Parity (%)				
0	72.1	60.0	77.3	66.7
≥ 1	27.9	40.0	22.7	33.3

***. The proportion of participants increased across the trimesters**

Table 2. Median (25th and 75th percentile) values (MET-h·wk^{-1}) for two self-administered Pregnancy Physical Activity Questionnaires in Chinese (PPAQ-C) by activity intensity and type (n = 125)

	1st PPAQ(MET-h·wk^{-1})			2nd PPAQ(MET-h·wk^{-1})		
	25th	Median	75th	25th	Median	75th
Summary activity scores						
Total activity (light and above)	32.2	62.9	98.4	36.6	56.3	85.2
By intensity						
Sedentary activity	33.6	56	86.5	28.4	47.4	83.6
Light-intensity activity	27	44.1	71.3	28.7	43.1	64
Moderate-intensity activity	1.5	9.8	27.1	1.5	9.7	23
Vigorous-intensity activity	0	0	1.6	0	0	0
By type						
Household/caregiving activity	15.4	33.3	62.1	16.6	29.2	50.4
Occupational activity	0	22.6	68.2	0	17.9	59.9
Sports/exercise	0.5	1.8	5.1	1.5	2.7	5.8

Table 3. Physical activity distribution during pregnancy from KL accelerometer recording. (n =160)

	All participants				First trimester (n = 49)	Second trimester (n = 70)	Third trimester (n = 41)
KL accelerometer	Mean ± SD or n (%)	25th	Median	75th	Mean ± SD or n (%)	Mean ± SD or n (%)	Mean ± SD or n (%)
Steps (.24h^{-1})	7478 ± 2759	5592	7461	8742	7170 ± 2704	7659 ± 2505	7538 ± 3239
Total activity (light and above) (MET-h·wk^{-1})	25.3 ± 10.2	18.4	24.4	29.9	24.2 ± 9.4	25.8 ± 9.1	25.6 ± 12.6
Light intensity activity (MET-h·wk^{-1})	18.5 ± 6.6	13.5	18.2	22.8	17 ± 15.6	19.1 ± 6.1	19.3 ± 7.3
Moderate intensity activity (MET-h·wk^{-1})	5.8 ± 4.8	2.4	4.1	8.3	6.6 ± 5.4	6.0 ± 4.7	4.3 ± 3.9
Vigorous intensity activity (MET-h·wk^{-1})	1.0 ± 5.0	0.1	0.2	0.6	0.6 ± 1.1	0.8 ± 2.2	1.9 ± 9.4
Moderate intensity or above activity (min·week^{-1})	98 ± 89.3	40.3	66.1	134.1	107.4 ± 84.4	100 ± 83.8	83.5 ± 103.6
Cumulating 150 min of Moderate intensity or above activity							
	35 (21.9%)				14 (28.6%)	15 (21.4%)	6 (14.6%)

Table 4. Intraclass correlation coefficientsa between two self-administered Pregnancy Physical Activity Questionnaires in Chinese (PPAQ-C) (n = 125)

	Intraclass Correlation Coefficient
Summary activity scores	
Total activity (light and above)	0.77
By intensity	
Sedentary activity	0.76
Light-intensity activity	0.75
Moderate-intensity activity	0.59
Vigorous-intensity activity	0.28
By type	
Household/caregiving activity	0.74
Occupational activity	0.75
Sports/exercise	0.34

Table 5. Mean (SD) values across tertiles of total energy expenditure based on the Pregnancy Physical Activity Questionnaire in chinese (PPAQ-C) (n = 125).

lifecorder measure	Lowest Tertile mean ±SD (n = 39)	Middle Tertile mean ±SD (n = 45)	Highest Tertile mean ±SD (n=40)	Linear Trend P
Total activities	21.2 ± 8.7	26.4 ± 11.1	28.9 ± 9.3	0.001
Steps	6304 ± 2447	7761 ± 2807	8529 ± 2531	0.000

Table 6. Spearman correlation coefficients between the Pregnancy Physical Activity Questionnaire (PPAQ) and accelerometer data (n = 125)

	KL accelerometer measure
PPAQ measures	Spearman correlations coefficients
Total activity (light and above)	0.35
Light-intensity activity	0.33
Moderate-intensity activity	0.19
Vigorous-intensity activity	0.15

CHAPTER 3
Physical Activity and Nutrient Intake during Pregnancy and their Associated Factors among Chinese Women with PPAQ-C

3.1 Background

The English version of the PPAQ was translated into Chinese, and its reliability and validity for use by pregnant Chinese women were determined. To understand the true impact of the modifiable lifestyle factors of PA during pregnancy on maternal and fetal health, it is necessary to conduct a detailed investigative study of Chinese women's PA with the validated PPAQ-C tool. To date, most studies have failed to include household activities and childcare activities, both of which are major activities for pregnant women (Schmidt et al., 2002). The association between PA in pregnancy and maternal and fetal health could be fail to find for misclassification resulting of PA during (Ainsworth et al., 2000). In addition, investigating pregnancy PA according to intensity and type can help to guide interventions for Chinese women.

Currently, one study has examined the types and intensities of PA during pregnancy among women in China (Zhang et al., 2014). However, that study examined women only from an urban region, although previous research showed that pregnancy PA was different depended on socioeconomic status (Foxcroft et

al., 2011). Moreover, that study did not examine other modifiable factors that not only influenced PA but also weight gain during pregnancy, such as nutrient intake (Kaiser et al., 2008, Gillman et al., 2001). Nutrient intake is a modifiable factor associated with weight gain during pregnancy and fetal growth (Kaiser et al., 2008,). Moreover, nutrient intake and PA are correlated behaviors (Gillman et al., 2001). It is thereby necessary to simultaneously examine PA and diet during pregnancy.

In addition, the associated factors of PA and nutrition intake in this population were unclear. Some studies showed that PA during pregnancy was positively associated with education and income and negatively associated with age (Ning et al., 2003, Trost et al., 2002). However, other studies have not found PA during pregnancy associated with these sociodemographic variables (Zhang et al., 1996). Thus, it is important to examine which factors influencing the PA and nutrition in pregnant Chinese women. This information would be useful to adjust these associated factors for accurately examining the effect of PA during pregnancy on GWG and BW. Therefore, the aim of this chapter 3 is to examine details of PA with the validated tool designed specifically to assess PA and nutrient intake during pregnancy and their associated factors among Chinese

women from both urban and rural regions.

3.2 Material and Methods

3.2.1 Participants

We recruited participants through the Maternal and Child Health Hospital of Chengdu Wuhou, in the Sichuan province of western China, which has both rural and urban areas. Pregnant women were eligible to participate if they were aged >20 years, with a singleton pregnancy, of Han Chinese nationality, and did not have any major chronic disease, including diabetes mellitus, hypertension, heart disease, chronic renal disease, or other diseases that would restrict PA before their pregnancy. From June 2014 to January 2016, 1272 pregnant women during the first, second, and third trimesters of pregnancy (<13 weeks, 13–28 weeks, and >28 weeks respectively) were recruited in five batches from the antenatal clinic of the hospital. We excluded 48 participants due to missing demographic information, 99 participants who did not complete the food frequency questionnaire (FFQ), 10 whose energy intake was >5000 kcal/day, 14 who did not complete the PPAQ-C, and 24 who reported more than 24 hours of average daily PA. No participant reported an energy intake of <500 kcal/day (Sauder et al., 2016). Finally, 1077 participants were included in the analysis.

Included and excluded participants did not differ significantly with respect to age, pre-pregnancy body mass index (BMI), exercise habits, education, income, weeks of pregnancy, employment status, or household income. This study was approved by the committee on research involving human subjects of Waseda University and by the Maternal and Child Health Hospital of Chengdu Wuhou from June 27, 2014 to March 31, 2017,【2014-037】; all participants provided written informed consent.

3.2.2 Data collection

All information was collected in person. To ensure an accurate understanding of the questionnaires, the participants were informed of the study's purpose and procedures and instructed on how to complete the survey. Investigators were present while the participants filled the questionnaires to answer any queries.

3.3.3 Questionnaires and measurements

Physical activity

Basing on the reliability and validity of the Chinese version of the PPAQ-C have been determined in chapter 2 (r = 0.77, 0.34). PPAQ-C which designed

specifically to assess PA during pregnancy was used to assess PA in our participants. The data of PA are classified by type: household/caregiving (13 activities), occupational (5 activities), and sports/exercise (8 activities). They are also classified by intensity: sedentary (<1.5 METs), light (1.5–<3.0 METs), moderate (3.0–6.0 METs), or vigorous (>6.0 METs). Time of each activity was multiplied by its intensity and summed together, which was defined as the Compendium of Physical Activities (total MET · h/day) (Chasan-Taber et al., 2004). Additional details of PPAQ-C also have been published elsewhere (Xiang et al., 2016).

Nutrient intake

The semi-quantitative FFQ was used to evaluate nutrient intake status; this scale's validity and reliability have been supported in a Chinese sample (Cheng et al, 2008). The FFQ requires participants to recall their usual frequency of consuming each food item in the past three months. Food intake frequency was measured using the following categories: per day, per week, per month, per year, or never. The amount of food consumed by an individual was estimated by items or categories of food, such as the intake of rice, wheat flour, meat, fish, legumes,

eggs, milk (fresh milk, milk powder, fat-free milk powder), vegetables, nuts, cakes, and fruit. For the dietary intake assessment, food samples were used by investigators to help participants estimate serving sizes. Based on a food composition database of combining Chinese Food Composition Tables from 2004 (Chinese Food Composition Table 2004) and 2009 (Chinese Food Composition Table 2009), nutrient intakes were calculated.

3.2.4 Covariate assessment and other measurements

Demographic information, including date of birth, height, weeks of pregnancy, exercise habits before pregnancy (>3 times per week; yes or no), education (categorized as less than high school, high school graduate, or college degree or higher), monthly household income (categorized as <4000, 4000–8000, or >8000 RMB), employment status (yes or no), and previous live births (first-time pregnancy = 0 or not ≥ 1), was obtained using a questionnaire. When they came to hospital for first time in their first trimester, pre-pregnancy weight was recorded by their self-reported.

