Fakultät Wissenschaftszentrum Weihenstephan für Ernährung, Landnutzung und Umwelt

Lehrstuhl für Ernährungsmedizin

Effects of lifestyle counselling in the antenatal routine care setting on dietary behaviour and maternal and offspring weight development

Julia Katharina Günther

Vollständiger Abdruck der von der Fakultät Wissenschaftszentrum Weihenstephan für Ernährung, Landnutzung und Umwelt der Technischen Universität München zur Erlangung des akademischen Grades eines

Doktors der Naturwissenschaften

genehmigten Dissertation.

Vorsitzender:	Prof. Dr. Martin Klingenspor
Prüfer der Dissertation:	1. Prof. Dr. Johann J. Hauner
	2. Prof. Dr. Regina Ensenauer

Die Dissertation wurde am 19.09.2019 bei der Technischen Universität München eingereicht und durch die Fakultät Wissenschaftszentrum Weihenstephan für Ernährung, Landnutzung und Umwelt am 02.03.2020 angenommen.

Table of contents

Tables and Figures

Tables

Figures

Abstract

Maternal overweight and excessive gestational weight gain (GWG) increase the risk of pregnancy and obstetric complications such as gestational diabetes and associated future health problems including obesity both in the mother and the offspring. Interventions aimed to modify the lifestyle of pregnant women and to normalise GWG. These interventions were almost exclusively conducted in controlled research settings. To ensure applicability at the population level, it remains to be addressed whether lifestyle counselling can effectively reduce GWG when performed directly in the setting of routine care.

Counselling in the antenatal care system was the subject of the **FeLIPO** (**Fe**asibility of a **li**festyle-intervention in **p**regnancy to **o**ptimise maternal weight development) pilot study and the subsequent large-scale **GeliS** ("**Ge**sund **l**eben **i**n der **S**chwangerschaft" /healthy living in pregnancy) trial. This thesis elucidates the effects of the FeLIPO lifestyle counselling on maternal and offspring weight one year after delivery as well as the effectiveness of the GeliS intervention in modifying maternal dietary behaviour, reducing excessive GWG and decreasing pregnancy complications. Furthermore, associations between the maternal diet and GWG as well as offspring birth weight were investigated in the pooled GeliS cohort.

In both trials, counselling was attached to routine care visits and focused on optimising maternal weight gain, a healthy antenatal diet and physical activity. In the cluster-randomised FeLIPO study (n=250 participants), the intervention group (IV) received two counselling sessions by a dietary expert, whereas in the multi-centre, cluster-randomised, controlled GeliS trial (n=2286 participants), the intervention comprised three prenatal and one early postpartum counselling sessions given by trained medical personnel, a midwife or a gynaecologist. Women in the control groups (CG) of both trials attended routine antenatal care appointments and were provided with flyers about a healthy prenatal lifestyle. Data on maternal and offspring weight, health and maternal dietary behaviour were collected from maternity and birth records and via food frequency questionnaires.

Although counselling in the **FeLIPO** trial successfully reduced the rate of excessive GWG, maternal weight retention at 12 months postpartum was not significantly lower in the IV (IV: 0.2 kg, CG: 0.8 kg, p=0.321). However, less women in this group retained more than 5 kg weight postpartum (IV: 8%, CG: 17%, p=0.044). The body weight of infants was by trend lower in the IV (IV: 9382 g, CG: 9736 g, p=0.099).

In the **GeliS** trial, lifestyle counselling had no significant effect on the rate of women with excessive GWG (IV: 45.1%, CG: 45.7%, p=0.789) and pregnancy complications such as gestational diabetes. Dietary counselling in the GeliS trial was not successful in modifying

energy intake (IV: 2000 kcal/day, CG: 2011 kcal/day, p=0.724). Intake of vegetables (IV: 201 g, CG: 176 g, p=0.023) and fish (IV: 15 g, CG: 12 g, p=0.002) were increased in the IV. Soft drink consumption was higher in women allocated to the CG (IV: 155.45 mL/day, CG: 235.36 mL/day, p<0.001). Diet quality rated with the Healthy Eating Index (HEI) was not consistently influenced by the intervention (IV: 59.3 points, CG: 57.6 points, p=0.162). In the pooled cohort, the consumption of animal products, sweets and fast food was positively associated with GWG. Fruit intake, vegetable intake and the HEI were positively associated with birth weight, while there was evidence of an inverse correlation between infant weight at birth and saccharose, soft drink and alcohol consumption.

In conclusion, the maternal antenatal diet played a significant role in pregnancy and infant weight development. However, inducing changes in the prenatal lifestyle through an intervention delivered by health care providers within the routine care system is challenging. While the pilot intervention involving a dietary expert was effective in reducing GWG, this finding could not be replicated in the large-scale GeliS trial. Future approaches should consider cooperation with experts and counselling should emphasise the moderation of energy consumption to enhance the prospects of success in optimising weight development and health in mothers and their offspring.

Zusammenfassung

Ein erhöhtes Körpergewicht sowie eine übermäßige Gewichtszunahme in der Schwangerschaft bringen kurz- und langfristige Risiken für Mutter und Kind mit sich. Diese umfassen Schwangerschaftskomplikationen wie Gestationsdiabetes, aber auch ein erhöhtes Adipositasrisiko. Aus diesem Grund wurden verschiede Konzepte der Lebensstilberatung entwickelt. Jedoch wurden Interventionsstrategien bisher fast ausschließlich unter sehr kontrollierten und daher praxisfernen Bedingungen erprobt.
Um ein auf Bevölkerungsebene umsetzbares Beratungskonzept zu etablieren, wurden in der Pilot-Studie **FeLIPO** („**Fe**asibility of a **li**festyle-intervention in **p**regnancy to **o**ptimise maternal weight development“) und der daraus entstandenen großangelegten **GeliS**-Studie (**Ge**sund **le**ben **i**n der **S**chwangerschaft) die Auswirkungen einer Lebensstilberatung, die in das Vorsorgesystem integriert wurde, evaluiert. In der vorliegenden Arbeit wurde der Effekt der in der FeLIPO-Studie durchgeführten Beratung auf die postpartale Gewichtsentwicklung von Frauen und ihren Kindern untersucht. Schwerpunktmäßig wurde die Effektivität der GeliS-Intervention, das Ernährungsverhalten der Frauen zu verbessern und dadurch einer übermäßigen Gewichtszunahme sowie Geburtskomplikationen vorzubeugen, evaluiert. Darüber hinaus wurden Assoziationen zwischen dem Ernährungsverhalten und der mütterlichen Gewichtszunahme, sowie dem Geburtsgewicht der Kinder in der gesamten GeliS-Kohorte untersucht.

Mit dem primären Ziel, einer exzessiven Gewichtszunahme vorzubeugen, wurden Frauen in beiden Studien hinsichtlich gesunder Ernährung und ausreichend körperlicher Bewegung beraten. Die Gespräche wurden im Rahmen der Routinevorsorge durchgeführt. In der cluster-randomisierten FeLIPO-Studie (n=250 Teilnehmerinnen) erhielten Frauen in der Interventionsgruppe (IV) im Laufe der Schwangerschaft zwei Beratungseinheiten von einer Ernährungsexpertin. In der multizentrischen, cluster-randomisierten, kontrollierten GeliS-Studie (n=2286 Teilnehmerinnen) wurden drei Gespräche während der Schwangerschaft und eines kurz nach der Geburt von zuvor geschulten medizinischen Fachangestellten, Hebammen und Gynäkologen durchgeführt. Frauen in den Kontrollgruppen (CG) beider Studien erhielten neben der Routinevorsorge Informationsblätter mit allgemeinen Ratschlägen zu einem gesunden Lebensstil in der Schwangerschaft. Daten zur mütterlichen und kindlichen Gewichtsentwicklung sowie der maternalen Ernährungsweise wurden über Mutterpässe, Geburtenprotokolle und Fragebögen erhoben.

Die **FeLIPO**-Intervention, die zu einer Verringerung der Gewichtszunahme in der Schwangerschaft geführt hatte, wirkte sich nicht nachweisbar auf die Gewichtsretention der

Mütter ein Jahr nach der Geburt aus (IV: 0.2 kg, CG: 0.8 kg, p=0.321). Jedoch war der Anteil an Frauen mit einem Gewichtsbehalt über 5 kg in der Interventionsgruppe geringer (IV: 8%, CG: 17%, p=0.044). Bei den Kindern zeigte sich ein Trend zu einem etwas geringeren Körpergewicht zum Ende des ersten Lebensjahres (IV: 9382 g, CG: 9736 g, p=0.099).
Durch die **GeliS**-Intervention konnte der Anteil der Frauen mit übermäßiger Gewichtszunahme in der Schwangerschaft nicht gesenkt werden (IV: 45.1% vs. CG: 45.7%, p=0.789) und Komplikationen wie Gestationsdiabetes nicht effektiv verhindert werden. Die Ernährungsberatung bewirkte keine Einschränkung der Energiezufuhr (IV: 2000 kcal/Tag, CG: 2011 kcal/Tag, p=0.724), erzielte aber Anpassungen im mütterlichen Ernährungsverhalten. Frauen, die die Beratung erhielten, verzehrten im Mittel mehr Gemüse (IV: 201 g, CG: 176 g, p=0.023) und Fisch (IV: 15 g, CG: 12 g, p=0.002) und reduzierten den Konsum energiehaltiger Getränke (IV: 155 g, CG: 235 g, p<0.001). Die mit einem Index bewertete Ernährungsqualität konnte nicht signifikant verbessert werden (IV: 59.3 Punkte, CG: 57.6 Punkte, p=0.162). Ein positiver Zusammenhang mit der Gewichtszunahme in der Schwangerschaft wurde für den Konsum tierischer Lebensmittel, aber auch von Süßigkeiten und Fast Food beobachtet. Das Geburtsgewicht der Kinder war positiv mit dem Konsum von Obst und Gemüse sowie der allgemeinen Ernährungsqualität assoziiert. Der Konsum weniger gesund bewerteter Komponenten wie Zucker, energiehaltiger Getränke und Alkohol war in der GeliS-Kohorte negativ mit dem Geburtsgewicht der Kinder assoziiert.

Insgesamt schien die Ernährung der Frauen während der Schwangerschaft eine wichtige Rolle für die maternale und fötale Gewichtsentwicklung zu spielen. Besonders innerhalb der Routineversorgung ist es eine große Herausforderung, Veränderungen im Lebensstil schwangerer Frauen zu bewirken. Während eine Beratung durch eine Ernährungsfachkraft in der Pilotstudie Erfolge erzielen konnte, blieb bei der Beratung durch geschultes medizinisches Personal in der GeliS-Studie der gewünschte Effekt auf die maternale Gewichtszunahme aus. Zukünftige Ansätze sollten daher eine Zusammenarbeit mit Fachexperten erwägen und in der Beratung besonderen Wert auf eine moderate Energiezufuhr legen, um ihre Erfolgsaussichten zu erhöhen, die Gewichtsentwicklung und die Gesundheit von Mutter und Kind nachhaltig positiv zu beeinflussen.

List of Abbreviations

ACOG	American College of Obstetrics and Gynaecology
BMI	body mass index
C	counselling session
CG	control group
CH	carbohydrates
CI	confidence interval
DEGS	“Studie zur Gesundheit Erwachsener in Deutschland“ / German Health Interview and Examination Survey for Adults
DGE	German Nutrition Society
DHA	docosahexaenoic acid
DHHS	Department of Health and Human Services
E%	percentage of energy intake
FAO	Food and Agriculture Organization
FeLIPO	Feasibility of a lifestyle-intervention in pregnancy to optimise maternal weight development
FFQ	food frequency questionnaire
GDM	gestational diabetes mellitus
GeliS	“Gesund leben in der Schwangerschaft“ / healthy living in pregnancy
GI	glycaemic index
GL	glycaemic load
GWG	gestational weight gain
HbA_{1c}	glycosylated haemoglobin A_{1c}
HEI	Healthy Eating Index
IOM	Institute of Medicine
IPD	individual participant data
IV	intervention group
i-WIP	The International Weight Management in Pregnancy Collaborative Group
LGA	large for gestational age
LGI	low glycaemic index
MRI	Max Rubner Institute
oGTT	oral glucose tolerance test
OR	odds ratio
PA	physical activity
pp	postpartum
PPWR	postpartum weight retention

PUFAs	polyunsaturated fatty acids
Q	questionnaire
RADIEL	The Finnish Gestational Diabetes Prevention Study
RCT	randomised controlled trial
RKI	Robert Koch Institute
SGA	small for gestational age
T0	data collection before or in the 12th week of gestation
T1	data collection after the 29th week of gestation
UNU	United Nations Unified
UPBEAT	UK Pregnancies Better Eating and Activity Trial
V0	screening visit
WHO	World Health Organization

1 Introduction

1.1 The importance of maternal body weight

Over the last years, maternal body weight during pregnancy and associated health parameters including metabolic and cardiovascular risks have become a subject of major interest. The prevalence of obesity in women of reproductive age as well as mean gestational weight gain (GWG) have increased in Germany (Mensink et al. 2013; Bergmann et al. 2007) and worldwide during the last decades (Chooi et al. 2019; Johnson et al. 2015). Obesity in pregnancy and excessive GWG bear numerous risks for both mothers and their unborn children. Both are discussed to increase for example the risk of gestational diabetes mellitus (GDM) (Brunner et al. 2015; Hedderson et al. 2010; Torloni et al. 2009), gestational hypertension (Ren et al. 2018; Gaillard et al. 2013; Liu et al. 2012) and delivery via caesarean section (Margerison Zilko et al. 2010; Poobalan et al. 2009). Excessive weight gain in pregnancy is additionally associated with postpartum (pp) maternal weight retention (PPWR) (Nehring et al. 2011) and bears a long-term risk for the development of post-gestational overweight and obesity (Mannan et al. 2013; Mamun et al. 2010). Furthermore, body weight development and health of the offspring seem to be affected by maternal obesity and excessive GWG. Both have been linked to an increased risk for large for gestational age (LGA) newborns (Cosson et al. 2016; Black et al. 2013) and are discussed to promote overweight and obesity in childhood (Tie et al. 2014; Ensenauer et al. 2013; Yu et al. 2013) and beyond (Mamun et al. 2014; Pirkola et al. 2010).

