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Maternal hand grip strength in pregnancy, newborn sex and birth weight

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ABSTRACT

Aim: Hand grip strength (HGS) is a non-invasive measure of physical strength, overall health, and nutritional status. The aim of the study was to test if HGS and its changes in pregnancy are related with offspring sex and birth weight.

Methods: We conducted longitudinal study on 95 healthy pregnant women (mean age 29.57 ± 3.43). HGS was measured in each trimester. A woman's height and changes in weight in pregnancy were also measured. The information on a child's sex, birth weight and the pregnancy week at delivery were derived from hospital records. Fifty one women delivered a boy, and forty four women delivered a girl.

Results: HGS decreased from the first to the third trimester of pregnancy ($F(2,188) = 15.94$, $p < 0.001$). Women with greater HGS in each trimester were more likely to give birth to a boy ($p < 0.05$), and the decrease in HGS in pregnancy was comparable in the two groups of mothers ($F(2,186) = 1.39$, $p = 0.25$). HGS in pregnancy was related with offspring birth weight when controlled for a child's sex and week at delivery ($F(2,182) = 3.15$, $p = 0.04$). Maternal height also important predictor of HGS in pregnancy, and the decrease in HGS was only observed in shorter women.

Conclusion: The results of this study indicate that HGS is a sensitive marker, differentiating the variation in physical condition in healthy, well-fed pregnant women in affluent population and pregnancy outcome (offspring sex and birth weight). Also, the result indicates that relatively taller women bear lower cost of pregnancy and are able to invest more in developing foetus.

1. Introduction

Pregnancy involves increased nutritional and metabolic demands, changes in maternal physiology, which requires significant additional energetic expenditure [1,2]; and may alter a woman's nutritional status, and thus her muscle strength. Total energy cost of pregnancy for women is estimated for c.a. 325 MJ [2], thus adequate energy stores and nutritional status of a pregnant woman are important for optimal pregnancy outcome, a child's prenatal and postnatal growth, and to prevent perinatal morbidity and mortality [2].

Hand grip strength (HGS) is a simple, non-invasive method of muscle strength and function measurement, and also a good indicator of an individual's overall health and nutritional status [3]. In clinical practice, HGS was shown to predict e.g. postoperative complications [4], patients' nutritional status and recovery pace, current and future health, risk of disability, morbidity, and mortality [5,6]. As HGS is related to physical and health, it may be also a useful, non-invasive indicator of general condition and physiological burden, born by a woman in pregnancy. Although pregnancy involves a great physiological cost for women, is characterized by a series of physiological, psychological and physical alterations, including musculoskeletal changes, there is little data on women's hand grip strength during pregnancy. Cross-sectional studies showed lower HGS in pregnant women compared to non-pregnant [7]. However, there is no longitudinal data on HGS in pregnancy as a measure of a pregnant woman's condition.

There is also no data showing if maternal hand grip in pregnancy may be related to offspring neonatal condition. Many traits related to a woman's biological condition are also related with her offspring's neonatal characteristics, reflecting its general condition. Maternal height and weight, signals of maternal health, well-being and non-specific indices of prior environmental sufficiency [8,9], have been shown to be related to offspring neonatal size and health [9,10]. Birth size is a crucial marker of prenatal exposures, related not only to neonatal survival [11], but also to many adult health problems, such as hypertension and obesity risk [12]. Since traits indicating a woman's biological condition are related with offspring sex ratio or neonatal characteristics [10], it is likely that if HGS reflects maternal condition in pregnancy, is should be also related to human foetal development and therefore an offspring neonatal birth weight.

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Hand grip strength in pregnancy should also differ, depending on traits indicating a woman's general condition. Inskip et al. [13] showed that taller women have greater hand grip strength at 19th pregnancy week, compared to shorter women, but they did not investigate longitudinal changes in grip strength in pregnancy. As HGS is positively related with height [5], it is not clear if pregnancy influenced hand grip strength in women or it was a result of normal differences between shorter and taller women, observed also in non-pregnant women. Maternal height is a proxy for nutrition status during development, and is used as a marker of long-term health, potentially related to female condition while bearing the cost of pregnancy [14] and risk of complications during labour [15–17]. Similarly, maternal weight before and in gestation may also be related to her hand grip strength in pregnancy, as well-nourished women seem to pay lesser energetic physiological cost of pregnancy [18].

Thus, the aim of this study is to test longitudinally if a woman's hand grip strength changes during the course of pregnancy. We will also test if maternal hand grip strength in pregnancy is related to foetal sex or offspring birth weight. Finally we will, test if HGS in pregnancy is related to a woman's height or body weight, morphological cues related to a long-term individual's condition, confirming suitability of HGS as a measure of maternal condition in gestation.

2. Methods

Participants were recruited through positing to pregnancy-related websites, leaflets, information in local newspapers and on the radio. One hundred twenty six women started the research project, after signing an informed consent. Due to various reasons (miscarriage, relocation etc.) eleven participants left the project. Seventeen participants were discarded due to smoking or the inability to participate in one of the stages of the study. As multiple gestation imposes a greater biological cost and potentially might influence HGS, twin pregnancies were excluded from the study ($N = 2$). Also, due to hormonal disturbances we have excluded pregnancies resulting from IVF ($N = 3$).