3.2.5 Statistical analysis

Chi-square tests and one-ANOVA were used to compare categorical and

continuous variables respectively, among participants in each trimester. Following previous research, we compared energy expenditure during sports or exercise (kcal) with a standard of 900 kcal; this criterion was chosen as exercise improves the whole-body insulin sensitivity only when total energy expenditure is >900 kcal per session (Johnson et al., 2007). Nutrient intake from fat was compared with the standards by Chinese Dietary Reference Intakes. In addition, participants' PA was categorized using the international guideline for PA (≥150 min of moderate- or higher-intensity activity per week), and energy derived from fat was categorized as low or high, relative to the median value. Multiple binary logistic regression analysis was used to examine the effects of socio-demographic characteristics on PA and energy derived from fat. Pearson's correlation coefficient was used to examined the association between PA and nutrient intake. Values of $P < 0.05$ were considered significant. SPSS v.21 was used for all analysis (IBM Corp., Armonk, NY).

3.3 Results

Table 7 presents participants' demographic characteristics. Participants were divided into trimester groups (first, second, and third trimester: 314, 395, and 368 participants; 29.2%, 36.7%, and 34.2%, respectively). Participant's mean

age was 29 ± 5 years; 71.3% were first-time mothers and 59.9% exercised habitually before pregnancy. Slow walking was the most commonly reported form of exercise. Further, 72% of the participants began their pregnancy with a normal pre-pregnancy BMI and 43% had a high school education or less. Participants in each trimester group did not differ significantly regarding age, pre-pregnancy BMI, education, household income, and previous live births, excluding employment status and exercise habits before pregnancy.

Participants' mean total PA was 68.8 ± 55.9 MET · h/wk (Table 8). Time spent on physical activities differed significantly between the trimester groups when classified by type ($p < 0.01$), but not when classified by intensity. Participants spent 15.6 ± 15.7 and 19.5 ± 22.7 h/wk on housekeeping/caregiving and occupational activities respectively, but spent only 1.2 ± 1.5 h/wk on exercise. Participants' mean energy intake was 2008 ± 748 kcal, and varied significantly between the trimesters ($p < 0.01$). The first, second, and third trimester group's mean energy intake was 1839 ± 762 kcal, 2030 ± 716 kcal, and 2129 ± 738 kcal, respectively; only 27.3% of participants' intake was >2300 kcal per day (Chinese Dietary Reference Intakes) and the mean energy derived from fat was 41.7 ± 8.7%. Fifty-seven percent of participants met the international guideline for PA

(≥150 mins of moderate- or higher-intensity PA per week). In contrast, only 5.2% of participants expended >900kcal on sports or exercise.

Table 9 presents the results of logistic analysis of socio-demographic characteristics' relationship with participants' PA guideline and energy derived from fat. Participants who did not exercise regularly before pregnancy were less likely to meet the PA guideline in the second trimester (OR = 0.47, 95% CI: 0.31–0.71; $p < 0.01$), and participants who were pregnant for the first time were less likely to meet the PA guideline in the third trimester (OR = 0.40, 95% CI: 0.17–0.90; $p < 0.05$). Participants who were young were less likely to consume more energy as fat in the second trimester (OR = 0.40, 95% CI: 0.22–0.71; $p < 0.01$), and those who had lesser education were less likely to consume energy as fat in the third trimester (OR = 0.48, 95% CI: 0.26–0.89; $p < 0.05$). Household income and pre-pregnancy BMI did not significantly predict PA or fat energy consumption; similarly, PA and nutrient intake were not significantly related in our study (r=0.13, p=0.66) (date not shown).

3.4 Discussion

This is the first study to simultaneously examine multiple modifiable factors during pregnancy among Chinese women, with a detailed focus on PA by

intensity and type. In this study, participants had a high total PA; they tended to spend more time on low-intensity activities, such as housekeeping/caregiving and occupational activities, than on high-intensity activities, such as exercise or sport. Participants' mean PA was 68.8 METs per week, exceeding a previous study in an urban region of China (approximately 20 METs per week) (Zhang et al., 2014). Most participants reported that their primary exercise was walking, and they spent little time on exercise or sport (1.2 h/week); this finding resembles the previous study (Zhang et al., 2014), and may reflect the Chinese cultural context, which considers pregnancy a vulnerable period and accordingly advises against exercise (Zhang et al., 2014). From these results, the characteristics of PA in this population have been revealed. This information would be useful for improving PA for Chinese women in future intervention.

Habitual pre-pregnancy exercise and previous live births increased participants' likelihood of completing adequate PA. This supports the study which showed that women who have exercise before the pregnant would continue to exercise during pregnant period (Bungum et al., 2000). We also found that participants who had previously given birth were more likely to exercise, which is consistent with Foxcroft et al.'s findings (Foxcroft et al., 2011). This is because

women who had previous live births experienced less fear of miscarriage, which is the primary reason for not exercising during pregnancy among Chinese women (Zhang et al., 2014). In our data, the high rates of habitual exercise before pregnancy (60%) and previous live births (29%) may have resulted in a higher total PA compared to previous studies.

The result of nutrient intake in this study also demonstrated that most participants had an imbalanced diet, and fat comprised an excessive proportion of the participants' mean energy intake (41.7%; higher than the Chinese dietary reference: <30%). This is similar to studies that revealed that Chinese women derive approximately 40% of their energy from fat (Gao et al., 2013, Liu et al., 2015). Animal study has revealed the impact of maternal nutritional behavior on infant (Srinivasan et al., 2006). High-fat diet during pregnancy could alter the environment of uterus and adversely affect the infant through its adulthood. Thereby it is a need to examine whether the few high-fat foods should be recommend to pregnant Chinese women in our future research.

This study also examined factors associated with fat energy intake in the Chinese population. Older and better-educated participants were more likely to have high-fat diets. A large number of Western studies indicate that

socioeconomic status, such as education, positively affects diet quality, including regarding low-fat dairy products (Darmon et al., 2008). In contrast, a Japanese study has reported negative associations between education and health status, For example, people with higher waist-to-hip-ratio had lower high-density lipoprotein cholesterol (Martikainen et al., 2001). In this study, education was associated with higher fat intake, supporting the findings of the Japanese study (Martikainen et al., 2001). This suggests that socioeconomic status' association with nutrition intake may differ between Western and Asian countries.

Finally, relationships between PA and nutrient intake have been examined in this study. Some studies have found the positive relationship or a synergistic effect of the two modifiable lifestyle factors in general investigation, for all the general adults man or women (Blair et al., 1996, Gillman et al.., 2001), but we did not find this phenomenon in participant of pregnant woman. It may be due to that although both of PA and nutrient intake are interactive, they are all influenced by health willings. Health willings is a decisive factor, which is high in pregnancy regardless of high or low PA, healthy or suboptimal diet. Therefore, It is useful to access them simultaneously in our future research when we are examining the association between lifestyle during pregnancy and GWG and BW.

3.5 Conclusion

Pregnant Chinese women spend a significant amount of time on low-intensity activities, rather than high-intensity activities, and commonly consume an excessive amount of energy from fat. The PA of Chinese women during pregnancy was influenced by factors of Exercise habits before pregnancy and previous live births. These findings is necessary for examining the effect of lifestyle during pregnancy on pregnant outcome among Chinese women, and as baseline data, our findings would also contribute to the development of PA guidelines during pregnancy to improve maternal and child health in China.

Table 7. Socio-demographic characteristics of pregnant women n (%) (n=1077).

	Overall		1st trimester		2nd trimester		3rd trimester		P value
n(%)	1077	100.0	314	29.2	395	36.7	368	34.2	
Age(year)									0.990
< 25	273	25.3	79	25.3	99	25.1	94	25.6	
25 -< 30	545	50.6	157	50.0	199	50.5	189	51.4	
≧ 30	259	24.0	78	24.7	96	24.4	85	23.1	
Education									0.176
Lower than high school	183	17.0	60	19.2	66	16.7	57	15.5	
High school graduate	275	25.5	80	25.6	113	28.5	82	22.3	
College or higher degree	619	57.4	174	55.3	216	54.8	229	62.1	
Currently employed	479	44.5	160	51.0	171	43.3	148	40.2	***0.016***
Monthly household income (RMB)									0.309
< 4000	282	26.2	79	25.2	99	25.0	104	28.2	
4000－8000	510	47.4	145	46.1	203	51.3	163	44.3	
> 8000	285	26.5	90	28.8	94	23.7	101	27.6	
Exercise habits before pregnancy	645	59.9	171	54.5	237	60.1	236	64.2	***0.038***
Pre-pregnency BMI (kg/m^2)									0.493
< 18.5	226	21.0	62	19.6	84	21.2	81	21.9	
18.5－25	771	71.5	228	72.5	276	69.9	267	72.5	
> 25	80	7.5	24	7.8	35	8.9	21	5.6	
Previous live births (≧ 1)	309	28.7	98	31.3	102	25.8	109	29.5	0.602

Note. *P value*,Chi-square test.