While the prevention of obesity needs to start prior to conception, adequate GWG can still be targeted in the course of pregnancy. Accordingly, guidelines for an adequate range of GWG have been developed and published by the American Institute of Medicine (IOM) in 1990 and have been updated in 2009 (IOM 2009, 1990). Depending on the pre-pregnancy body mass index (BMI), the IOM recommends ranges for adequate GWG (**Table 1**). Inadequate and excessive GWG, describing weight gain below or above these guidelines, respectively, are both associated with risks for maternal and foetal health and should thus be prevented (IOM 2009).

1.2 A healthy antenatal lifestyle

A healthy lifestyle is crucial for maternal and offspring pre- and postnatal weight development and health and is worthwhile to be promoted. Maternal antenatal behaviour has received increasing attention over the last decades. The information provided in the following focuses on the recommendations developed by the “Healthy Start – Young Family Network” (Koletzko et al. 2018; Koletzko et al. 2013). Harmonising official statements and publications from

institutions and professionals, these guidelines were developed as common basis for recommendations given to pregnant women. They encompass advice on a healthy balanced diet and regular physical activity including the prevention of potential risks.

Table 1 Recommendations for gestational weight gain provided by the IOM.

Pre-pregnancy BMI [kg/m²]	Recommended weight gain
<18.5	12.5–18.0 kg
18.5–24.9	11.5–16.0 kg
25.0–29.9	7.0–11.5 kg
≥30.0	5.0–9.0 kg

BMI, body mass index; IOM: Institute of Medicine.
Data source: IOM (2009).

1.2.1 Maternal dietary requirements and recommendations

Dietary recommendations for pregnant women given by the "Healthy Start – Young Family Network" predominantly focus on references for energy and nutrient intake, supplementation of critical micronutrients and the avoidance of foodborne infections. As requirements of some micronutrients such as folate and iodine increase considerably more than energy requirements during pregnancy, products with high nutrient density should be chosen to meet the increased demands. Therefore, a balanced diet with regular meals rich in vegetables, fruit and whole grain products is recommended, including moderate amounts of preferably low-fat animal products, oily fish and plant oils rich in essential fatty acids as well as a limited consumption of sweets and snacks (Koletzko et al. 2018).

Energy and macronutrient requirements

During pregnancy, energy requirements are increased (FAO/WHO/UNU 2004). Next to the weight of the foetus, components of GWG comprise extension of maternal breasts, uterus, extracellular fluid and blood volume, fat tissue stored for the lactation period, as well as the weight of the placenta and amniotic fluid (Pitkin 1976). Energy costs include needs for maternal and foetal tissue formation, as well as the increased basal metabolic rate resulting from elevated body mass and enhanced activity of the cardiovascular and respiratory system (FAO/WHO/UNU 2004).

Energy needs are distributed unevenly over the course of pregnancy. They are only minimally elevated in early pregnancy (375 kJ per day). An extra of 1.200 kJ and 1.950 kJ is required in

the second and third trimester respectively (Butte and King 2005). There is, however, considerable variation in energy expenditure, for instance due to differences in physical activity (Koletzko et al. 2018). Many women reduce physical activity during pregnancy and often choose lower-impact types of activity (Poudevigne and O'Connor 2006). As excessive energy intake may affect maternal and foetal health by promoting excessive GWG, women are recommended to supply additional energy of only 10% in the last months of gestation (Koletzko et al. 2018).

In parallel to energy requirements, **fluid** needs increase. Pregnant women are advised to consume an extra of 300 mL per day, assuming moderate physical activity as well as moderate environmental temperature (EFSA 2010).

The requirements of **macronutrients** are only marginally altered during pregnancy. Like the non-pregnant population, pregnant women are recommended to consume more than 50% of their energy intake from carbohydrate sources, while dietary fat should account for 30 – 35% of energy intake (D-A-CH 2015).

Protein requirements are slightly enhanced in early pregnancy and increase further in later stages of gestation. Over the course of pregnancy, 925 g additional protein is needed in total (Hytten and Leitch 1971). Pregnant women should thus increase daily protein intake from 48 g to 58 g from the 4th month on (D-A-CH 2015). The major part of additionally required protein is deposited in foetus, uterus and placenta, but protein is also needed for the extension of maternal breast and blood volume (Hytten and Leitch 1971). A balanced diet usually contains sufficient protein to meet these requirements, and the majority of women in Germany are adequately supplied with dietary protein (MRI 2008b).

Although the total demand of **fat** is not increased, women should pay intensified attention to the composition of dietary fat. Due to their important role in foetal growth, development of brain and retinas, consumption of essential polyunsaturated fatty acids should be emphasised (Williamson 2006). Long-chain fatty acids such as arachidonic acid and docosahexaenoic acid (DHA) can be synthesised from linoleic acid and α-linolenic acid. Since the conversion of α-linolenic acid to DHA is however inefficient (Coletta et al. 2010), dietary intake of DHA is crucial. The recommended intake of 200 mg per day can be achieved by consumption of one or two sea fish meals per week, if oily fish is included (Koletzko et al. 2007). As plant-based food is a poor source of DHA, pregnant women who do not consume fish regularly are advised to supplement DHA (Koletzko et al. 2013; Bezard et al. 1994).

Micronutrient requirements

Other than the marginally increased demands for energy and macronutrients, needs of some **micronutrients** increase considerably. **Table 2** depicts vitamins and minerals with higher needs during pregnancy. While increased demands of most vitamins and minerals can usually be met with a balanced diet, other micronutrients such as folic acid and iodine should be supplemented.

Folate is crucial for the development of the foetus given its essential function in cell proliferation and neural development including neural tube closure (Scott et al. 1994). Requirements of folic acid in the first trimester of pregnancy (550 µg/day) are usually not met by the diet alone (Williamson 2006). The majority of German women do not even reach the recommended intake for non-pregnant women (MRI 2008a). It is advised to start supplementation before pregnancy, as closure of the neutral tube happens early in pregnancy (Moussa et al. 2016). Besides the prevention of neural tube defects, potential other benefits of folic acid supplementation are discussed, including a reduced risk of megaloblastic anaemia, low birth weight and preeclampsia (Moussa et al. 2016; Lassi et al. 2013; Fekete et al. 2012; Wen et al. 2008).

Vitamin D is crucial for calcium metabolism and foetal bone formation. Although requirements of vitamin D do not increase during pregnancy, supplementation may be necessary to avoid undersupply (Koletzko et al. 2018; Williamson 2006). As a large proportion of the required amount is formed in the skin, a daily supplement of 20 µg is recommended if sun exposure is low, as for instance during the winter months (D-A-CH 2015).

Requirements of several **other vitamins** increase in the second and third trimester, including vitamin A, vitamin C, thiamin, riboflavin, niacin and vitamin B_6 (**Table 2**). As sufficient intake of these is usually ensured by a balanced diet, supplementation is only necessary in exceptional cases and should be advised individually (Williamson 2006). Women on a strict vegan diet should supplement vitamin B_{12}, as it is only available from animal sources (D-A-CH 2015).

The demand of some minerals increases as well during pregnancy (**Table 2**). Several physiologic adaption strategies help to cover these extra needs. Next to enhanced dietary intake, they include an increase in intestinal absorption and decrease in excretion, as well as a release of stored minerals (Prentice 2003). Adaptions mainly affect minerals involved in bone formation. In case of **calcium**, adaption processes are so efficient that there is no need to increase dietary intake during pregnancy, although foetal calcium requirements are high (D-A-CH 2001). Some women, e.g. vegans, are at risk to be undersupplied (Koletzko et al. 2018).

Table 2 Demand of selected micronutrients during pregnancy.

	Normal requirement	Extra requirement	Relative increase	Timeframe
Vitamins				
Folate	300 µg	+250 µg	83%	1st trimester
Vitamin A	0.8 mg	+0.3 mg	38%	2nd-3rd trimester
Vitamin C	95 mg	+10 mg	11%	2nd-3rd trimester
Thiamin	1.0 mg	+0.2 mg / +0.3 mg	20% / 30%	2nd / 3rd trimester
Riboflavin	1.1 mg	+0.2 mg / +0.3 mg	18% / 27%	2nd / 3rd trimester
Niacin	12-13 mg[1]	+2 mg / +4 mg	17% / 33%	2nd / 3rd trimester
Vitamin B_6	1.4 mg	+0.1 mg / +0.4 mg	7% / 29%	1st / 2nd-3rd trimester
Vitamin B_{12}	4.0 µg	+0.5 µg	13%	1st-3rd trimester
Minerals				
Calcium	1000 mg	+0 mg	0%	1st-3rd trimester
Magnesium	300-310 mg[1]	+0-10 mg	0-3%	1st-3rd trimester
Phosphorus	700 mg	+100 mg	14%	1st-3rd trimester
Iodine	200 µg	+30 µg	15%	1st-3rd trimester
Iron	15 mg	+15 mg	100%	1st-3rd trimester
Zinc	8 mg	+1 mg / +3 mg	13% / 38%	1st / 2nd-3rd trimester

[1]depending on the age of the women. Data source: D-A-CH (2015).

Recommended intake of **magnesium** is only slightly increased in pregnancy (D-A-CH 2001). Although the risk of underprovision is low, magnesium is regularly supplemented during pregnancy (Becker and Schmid 2013). Several benefits of magnesium supplementation, such as a reduced risk of pre-eclampsia or low birth weight are discussed, but could not be confirmed yet (Makrides et al. 2014).

Due to its important role in foetal brain development, sufficient **iodine** intake is crucial during pregnancy and should thus be emphasised already before conception. Although iodine requirements are only increased by 15%, adequate intake should receive particular attention (D-A-CH 2001). Recommendations are often not met, especially if iodinated salt is not used (MRI 2008b). Next to consumption of foods rich in iodine, supplementation of an extra 100-150 µg is recommended to ensure adequate supply (Koletzko et al. 2018).

Iron demands in pregnant women are twice as high as in non-pregnant women (D-A-CH 2001). The majority of additional iron is needed for the expansion of maternal blood volume, but also foetal development and placental accretion demand extra iron (Hallberg 1988). Missing menstruation losses as well as increased intestinal absorption facilitate achievement

of these requirements (Bothwell 2000). In Germany, iron supplementation is not generally recommended. Common side effects of iron supplements, such as obstipation, nausea and diarrhoea should be considered (Peña-Rosas et al. 2015). Blood haemoglobin values should be taken as basis for individual medical advice on supplementation (Koletzko et al. 2018).

Food safety

For safety reasons, further diet-related aspects should be considered. Pregnant women should strictly avoid **alcohol** consumption. Ethanol is transported through the placenta and can provoke severe health outcomes such as growth restriction, birth defects and mental retardation (Sokol et al. 2003). Although risks are highest in the case of high and regular alcohol intake, there is no established safety limit (Mukherjee et al. 2005) and also low doses have been suggested to affect the foetus (Mamluk et al. 2017).

Caffeine is a further food constituent without a defined safe dose, and its intake should thus be limited as a precaution. Moderate amounts of caffeine (<300 mg/day) have not been shown to significantly influence offspring birth weight and length of pregnancy. However, a high consumption is discussed to affect foetal growth (Bakker et al. 2010; Bech et al. 2007) and is thus discouraged during pregnancy (Koletzko et al. 2018).