Using this exclusionary criteria, we obtained the sample of 95 pregnant women without chronic, or pregnancy-related health problems, ranging in age from 21 to 36 years (M ± SD = 29.57 ± 3.43). Most of the participants graduated from the university ($N = 85$) or high school ($N = 10$). Over 80% of the pregnancies were the first pregnancy. All participants reported at least average (for the country) economic status (based on the household income). None of those variables were related to a woman's hand grip strength (for each variable $p > 0.05$). Participants declared having mental labour ($N = 88$) and light physical labour ($N = 7$). Type of a woman's work did not influence her HGS ($p > 0.05$). Fifty seven women in the 2nd trimester, and eighteen in the 3rd trimester, continued professional work, but those were only white-collar workers. None of the participants were recommended bed rest during pregnancy and none of them declared health problems during pregnancy.

Participants visited the laboratory three times during the course of pregnancy. The first visit was scheduled up to 12th week of pregnancy (1st trimester); the second was scheduled around 21st (2nd trimester), and the third around 33rd pregnancy week (3rd trimester). A week of pregnancy was calculated as the difference between date of conception, given by a gynaecologist in a pregnancy book, and the date of participation in each of the research stages. All procedures and study design were accepted by a local ethics committee (DIL, Wrocław, Poland).

Hand grip strength was measured at each pregnancy trimester. Each time, participants were shown how to use a handheld dynamometer. HGS was measured in kilograms force (kgs). Participants were asked to perform a maximum-force trial for each hand. Measurements were recorded in on two separate squeezes from each hand. The arithmetical mean of the maximum value of right- and left-hand measurements was calculated for each pregnancy trimester. Previous research showed no difference if the maximum value with that of the average value of the consecutive measurements of grip strength is used in the analyses [19]. The correlations between maximum and the average value of HGS measurements were as follow: 1st trimester: $r = 0.98$; $p < 0.001$; 2nd trimester: $r = 0.96$, $p < 0.001$; 3rd trimester: $r = 0.91$, $p < 0.001$.

Height was measured with anthropometer to the nearest 0.1 cm during the first visit. Weight was measured to the nearest 0.1 kg at each pregnancy trimester. Pregravid BMI was calculated based on pregravid weight, reported by a woman, and height measured at the first visit. The correlation between reported pregravid weight and body weight measured in the first trimester was high ($r = 0.97$, $p < 0.001$), showing little weight change since conception to the first visit. Weight change in the studied pregnancy period was calculated as the difference between the weight measured in the third and the first trimester.

Women also completed a questionnaire on their age, demographic data, type of work, pre-pregnancy weight, general health, sport practice during pregnancy, sex of the baby. None of the women reported a significant reduction in their daily activity during pregnancy and none practiced sport professionally before pregnancy.

After the delivery, women also reported a child's birth weight and the pregnancy week at delivery, information derived from hospital records, and confirmed the sex of the baby. Fifty one women delivered a boy, and forty four women delivered a girl.

Changes in hand-grip strength during pregnancy were analysed with ANOVA for repeated measurements test. The post-hoc analyses were performed with Tukey test. The difference in HGS between women who worked in pregnancy and women who were on pregnancy leave was tested with *t*-test. The difference in continuous variables (height, weight, BMI) between mothers of sons and mothers of daughters were also tested with *t*-test. Pearson's correlation coefficient was used to test the relationship between height, weight and HGS at each trimester. GLM model was used to test the relationship between maternal height and weight, child's sex and birth weight and changes in the hand-grip strength during the course of pregnancy. Regression analyses were used to analyse the relationship between maternal height and a child's birth weight, controlled for child's sex and pregnancy week at delivery. The results at $p < 0.05$ were interpreted as significant. Analyses were performed with Statistica analysis package version 12.0 for Windows.

3. Results

Descriptive statistics for the analysed variables are presented in the Table 1. Hand grip strength (HGS) decreased from the first to the third trimester of pregnancy ($F(2,188) = 15.04$, $p < 0.001$). The post hoc analyses showed that HGS in the second trimester was lower than in the first trimester ($p = 0.02$), and in the third trimester was lower than in

Table 1
Descriptive statistics for the analysed variables ($N = 95$).

	Mean	Min	Max	SD
Right HGS I [kg]	29.40	14.00	40.00	4.66
Left HGS I [kg]	27.55	14.00	42.00	4.64
Right HGS II [kg]	28.65	14.00	40.00	5.19
Left HGS II [kg]	27.01	14,00	39.00	4.79
Right HGS III [kg]	28.00	14,00	40.00	5.76
Left HGS III [kg]	25.95	14,00	38.00	5,45
HGS I [kg]	28.47	14.00	41.00	4.36
HGS II [kg]	27.83	14.00	38.50	4.77
HGS III [kg]	26.98	14.00	39.00	5.42
Height [cm]	166.57	154,40	180.50	6.22
Pregravid BMI [kg/m^2]	22.99	16.07	34.01	3.76
Body weight I [kg]	65.03	47.68	95.02	11.44
Body weight II [kg]	69.39	51.26	98.70	11.54
Body weight III [kg]	74.47	56.09	103.92	11.56
Difference in body weight [kg]	9.31	2.01	16.14	2.99
Child's neonatal weight [g] - boys	3586.86	2520.00	4400.00	452.08
Child's neonatal weight [g] - girls	3396.36	2780.00	4300.00	346.32
Pregnancy time [weeks]	39.76	37	42	1.10