Table8. Physical activity and energy intake during pregnancy in chinese women (n=1077)

	Overall		1st trimester		2nd trimester		3rd trimester		*P value*
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Total activity (light and above, MET·h/wk)	68.8	55.9	65.3	53.5	67.7	56.5	72.9	56.7	0.191
Time by intensity (h/wk)									
Sedentary activity	42.4	24.6	45.1	26.1	41.3	24.0	41.3	23.5	0.066
Light-intensity activity	21.6	14.8	20.7	14.4	21.2	14.4	22.8	15.6	0.155
Moderate-intensity activity	5.8	8.6	5.7	8.1	5.6	8.9	6.1	8.3	0.682
Vigorous-intensity activity	0.1	0.4	0.1	0.3	0.1	0.5	0.1	0.3	0.077
Time by type (h/wk)									
Household/caregiving activity	15.6	15.7	13.7	14.8	15.4	15.6	17.4	16.6	***0.007***
Occupational activity	19.5	22.7	24.1	24.2	18.1	22.2	17.1	21.1	***0.000***
Sports/exercise	1.2	1.5	0.8	1.0	1.3	1.6	1.5	1.6	***0.000***
Total energy intake (kcal/day)	2008	748	1839	762	2030	715	2129	738	***0.000***
Protein (% total energy)	15.2	3.1	14.8	3.3	15.4	2.9	15.6	3.1	***0.003***
Fat (% total energy)	41.7	8.7	41.6	9.0	42.2	9.1	41.3	8.1	0.319
Carbohydrate (% total energy)	43.0	9.9	43.6	10.1	42.4	10.3	43.2	9.4	0.265

Note.*P value*,one-way ANOVA.

Table9. Sociodemographic and health behaviour predictors associated with physical activities and energy derived from fat during pregnancy (n=1077)

	Physical activities (n=1077)												Fat intake (n=1077)											
	1st trimester				2nd trimester				3rd trimester				1st trimester				2nd trimester				3rd trimester			
	OR[1]	95%CI		P value	OR[1]	95%CI		P value	OR[1]	95%CI		P value	OR[2]	95%CI		P value	OR[2]	95%CI		P value	OR[2]	95%CI		P value
Age(year)																								
< 25	1.87	0.99	3.55	0.055	0.93	0.53	1.65	0.808	0.92	0.50	1.70	0.795	0.53	0.28	1.01	0.054	0.40	0.22	0.71	***0.002***	0.74	0.41	1.34	0.324
25 -< 30	1.69	0.97	2.95	0.063	0.96	0.58	1.58	0.873	0.87	0.51	1.48	0.606	0.85	0.49	1.48	0.566	0.66	0.40	1.10	0.111	0.66	0.39	1.11	0.115
≧ 30	1.00				1.00								1.00				1.00				1.00			
Pre-pregnency BMI (kg/m^2)																								
< 18.5	1.61	0.62	4.18	0.329	1.36	0.61	3.05	0.450	0.95	0.36	2.56	0.926	1.00	0.39	2.58	1.000	0.63	0.28	1.44	0.275	1.58	0.59	4.25	0.363
18.5−25	1.11	0.48	2.59	0.801	1.81	0.88	3.71	0.107	1.53	0.61	3.82	0.366	1.11	0.48	2.59	0.801	0.63	0.30	1.32	0.221	0.97	0.39	2.41	0.944
> 25	1.00				1.00								1.00				1.00				1.00			
Education																								
Lower than high school	1.42	0.78	2.58	0.256	1.30	0.74	2.29	0.359	1.21	0.66	2.21	0.543	0.80	0.45	1.45	0.469	0.77	0.44	1.35	0.365	0.48	0.26	0.89	***0.019***
High school graduate	0.84	0.49	1.42	0.512	1.27	0.80	2.03	0.308	1.07	0.64	1.80	0.791	0.82	0.48	1.39	0.459	1.10	0.69	1.74	0.685	0.92	0.56	1.52	0.745
College or higher degree	1.00				1.00								1.00				1.00				1.00			
Curently employed																								
no	0.88	0.57	1.37	0.580	0.83	0.56	1.25	0.376	0.82	0.53	1.26	0.370	0.88	0.57	1.37	0.580	0.68	0.45	1.01	0.057	1.06	0.70	1.62	0.769
yes	1.00				1.00								1.00				1.00				1.00			
Monthly household income (RMB)																								
< 4000	1.55	0.84	2.88	0.163	1.01	0.57	1.81	0.968	1.47	0.82	2.65	0.195	0.81	0.44	1.49	0.492	0.74	0.41	1.33	0.313	0.72	0.41	1.27	0.253
4000−8000	1.12	0.66	1.91	0.668	1.20	0.73	1.99	0.472	1.06	0.63	1.78	0.826	0.99	0.58	1.69	0.974	0.61	0.37	1.01	0.054	0.81	0.48	1.35	0.412
> 8000	1.00				1.00								1.00				1.00				1.00			
Exercise habits before pregnancy																								
no	0.95	0.61	1.48	0.819	0.47	0.31	0.71	***0.000***	0.70	0.45	1.09	0.118	0.86	0.55	1.35	0.521	0.72	0.48	1.08	0.113	0.79	0.51	1.21	0.279
yes	1.00				1.00								1.00				1.00				1.00			
Previous live births																								
0	0.51	0.25	1.05	0.067	0.60	0.26	1.39	0.234	0.40	0.17	0.90	***0.026***	0.84	0.41	1.69	0.620	0.68	0.31	1.52	0.350	1.02	0.48	2.13	0.968
≧ 1	1.00				1.00								1.00				1.00				1.00			

Note. Multiple binary logistic regression. [1]OR of International guideline for physical activity (≧150 min moderate and above intensity activities per week), [2]Energy derived from fat was categorized as low or high by the median value.

CHAPTER 4
Effect of physical activity during pregnancy on gestational weight gain and infant's birth weight among Chinese women

4.1 Background

As previously described in the introduction section of chapter 1, GWG and BW are associated with maternal and fetal health and are predictors of future health outcomes for mothers and infants (Calkins et al., 2011). Some studies, primarily on Caucasian women, suggest that PA, which is a highly modifiable behavior in pregnancy, has been associated with both GWG (Stuebe et al., 2009) and BW (Leiferman et al., 2003, McCullough et al., 2015). However, there is some debate with regard to the effect of PA on BW and GWG. Some studies showed no association between the PA during pregnancy and GWG (Chasan - Taber et al., 2014); others showed that PA only in the third trimester or only vigorous PA during pregnancy was associated with GWG or BW (Haakstad et al., 2007, Stuebe et al., 2009, McCullough et al., 2015). In addition, recent meta-analyses and the IOM also suggested that existing studies were unable to establish the characteristics of effective interventions to prevent inadequate GWG and BW (IOM 2009, Streuling et al., 2011, Gardner et al., 2011). Since effective interventions are needed to define appropriately the intensity, type, and amount

of PA, as well as the timing during pregnancy. However, many studies have focused only on one trimester, employed tools that had not been validated for pregnancy, and were unable to differentiate PA during pregnancy by the type and intensity (Leet et al., 2003, Haakstad et al., 2007, Sanabria-Martinez et al., 2015, Ehrlich et al., 2016).

Moreover, most previous studies that examined the association between PA and GWG or BW did not adjust for nutrient intake, which is an important factor influencing GWG (Stuebe et al., 2009, Chasan‐Taber et al., 2014). In addition, the effects of PA during pregnancy on GWG and BW were different based on race (IOM 2009, McCullough et al., 2015). Thus, a detailed characterization of the intensity and types of PA of the respondents is needed in a study focusing on Asian women.

Therefore, the study in chapter 4 aimed to accurately examine the effect of PA during the first, second, and third trimesters by intensity and type on GWG and BW in Chinese women. The current research would be beneficial for designing interventions aiming to control weight gain in pregnant Chinese women.

4.2 Methods

4.2.1 Study design and Participants

Based on chapter 3, from June 2014 to January 2016, we collected the baseline data such as PA, nutrient intake, and socio-demographic information of the participants in the Maternal and Child Health Hospital of Chengdu Wuhou, in the Sichuan province of western China. All eligible participants who consented to participate were informed about the study's purpose. To avoid disconnection, their contact information such as telephone number was recorded. The participants could withdraw from the study whenever they wanted to. Investigators collected information on socio-demographic parameters, pregnancy PA, and nutrition intake from participants in the first trimester, second trimester, and third trimester. We followed up the participants until delivery. After delivery, information on GWG and BW was obtained from the medical records.

4.2.2 Eligibility

Pregnant women were eligible to participate if they were aged >20 years with a singleton pregnancy, were of Han Chinese nationality, and had no major chronic disease, including diabetes mellitus, hypertension, heart disease, chronic renal disease, or other diseases that would restrict PA before pregnancy.

Because of missing information on demographic data, PA, and nutrition intake,

and anomalous values such as energy intake of >5000kcal/day (Sauder et al, 2016), the demographic information such as age, pre-pregnancy BMI, pre-pregnancy exercise habits, education, employment status or household income, pregnancy PA data, and nutrition intake data during pregnancy was available for 1077 women (83%). The weight at delivery was available for 599 (55.6%) participants, and BW data was available for 606 (56.3%) participants. The reasons for missing weight at delivery and BW data included preterm delivery, changing hospital before delivery, and disconnected telephone. Importantly, included and missing participants did not differ significantly with respect to age, pre-pregnancy BMI, exercise habits, education, income, weeks of pregnancy, employment status, or household income.

4.2.3 Physical activity

PPAQ-C was used to assess the PA during pregnancy in chapter 3 when the participants were recruited. Total PA (total MET・h/week) (light and above) was calculated and the time spent on each activity was summed together. The collected data were classified based on a previous study (Chasan-Taber et al., 2014). Total PA and time of each PA were categorized into quartiles in which the lowest quartile (first quartile) indicated the lowest PA. Sedentary behavior was

also grouped into quartiles in which the lowest quartile (first quartile) was the least sedentary activity group. Due to the small number of participants in the vigorous activity group, the vigorous activity was categorized into two types (any or none). For the same reason, three categories (unemployed, low, high) were set for occupational activity. The low occupational group included those who worked less than the median (h/week) of the employed participants. The high occupational group included those who worked more than the median.

PA was also categorized using the international guideline for PA; meeting the PA recommendations was defined as ≥150 min of moderate- or higher-intensity activity per week (ACOG 2002).