As **food pathogens** like *Listeria monocytogenes* and the parasite *Toxoplasma gondii* can cross the placenta, an infection with these microorganisms can have severe consequences. *Listeria monocytogenes* infection is associated with an increased risk of miscarriage and preterm birth, and neonatal affection can potentially lead to meningitis, sepsis and death (ACOG 2014). *Toxoplasma gondii* infection can cause abortion, visual impairment, deafness, mental retardation and other neurological deficiencies (Tenter et al. 2000). As both pathogens are destroyed during heating processes, pregnant women should avoid raw or smoked meat and fish products, raw milk products and unboiled eggs to prevent an infection (Koletzko et al. 2018). Fruit and vegetables need to be cleaned thoroughly under water before consumption (Tenter et al. 2000). Prepared meals should be reheated immediately before consumption, and ready-made dishes that cannot be heated, such as salads, should be avoided (Williamson 2006).

1.2.2 Physical activity recommendations

The “Healthy Start – Young Family Network” also gives recommendations for **physical activity** during pregnancy (Koletzko et al. 2018). Although multiple risks have been discussed in the past, physical activity during gestation has not been shown to increase the risk of abortion (Clapp 2000), malformation (Larsson and Lindqvist 2005) and premature rupture of

membranes (Hegaard et al. 2007). During uncomplicated pregnancies, moderate exercise is consistently regarded as safe (ACOG 2015). Inactive women should be encouraged to initiate physical activity, and previously active women can continue their activities with a few exceptions. Pregnant women are advised to spend 30 min on most days or 150 min per week with moderate physical activity (ACOG 2015; DHHS 2008). The Borg scale of perceived exertion can assist estimating exercise intensity (Borg 1962). A value of 12-14 on this scale, corresponding to moderate physical activity, should be targeted during exercise (Melzer et al. 2010). Both aerobic and strength training are appropriate for pregnant women, however, exercise activating large muscle groups should be preferred (Koletzko et al. 2018). Particularly suitable are activities like brisk walking, biking, swimming and water aerobics (Melzer et al. 2010). Contact sports and other activities with a high risk for falls or injuries, such as fighting or horse riding, as well as scuba diving and sports at high altitudes should be avoided (Koletzko et al. 2018; Melzer et al. 2010).

1.3 Associations between maternal dietary behaviour and pregnancy outcomes

Diet and physical activity during pregnancy may have an impact on various pregnancy outcomes and health parameters in women and their offspring. Cohort studies have addressed potential associations of nutritional aspects during pregnancy with maternal and infant outcomes. Many of them focus on energy and macronutrient intake, but also dietary patterns and specific foods are considered. Associations of these parameters with GWG and offspring weight at birth are considered in the following.

1.3.1 Associations between maternal dietary behaviour and gestational weight gain

The association of dietary variables with GWG has been discussed in several systematic reviews (Jebeile et al. 2016; Samura et al. 2016; Tielemans et al. 2016; Kapadia et al. 2015; Chasan-Taber 2012; Streuling et al. 2011).

Weight gain in non-pregnant individuals is predominately driven by a higher **energy intake** compared to energy expenditure. GWG involves multiple maternal and foetal compounds and thus represents a complex interaction between different determinants (Tielemans et al. 2016; Hill and Peters 1998). Large cohort studies indicate a relation between energy intake during pregnancy and maternal weight gain, although the overall study situation is not completely consistent (Changamire et al. 2014; Gaillard et al. 2013). Taking account of the heterogeneity in quality, reviews of observational studies agree with this finding (Tielemans et al. 2016; Streuling et al. 2011). Jebeile et al. (2016), however, who reported changes in energy intake over the course of pregnancy in a meta-analysis, could not show a clear association between

energy intake and GWG. Drawing conclusions seems to be complicated by the diversity of dietary assessment tools applied in different studies and the varying approaches of GWG calculation (Streuling et al. 2011).

It is unclear if the **macronutrient composition** of the maternal diet plays a modifying role in overall GWG (Tielemans et al. 2016). Studies reported positive associations between **carbohydrate** or **sugar intake** and GWG (Diemert et al. 2016; Maslova et al. 2015; Renault et al. 2015a), while others observed no (Rodrigues et al. 2008) or even a negative correlation (Lagiou et al. 2004). Evidence for a relation between **protein** or **fat intake** and maternal GWG is also inconclusive (Maslova et al. 2015; Gaillard et al. 2013; Uusitalo et al. 2009; Rodrigues et al. 2008; Lagiou et al. 2004; Ancri et al. 1977). In a systematic review, Tielemans et al. (2016) pointed out that the relation between fat consumption and GWG may depend on the type of fat. Because of the inconclusive data situation, effects of dietary macronutrients on GWG remain to be further evaluated. Underreporting of food intake is a major problem of self-reported dietary data. This may partly explain inconsistencies in reported results concerning energy and macronutrient consumption. Especially pregnant women with a BMI ≥25 kg/m^2 seem to underreport dietary intake frequently (McGowan and McAuliffe 2012).

Next to macronutrients, an influence of **energy density** or **portion size** on GWG is conceivable (Blumfield et al. 2016; Deierlein et al. 2008). Additionally, a potential influence of particular **food groups** on GWG is discussed. Studies report associations between the consumption of dairy products and the risk for excessive maternal weight gain (Stuebe et al. 2009; Olafsdottir et al. 2006). A high consumption of fatty fish (Larsen et al. 2016) and seafood (Restall et al. 2014) is also discussed to promote GWG. Choosing snacks (Bärebring et al. 2016), fried food (Stuebe et al. 2009), highly-processed food (Rohatgi et al. 2017) and takeaway meals (Heery et al. 2015) has been positively associated with GWG as well. While consumption of fruit in form of drinks (Guilloty et al. 2015) and energy-containing beverages in general (Bärebring et al. 2016) have been linked to an increased risk of excessive GWG, a high intake of unprocessed fruits and vegetables could contribute to adequate GWG (Shin et al. 2014; Olson and Strawderman 2003). As findings were mainly based on self-reports, the potential influence of these factors on GWG requires further investigation.

It has to be acknowledged that **dietary patterns** may have a more pronounced effect on health parameters than single food groups or nutrients. In studies analysing the relation between diet and maternal weight gain, such patterns are rarely described. Examples for potentially favourable patterns include both vegetarian and mixed diets (Shin et al. 2016; Stuebe et al. 2009), while the Western diet has been linked to higher GWG in a recent observational study (Wrottesley et al. 2017).

Concluding from the above-named associations, there is some evidence that dietary factors influence maternal weight gain, although further investigation is needed. The following section will focus on the relation between the maternal diet and infant birth weight.

1.3.2 Associations between maternal dietary behaviour and infant birth weight

Maternal lifestyle during pregnancy plays an important role in the development and health of the offspring. Maternal undernutrition is closely linked to the risk of low infant birth weight (Han et al. 2011; Thame et al. 1997). In a similar manner, overnutrition could have an effect on newborn weight and health.

In Germany, an increase in mean birth weight was recorded over the last decades (Hesse et al. 2003). **Energy** and protein supplementation can increase birth weight in children of malnourished women (Imdad and Bhutta 2011). By contrast, in developed countries, observational studies do not show a consistent link between energy intake and offspring birth weight (Pereira-da-Silva et al. 2014; Hsu et al. 2013; Lagiou et al. 2004; Langley-Evans and Langley-Evans 2003; Mathews et al. 1999).

A potential impact of the **macronutrient composition** of the maternal diet on infant birth weight is also not yet understood. Studies failed to indicate a clear association between **carbohydrate intake** during pregnancy and offspring birth weight (Pathirathna et al. 2017; Chong et al. 2015; Moore et al. 2004; Mathews et al. 1999; Godfrey et al. 1996). Although some observational studies showed correlations between carbohydrate consumption in pregnancy and newborn fat mass, evidence is inconclusive (Crume et al. 2016; Kizirian et al. 2016; Renault et al. 2015b). Single studies relate parameters such as the **glycaemic index** or **load** to offspring birth weight (Knudsen et al. 2013; Moses et al. 2006; Scholl 2004). Nutrition focusing on a low glycaemic index was able to reduce the rate of LGA newborns in several intervention trials (Zhang et al. 2016).
Evidence for a relation between **fat intake** and infant birth weight is insufficient (Crume et al. 2016; Kizirian et al. 2016; Chong et al. 2015; Pereira-da-Silva et al. 2014; Mathews et al. 1999). Although **omega-3 fatty acids** have been analysed repeatedly regarding offspring weight, evidence for an effect is weak (Imhoff-Kunsch et al. 2012; Abu-Saad and Fraser 2010).
Moreover, a potential link between **protein intake** during gestation and infant birth weight is subject of many studies. While some support an association between these parameters (Pathirathna et al. 2017; Cucó et al. 2006; Moore et al. 2004; Sloan et al. 2001), others report no relation (Pathirathna et al. 2017; Chong et al. 2015; Mathews et al. 1999). Considering only protein from dairy sources, increasing intake during pregnancy seems to be associated with

higher offspring birth weight in developed countries (Heppe et al. 2011; Olsen et al. 2007; Moore et al. 2004).
However, studies relating macronutrient consumption to infant parameters differ methodologically and describe different time points during the course of pregnancy (Chong et al. 2015). Differences in sources or composition of macronutrients could be an additional reason for the conflicting data situation.

The consumption of **dairy products** and its influence on infant birth weight has been addressed repeatedly. Positive associations between maternal milk intake and infant birth weight have been reported in large cohort studies (Hrolfsdottir et al. 2013; Heppe et al. 2011; Xue et al. 2008; Olsen et al. 2007; Mannion et al. 2006) and are described in reviews (Melnik et al. 2015; Brantsæter et al. 2012).
Fish intake may promote birth weight (Leventakou et al. 2014) and reduce the risk of having a child with low birth weight (Canda et al. 2011; Olsen and Secher 2002). However, other studies suggest increased risks for reduced birth weight due to the consumption of seafood (Halldorsson et al. 2007; Oken et al. 2004). Observed associations seem to vary with different types of fish (Ramón et al. 2009; Guldner et al. 2007). These inconsistencies could be related to environmental pollutants present in several types of fish, potentially interfering with foetal growth (Papadopoulou et al. 2013; Abu-Saad and Fraser 2010).
A substance also frequently discussed to affect foetal growth is **caffeine**. Coffee consumption and caffeine exposure *in utero* have been negatively associated with offspring weight at birth in several observational studies (Voerman et al. 2016; Sengpiel et al. 2013; CARE Study Group 2008; Xue et al. 2008; Eskenazi et al. 1999). However, a randomised controlled trial with the aim to reduce caffeine intake by substituting caffeinated with decaffeinated coffee could not show any effect on offspring weight (Bech et al. 2007).
Other foods considered to have an impact on infant birth weight include meat, specifically barbecued or roasted meat (Lamichhane et al. 2016; Jedrychowski et al. 2012), fast food (Wen et al. 2013), soft drinks (Phelan et al. 2011a) as well as artificially sweetened soft drinks (Zhu et al. 2017). However, there is no convincing evidence on whether these food groups may influence infant birth weight.

A further aspect is the role of **dietary patterns and habits**, which may exert a more pronounced effect on birth weight than single foods or food groups (Grieger and Clifton 2014). High adherence to recommended dietary behaviour has been associated with a lower risk to be born with low birth weight (Gresham et al. 2016) or small for gestational age (SGA) (Hillesund et al. 2014). Studies associating dietary patterns with birth weight are however very limited. Available data suggested a potential influence of the Mediterranean diet (Chatzi et al.

2012; Timmermans et al. 2012), patterns rich in protein or dense in nutrients (Wolff and Wolff 1995), a pattern rich in snacks (Coelho et al. 2015) and other individual patterns (Starling et al. 2017; Zulyniak et al. 2017; Chia et al. 2016; Lu et al. 2016; Colón-Ramos et al. 2015; Okubo et al. 2012; Knudsen et al. 2008).

In conclusion, while the maternal diet clearly influences offspring birth weight in malnourished women (Imdad and Bhutta 2011), evidence for an effect in developed countries is less obvious. Some dietary patterns, food groups and overall macronutrient composition may have an impact on infant birth weight, but evidence is still limited (Grieger and Clifton 2014).

Numerous lifestyle intervention studies have been initiated in the last years, aiming to modify the antenatal diet and lifestyle and by that to optimise GWG, to reduce pregnancy and obstetric complications and to improve maternal and infant health. An overview of lifestyle interventions is provided in the following part.

1.4 Lifestyle interventions targeting dietary behaviour and physical activity

Lifestyle interventions in pregnancy have been conducted worldwide and have been extensively reviewed (Lamminpää et al. 2018; Shieh et al. 2018; i-WIP 2017; Flynn et al. 2016; O'Brien et al. 2016; Muktabhant et al. 2015; Oteng-Ntim et al. 2012; Thangaratinam et al. 2012; Gardner et al. 2011; Dodd et al. 2010; Skouteris et al. 2010; Streuling et al. 2010). Although some trials have shown beneficial effects, results of intervention studies in respect to GWG, pregnancy complications and birth parameters are largely inconsistent.

1.4.1 Effects of lifestyle interventions on gestational weight gain

Lifestyle interventions are very diverse and include dietary advice, counselling on physical activity, exercise classes, behavioural change and self-monitoring techniques and combinations of these components (Muktabhant et al. 2015). The effectiveness of lifestyle interventions to reduce **GWG** is heterogeneous. While some interventions failed to modify GWG, others were successful in reducing overall GWG or the proportion of women showing excessive weight gain. A recently conducted meta-analysis based on individual participant data (IPD) from 36 randomised controlled trials (i-WIP) demonstrated that lifestyle interventions have a moderate effect and reduce mean GWG by 0.7 kg (i-WIP 2017). This effect was observed independently from age, parity and pre-pregnancy BMI of the included study population.

Many lifestyle interventions, including two of the largest conducted trials, focus exclusively on overweight and obese pregnant women. In the UPBEAT study, analysing the effect of an intensive lifestyle programme in 1555 obese pregnant women, GWG was reduced by 0.55 kg

in the intervention group (Poston et al. 2015). By contrast, in the Australian LIMIT trial, including 2212 overweight and obese pregnant women, counselling on diet and physical activity did not significantly reduce GWG (Dodd et al. 2010). Although excessive GWG is also frequently observed in normal-weight women, this subgroup is less often targeted in pregnancy interventions (O'Brien et al. 2016). Nevertheless, a systematic review showed that lifestyle counselling can also achieve a significant reduction of GWG in normal-weight women (O'Brien et al. 2016).

1.4.2 Effects of lifestyle interventions on pregnancy and obstetric complications

Next to excessive GWG, lifestyle interventions often aim to reduce pregnancy and obstetric complications such as **gestational diabetes mellitus** or the rate of delivery via caesarean section. The UPBEAT trial primarily aimed to reduce the incidence of GDM, but failed to yield an effect on this outcome (Poston et al. 2015). In the LIMIT trial, no impact on the GDM rate was observed (Dodd et al. 2014b). In the RADIEL trial, a Finnish intervention study recruiting women at high risk for GDM, the incidence could by contrast be reduced by 39% with a moderate intervention programme offering individual advice on diet and physical activity as well as weight monitoring (Koivusalo et al. 2016). The i-WIP meta-analysis showed no benefit on the rate of GDM in the IPD analysis, but provided evidence for a risk reduction by 24% when data from all available studies, including those not providing individual data, were taken into account (i-WIP 2017).

Furthermore, the i-WIP analysis indicated a reduction in the rate of **caesarean** delivery by 9% (i-WIP 2017). There was no evidence for an effect of lifestyle counselling on other maternal and offspring outcomes such as hypertension, preterm birth, SGA or LGA (i-WIP 2017), although some studies suggested positive results in offspring outcomes (Wang et al. 2017; Dodd et al. 2014b; Luoto et al. 2011).

1.4.3 Effects of lifestyle interventions on dietary behaviour

While most lifestyle intervention studies reported on health outcomes, only a minority of trials examined the impact of lifestyle counselling on behavioural parameters. In the following, an overview of trials analysing dietary behaviour in pregnant women after a lifestyle intervention is provided.

Table 3 lists lifestyle intervention studies reporting on **maternal dietary behaviour**. Maternal nutrition was assessed with different methods including food frequency questionnaires (FFQs) and dietary records. Studies report on a broad range of dietary parameters such as energy and macronutrient intake, measures of dietary quality or consumption of specific food groups

(**Table 3**). In three of these studies, no effects on the maternal diet were observed (Hawkins et al. 2014; Hui et al. 2006; Polley et al. 2002). However, in most of the trials, lifestyle counselling resulted in changes in maternal dietary behaviour. Some effectively reduced **energy intake** (Poston et al. 2015; Hui et al. 2014; Poston et al. 2013; Rauh et al. 2013; Hui et al. 2012; Walsh et al. 2012; Rhodes et al. 2010; Khoury et al. 2005; Bechtel-Blackwell 2002). In other studies, scores of **dietary quality** were improved by a lifestyle intervention (Koivusalo et al. 2016; Sagedal et al. 2016; Dodd et al. 2014a) or **healthier patterns** were reported (Moran et al. 2017; Flynn et al. 2015). The intake of **fruits and vegetables** could frequently be increased in women receiving a lifestyle intervention (Simmons et al. 2017; Asci and Rathfisch 2016; Dodd et al. 2014a; Kieffer et al. 2014; Kinnunen et al. 2014; Jackson et al. 2011; Quinlivan et al. 2011; Guelinckx et al. 2010; Kinnunen et al. 2007). In some studies, the consumption of **protein** or **fibre** was successfully increased by lifestyle counselling (Asci and Rathfisch 2016; Poston et al. 2015; Dodd et al. 2014a; Kieffer et al. 2014; Kinnunen et al. 2014; Moses et al. 2014; Poston et al. 2013; Walsh et al. 2012; Louie et al. 2011; Luoto et al. 2011; Guelinckx et al. 2010; Rhodes et al. 2010; Wolff et al. 2008; Kinnunen et al. 2007). By contrast, the intake of **total** or **saturated fat** was frequently reduced by the counselling (Simmons et al. 2017; Poston et al. 2015; Dodd et al. 2014a; Hui et al. 2014; Kieffer et al. 2014; Kinnunen et al. 2014; Poston et al. 2013; Hui et al. 2012; Luoto et al. 2011; Guelinckx et al. 2010; Wolff et al. 2008; Khoury et al. 2005; Bechtel-Blackwell 2002).

1.4.4 Effects of lifestyle interventions on maternal weight retention

Lifestyle interventions are additionally discussed to have effects beyond pregnancy. The difference between maternal pp and pre-pregnancy body weight is defined as **maternal weight retention**. An effect of antenatal lifestyle counselling on short- and long-term PPWR has repeatedly been considered (Shepherd et al. 2017; Bain et al. 2015; Muktabhant et al. 2015; Agha et al. 2014; Tanentsapf et al. 2011). Some trials showed that women receiving an antenatal intervention were more likely to return to their pre-pregnancy body weight and described a reduction in PPWR following to the intervention at 6 months pp (Phelan et al. 2011b) or 12 months pp (Sagedal et al. 2017). A systematic review showed a lower mean PPWR 6 months after delivery in women receiving lifestyle counselling (Tanentsapf et al. 2011), but overall evidence is inconclusive. In particular, data on long-term PPWR are sparse.

Table 3 Overview of lifestyle intervention trials reporting on maternal dietary behaviour.

Study	Design	Country	Sample size	Intervention components	Dietary data collection	Effects on dietary behaviour
Asci and Rathfisch 2016	RCT	Turkey	n=102	counselling on diet and physical activity, weight control	3-day dietary recalls	↑intake of protein, vegetables
Bechtel-Blackwell 2002	RCT	USA	n=60	group counselling on diet	24-hour dietary recall, questionnaire	↓energy intake, fat intake
Bosaeus et al. 2015	RCT	Sweden	n=101	counselling on diet (to increase fish intake)	semiquantitative FFQ	↑fish intake
Dodd et al. 2014a	RCT	Australia	n=2212	counselling on diet, physical activity, weight control	FFQ	↑intake of fruits and vegetables, fibre intake, HEI ↓E% saturated fat
Flynn et al. 2015	RCT	UK	n=183	counselling on diet and physical activity	FFQ	↓ score of processed pattern and traditional pattern
Gray-Donald et al. 2000	CT	Quebec	n=219	counselling on diet, and physical activity	24h recall	↓caffeine intake
Guelinckx et al. 2010	RCT	Belgium	n=195	2 intervention groups: counselling on diet or information via a brochure	7-day food records	↑intake of protein, vegetables ↓intake of fat and saturated fat in both intervention groups
Hawkins et al. 2014	RCT	USA	n=68	counselling on diet and physical activity	24 h recalls	no significant effects
Hui et al. 2006	RCT	Canada	n=52	counselling on diet, group and homebased exercise	FFQ	no significant effects
Hui et al. 2012	RCT	Canada	n=190	counselling on diet, exercise sessions	3-day food records	↓energy intake, intake of total and saturated fat, cholesterol intake

Study	Design	Country	Sample size	Intervention components	Data collection	Effects on dietary behaviour
Hui et al. 2014	RCT	Canada	n=116	counselling on diet, exercise sessions	3-day food records	↓energy intake, intake of total and saturated fat, cholesterol intake ↓CH-intake in the subgroup of normal-weight women
Jackson et al. 2011	RCT	USA	n=321	video messages about diet, physical activity and weight gain	FFQ	↑intake of fruit and vegetables, whole grains, fish, avocado and nuts ↓intake of sugary foods, refined grains, high fat meats, fried foods, solid fats and fast food
Khoury et al. 2005	RCT	Norway	n=290	counselling on diet (cholesterol-lowering diet)	48-hour dietary recall	↑fish and oil intake ↓energy, saturated and total fat and cholesterol intake ↓intake of fatty milk and meat products
Kieffer et al. 2014	RCT	USA	n=278	counselling on diet	FFQ	↑intake of vegetables, fibre ↓intake of total and saturated fat, added sugar
Kinnunen et al. 2007	CT	Finland	n=132	counselling on diet and physical activity	FFQ, food records	↑intake of vegetables, fruits and fibre
Kinnunen et al. 2014	RCT	Finland	n=399	counselling on diet	FFQ	↑intake of vegetables, fruits and berries, fibre, PUFAs ↑% of high-fibre bread, low-fat cheese, vegetable fats ↓intake of saturated fatty acids
Koivusalo et al. 2016	RCT	Finland	n=293	counselling on diet and physical activity, weight control	FFQ	↑dietary quality

Study	Design	Country	Sample size	Intervention components	Data collection	Effects on dietary behaviour
Louie et al. 2011	2-arm parallel-design trial (no CG)	Australia	n=99	LGI- dietary advice vs. high-fibre diet advice	3-day food records	LGI group: ↓GI, ↑intake of fibre
Luoto et al. 2011	RCT	Finland	n=399	counselling on diet, physical activity and weight gain	FFQ	↑intake of fibre and PUFAs ↓intake of saturated fat and saccharose
Moran et al. 2017	RCT	Australia	n=2212	counselling on diet and lifestyle	FFQ	↑score for prudent dietary pattern ↓score for Western dietary pattern
Moses et al. 2009	2-arm parallel-design trial (no CG)	Australia	n=63	LGI dietary advice vs. high-fibre diet advice	3-day food records	LGI group: ↓GI
Moses et al. 2014	2-arm parallel-design trial (no CG)	Australia	n=691	LGI dietary advice vs. healthy eating advice	3-day food records	LGI group: ↓GI, ↑intake of protein
Polley et al. 2002	RCT	USA	n=120	counselling on diet, physical activity and weight gain	Block FFQ (analyses intake of high-fat foods)	no effect on fat intake
Poston et al. 2013	RCT	UK	n=183	counselling on diet and physical activity	24h dietary recall, FFQ	↑fibre intake ↓energy intake, GL, fat and saturated fat intake
Poston et al. 2015	RCT	UK	n=555	counselling on diet and physical activity	FFQ, PA	↑intake of protein and fibre ↓energy intake, GL, CH, fat, and saturated fat intake

Study	Design	Country	Sample size	Intervention components	Data collection	Effects on dietary behaviour
Quinlivan et al. 2011	RCT	Australia	n=134	counselling on diet	questionnaire	↑intake of water, fresh fruit, vegetables and home-cooked meals ↓intake of carbonated drinks, juices and fast food
Rauh et al. 2013	RCT	Germany	n=250	counselling on diet, physical activity and weight gain	7-day dietary records	↓energy intake
Rhodes et al. 2010	RCT	USA	n=46	counselling on diet (LGL vs. low-fat diet)	24h dietary recall	LGL group: ↑intake of fibre ↓GI and GL, energy intake
Sagedal et al. 2016	RCT	Norway	n=606	counselling on diet, exercise groups	FFQ	↑dietary quality
Simmons et al. 2017	RCT	Europe	n=436	counselling on diet (HE) and/or physical activity (HE & PA)	FFQ	↑intake of vegetables and ↓intake of CH in women receiving HE or HE & PA advice ↓intake of sugared drinks and fat in women receiving only HE advice
Valkama et al. 2016	RCT	Finland	n=242	counselling on diet and physical activity, weight control	FFQ	↑intake of fish, low-fat cheese
Walsh et al. 2012	RCT	Ireland	n=800	counselling on diet (LGI-diet)	3-day food diaries	↑intake of fibre ↓GI and GL, energy intake
Wolff et al. 2008	RCT	Denmark	n=50	counselling on diet	7-day weighed food records	↑protein intake ↓energy, CH and fat intake

CG, control group; CH, carbohydrates; CT, controlled trial; E%, percentage of energy intake; FFQ, food frequency questionnaire; GI, glycaemic index; GL, glycaemic load; HE, Heathy Eating; HEI, Healthy Eating Index; LGI, low glycaemic index; LGL, low glycaemic load; PA, physical activity; PUFAs, polyunsaturated fatty acids; RCT, randomised controlled trial. Data source: own contribution.