4.2.4 Assessment of GWG and BW

We defined total GWG as the difference between delivery and pre-pregnancy in maternal weight (Chasan-Taber et al., 2014). From medical record of the individuals, we recorded weight at pre-pregnancy and delivery. It was self-reported when women missed the weight record. Total GWG was also categorized into inadequate, adequate, or exceeding based on the 2009 IOM (Institute of Medicine) guidelines (IOM 2009), which was previously described in the introduction section of chapter 1. Infant data included BW(g), height, and sex

obtaining from medical records.

4.2.5 Covariates

Demographic information, including age, prepregnancy maternal weight, height, marital status, exercise habits before pregnancy (≧3 times per week; yes or no), education (categorized as less than high school, high school graduate, or college degree or higher), monthly household income (categorized as <4000, 4000–8000 or >8000 RMB), and employment status (yes or no) was obtained by using a questionnaire and recorded for each participant. The semi-quantitative FFQ was used to evaluate energy intake status as an important confounding variable in the previous three months (Cheng et al., 2008). Additional details have been published elsewhere (Xiang et al., 2016).

4.2.6 Data analysis

The currently obtained data were analyzed according to a previous study (Chasan-Taber et al., 2014). Chi-square tests were employed to examine the association of sociodemographic characteristics with GWG (inadequate, adequate, and excessive). To estimate the effects of each intensity and type of PA on inadequate or excessive GWG, multinomial logistic regression was used. To

examine the relationship of PA by intensity and type with total GWG and BW, linear regression models were used. The odds ratios (OR) in Crude and adjusted models were calculated. The factors which associated with GWG (i.e., age, pregnancy BMI) were fully included in adjusted models. To assess other confounding factors, we evaluated each covariate by calculating changes of the ORs for PA in the regression model. A change of greater than 10% was used as a threshold to determine confounding. Given this criteria, age, education, pre-pregnancy BMI, marital status, exercise habits before pregnancy, household income, energy intake, and infant sex were included in multivariable models. PA was categorized as continuous linear variables to test the trend. Finally, according to the covariates, participants with and without missing information were compared. Values of $P < 0.05$ were considered significant. SPSS v.21 was used for all analyses (IBM Corp., Armonk, NY).

4.3 Results

Our study included a total of 606 women . There were 43.4% women with adequate GWG, 27.9% with inadequate GWG, and 28.7% with excessive GWG as determined by the IOM guidelines (Table 10). The average GWG was 14.12 ± 5.369 kg. Approximately half of the women (49.67%) were 25-30 years old.

Married women (89.8%) were more likely to have adequate GWG. Most participants (69.6%) had normal weight before pregnancy and overweight or obese (BMI >25) participants had increased risk of excessive GWG significantly. The mean birth weight was 3344.71 ± 441.86 g and 55% of the infants were boys. The women who had given birth to boys also had a significant increased risk of excessive GWG. The mean maternal energy intake during the first, second, and third trimesters was 2019 ± 798kcal/day, 1964 ± 639 kcal/day, and 2159 ± 824 kcal/day, respectively (data not shown).

We first examined the relationship between intensity and type of PA during the first trimester and GWG (Table 11). In crude and adjusted (age, education, pre-pregnancy BMI, marital status, exercise habits before pregnancy, household income, and energy intake) analysis models, there was not any significant associations between intensity or type of PA during the first trimester and inadequate or excessive GWG. Similarly, women who meet PA recommendations during the first trimester have not reduced risk of inadequate or excessive GWG.

Table 12 shows the relationship between second trimester activity and GWG. As seen with PA during the first trimester, there was not any significant difference during second trimester between the highest total PA and the lowest

total PA regarding to decreasing risk of inappropriate GWG in pregnant women, such as inadequate GWG (OR = 0.52, 95% CI 0.18-1.47) or excessive GWG (OR = 0.92, 95% CI 0.34-2.52). In addition, women who met these recommendations during the second trimester have not significantly reduced risk of inadequate or excessive GWG compared to women whose PA did not meet recommendations. However, unlike the first trimester results, we did observe that women who had participated in sports/exercise activity during the second trimester were more likely to have excessive GWG (OR = 6.27, 95% CI 1.50-26.15). However, there were no significant associations between other types of activity and GWG.

The association between PA and GWG during the third trimester was also examined (Table 13). Although there was not a significant decreased risk with increasing total PA, compared to women with the lowest levels of total PA, women with the highest levels of total PA during the third trimester had a 69% reduced risk of inadequate GWG (OR = 0.31, 95% CI 0.10-0.92) and a 67% reduced risk of excessive GWG (OR = 0.33, 95% CI 0.12-0.91), and both of these differences were significant (Table 13). However, there was no significant association between meeting PA recommendations and inadequate or excessive GWG during the third trimester. In addition, we noted significant associations between sedentary

activity and excessive GWG (OR = 0.23, 95% CI 0.08-0.70).

The relationship of PA with total GWG and BW at each stage of pregnancy (first, second and third trimester) was examined and the results are outlined in Table 14. There were no significant associations between meeting PA recommendations or total PA and total GWG during the first, second and third trimester. However, there were significant relationship between meeting PA recommendations and BW during the second and third trimester. Women who did not meet PA recommendations had infants with significantly higher BWs compared to those who did meet these recommendations in the second and third trimesters (ß= -0.17, SE = 64.56, P = 0.02; ß= -0.16, SE = 62.97, P = 0.02, respectively). As well as on average, higher BW (136.98 ± 63.84, P = 0.033; 157.29 ± 62.86, P = 0.013, respectively), as compared to women who met physical activity recommendations.

Finally, differences in sociodemographic characteristics between included participants and missing samples were also examined. There was no statistically significant difference with respect to age, education, pre-pregnancy BMI, exercise habits before pregnancy, household income, or energy intake between included participant and missing samples; however, there was a difference in

marital status (89.8% vs 94.1%, respectively, P = 0.003) (data not shown).

4.4 Discussion

This is the first study to examine the association between intensity and type of PA during pregnancy with GWG and BW in Chinese women using validated assessment tools. In the present study, less than half (43.4%) of participants had adequate GWG, despite the fact that most participants (69.6%) were of normal weight prior to pregnancy. We found that women with the highest total PA in the third trimester of pregnancy had a 69% reduced risk of inadequate GWG and a 67% reduced risk of excessive GWG, compared to women who had the lowest total PA. There was no any significant relationship of meeting PA guidelines and inadequate GWG or excessive GWG and total GWG at any stage during pregnancy. However, women who met PA guidelines in the second and third trimesters had infants with significantly lower BW.

The results described in our study are consistent with those in previous literature, which support that less than half of Chinese pregnant women had adequate GWG (Jiang et al., 2012), and PA could relieve the risk of inadequate or excessive GWG (Stuebe et al., 2009, Hopkins et al., 2010). Similarly, our data were consistent with reports by Haakstad and Clapp, who found that compared

to women with the lowest PA, women who exercised in the third trimester gained significant lower weight, whereas there was no association between exercise and GWG in the first and second trimesters (Haakstad et al., 2007, Clapp et al., 1995). This is probably because the significant association of PA and GWG in the third trimester is partly attributable to the metabolic changes during pregnancy, which include maternal insulin resistance and fetal lipid metabolism during the third trimester (Clapp et al., 1995).

Unlike the previous study that showed an association of moderate or vigorous exercise with GWG (Stuebe et al., 2009), in the current study, I did not observe a significant association between meeting PA recommendations (moderate and vigorous exercise: ≥150 min / week) and GWG at any stage of pregnancy. These findings suggest that the total amount of PA during the third trimester of pregnancy may be more important than intensity of PA to reduce the risk of inadequate GWG or excessive GWG. Moreover, this study found that the level of PA according to the ACOG 2009 guidelines may be insufficient to improve the GWG of Chinese women. These findings provide a new benchmark for guidelines and interventions to control the GWG of Chinese women. In addition, Previous study showed that there was positive association between

sports/exercise and GWG among Hispanic women by bivariate analyses (Chasan - Taber et al., 2008), which is consistent with the current finding for the second trimester. However, multivariable analyses in that study showed no association between exercise and GWG (Chasan - Taber et al., 2008). This may be because there were no sports/exercise habits in a large proportion of the participants, influencing the statistical result. Further studies are warranted to clarify the associations of sports/exercise with GWG.

As for the association of PA with BW, the current study presented that infant BW was significantly lower among the Chinese women who met PA recommendations (moderate and vigorous exercise: ≥150 min / week) in the second and third trimester. This finding is consistent with that of previous studies (Juhl et al., 2010, Hegaard et al., 2010, McCullough et al., 2015), suggesting that PA is an effective factor to prevent a high infant BW. Moreover, the current finding also agrees with a randomized intervention trial, which found that babies of women who participated in a bicycling program from 20 weeks of gestation until delivery were lower in weight (compared to the babies of the control women, lower than about 140 g) (Hopkins et al., 2010). Given that total PA in any stage of pregnancy was not significantly associated with BW in our

study, moderate and vigorous intensities of PA during pregnancy may have a pivotal role in decreasing BW than the total volume of PA does. This result is very significant for China, where the rate of macrosomia has increased significantly.

Although the mechanisms underlying how maternal PA reduces BW have not been fully clarified, one hypothesis is that maternal PA influences fetal growth by regulating the delivery of oxygen and nutrients to the placenta. Intermittent fluctuations in oxygen and nutrient delivery to the placenta can be caused by PA during pregnancy, which may result in fetal hypoxia and growth restriction (Clapp et al, 2006, Hopkins et al., 2011, McCullough et al., 2015). In addition, Clapp demonstrated that PA in early pregnancy could stimulate placental growth while PA in late pregnancy could determine its effect on late fetal growth (Clapp et al., 2006). Furthermore, the authors demonstrated that a high-intensity, high-volume PA regimen throughout pregnancy was associated with a decreased BW (Clapp et al., 2006). This finding may partly explain why our data showed that only women who met PA recommendations (moderate- or higher-intensity ≥ 150 min per week) in the second and third trimester had infants with lower BW.