1.5 Lifestyle intervention within the routine antenatal care setting

As outlined in the previous sections, numerous lifestyle intervention concepts targeting maternal weight and health during pregnancy and the pp period have been evaluated over the last years. However, the majority of these studies has been conducted in academic settings and effectiveness of lifestyle counselling within the real-life setting of routine antenatal care remains to be assessed.

Based on this, the **FeLIPO** pilot trial (**Fe**asibility of a **li**festyle-intervention in **p**regnancy to **o**ptimise maternal weight development) was initiated. As the pilot trial was effective in reducing the proportion of women with excessive GWG (Rauh et al. 2013), the large-scale **GeliS** study ("**Ge**sund **l**eben **i**n der **S**chwangerschaft"/ healthy living in pregnancy) was developed. The GeliS study was performed in multiple districts of Bavaria and focused on maternal and foetal health. In a structured lifestyle counselling programme, pregnant women were encouraged to follow a balanced diet and regular physical activity during their pregnancy.

2 Aim of the thesis

The present work aims to elucidate the effectiveness of lifestyle counselling conducted within the setting of routine antenatal care. The 12-months follow-up results of the FeLIPO pilot study as well as primary and secondary outcomes of the GeliS trial are addressed. The following main research questions are investigated with the aim to assess

1) the effect of lifestyle counselling in the **FeLIPO study** on **maternal and offspring weight** development in the **first year pp**,
2) the effect of lifestyle counselling in the **GeliS study** on the proportion of women with **excessive GWG** and the incidence of pregnancy and obstetric complications,
3) the effect of lifestyle counselling in the **GeliS study** on maternal prenatal **dietary behaviour**,
4) associations between maternal prenatal **dietary behaviour and GWG** in the **GeliS cohort**, and
5) associations between maternal prenatal **dietary behaviour and neonatal body weight** in the **GeliS cohort**.

Study designs and procedures of both the FeLIPO and the GeliS trials are presented in the subsequent part, followed by a summary of research results and a discussion of the effects and limitations of these trials, as well as implications for future approaches.

3 Methods

3.1 The FeLIPO trial

3.1.1 Design of the FeLIPO trial

The FeLIPO trial is a cluster-randomised controlled lifestyle intervention study conducted within gynaecological practices in the area around Munich, Bavaria. The pilot trial was performed to ensure safety and feasibility of the applied methods. The trial protocol was approved by the ethical committee of the Technical University of Munich and is registered in the German Clinical Trials register (DRKS00003801). The FeLIPO study was conducted in conformity with the declaration of Helsinki and Good Clinical Practice guidelines, as well as with local laws and regulatory requirements. Study design and primary results have been published in 2013 (Rauh et al. 2013).

Eight gynaecological practices were recruited for participation and were randomly assigned to four intervention and four control practices. Between February 2010 and August 2011, 250 pregnant women were recruited in gynaecological practices by their staff. Women were considered for study participation if they were pregnant with a single child for <18 weeks, full-aged, had sufficient German language skills and a BMI ≥18.5 kg/m^2. They were excluded in case of diagnosed diabetes mellitus, uncontrolled diseases and conditions contraindicating physical activity. Prior to inclusion, all women completed a declaration of consent in written form (Rauh et al. 2013).

3.1.2 The lifestyle intervention programme of the FeLIPO trial

Women in the control group (CG) received a leaflet with general information about a healthy lifestyle (DGE 2017), while a structured lifestyle counselling programme was offered to participants in the intervention group (IV). In two individually scheduled appointments at the 20th and the 30th week of gestation, women received advice on a healthy antenatal lifestyle. Next to a balanced maternal nutrition and regular physical activity, the focus of these sessions was on monitoring of GWG as recommended by the IOM. Counselling sessions were performed by a dietary expert. The first session lasted up to 60 min and the second approximately 30 min. Next to the pre-defined contents, the counselling included an individual part with feedback based on dietary records and a physical activity questionnaire filled in by the women. More details on the content of the lifestyle counselling are given by Rauh et al. (2013).

3.1.1 Data collection in the FeLIPO trial

The primary outcome of the FeLIPO trial was the proportion of women with excessive GWG according to the recommendations given by the IOM. Data on maternal weight development during pregnancy as well as pregnancy and obstetric complications were collected from maternity and birth records that are routinely used by practice and clinic staff. Details about data collection of the primary and some of the secondary outcomes have previously been published (Rauh et al. 2013).

Maternal dietary behaviour

Dietary data was assessed by means of 7-day dietary records filled in by women three times during pregnancy in the IV (16^{th}-18^{th} week, 26^{th}-28^{th} week, 36^{th}-38^{th} week) and two times in the CG (16^{th}-18^{th} week, 36^{th}-38^{th} week). Energy, carbohydrate, fat, protein and fibre intake were calculated based thereon with the OptiDiet software (version 5.0.0.029; Gesellschaft für optimierte Ernährung mbH-GOE, Linden, Germany).

Twelve months follow-up of the FeLIPO trial

After birth, mothers and their offspring were followed-up for one year. At four and twelve months pp, women in both groups were contacted via a phone call or an e-mail. In these interviews, information on maternal and infant weight development as well as on breastfeeding behaviour was collected. Maternal PPWR at four and twelve months pp was defined as the difference between self-reported follow-up weight and self-reported pre-pregnancy weight. PPWR >5 kg was considered as relevant weight retention (Gunderson and Abrams 1999; Ohlin and Rössner 1990). Weight data of children were retrieved from the well-baby checkup booklet. In this booklet, pediatricians document data such as infant weight, length and health from check-ups that are routinely performed from birth until school entry.

3.1.2 Data analysis in the FeLIPO trial

Data analysis in the FeLIPO trial was performed as described in Rauh et al. (2015) and Rauh et al. (2013). Linear and logistic regression models were applied for the analysis of group differences. Covariates included in the models as well as further details have been described previously (Rauh et al. 2015).

3.2 The GeliS trial

3.2.1 Design of the GeliS trial

Subsequent to the primary phase of the FeLIPO study, the GeliS trial was initiated. The GeliS study is a cluster-randomised, multi-centre, controlled, open intervention trial primarily aiming

to limit excessive GWG by providing lifestyle counselling. The study protocol was approved by the ethical committee of the Technical University of Munich and is registered at ClinicalTrials.gov (NCT01958307). The trial is conducted in conformity with the declaration of Helsinki and Good Clinical Practice guidelines as well as with local laws and regulatory requirements. A description of the study design was published by Rauh et al. (2014).

Ten regions of Bavaria were chosen as setting for the intervention study. Five pairs of regions were matched based on sociodemographic data and birth figures. Randomisation to intervention and control regions was performed within these pairs (Rauh et al. 2014).

3.2.2 Recruitment and qualification of counsellors

Lifestyle counselling was realised by trained midwives, gynaecologists and medical personnel. Health care providers had to attend two standardised qualifying seminars, which followed a predefined schedule with a fixed content. The first seminar, informing about study procedures and the counselling content, had to be visited prior to conducting lifestyle counselling. Next to basic information about nutrition, physical activity and exercise during pregnancy, detailed knowledge about GWG, dietary supplement use as well as several risk factors such as alcohol, smoking and foodborne infections was communicated. Six months later, a follow-up seminar providing information about breastfeeding, feeding practices and physical activity during early infancy was scheduled. Content and material of the seminars were developed in collaboration with the “Healthy Start – Young Family Network” (Koletzko et al. 2013).

3.2.3 Recruitment of study participants

A total of 2286 pregnant women were recruited for participation between July 2013 and December 2015. Recruitment was realised by medical personnel in gynaecological practices. Women were addressed before the 12th week of their pregnancy. They reported characteristics such as age, nationality, educational and employment level, anthropometric data including body weight and height, and the number of previous births in a questionnaire. Based on this, inclusion and exclusion criteria for study participation were verified (**Table 4**). Prior to study participation, women completed a declaration of consent in written form.

3.2.4 The lifestyle intervention programme of the GeliS trial

Next to routine prenatal care, women in control regions received a leaflet with general information about a healthy lifestyle (DGE 2017). Participants in the IV were provided a comprehensive lifestyle counselling programme, comprising three appointments with their assigned counsellor during pregnancy as well as one session pp (**Figure 1**). Counselling

sessions focused on a balanced diet, regular physical activity and monitoring of GWG (**Table 5**). Pedometers recording daily steps as well as weight gain charts displaying body weight development over the course of pregnancy as recommended by the IOM, were provided to support self-monitoring of behaviour.

Table 4 Inclusion and exclusion criteria for participation in the GeliS trial.

Inclusion criteria	Exclusion criteria
Pregnancy week: ≤12th	Multiple pregnancy
Age: 18-43 years	High-risk pregnancy
BMI: ≥18.5 and ≤40.0 kg/m^2	Diabetes mellitus or early GDM
Sufficient German language skills	Uncontrolled chronic disease
	Psychiatric disease

BMI, body mass index; GDM, gestational diabetes mellitus.
Data source: own contribution, based on Rauh et al. (2014).

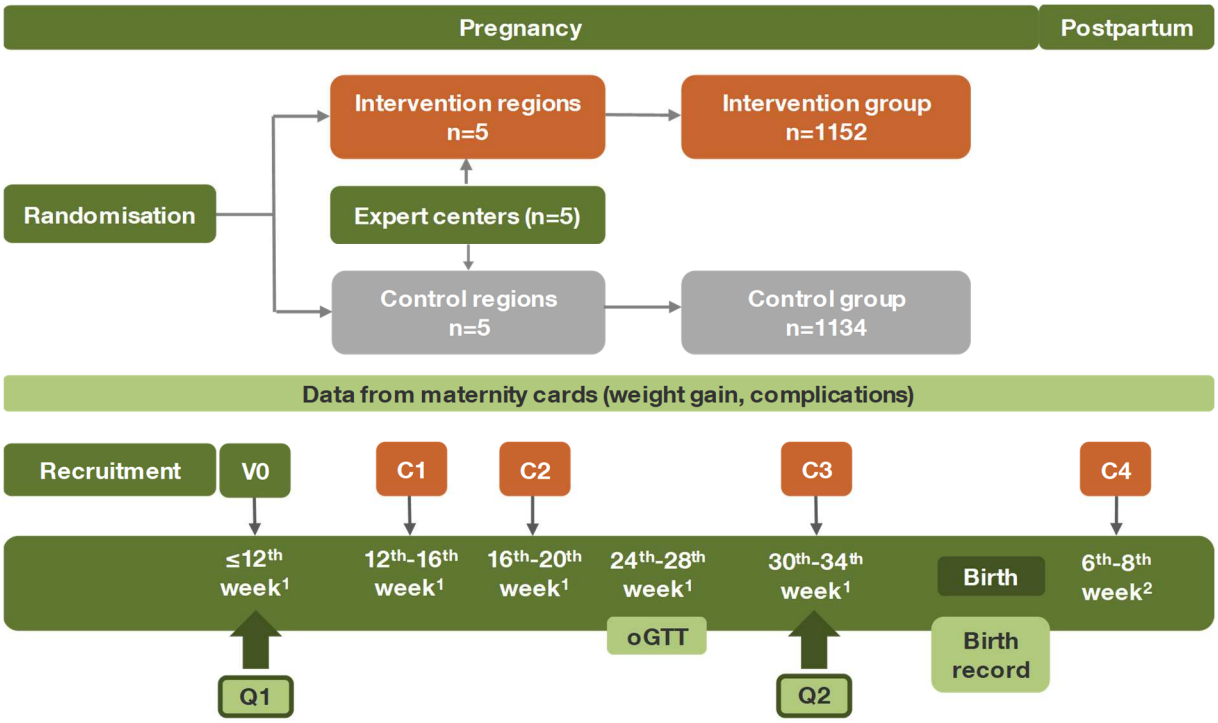

Figure 1 Design and procedures of the GeliS study from pregnancy to the early postpartum phase.
[1]week of gestation; [2]week postpartum; C, counselling session; oGTT, oral glucose tolerance test; Q, questionnaire; V0, screening visit. Data source: modified from Rauh et al. (2014).

Table 5 The GeliS lifestyle counselling programme.

	Timing	Focus	Specifics
Session 1	12^{th}–16^{th} week of gestation	Counselling on a healthy lifestyle, including information about adequate GWG, physical activity, nutrition, critical nutrients and harmful substances	Handout of supplemental information material
Session 2	16^{th}–20^{th} week of gestation	Repetition of the content covered in the first session, individual counselling taking into account personal dietary habits and physical activity	Information on an optional oGTT between the 24^{th} and 28^{th} week
Session 3	30^{th}–34^{th} week of gestation	Repetition of previously discussed content, focusing on weight monitoring and information on breastfeeding	Blood sampling for measuring HbA_{1c}
Session 4	6^{th}–8^{th} week postpartum	Counselling on nutrition in the breastfeeding phase, infant feeding practices	

GWG, gestational weight gain; HbA_{1c}, glycosylated haemoglobin A_{1c}; oGTT, oral glucose tolerance test.
Data source: based on Rauh et al. (2014).