4.5 Conclusion

This cohort study showed that the risk of inappropriate GWG (inadequate GWG or excessive GWG) in pregnancy can be decreased significantly by increasing PA levels in the third trimester among the Chinese women. In addition, Chinese women who met PA recommendations in the second and third trimester of pregnancy significantly reduce infants BW. Thus, our findings suggested that increasing of PA during pregnancy is an effective way to promote maternal and child health.

Table10. Maternal characteristics and association with gestational weight gain.

	Total		Inadequate GWG[a]	Met GWG guidelines	Excessive GWG	P-values[b]
	N	%	%	%	%	
Total	606		27.9	43.4	28.7	
Characteristics						
Age(year)						0.157
< 25	165	27.3	24.1	28.7	27.5	
25 -< 30	301	49.7	46.4	49.6	50.9	
≧ 30	140	23.1	28.9	21.3	19.3	
Education						0.564
Lower than high school	113	18.6	21.1	18.4	17.1	
High school graduate	156	25.7	24.1	23.8	30.0	
College or higher degree	338	55.7	54.8	57.8	52.9	
Monthly household income (RMB)						0.574
< 4000	162	26.8	28.0	24.9	27.4	
4000－8000	288	47.6	49.1	45.8	49.4	
> 8000	155	25.6	23.0	29.3	23.2	
Marital status						**0.018**
single/divorced/separated/widowed	62	10.2	12.2	6.3	14.4	
married	544	89.8	87.8	93.7	85.6	
live with parents						0.830
no	301	49.7	51.2	50.0	47.9	
yes	305	50.3	48.8	50.0	52.1	
Exercise habits before pregnancy						0.083
no	244	40.3	34.9	45.3	38.0	
yes	362	59.7	65.1	54.7	62.0	
Pre-pregnency BMI (kg/m2)						**0.002**
< 18.5	135	22.2	15.7	29.5	18.1	
18.5－25	422	69.6	76.5	65.5	70.8	
> 25	46	7.5	7.8	5.0	11.1	
infrant sex						**0.001**
boys	330	54.5	50.0	49.4	66.9	
girls	276	45.5	50.0	50.6	33.1	

a. GWG : gestational weight gain, categorized into inadequate, adequate, or exceeding based on the 2009 IOM guidelines.
b. P-values are from Chi square tests.

Table11. Relationship between intensity and type of physical activity (PA) during the first trimester and gestational weight gain.

	Inadequate GWG[a]				Excessive GWG[a]			
	Crude		Adjusted[b]		Crude		Adjusted[b]	
	OR[a]	(95%CI)	OR[a]	95%CI	OR[a]	95%CI	OR[a]	95%CI
Total PA								
1st quartile	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
2nd quartile	0.69	(0.25,1.92)	0.61	(0.20,1.86)	1.54	(0.51,4.62)	1.39	(0.40,4.83)
3rd quartile	0.42	(0.15,1.20)	0.33	(0.10,1.03)	0.71	(0.22,2.26)	0.54	(0.15,1.98)
4th quartile	0.72	(0.26,1.95)	0.78	(0.25,2.42)	1.01	(0.32,3.20)	1.24	(0.34,4.55)
P-trend	0.34		0.37		0.64		0.84	
PA by intensity								
Sedentary								
1st quartile	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
2nd quartile	0.79	(0.28,2.26)	0.79	(0.25,2.49)	0.71	(0.25,2.07)	0.66	(0.20,2.15)
3rd quartile	1.21	(0.46,3.19)	1.02	(0.33,3.14)	0.53	(0.17,1.62)	0.41	(0.11,1.57)
4th quartile	0.79	(0.27,2.33)	0.72	(0.20,2.58)	0.97	(0.34,2.74)	0.84	(0.23,3.04)
P-trend	0.93		0.72		0.81		0.67	
Low intensity								
1st quartile	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
2nd quartile	0.98	(0.35,2.74)	0.71	(0.23,2.16)	0.96	(0.34,2.76)	0.68	(0.21,2.25)
3rd quartile	0.32	(0.10,0.97)	0.23	(0.07,0.77)	0.46	(0.16,1.31)	0.38	(0.12,1.25)
4th quartile	1.52	(0.57,4.07)	1.70	(0.56,5.15)	0.82	(0.27,2.48)	1.15	(0.34,3.94)
P-trend	0.86		0.91		0.39		0.76	
Moderate								
1st quartile	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
2nd quartile	0.52	(0.18,1.49)	0.51	(0.17,1.58)	0.61	(0.21,1.78)	0.41	(0.12,1.42)
3rd quartile	0.61	(0.22,1.71)	0.57	(0.19,1.70)	0.85	(0.30,2.38)	0.71	(0.23,2.18)
4th quartile	0.85	(0.32,2.27)	0.73	(0.23,2.26)	0.43	(0.13,1.38)	0.31	(0.08,1.18)
P-trend	0.84		0.57		0.27		0.18	
Vigorous								
None	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Any	1.65	(0.64,4.24)	2.12	(0.76,5.91)	1.57	(0.58,4.30)	1.78	(0.59,5.37)
PA by type								
sports/exercise								
None	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Low	1.92	(0.75,4.88)	2.10	(0.75,5.87)	1.35	(0.49,3.71)	1.37	(0.44,4.29)
High	1.56	(0.56,4.30)	1.68	(0.54,5.23)	2.00	(0.72,5.58)	2.04	(0.62,6.70)
P-trend	0.44		0.43		0.16		0.21	
Household/caregiving								
1st quartile	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
2nd quartile	0.80	(0.28,2.32)	0.69	(0.22,2.18)	0.53	(0.16,1.77)	0.45	(0.12,1.72)
3rd quartile	1.03	(0.40,2.65)	0.79	(0.28,2.28)	0.93	(0.35,2.48)	0.81	(0.26,2.50)
4th quartile	0.75	(0.28,2.02)	0.69	(0.21,2.22)	0.64	(0.23,1.82)	0.82	(0.23,2.89)
P-trend	0.69		0.54		0.54		0.78	
Occupation								
unemployed	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Low	1.04	(0.46,2.35)	1.10	(0.44,2.75)	0.79	(0.33,1.89)	0.78	(0.29,2.11)
High	1.16	(0.44,3.08)	1.00	(0.33,3.06)	0.98	(0.35,2.75)	1.03	(0.32,3.30)
P-trend	0.78		0.97		0.86		0.96	
Met PA guideline								
Yes	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
No	1.04	(0.50,2.17)	0.90	(0.41,1.98)	1.00	(0.46,2.17)	0.87	(0.37,2.07)

a. GWG : gestational weight gain; OR : Odds ratios, referent categories were : meeting IOM guidelines.
b. Adjusted for age, education, Pre-pregnancy BMI, marital status, exercise habits before pregnancy, household income and energy intake.

Table12. Relationship between intensity and type of physical activity (PA) during the second trimester and gestational weight gain.

	Inadequate GWG[a]				Excessive GWG[a]			
	Crude		Adjusted[b]		Crude		Adjusted[b]	
	OR[a]	95%CI	OR[a]	95%CI	OR[a]	95%CI	OR[a]	95%CI
Total PA								
1st quartile	1	Reference	1	Reference	1	Reference	1	Reference
2nd quartile	0.79	(0.32,1.98)	0.66	(0.25,1.75)	0.59	(0.23,1.55)	0.53	(0.19,1.51)
3rd quartile	1.02	(0.41,2.54)	0.99	(0.38,2.59)	0.68	(0.26,1.79)	0.59	(0.20,1.72)
4th quartile	0.65	(0.24,1.76)	0.52	(0.18,1.47)	1.19	(0.48,2.95)	0.92	(0.34,2.52)
P-trend	0.57		0.4		0.5		0.93	
PA by intensity								
Sedentary								
1st quartile	1	Reference	1	Reference	1	Reference	1	Reference
2nd quartile	0.96	(0.39,2.37)	0.86	(0.33,2.24)	1.29	(0.51,3.27)	1.67	(0.62,4.56)
3rd quartile	1.02	(0.41,2.51)	0.83	(0.31,2.19)	1.05	(0.40,2.74)	1.18	(0.41,3.41)
4th quartile	0.58	(0.23,1.48)	0.34	(0.11,1.02)	1.07	(0.43,2.65)	0.99	(0.33,3.02)
P-trend	0.32		0.08		1		0.88	
Low intensity								
1st quartile	1	Reference	1	Reference	1	Reference	1	Reference
2nd quartile	1.25	(0.49,3.16)	1.35	(0.51,3.62)	0.82	(0.31,2.15)	1.02	(0.36,2.87)
3rd quartile	0.85	(0.35,2.07)	0.78	(0.31,1.99)	0.61	(0.24,1.51)	0.53	(0.20,1.40)
4th quartile	1.1	(0.43,2.80)	0.98	(0.37,2.59)	1.19	(0.49,2.92)	0.84	(0.32,2.18)
P-trend	0.94		0.72		0.93		0.44	
Moderate								
1st quartile	1	Reference	1	Reference	1	Reference	1	Reference
2nd quartile	0.82	(0.34,2.02)	0.79	(0.31,2.00)	0.69	(0.26,1.84)	0.64	(0.22,1.81)
3rd quartile	0.88	(0.35,2.22)	0.96	(0.36,2.53)	1.14	(0.45,2.92)	1.21	(0.44,3.32)
4th quartile	0.89	(0.34,2.33)	0.8	(0.30,2.15)	1.58	(0.62,4.03)	1.31	(0.49,3.53)
P-trend	0.85		0.78		0.21		0.37	
Vigorous								
None	1	Reference	1	Reference	1	Reference	1	Reference
Any	0.9	(0.38,2.17)	0.85	(0.34,2.12)	2.3	(1.06,4.99)	2.13	(0.93,4.88)
Moderate or more								
1st quartile	1	Reference	1	Reference	1	Reference	1	Reference
2nd quartile	1.08	(0.45,2.64)	1.04	(0.41,2.60)	0.72	(0.27,1.92)	0.65	(0.23,1.86)
3rd quartile	0.74	(0.29,1.90)	0.81	(0.30,2.18)	1.11	(0.44,2.79)	1.07	(0.39,2.94)
4th quartile	1	(0.38,2.65)	0.87	(0.32,2.36)	1.59	(0.62,4.09)	1.39	(0.51,3.79)
P-trend	0.78		0.67		0.24		0.36	
PA by type								
sports/exercise								
None	1	Reference	1	Reference	1	Reference	1	Reference
Low	0.94	(0.38,2.38)	0.92	(0.35,2.46)	4.18	(1.11,15.73)	**5.17**	**(1.27,21.07)**
High	1.22	(0.48,3.09)	1.24	(0.45,3.40)	4.82	(1.27,18.30)	**6.27**	**(1.50,26.15)**
P-trend	0.57		0.55		0.05		**0.03**	
Household/caregiving								
1st quartile	1	Reference	1	Reference	1	Reference	1	Reference
2nd quartile	0.59	(0.24,1.48)	0.74	(0.29,1.91)	0.43	(0.17,1.10)	0.45	(0.16,1.24)
3rd quartile	0.51	(0.19,1.37)	0.5	(0.18,1.41)	0.53	(0.20,1.37)	0.43	(0.15,1.23)
4th quartile	0.74	(0.28,1.94)	0.77	(0.28,2.10)	0.75	(0.29,1.93)	0.61	(0.22,1.69)
P-trend	0.54		0.5		0.69		0.37	
Occupation								
unemployed	1	Reference	1	Reference	1	Reference	1	Reference
Low	0.74	(0.33,1.67)	0.57	(0.24,1.34)	1.16	(0.52,2.58)	0.95	(0.40,2.28)
High	0.53	(0.23,1.24)	0.41	(0.16,1.04)	0.93	(0.41,2.10)	0.85	(0.34,2.13)
P-trend	0.13		0.05		0.92		0.73	
Met PA guideline								
Yes	1	Reference	1	Reference	1	Reference	1	Reference
No	1.27	(0.64,2.50)	1.32	(0.65,2.70)	1.33	(0.67,2.63)	1.31	(0.62,2.77)

a. GWG : gestational weight gain; OR : Odds ratios, referent categories were : meeting IOM guidelines.
b. Adjusted for age, education, Pre-pregnancy BMI, marital status, exercise habits before pregnancy, household income and energy intake.

Table13. Relationship between intensity and type of physical activity (PA) during the third trimester and gestational weight gain.

	Inadequate GWG[a]				Excessive GWG[a]			
	Crude		Adjusted		Crude		Adjusted	
	OR[a]	95%CI	OR[a]	95%CI	OR[a]	95%CI	OR[a]	95%CI
Total PA								
1st quartile	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
2nd quartile	0.48	(0.19, 1.25)	**0.29**	**(0.10, 0.84)**	0.50	(0.21, 1.18)	0.41	(0.16, 1.06)
3rd quartile	0.70	(0.28, 1.79)	0.44	(0.15, 1.27)	0.58	(0.24, 1.40)	0.54	(0.20, 1.41)
4th quartile	0.61	(0.24, 1.54)	**0.31**	**(0.10, 0.91)**	0.47	(0.19, 1.15)	**0.33**	**(0.12, 0.91)**
P-trend	0.48		0.09		0.15		0.07	
PA by intensity								
Sedentary								
1st quartile	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
2nd quartile	0.70	(0.28, 1.76)	0.86	(0.30, 2.50)	0.54	(0.22, 1.32)	0.52	(0.19, 1.46)
3rd quartile	0.64	(0.25, 1.64)	0.84	(0.28, 2.48)	0.70	(0.29, 1.69)	0.67	(0.24, 1.84)
4th quartile	0.24	(0.09, 0.68)	0.29	(0.09, 1.01)	0.30	(0.12, 0.75)	**0.23**	**(0.08, 0.70)**
P-trend	0.01		0.06		0.02		**0.02**	
Low intensity								
1st quartile	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
2nd quartile	1.11	(0.45, 2.73)	0.82	(0.30, 2.20)	0.99	(0.42, 2.32)	0.90	(0.36, 2.28)
3rd quartile	0.94	(0.37, 2.40)	0.61	(0.21, 1.73)	1.03	(0.44, 2.43)	0.91	(0.36, 2.34)
4th quartile	0.94	(0.37, 2.40)	0.50	(0.17, 1.46)	0.86	(0.36, 2.07)	0.62	(0.23, 1.67)
P-trend	0.82		0.17		0.78		0.39	
Moderate								
1st quartile	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
2nd quartile	0.88	(0.35, 2.22)	0.69	(0.25, 1.90)	0.66	(0.29, 1.55)	0.52	(0.20, 1.30)
3rd quartile	0.53	(0.20, 1.43)	0.37	(0.12, 1.12)	0.54	(0.23, 1.28)	0.37	(0.14, 0.98)
4th quartile	1.06	(0.42, 2.67)	0.65	(0.22, 1.92)	0.55	(0.23, 1.36)	0.39	(0.14, 1.11)
P-trend	0.89		0.27		0.16		0.05	
Vigorous								
None	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Any	1.40	(0.59, 3.34)	1.11	(0.40, 3.06)	1.99	(0.91, 4.34)	2.26	(0.95, 5.36)
PA by type								
sports/exercise								
None	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Low	2.09	(0.62, 7.05)	1.70	(0.46, 6.31)	1.26	(0.47, 3.39)	1.38	(0.46, 4.12)
High	2.05	(0.60, 7.03)	1.87	(0.49, 7.21)	1.20	(0.44, 3.28)	1.05	(0.33, 3.32)
P-trend	0.41		0.42		0.84		0.81	
Household/caregiving								
1st quartile	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
2nd quartile	1.67	(0.65, 4.30)	1.07	(0.38, 3.01)	1.48	(0.63, 3.47)	1.16	(0.46, 2.92)
3rd quartile	2.21	(0.87, 5.63)	1.18	(0.40, 3.43)	1.47	(0.61, 3.54)	1.09	(0.40, 2.99)
4th quartile	1.00	(0.38, 2.60)	0.35	(0.11, 1.10)	0.83	(0.35, 1.97)	0.52	(0.19, 1.40)
P-trend	0.84		0.10		0.70		0.19	
Occupation								
unemployed	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Low	0.50	(0.23, 1.09)	0.50	(0.21, 1.21)	1.01	(0.51, 1.98)	1.01	(0.48, 2.16)
High	0.60	(0.23, 1.55)	0.99	(0.35, 2.79)	0.68	(0.27, 1.69)	0.88	(0.32, 2.42
P-trend	0.13		0.57		0.50		0.88	
Met PA guideline								
Yes	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
No	0.99	(0.49, 2.00)	0.76	(0.34, 1.66)	0.74	(0.39, 1.41)	0.60	(0.29, 1.22)

a. GWG : gestational weight gain; OR : Odds ratios, referent categories were : meeting IOM guidelines.
b. Adjusted for age, education, Pre-pregnancy BMI, marital status, exercise habits before pregnancy, household income and energy intake.

Table14. Relationship of physical activity (PA) with total gestational weight gain and birth Weight at each stage of pregnancy (first, second and third trimester).

	Total GWG[a]						Birth Weight					
	Crude			Adjusted[b]			Crude			Adjusted[c]		
	Beta	(SE)[a]	P-value	Beta	(SE)[a]	P-value	Beta	(SE)[a]	P-value	Beta	(SE)[a]	P-value
First trimester												
Total PA												
1st quartile	Reference			Reference			Reference			Reference		
2nd quartile	0.07	(1.23)	0.44	0.14	(1.24)	0.16	0.08	(106.02)	0.42	0.05	(112.44)	0.61
3rd quartile	0.15	(1.24)	0.12	0.19	(1.24)	0.05	0.05	(106.67)	0.60	0.10	(111.80)	0.32
4th quartile	0.07	(1.24)	0.48	0.08	(1.27)	0.42	0.06	(106.02)	0.54	0.09	(112.78)	0.42
P-trend	0.36			0.30			0.63			0.84		
Met PA guideline												
No	Reference			Reference			Reference			Reference		
Yes	0.00	(0.88)	0.97	0.00	(0.88)	0.97	-0.02	(74.67)	0.77	-0.01	(77.47)	0.95
Second trimester												
Total PA												
1st quartile	Reference			Reference			Reference			Reference		
2nd quartile	-0.07	(1.17)	0.45	-0.08	(1.20)	0.37	-0.14	(85.93)	0.10	-0.13	(88.94)	0.14
3rd quartile	-0.09	(1.17)	0.32	-0.10	(1.20)	0.24	-0.19	(85.93)	0.03	-0.17	(88.97)	0.05
4th quartile	0.05	(1.17)	0.59	0.04	(1.21)	0.62	-0.04	(86.79)	0.62	-0.05	(90.34)	0.56
P-trend	0.66			0.67			0.52			0.56		
Met PA guideline												
No	Reference			Reference			Reference			Reference		
Yes	-0.05	(0.85)	0.44	-0.06	(0.88)	0.40	-0.17	(62.10)	0.02	**-0.17**	**(64.56)**	**0.02**
Third trimester												
Total PA												
1st quartile	Reference			Reference			Reference			Reference		
2nd quartile	-0.07	(0.87)	0.38	-0.03	(0.91)	0.76	-0.09	(82.18)	0.31	-0.09	(83.74)	0.32
3rd quartile	-0.03	(0.87)	0.72	0.03	(0.91)	0.72	-0.08	(83.29)	0.37	-0.03	(85.71)	0.74
4th quartile	-0.02	(0.88)	0.77	0.01	(0.94)	0.93	-0.09	(82.54)	0.27	-0.06	(86.31)	0.47
P-trend	0.91			0.76			0.31			0.13		
Met PA guideline												
No	Reference			Reference			Reference			Reference		
Yes	-0.04	(0.65)	0.54	-0.02	(0.68)	0.73	-0.14	(61.33)	0.03	**-0.16**	**62.97**	**0.02**

a. Total GWG : total gestational weight gain (kg); SE : standard errors.
b. Adjusted for age, education, Pre-pregnancy BMI, marital status, exercise habits before pregnancy, household income and energy intake.
c. Adjusted for age, education, Pre-pregnancy BMI, marital status, exercise habits before pregnancy, household income, energy intake and baby sex.