3.2.5 Data collection in the GeliS trial

Pregnancy-associated and birth parameters

GWG was calculated as difference between the first and the last measured prenatal weight as documented in maternity records by gynaecologists. In addition, diverse secondary parameters were analysed (**Table 6**). GDM was diagnosed with a 2-hour 75 g oral glucose tolerance test (oGTT) between the 24^{th} and the 28^{th} week of gestation. The standardised test was performed with reference to national and international guidelines in gynaecological practices (Kleinwechter et al. 2016; Metzger et al. 2010). GDM was diagnosed if blood glucose equalled or exceeded one of the following thresholds: 92 mg/dL (fasted), 180 mg/dL (1 hour after glucose intake), 153 mg/dL (2 hours after glucose intake).

Combined questionnaires assessing dietary behaviour, physical activity and mental health were collected in early ($\leq 12^{th}$ week) as well as late pregnancy ($>29^{th}$ week) and 6-8 weeks pp. In the following, details on the assessment and evaluation of dietary behaviour are provided.

Maternal dietary behaviour

Self-reported data on maternal dietary behaviour were collected in the semi-quantitative FFQ that was validated and applied in the DEGS study ("German Health Interview and Examination

Survey for Adults") at the Robert Koch Institute (Haftenberger et al. 2010). The questionnaire assesses the average dietary intake of 54 food items over the last four weeks with questions about the frequency and amount of consumption. For each food item, participants could choose between 11 different categories of frequencies ranging from "never" to "more than five times per day". Categories of portion sizes are defined for the different food groups in usual measures, such as plates, bowls, cups, glasses, spoons and pieces. For meat, fish and vegetables, information on the typical way of preparation is collected. In addition, questions about specific diets (e.g. vegetarian, vegan) and the frequency of food preparation are asked.

Table 6 Primary and selected secondary outcomes of the GeliS study.

	Parameter	Data source
Primary outcome	Excessive gestational weight gain	Maternity record
Pregnancy complications	Gestational diabetes mellitus	Maternity record
	Hypertension	Maternity record
Obstetric complications	Mode of delivery	Birth protocol
	Induction of labour	Birth protocol
Newborn parameters	Birth weight	Birth protocol
	Height	Birth protocol
	Head circumference	Birth protocol
Maternal body weight	6-8 weeks pp weight retention	Maternity record

pp: postpartum. Data source: based on Rauh et al. (2014).

3.2.6 Data analysis in the GeliS trial

Pregnancy-associated and birth parameters

SAS software, version 9.4 for Windows (SAS Institute Inc., Cary, NC, USA) was used for statistical analyses. For the primary endpoint, a complete-case analysis was performed, including all women with available GWG data except those with a preterm delivery (<37 weeks of gestation) and women dropping out between inclusion and delivery. For secondary pregnancy- and birth-associated outcomes, the same dataset was used including women with a preterm delivery. Due to the cluster-randomised design, statistical analyses were performed using generalised estimating equations according to Donner and Klar (2000). Logistic and linear models were fit for binary and continuous parameters. Group differences are presented as estimated mean differences or odds ratios (ORs) and 95% confidence intervals (CIs), respectively. Details about statistical analyses have been described by Kunath et al. (2019).

Maternal dietary behaviour

In the analysis of the FFQ, data was discarded if more than 20 answers to food items were missing. Furthermore, data of women reporting implausibly high food intakes (liquids >15 kg, solid foods >10 kg, or liquids >4 kg and solid foods >6 kg) were excluded from the analyses due to overreporting of food intake, as defined by the developers of the DEGS-FFQ (RKI 2018).

The 54 food items were grouped to 17 food groups: non-alcoholic beverages, caffeinated beverages, soft drinks, alcoholic drinks, vegetables, fruit, cereal, side dishes, nuts, dairy products, cheese, eggs, fish, meat products, fats, sweets and snacks, and fast food. On the basis of the German food composition database ("Bundeslebensmittelschlüssel", version 3.02), energy and macronutrient intake of women were estimated with the OptiDiet PLUS software (version 6.0, GOE mbH, Linden, Germany). For questions in the FFQ referring to a spectrum of foods instead of single items, reference intake pattern from the German National Consumption Survey II were taken into account in order to improve accuracy (MRI 2018). For analysis of energy and macronutrient intake, data were further excluded in case energy intake was underreported (<4,500 kJ) or overreported (>20,000 kJ) (Meltzer et al. 2008).

A Healthy Eating Index (HEI), developed specifically for the DEGS-FFQ, was calculated (Kuhn 2017). Intake of 14 food categories form the basis of the HEI. For each of these categories, a score from 0 to 100 was calculated based on the women's adherence to the German Nutrition Society (DGE) recommendations. From the mean scores, a sum score was generated. The HEI ranges from 0 (low dietary quality) to 100 (high dietary quality).

Dietary outcomes were analysed with SPSS software (IBM SPSS Statistics for Windows, version 24.0, IBM Corp, Armonk, NY, USA). Food intake in late pregnancy was compared between IV and CG. Linear and logistic regression models based on generalised estimating equations were conducted to compare dietary parameters between groups. Changes in dietary behaviour from early to late pregnancy were analysed with linear mixed models. Associations of dietary behaviour and GWG as well as offspring weight parameters were analysed using linear and logistic regression models. For the latter type of analysis, groups were pooled to one cohort and group allocation was considered as an additional adjustment variable. Results are presented as estimated mean difference, effect size or OR and 95% CI, respectively. Details on statistical analysis of dietary data are provided by Günther et al. (2019a) and Günther et al. (2019b).

4 Results

In the following part, research results and the corresponding publications are presented, including pp weight development of mothers and children in the FeLIPO trial (Rauh et al. 2015), followed by the effects of the GeliS study on GWG (Kunath et al. 2019), pregnancy complications (Kunath et al. 2019) as well as maternal dietary behaviour (Günther et al. 2019a). In addition, data on associations between the maternal diet and maternal and offspring weight parameters are presented (Günther et al. 2019a; Günther et al. 2019b).

4.1 Effects of the FeLIPO lifestyle intervention on maternal postpartum weight retention and infant weight development

Lifestyle intervention to prevent excessive maternal weight gain: mother and infant follow-up at 12 months postpartum

Kathrin Rauh[1] & **Julia Günther**[1], Julia Kunath, Lynne Stecher and Hans Hauner
[1]The first two authors contributed equally to this work and share first authorship.

BMC Pregnancy and Childbirth 2015; 15:265; Open Access article available from: https://bmcpregnancychildbirth.biomedcentral.com/articles/10.1186/s12884-015-0701-2.

Summary of findings: Twelve months pp, weight data in the randomised controlled FeLIPO study were received from 148 women in the intervention group and 65 women in the control, corresponding to 85.2% of initially recruited study participants. Mean PPWR was 0.2 ± 3.6 kg in the IV and 0.8 ± 5.7 kg in the CG. There was no significant evidence for a difference between groups (p=0.321). The intervention resulted in a reduction of the proportion of women retaining more than 5 kg weight one year after delivery compared to their pre-pregnancy body weight (IV: 8%, CG: 17%, p=0.044). In a cohort analysis, higher GWG was positively associated with PPWR. Per 1 kg increase in GWG, mean PPWR was increased by 0.4 kg (p<0.001). No significant association between maternal energy and macronutrient intake with PPWR could be shown, neither in early nor in late pregnancy.
Offspring weight data up to 10 to 12 months pp were received for a total of 150 children in the IV and 70 in the CG. Until the 6th to 7th month pp weight measurement, no difference in infant weight development was shown between groups. 10 to 12 months after birth, offspring of women receiving lifestyle counselling during pregnancy tended to weigh less (IV: 9382 ± 931 g, CG: 9736 ± 999 g), but there was no statistically significant difference after adjusting for potential confounders (p=0.099). There was limited evidence of a positive association between GWG and infant weight at the 10th to 12th month (p=0.074). Maternal

antenatal energy and macronutrient intake were not shown to be significantly associated with offspring weight at the 10th to 12th month assessment.
In conclusion, the FeLIPO lifestyle intervention, which was effective in reducing GWG, showed limited effects on pp maternal and offspring weight development. While GWG played a significant role in pp weight development of women and by trend of their infants, such an association could not be shown with maternal antenatal dietary behaviour.

Personal contribution: **Julia Günther** was in charge of data interpretation and the writing of the manuscript.

4.2 Effects of the GeliS lifestyle intervention on gestational weight gain and pregnancy complications

Effects of a lifestyle intervention during pregnancy to prevent excessive gestational weight gain in routine care – the cluster-randomised GeliS trial

Julia Kunath [1] & **Julia Günther**[1], Kathrin Rauh, Julia Hoffmann, Lynne Stecher, Eva Rosenfeld, Luzia Kick, Kurt Ulm and Hans Hauner

[1]The first two authors contributed equally to this work and share first authorship.

BMC Medicine 2019; 17:5; Open Access article available from https://bmcmedicine.biomedcentral.com/articles/10.1186/s12916-018-1235-z.

Summary of findings: In the cluster-randomised GeliS intervention trial, a total of 2286 pregnant women were recruited in 71 gynaecological practices. 1139 women received counselling sessions on a healthy antenatal lifestyle, while 1122 women were allocated to the CG. Data from 83.4% of the initially enrolled women were considered for the primary analysis. Lifestyle counselling had no effect on the proportion of women with excessive GWG. The IOM weight gain recommendations were exceeded by 45.1% of women in the IV and 45.7% in the CG (p=0.789). Mean GWG did also not differ significantly between groups (14.1 ± 5.3 kg vs. 14.1 ± 5.2 kg, p=0.838). There were no major differences in pregnancy and obstetric complications between groups. GDM was diagnosed in 10.8% and 11.1% of women in the IV and the CG, respectively (p=0.622), and 3.5% (IV) and 4.9% (CG) received treatment (p=0.364). In the IV, the proportion of women with hypertension was higher than in the routine care group (IV: 9.5%, CG: 6.4%, p=0.017). Moreover, the rate of planned caesarean delivery was higher in the group receiving lifestyle counselling (IV: 15.5%, CG: 11.6%, p=0.017). Induction of labour as well as preterm labour was more frequent among women in the CG (IV: 17.3%, CG: 23.5%, p=0.038; IV: 1.6%, CG: 2.9%, p=0.003).

Slight differences between groups were observed in neonatal parameters. Both mean birth weight (IV: 3313 ± 536 g, CG: 3363 ± 498 g, p=0.020) and length (IV: 51.1 ± 2.7 cm, CG: 51.6 ± 2.5 cm, p=0.001) were slightly lower in the IV compared to the control. The proportion of preterm born infants was comparable between the two groups (IV: 7.1%, CG: 6.0%, p=0.310).
In conclusion, lifestyle counselling in the setting of routine antenatal care neither reduced the proportion of women with excessive GWG nor the frequency of pregnancy and obstetric complications. Slight differences were observed in neonatal weight and length.

Personal contribution: **Julia Günther** was in parts responsible for study procedures, data collection, data monitoring and conception of data analysis. Furthermore, **Julia Günther** contributed to the data interpretation and wrote the manuscript together with the other first author.

4.3 Effects of the GeliS lifestyle intervention on antenatal dietary behaviour

Effects of a lifestyle intervention in routine care on prenatal dietary behaviour – findings from the cluster-randomised GeliS trial

Julia Günther, Julia Hoffmann, Julia Kunath, Monika Spies, Dorothy Meyer, Lynne Stecher, Eva Rosenfeld, Luzia Kick, Kathrin Rauh and Hans Hauner

Journal of Clinical Medicine 2019; 8:960; Open Access article available from https://www.mdpi.com/2077-0383/8/7/960.

Summary of findings: The GeliS lifestyle counselling programme was effective in modifying certain components of maternal dietary behaviour. In late pregnancy, mean daily vegetable as well as fish intake was higher in women in the counselling group than in the CG (adjusted effect size for vegetable intake 19.83 g/day, CI 2.75–36.91 g/day, p=0.023; adjusted effect size for fish intake: 1.82 g/day, CI 0.68–2.96 g/day, p=0.002). Another beneficial effect of the intervention was a decrease in maternal soft drink intake (IV: 155.45 mL/day, CG: 235.36 mL/day, p<0.001). Women allocated to the counselling programme were more likely to choose healthier alternatives such as olive or rapeseed oil instead of other oils (p<0.001), whole-grain bread (p=0.002) and low-fat varieties of dairy products (p<0.001).
Lifestyle counselling did not induce changes in energy intake (IV: 2000 kcal/day, CG: 2011 kcal/day, p=0.724) and in the macronutrient composition of the prenatal diet. Mean dietary quality in late pregnancy was rated with a HEI and differed by trend between the IV and the CG (IV: 59.3 points, CG: 57.6 points) but was not significantly influenced by the intervention (p=0.162). Subgroup analyses provided evidence for a difference in the HEI

between groups in women aged 18-25 years (p=0.001) and women with general secondary education (p<0.001).