CHAPTER 5
COMPREHENSIVE DISCUSSION

The aim of this chapter was to integrate the findings from the three studies described in this dissertation: (1) Reliability and Validity of a Chinese-Translated Version of a Pregnancy Physical Activity Questionnaire (PPAQ-C); (2) PA and Nutrient Intake During Pregnancy and Their Associated Factors Among Chinese Women with PPAQ-C; and (3) Effect of PA During Pregnancy on GWG and BW Among Chinese Women.

5.1 Discussions

5.1.1 Reliability and validity of a Chinese-translated version of a pregnancy physical activity questionnaire (PPAQ-C)

To accurately measure PA, a key modifiable factor, in pregnant Chinese women with a validated tool, we translated the English version of the PPAQ (this is the only validated instrument specifically designed to assess PA during pregnancy) into Chinese (PPAQ-C) in chapter 2 and determined its reliability and validity for use by pregnant Chinese women. To our knowledge, this is the first study to use accelerometers for objective measurement of PA among pregnant Chinese women to investigate PA during pregnancy. Our results indicated that the PPAQ-C has good reliability and validity for assessing total

activity among pregnant Chinese women, which is comparable to the validity of the original PPAQ.

Before this version of the PPAQ-C, there was no Chinese version to measure pregnant women's PA. Therefore, it is necessary and important to accurately assess the comprehensive measurement of PA for pregnant women in China. Our findings also suggest that the PPAQ-C can be widely used in other studies regarding the level of PA during pregnancy among Chinese women from other regions.

5.1.2 Physical Activity and Nutrient Intake during Pregnancy and their Associated Factors among Chinese Women with PPAQ-C

Based on chapter 2, this chapter revealed the characteristics of the key lifestyle factors of PA and nutrient intake of pregnant Chinese women in detail using the PPAQ-C, which was determined in chapter 2 to be reliable and valid for pregnant Chinese women.

This study was the first to simultaneously examine multiple modifiable lifestyle factors of PA during pregnancy among Chinese women, with a detailed focus on PA by intensity and type. Our results showed that the total PA of pregnant women in our study exceeded that in the study by Zhang et al. in an

urban region and showed that pregnant Chinese women spent little time on high-intensity activities, and they were consistent with findings of Liu et al. showing that nutrient intake was imbalanced, containing excessive calories from fat.

Previous studies showed that social variables such as education, income, age, pre-pregnancy BMI, exercise habits before pregnancy, and previous live births are associated with PA in pregnancy, whereas several other studies found no relationship between these variables and women's PA levels during pregnancy (Zhang et al., 1996, Trost et al., 2002, Ning et al., 2003). In our data, we found that only patients with good exercise habits before pregnancy and previous live births were more likely to have adequate PA. These findings suggest that future interventions should focus on all women, not just high-risk women such as those with a high pre-pregnancy BMI or a low level of education. In addition, our data showed that these factors that influence a woman's lifestyle may be different depending on the country and region.

Chapter 3 revealed the characteristics of lifestyle during pregnancy among Chinese women by investigating PA during pregnancy according to intensity, type, and trimester. This was a necessary stage for our future prospective research examining the association between lifestyle during pregnancy and

GWG and BW in Chinese populations. Moreover, it can be used to compare data from pregnant women in China with those from pregnant women in other countries in future studies. In addition, our findings, as baseline data, would also contribute to the development of prenatal PA guidelines to improve maternal and child health in China, which is an urgent need.

5.1.3 Effect of physical activity during pregnancy on gestational weight gain and infant's birth weight among Chinese women

Based on the results of chapters 2 and 3, chapter 4 examines the relationship between PA and GWG as well as BW according to intensity and type of PA among pregnant Chinese women by using the validated tool: PPAQ-C. Our data showed that less than half of Chinese women had adequate GWG, but the risk of inadequate GWG or excessive GWG was significantly decreased in women with the highest levels of total PA in the third trimester. Additionally, the infants of women who met PA recommendations in the second and third trimester had a significantly lower BW. Similar to some previous studies of Caucasian women, the findings of this chapter suggested that PA in the Asian population is useful to prevent inadequate or excessive GWG, especially in the third trimester. However, unlike a previous study that showed an association between PA and

GWG for moderate or vigorous exercise only, our investigation showed that the total amount of PA during pregnancy may be more important than intensity in reducing the risk of inadequate GWG or excessive GWG. Moreover, this study found that the level of PA from the ACOG 2009 guidelines may be insufficient to influence the GWG of Chinese women. These findings provide a new overview to guide future interventions for controlling the GWG of Chinese women.

On the other hand, the infant BW was significantly lower among the Chinese woman who met PA recommendations in the second and third trimester. This is consistent with previous studies, suggesting that PA is a useful factor to prevent a high infant BW. However, our data found that activity of moderate or vigorous intensity during pregnancy was more effective in decreasing BW than the total volume of PA. Therefore, our data suggested that effective interventions to promote maternal and fetal health and influence GWG and BW should consider both the volume and intensity.

This section, which examined the association of PA and GWG as well as BW in detail according to intensity, type, and timing, is the first study of its kind in an Asian population. Such a detailed study is beneficial to define characteristics such as intensity, volume, and trimester in order to plan effective interventions.

We believe our results will be useful in the promotion of health improvements for Chinese women and their infants.

Maternal and infant health is always a hot topic in society. PA, GWG, and BW are key issues. This dissertation aimed to reveal the relationship between these three factors to obtain useful information for guiding behavior during pregnancy. To achieve this, three well-designed studies were carried out step by step. In the beginning, this dissertation explored and identified a suitable, high validity tool to measure PA in pregnant Chinese women. Then, to understand the effect of the modifiable lifestyle factor of PA during pregnancy on maternal GWG and infant BW, the lifestyle characteristics of pregnant Chinese women and PA classified by intensity and type using the validated PPAQ-C tool were investigated. Finally, to thoroughly research the relationship of these factors during pregnancy, a further study was conducted to examine the effect of PA on GWG as well as BW according to intensity, type, and timing among pregnant Chinese women.

One feature of this dissertation is that we collected data from three trimesters using validated tools for pregnancy PA, such as household activity,

and measured PA during pregnancy by intensity and type, which few studies have investigated. To date, existing research has not presented a complete portrait of the effect of PA on GWG and infant BW and has been unable to define features of effective interventions to assist women in controlling GWG and BW, as they have not included detailed information about PA during pregnancy, including the intensity, type, and trimester of PA. Furthermore, our study was the first to examine the effect of PA during pregnancy on GWG as well as BW according to all of the above determinants, including volume, intensity, type, and timing of PA, thus filling a gap in this field. These findings are very useful to guide effective interventions and can help to develop intervention guidelines to control GWG and BW, as current guidelines are insufficient and new guidelines are urgently needed not only in Asia but also in Western countries. It can also help reduce the risk of diseases such as maternal cardiovascular disease and numerous deleterious health consequences in adulthood due to inadequate GWG and BW and promote the health of pregnant women and their children, especially in Asian populations. Additionally, the PPAQ-C was proven to be a validated tool that can be widely used in other studies regarding the level of PA during pregnancy among Chinese women, and it also can facilitate development in other

fields in China.

5.2 Limitation

As we had employed the questionnaire as the investigative tool in this dissertation, there were some inevitable limitations, and various methods were adopted to avoid or alleviate these problems. First, participants were recruited from only one city, which may not create a generalizable result for all Chinese populations. To alleviate this problem, we chose a large city with both rural and urban regions so that the results could be applied to similar social environments elsewhere in China. Secondly, the PA of pregnant women was self-reported. To alleviate this, we used the PPAQ-C questionnaire, which was designed specifically to assess the PA of pregnant women and which was certified to have high validity when comparing the objective measurements of PA with accelerometers. Moreover, the questionnaire reduced participant burden and the ability to assess PA type (e.g., exercise, household) and intensity perceptions. Thirdly, because of preterm delivery, changing hospitals before delivery, and disconnected telephones, some follow-up work could not be finished. However, the missing participants did not differ significantly from the included participants regarding sociodemographic factors that would affect the final

results.

5.3 Future suggestion

Pregnancy is a special and important period for both women and their children. However, large sample sizes and long-term observation are needed to thoroughly study this topic. This work was completed only in three years; therefore, some improvements can be made in the future. Here, we present three main suggestions for future work.

Firstly, the PPAQ-C was translated from the template used in the United States and was used in China for the first time in this study. We made some revisions for the Chinese, but there are still some parts that need to be improved, such as walking while at home. We also found many places where revisions could be made by reviewing the statistical results. From the point of statistics, we could further modify the PPAQ-C by decreasing some redundant factors, such as garden activities, or increasing and combining some factors such as TV time. These improvements will be beneficial, enabling the collection of more useful and effective data and also reduce the cost and time required for the survey and improve the participants' willingness to complete the survey.

Secondly, some features of pregnancy and infancy are likely to result in

behavior changes to reduce maternal and infant disease risk. For instance, women seem to change their behavior during pregnancy periods to benefit their children. If effective interventions start during pregnancy and continue after birth, this can effectively reduce the risk of maternal and infant diseases, which successfully interrupts the negative intergenerational cycle. Therefore, further research on the long-term effects of PA during pregnancy on maternal health and fetal development is important.

Thirdly, we hope the results and findings of this work will be used as health improvement and behavior guidelines for pregnant women. That is our ultimate final goal, and we hope that studies on interventions among pregnant Chinese women will be conducted in the future.