In the pooled GeliS cohort, certain dietary parameters in early and late pregnancy were positively associated with GWG. Food groups promoting weight gain included cheese (p=0.045), eggs (p=0.013) and fast food (p<0.001) in early pregnancy, and dairy products (p<0.001), processed meat (p=0.028), sweets and snacks (p=0.001) and fast food (p=0.007) in late pregnancy. There was evidence for an association of both late pregnancy energy intake (p<0.001) and sugar consumption (p=0.004) with GWG.

In conclusion, lifestyle counselling resulted in some beneficial dietary changes but yielded no significant effect on energy intake or overall dietary quality. Multiple aspects of the maternal diet were positively associated with GWG in the GeliS cohort.

Personal contribution: **Julia Günther** was in parts responsible for study procedures and data collection. **Julia Günther** was in charge of data processing and statistical analysis, data interpretation and writing of the manuscript.

4.4 Associations between the maternal antenatal diet and infant weight parameters at birth

Associations between the prenatal diet and neonatal outcomes – a secondary analysis of the cluster-randomised GeliS trial

Julia Günther, Julia Hoffmann, Monika Spies, Dorothy Meyer, Julia Kunath, Lynne Stecher, Eva Rosenfeld, Luzia Kick, Kathrin Rauh and Hans Hauner

Nutrients 2019; 11:1889; Open Access article available from https://www.mdpi.com/2072-6643/11/8/1889.

Summary of findings: In this secondary cohort analysis, some factors of the maternal antenatal diet, assessed via food frequency questionnaires in early (T0) and late gestation (T1), were associated with infant weight parameters at birth. The HEI was positively associated with infant birth weight (T0: adjusted effect size 39.26 g per 10 points, CI 12.29 to 66.22 g, p=0.004; T1: adjusted effect size 42.76 g per 10 points, CI 15.98 to 69.55 g, p=0.002). Vegetable intake was also positively associated with birth weight in early (adjusted effect size 41.28 g per 150 g portion of vegetables, CI 17.87 to 64.70 g, p=0.001) and late pregnancy (adjusted effect size 36.67 g per portion, CI 15.95 to 57.39 g, p=0.001). This was similarly seen in offspring BMI (T0: p=0.017, T1: p=0.002). In late pregnancy, fruit consumption was positively associated with infant weight (adjusted effect size 15.25 g per 150 g portion of fruit, CI 3.67 to 26.83 g, p=0.010) and BMI at birth (p=0.009). Furthermore, an increased fruit intake

in early gestation increased the odds of LGA neonates (p=0.016). Fast food intake in early gestation was positively associated with the odds of the offspring being born with >4000 g (p=0.014).

Soft drink intake during pregnancy was negatively associated with birth weight in early (adjusted effect size -10.90 g per 200 mL glass, CI -18.17 to -3.64 g, p=0.003) and late gestation (adjusted effect size -8.19 g per glass, CI -16.26 to -0.11 g, p=0.047). There was no evidence for such an association with neonate BMI (T0: p=0.076, T1: p=0.437). A negative association was observed between birth weight and early gestational alcohol (adjusted effect size -15.32 g per g, CI -29.83 to -0.80 g, p=0.039) and saccharose consumption (adjusted effect size -8.27 g per 10 g, CI -15.83 to -0.70 g, p=0.032). Early pregnancy sugar intake was additionally associated with increased odds of having an offspring with a birth weight <2500 g (p=0.026), whereas the intake of other macronutrients as well as total energy intake were not shown to be associated with infant weight or weight-related parameters at birth.
In conclusion, there was evidence that a healthy diet during pregnancy is associated with a slightly higher mean offspring birth weight within the adequate range, whereas some less healthy dietary factors were related to a modestly decreased infant weight at birth.

5 Discussion

The aim of the present work was to analyse the effect of lifestyle counselling on maternal and offspring health, weight development and maternal dietary outcomes. Therefore, the influence of the FeLIPO lifestyle intervention on weight development of mothers and infants in the first year after birth was addressed (Rauh et al. 2015). Moreover, the effectiveness of the GeliS intervention in reducing the proportion of women with excessive weight gain and pregnancy complications was investigated (Kunath et al. 2019). Special emphasis was put on maternal dietary behaviour, changes induced by the lifestyle intervention (Günther et al. 2019a) and its relation to GWG (Günther et al. 2019a) and offspring body weight (Günther et al. 2019b).

5.1 Discussion of the main findings from the GeliS and FeLIPO trials

5.1.1 Findings from the FeLIPO trial

Effects of the FeLIPO intervention on maternal outcomes

Following an effective reduction of the proportion of women with excessive GWG (Rauh et al. 2013), the influence of the intervention on **pp weight development** of mothers and their offspring was investigated. As shown by Rauh et al. (2013), lifestyle counselling by a dietary expert had successfully reduced mean GWG (IV: 14.1 kg, CG: 15.6 kg, p=0.049) and the rate of excessive GWG (IV: 38%, CG: 60%, p=0.032). Although GWG had been lower in the IV, the weight retained one year after delivery did not significantly differ between groups (Rauh et al. 2015). However, the proportion of women showing relevant PPWR (>5 kg) was higher in the CG 4 months (Rauh et al. 2013) as well as 12 months after birth (Rauh et al. 2015). Potential effects of lifestyle counselling during pregnancy on PPWR have also been considered in various other studies (Sagedal et al. 2017; Ronnberg et al. 2016; Vesco et al. 2016; Althuizen et al. 2013; Phelan et al. 2011b). Recently, we concluded in a meta-analysis that a lifestyle intervention starting in pregnancy can significantly reduce PPWR in the first year after childbirth by 0.73 kg (CI -1.32 to -0.14, p=0.015) (Michel et al. 2019). Although the mean group difference was strongest at 4-6 months pp and attenuated over time, there was still evidence for a group difference at 12 months after delivery (Michel et al. 2019). Effects of lifestyle interventions on pp weight development were however heterogeneous and the quality of included studies was often limited. Well-designed large-scaled trials with longer follow-up periods are required to confirm if lifestyle counselling can profoundly impact long-term maternal weight development. Maternal weight development after birth is of major relevance, as PPWR modifies the long-term risk of overweight and obesity (Gore et al. 2003). Evaluation of the 5-year follow-up of the GeliS intervention will add value in the understanding of the

effect of a pregnancy lifestyle intervention on maternal weight development in the first years pp.

Among women in the FeLIPO cohort, there was statistical evidence for a positive **association between GWG and PPWR**, but no evidence for a relation between self-reported antenatal dietary behaviour and the amount of retained weight (Rauh et al. 2015). Higher post-pregnancy body weight in women gaining excessive weight during gestation is common and has been confirmed in a meta-analysis by Nehring et al. (2011). Less is known on the impact of specific lifestyle factors on weight development beyond pregnancy (Ng et al. 2014; Rooney and Schauberger 2002). Multiple other factors are discussed as determinants of PPWR, including parity, pre-pregnancy BMI, educational level and breastfeeding behaviour (Hill et al. 2017; Hollis et al. 2017; Baker et al. 2008; Amorim et al. 2007). High and excessive GWG have been suggested as key determinants in short-term but also in long-term pp weight development of women (Mannan et al. 2013; Mamun et al. 2010; Amorim et al. 2007; Linné et al. 2004). Thus, interventions during pregnancy with the aim to normalise GWG may have long-term beneficial effects on maternal weight and health (Michel et al. 2019).

Effects of the FeLIPO intervention on offspring outcomes

According to meta-analyses, excessive GWG also seems to be an important determinant of short- and long-term weight development and obesity risk of the offspring (Mamun et al. 2014; Nehring et al. 2013). In the FeLIPO cohort, an increase in maternal GWG was by trend related to an increase in infant weight one year after birth (Rauh et al. 2015).

The FeLIPO intervention did not induce significant group differences in **weight development in the first year of life**, although weight at 10 to 12 months was by trend lower in the IV compared to the CG (Rauh et al. 2015). Infant weight development after antenatal lifestyle intervention has also been analysed in various other studies reporting mixed results. In most of the studies, antenatal lifestyle intervention showed no effect on early weight development in infants of women across all BMI categories (Ronnberg et al. 2017; Horan et al. 2016; Kolu et al. 2016; Mustila et al. 2012). For offspring of women with obesity, previous results have been promising (Vesco et al. 2016; Tanvig et al. 2014). A recent systematic review showed a reduced risk of obesity in children of women with obesity receiving lifestyle counselling during pregnancy, but highlighted the need for further investigations due to the high heterogeneity in performed trials (Dalrymple et al. 2018).

Given that breastfeeding is an important determinant of infant weight development (Harder et al. 2005; Arenz et al. 2004), an alternative explanation for the trend in infant weight difference observed in the FeLIPO study is that the mean duration of breastfeeding was by trend higher

in the IV (Rauh et al. 2015). Large-scaled trials monitoring infant weight and health in the first years of life will be essential to further elucidate the impact of lifestyle counselling on offspring development. Following the pilot study FeLIPO, the GeliS trial with its extended follow-up period until the 5th year of life will provide more insight into offspring weight development during infancy.

5.1.2 Findings from the GeliS trial

Main findings from the GeliS trial

In the large-scaled GeliS trial, the effectiveness of counselling on a healthy antenatal diet, regular physical activity and adequate GWG, delivered by health care providers, was investigated. Main findings discussed in the following are summarised in **Figure 2.**

The primary aim of the study, a reduction in the proportion of women **gaining excessive weight** during pregnancy, was not achieved (Kunath et al. 2019). Although adherence to the scheduled counselling sessions was high, the IOM recommendations for healthy GWG were exceeded by 45.1% of women in the IV and by a comparable 45.7% of women receiving routine prenatal care (Kunath et al. 2019). A lack of effectiveness of antenatal lifestyle counselling in reducing GWG has also been reported by others. Various lifestyle intervention programmes have been initiated and their effects on GWG have been inconsistent (Shieh et al. 2018; O'Brien et al. 2016; Muktabhant et al. 2015; Thangaratinam et al. 2012; Gardner et al. 2011; Dodd et al. 2010; Ronnberg and Nilsson 2010; Skouteris et al. 2010; Streuling et al. 2010). Among the two largest lifestyle intervention studies next to the GeliS trial, the UPBEAT study showed only modest effects on GWG (Poston et al. 2015), and the LIMIT study showed no effect on GWG (Dodd et al. 2014b), being consistent with the findings from the GeliS trial (Kunath et al. 2019). The i-WIP IPD meta-analysis concluded that overall, lifestyle interventions are modestly effective in reducing mean GWG by 0.7 kg (i-WIP 2017). There was, however, a high heterogeneity between the studies in terms of intensity, duration, target groups and provider of the intervention (i-WIP 2017). Success of counselling programmes may further depend on multiple factors such as maternal BMI, parity or educational level (i-WIP 2017; Goldstein et al. 2016), albeit the authors of the IPD meta-analysis found no significant evidence for subgroup differences (i-WIP 2017). Concluding therefrom, lifestyle interventions seem to be modestly effective in limiting GWG, but successful strategies feasible in large groups and realistic settings remain to be developed.

Besides a small but significant effect on GWG, the IPD meta-analysis provided evidence for a reduction in the risk of caesarean delivery and limited evidence for a reduction in the rate of GDM (i-WIP 2017). In the GeliS study, lifestyle counselling was not effective in reducing

pregnancy and obstetric complications (Kunath et al. 2019). Prevalence of **GDM** (11.0%) was comparable to the general rate in the German population (13.2%) (Melchior et al. 2017) and **elective caesarean section** was even more frequent among women receiving lifestyle counselling compared to women attending routine antenatal care. Mode of delivery was not included as a component in the lifestyle counselling, and the intervention is thus an unlikely explanation for this observation (Kunath et al. 2019). Cluster-randomisation of study regions instead of individual participants caused that women in the IV gave birth in other hospitals than women in the CG. As birth procedures differ between hospitals, reflected in a high regional variation in the caesarean section rate (Kolip et al. 2012), this is a potential explanation for the difference in the frequency of elective caesarean sections (Kunath et al. 2019).

Mean **offspring weight at birth** was slightly higher in the CG compared to the IV (Kunath et al. 2019). However, the rate of macrosomia and LGA was not different between groups. In addition to weight, the length of children at birth was higher in the CG, which might explain the difference in birth weight. Other offspring outcomes were not influenced by the lifestyle intervention (Kunath et al. 2019). Consistent with that, the IPD meta-analysis and other systematic reviews provided no evidence of an effect of lifestyle intervention during pregnancy on offspring outcomes (Dalrymple et al. 2018; i-WIP 2017; O'Brien et al. 2016).