5.4 Conclusion

In summary, PPAQ-C was proven to be a validated tool that can be widely used to assess PA for pregnant Chinese women. Pregnant Chinese women have a high total PA, tend to spend a significant amount of time on low-intensity activities rather than high-intensity activities, and commonly consume an excessive amount of energy from fat. Exercise habits before pregnancy and previous live births influenced their PA during pregnancy. These findings are

useful for designing interventions for improving PA of Chinese women during pregnancy. In addition, Chinese women with the highest levels of PA during the third trimester had a significantly decreased risk of inadequate GWG or excessive GWG. Women who met PA recommendations in the second and third trimester had infants with significantly lower BW. These findings support that increasing of PA during the pregnancy is an effective way to improve maternal and child health for the Chinese population.

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ID:

姓名：_____

孕妇身体活动量调查问卷

回答方法：

请使用铅笔或圆珠笔作答，在你认为合适的选项前的方框里画钩☑。

例 ：在最近一个月，当您没有在工作时，通常你会花多少时间做以下活动：

如果您每天照顾您母亲 2 个小时，您的答案应该是 ⟶

E1. 照顾老人

☐ 无

☐ 每天小于半小时 **（不足半小时）**

☐ 每天半小时到1小时之间 **（不足1小时）**

☐ 每天1到2小时 **（不足2小时）**

☑ 每天2到3小时 **（不足3小时）**

☐ 每天3小时或以上

在本调查中，请您如实填写有关情况。调查中并没有对或错的答案，我们只是想了解您 最近一个月的平均体力活动 情况。

1. 填写日期：_____年_____月_____日

2. 今天是怀孕第几周： 第_____周

3. 您的预产期：_____年_____月_____日

家务及照料老人小孩

在最近一个月里，工作以外时间，平均每天你会花多少时间做以下活动：

4. 准备膳食（做饭，摆设餐具，洗碗）

☐ 无

☐ 每天小于半小时

☐ 每天半小时到1小时之间

☐ 每天1到2小时

☐ 每天2到3小时

☐ 3小时或以上

5. 在坐着的状态下，着衣，洗浴，喂孩子

☐ 无

☐ 每天小于半小时

☐ 每天半小时到1小时之间

☐ 每天1到2小时

☐ 每天2到3小时

☐ 3小时或以上

6. 在站着的状态下，给小孩衣装打扮，洗浴，喂饭

☐ 无
☐ 每天小于半小时
☐ 每天半小时到1小时之间
☐ 每天1到2小时
☐ 每天2到3小时
☐ 3小时或以上

7. 坐着或站立的状态下，与小孩玩耍

☐ 无
☐ 每天小于半小时
☐ 每天半小时到1小时之间
☐ 每天1到2小时
☐ 每天2到3小时
☐ 3小时或以上

8. 奔跑或行走的状态下，与小孩玩耍

☐ 无
☐ 每天小于半小时
☐ 每天半小时到1小时之间
☐ 每天1到2小时
☐ 每天2到3小时
☐ 3小时或以上

9. 抱小孩走

☐ 无
☐ 每天小于半小时
☐ 每天半小时到1小时之间
☐ 每天1到2小时
☐ 每天2到3小时
☐ 3小时或以上

10. 照顾老人

☐ 无
☐ 每天小于半小时
☐ 每天半小时到1小时之间
☐ 每天1到2小时
☐ 每天2到3小时
☐ 3小时或以上

11. 余暇（非工作）时坐着使用电脑或写东西

☐ 无
☐ 每天小于半小时
☐ 每天半小时到1小时之间
☐ 每天1到2小时
☐ 每天2到3小时
☐ 3小时或以上

12. 看电视或录像

☐ 无
☐ 每天小于半小时
☐ 每天半小时到2小时之间
☐ 每天2到4小时
☐ 每天4到6小时
☐ 6小时或以上

13. 余暇(非工作)时坐着阅读，聊天或打电话

☐ 无
☐ 每天小于半小时
☐ 每天半小时到2小时之间
☐ 每天2到4小时
☐ 每天4到6小时
☐ 6小时或以上

14. 和宠物玩耍

☐ 无
☐ 每天小于半小时
☐ 每天半小时到1小时之间
☐ 每天1到2小时
☐ 每天2到3小时
☐ 3小时或以上

15. 轻体力家务（铺床，洗熨，收拾物品等）

☐ 无
☐ 每天小于半小时
☐ 每天半小时到1小时之间
☐ 每天1到2小时
☐ 每天2到3小时
☐ 3小时或以上

16. 购物（食物，衣物或其他物品等）

☐ 无
☐ 每天小于半小时
☐ 每天半小时到1小时之间
☐ 每天1到2小时
☐ 每天2到3小时
☐ 3小时或以上

17. 重体力家务（吸尘器吸尘，拖地，檫窗户等）

☐ 无
☐ 每周小于半小时
☐ 每周半小时到1小时之间
☐ 每周1到2小时
☐ 每周2到3小时
☐ 3小时或以上

18.用自动除草机除草

☐ 无
☐ 每周小于半小时
☐ 每周半小时到1小时之间
☐ 每周1到2小时
☐ 每周2到3小时
☐ 3小时或以上

19.用手扶式除草机或耙子等园艺工具除草

☐ 无
☐ 每周小于半小时
☐ 每周半小时到1小时之间
☐ 每周1到2小时
☐ 每周2到3小时
☐ 3小时或以上

交通活动

最近一个月里，在工作以外的时间，平均每天你会花多少时间做以下活动：

20. 不是为了休闲或健身，而是为了去某个地方（如去坐公交，去上班或去拜访他人等）慢走

☐ 无
☐ 每天小于半小时
☐ 每天半小时到1小时之间
☐ 每天1到2小时
☐ 每天2到3小时
☐ 3小时或以上

21. 不是为了休闲或健身，而是为了去某个地方（如去坐公交，去上班或学校等）快走

☐ 无
☐ 每天小于半小时
☐ 每天半小时到1小时之间
☐ 每天1到2小时
☐ 每天2到3小时
☐ 3小时或以上

21-1. 不是为了休闲或健身，而是为了去某个地方（如去坐公交，去上班或去拜访他人等）骑自行车

☐ 无
☐ 每天小于半小时
☐ 每天半小时到1小时之间
☐ 每天1到2小时
☐ 每天2到3小时
☐ 3小时或以上

22.开车或乘电车和公交车去某地

☐ 无
☐ 每天小于半小时
☐ 每天半小时到1小时之间
☐ 每天1到2小时
☐ 每天2到3小时
☐ 3小时或以上

休闲锻炼

在最近一个月里，在工作以外的时间，平均每天你会花多少时间进行休闲锻炼：

23. 以休闲或锻炼为目的的慢步行走

☐ 无
☐ 每周小于半小时
☐ 每周半小时到1小时之间
☐ 每周1到2小时
☐ 每周2到3小时
☐ 3小时或以上

24. 以休闲或锻炼为目的的快步行走

☐ 无
☐ 每周小于半小时
☐ 每周半小时到1小时之间
☐ 每周1到2小时
☐ 每周2到3小时
☐ 3小时或以上

25. 以休闲或锻炼为目的的快步上坡

☐ 无
☐ 每周小于半小时
☐ 每周半小时到1小时之间
☐ 每周1到2小时
☐ 每周2到3小时
☐ 3小时或以上

26. 慢跑

☐ 无
☐ 每周小于半小时
☐ 每周半小时到1小时之间
☐ 每周1到2小时
☐ 每周2到3小时
☐ 3小时或以上

27. 产前运动班（瑜伽，水中走路等）课程名称：_____

☐ 无
☐ 每周小于半小时
☐ 每周半小时到1小时之间
☐ 每周1到2小时
☐ 每周2到3小时
☐ 3小时或以上

28. 游泳

☐ 无
☐ 每周小于半小时
☐ 每周半小时到1小时之间
☐ 每周1到2小时
☐ 每周2到3小时
☐ 3小时或以上

29. 跳舞

☐ 无
☐ 每周小于半小时
☐ 每周半小时到1小时之间
☐ 每周1到2小时
☐ 每周2到3小时
☐ 3小时或以上

如果您有参加其他的休闲或锻炼活动，请告诉我们：

30. _____（活动名称）

☐ 每周小于半小时
☐ 每周半小时到1小时之间
☐ 每周1到2小时
☐ 每周2到3小时
☐ 3小时或以上

31. _____（活动名称）

☐ 每周小于半小时
☐ 每周半小时到1小时之间
☐ 每周1到2小时
☐ 每周2到3小时
☐ 3小时或以上

工作活动

如果您依然在工作，或在做义工，或者您还是学生，请填写以下部分。如果您是家庭主妇，失业或不能工作则无需填写。

※以下的“工作”，包括拿工资的工作，也包括做义工及学生生活的活动

在最近一个月里，工作时间期间平均每天你会花多少时做以下活动：

32. 坐着的状态，工作或上课

☐ 无
☐ 每天小于半小时
☐ 每天半小时到2小时之间
☐ 每天2到4小时
☐ 每天4到6小时
☐ 6小时或以上

33. 工作时负重（重量超过约 3 公斤）站立或者慢走

☐ 无
☐ 每天小于半小时
☐ 每天半小时到2小时之间
☐ 每天2到4小时
☐ 每天4到6小时
☐ 6小时或以上

34. 工作时无负重的站立或者慢走

☐ 无
☐ 每天小于半小时
☐ 每天半小时到2小时之间
☐ 每天2到4小时
☐ 每天4到6小时
☐ 6小时或以上

35. 工作时负重（重量超过约 3 公斤）快速行走

☐ 无
☐ 每天小于半小时
☐ 每天半小时到2小时之间
☐ 每天2到4小时
☐ 每天4到6小时
☐ 6小时或以上

36. 工作时无负重的快速行走

☐ 无
☐ 每天小于半小时
☐ 每天半小时到2小时之间
☐ 每天2到4小时
☐ 每天4到6小时
☐ 6小时或以上

感谢您的填写，如有疑问请写在下面的空白处。