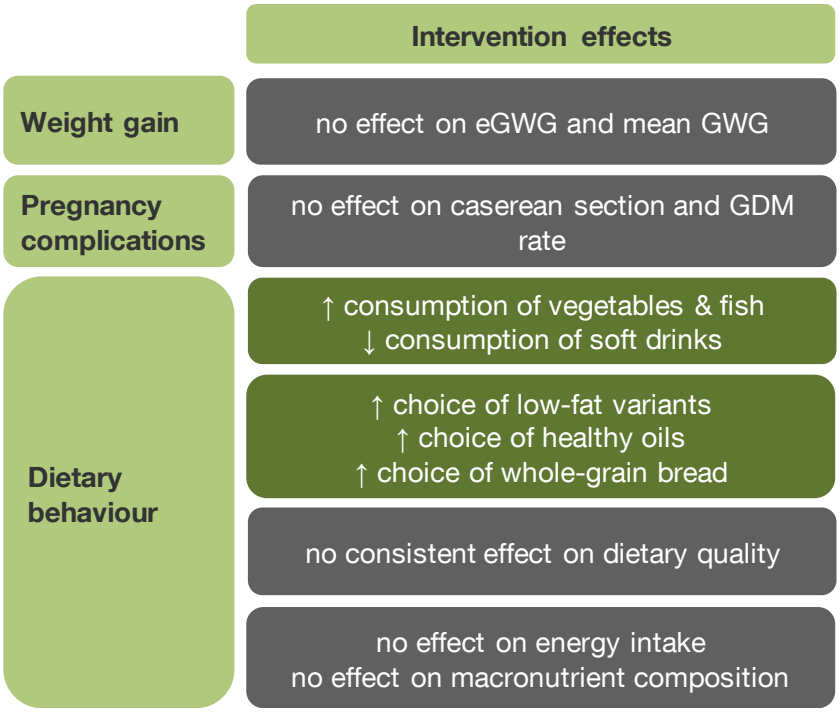

Figure 2 Summary of the presented intervention effects of the GeliS trial.
eGWG, excessive gestational weight gain; GDM, gestational diabetes mellitus; GWG, gestational weight gain. Data source: own contribution.

Effects of the GeliS intervention on maternal dietary behaviour

Analysis of the self-reported **maternal diet** in the GeliS trial provided evidence for adaptations following the lifestyle counselling (Günther et al. 2019a). The intervention favoured a number of behaviours that are regarded as healthy such as a higher vegetable intake or lower soft drink consumption (**Figure 2**). Nevertheless, antenatal **energy intake** was not influenced by the intervention, which is consistent with the missing effect on GWG (Günther et al. 2019a). This has similarly been observed in the large-scaled LIMIT trial, where dietary counselling could also modify neither energy intake nor GWG (Dodd et al. 2014a; Dodd et al. 2014b). In contrast to that, the intense intervention programme of the UPBEAT trial successfully reduced both energy consumption and mean GWG (Poston et al. 2015). Generally, the effectiveness of different lifestyle interventions in modifying energy intake has been heterogeneous (see **Table 3**).

The results of the LIMIT and the UPBEAT trial as well as dietary data collected in the GeliS study suggest that **specific aspects of the diet** are more likely to be influenced by the counselling than overall patterns and energy intake. Multiple factors reflecting a health-conscious diet were promoted by the counselling sessions in the GeliS trial. Observed effects included a slightly higher mean intake of fish and vegetables, a reduction in the consumption of sugar-sweetened beverages, and increased likelihood to choose low-fat dairy, whole-grain variants and rapeseed or olive oil (Günther et al. 2019a). These changes in behaviour are in line with specific recommendations that were communicated in the counselling sessions (Rauh et al. 2014; Koletzko et al. 2013). Moreover, these aspects of the antenatal diet have also been successfully modified in other intervention trials (Valkama et al. 2016; Dodd et al. 2014a; Kinnunen et al. 2014; Guelinckx et al. 2010).

The overall maternal diet was rated with a HEI specifically developed for the applied FFQ. Despite the above-described small but significant modifications in aspects of the maternal diet, there was no evidence for a higher **overall dietary quality** in the IV compared to the CG (Günther et al. 2019a). This finding is contradictory to other trials showing a beneficial effect on dietary quality (Sagedal et al. 2016; Dodd et al. 2014a). In specific subgroups of the GeliS cohort, however, overall dietary quality was significantly promoted by lifestyle counselling. There was significant evidence for an intervention effect in women younger than 26 years and in women with lower educational level (Günther et al. 2019a). The success of antenatal lifestyle counselling in promoting dietary adaptations may thus depend on maternal sociodemographic characteristics, which should be considered in delivering such interventions in the future.

Associations of the maternal diet with maternal and offspring weight parameters

Highlighting aspects of the diet that are of particular relevance for GWG may help to identify important key components of lifestyle counselling that should be emphasised in order to promote GWG within the adequate range. In the GeliS cohort, identified components that were positively **associated with GWG** were mostly foods of animal origin such as meat products, eggs, cheese, dairy products and high-processed foods such as sweets, snacks and fast food (Günther et al. 2019a). Generally, evidence in this field is sparse. However, some studies also showed positive associations between energy-dense and animal-derived foods and GWG (Bärebring et al. 2016; Stuebe et al. 2009). Choosing low-fat products as well as intake of energy and sugar in late pregnancy were additional factors favouring a higher GWG among women included in the GeliS trial (Günther et al. 2019a). Promoting effects of energy and sugar intake on GWG have also been shown by others (Tielemans et al. 2016; Maslova et al. 2015; Renault et al. 2015a), whereas no comparable data could be found to support the observed unexpected relation between an increased consumption of low-fat variants and higher GWG. A possible explanation is that women choosing fat-reduced alternatives may tend to consume more energy from the same or other products, although there was still evidence for an association after adjusting for energy intake (Günther et al. 2019a). If this observation can be repeated in further research, recommending low-fat variants in lifestyle counselling should be reconsidered.

Some characteristics of the maternal antenatal diet were further **related to offspring weight** and weight-related parameters. Factors reflecting a healthy dietary behaviour, such as consumption of fruits and vegetables, were positively associated with offspring weight and BMI at birth (Günther et al. 2019b). This has similarly been observed in other trials (Kjøllesdal and Holmboe-Ottesen 2014; Murphy et al. 2014). Data from the GeliS study provided no evidence for an impact of fruit and vegetable intake on the risk for low birth weight or SGA, whereas increased consumption of fruit in early pregnancy was associated with slightly increased odds of LGA. Overall dietary quality, measured with the HEI, was neither related to SGA nor to LGA, but there was evidence for an increase in mean birth weight in offspring of women with higher antenatal healthy diet scores (Günther et al. 2019b). Maternal fruit and vegetable intake may thus exemplarily reflect healthier dietary choices and may potentially explain the associations with birth weight and BMI. A positive association between dietary quality and birth weight has previously been reported (Rodríguez-Bernal et al. 2010). However, this requires further investigation within adequately powered samples, as overall, not much evidence is available substantiating this observation.

A number of parameters considered as unhealthy components of the diet were suggested to be inversely associated with birth weight, including sugar-containing drinks as well as sugar consumption in general (Günther et al. 2019b). An inverse association of sugar intake with neonatal weight has also been reported in other studies (Kjøllesdal and Holmboe-Ottesen 2014; Lenders et al. 1997), but evidence for sugar consumed in the form of beverages is inconclusive (Grundt et al. 2017; Phelan et al. 2011a). The effect on birth weight observed in the GeliS cohort may relate to the fact that products rich in sugar often have a low nutrient density, and their consumption may be connected to a lower intake of foods rich in nutrients (Günther et al. 2019b). Besides sugar, consumption of alcohol was negatively associated with birth weight, which is supported by available evidence even for low doses of ethanol (Mamluk et al. 2017). By contrast, intake of energy rich fast food was positively associated with high offspring birth weight (Günther et al. 2019b). This has previously been suggested in the literature (Wen et al. 2013) and may be related to a higher energy intake in diets rich in energy-dense food (Ledikwe et al. 2006).

It has to be acknowledged that, next to the maternal diet, maternal physical activity during pregnancy can play a role in offspring weight development, as also suggested by data of the GeliS cohort (Hoffmann et al. 2019a).

5.2 Limitations and barriers of the counselling concepts

The GeliS study is currently the largest intervention trial conducted in the routine antenatal care setting that investigated the effect of a lifestyle counselling programme on maternal weight development, pregnancy and obstetric complications and reported on behavioural outcomes to such an extent (Kunath et al. 2019). Nevertheless, both the GeliS and the FeLIPO trials have some limitations that should be taken into account. Both were designed for the general population of women of child-bearing age and included a broad spectrum of participants with a wide range in age, BMI and socioeconomic status. Educational level of women was rather high in both study populations (Rauh et al. 2013; Kunath et al. 2019). The results may thus not be completely transferable to the general population. The educational level was nevertheless comparable between the intervention and control groups, albeit other baseline characteristics such as pre-pregnancy BMI and age in the FeLIPO study (Rauh et al. 2013), and parity in the GeliS trial differed between groups (Kunath et al. 2019). These differences were considered in analyses by adjusting for these variables. Nevertheless, a residual influence on study outcomes is possible.

Another shortcoming is the collection of weight data in the trials. In the FeLIPO trial, the primary outcome was calculated based on self-reported weight at the start of pregnancy (Rauh et al. 2013). By contrast, in the GeliS study, weight data from maternity records were

used to enhance precision of calculated GWG (Kunath et al. 2019). In the pp follow-up, maternal weight data were however self-reported in both studies (Rauh et al. 2015; Hoffmann et al. 2019c). Using self-reported weight data is susceptible to inaccuracies. Nevertheless, self-reported weight data from women of childbearing age have been shown to provide valid estimates (Brunner 2007) and are often used in comparable settings and study populations (Tanentsapf et al. 2011).

Dietary data was also self-reported in both lifestyle intervention studies and thus dependent on participant accuracy and reliability. Whereas in the pilot trial, women were asked to fill in 7-day dietary records (Rauh et al. 2013), data in the GeliS cohort were collected by means of FFQs assessing dietary behaviour over the preceding four weeks (Günther et al. 2019a). Application of the FFQs allowed dietary assessment over a longer time period and reduced the effort for participants as well as for data analysis, but generally provides estimates rather than accurate food intake data (Meltzer et al. 2008). However, the FFQ used for data collection in the GeliS study has been verified as a useful tool for the comparison of food intake between groups (Haftenberger et al. 2010). Energy and macronutrient data based on the information collected via the FFQ should nevertheless be rather regarded as estimates (Günther et al. 2019a).

Despite the above mentioned shortcomings, the GeliS trial and the preceding feasibility trial feature particular strengths and provide an important contribution in the mission to optimise maternal antenatal lifestyle and to promote adequate GWG within the antenatal care setting. Counselling yielded some effects on maternal behaviour, as a number of dietary aspects were successfully modified following the intervention (Günther et al. 2019a). Furthermore, the lifestyle intervention induced changes in maternal physical activity behaviour, as shown by Hoffmann et al. (2019b). The counselling concept thus seems to be adequate to deliver specific messages to the women. Maternal dietary patterns, however, were not changed sufficiently to reach an impact on energy intake, GWG as well as on clinical outcomes in mothers and infants (Günther et al. 2019a). The FeLIPO pilot trial showed effects in reducing energy intake, excessive GWG and pregnancy complications (Rauh et al. 2013) that could not be confirmed in the large-scaled GeliS study (Kunath et al. 2019; Günther et al. 2019a). Both trials were conducted in the public health setting of routine care with counselling sessions attached to antenatal visits. However, lifestyle counselling was provided by a dietary expert in the pilot study, whereas practice personnel delivered the intervention in the GeliS trial. For the modification of weight development and health parameters, professional lifestyle counselling may be the more promising strategy. Inclusion of experts in such an intervention concept could be of critical relevance in the achievement of pronounced behaviour changes

in pregnant women (Kunath et al. 2019). A further factor that may have contributed to the missing effect of the GeliS intervention on maternal weight and pregnancy complications, is that behaviour change techniques were not routinely applied in counselling sessions. Incorporation of methods such as motivational interviewing could have provided a valuable improvement of the intervention concept (Kunath et al. 2019). An additional reason for the lack of detectable differences between IV and CG could be that women in the CG adapted a more health-conscious behaviour as they were aware of participating in a study and answered questionnaires on their dietary and physical activity habits (Kunath et al. 2019). The rate of excessive GWG in the GeliS control group was comparable to data of the German population (Ferrari et al. 2014) but lower than in the FeLIPO control group (Rauh et al. 2013). Furthermore, repeating the success of pilot trials in larger populations seems to be generally challenging. Difficulties in scaling-up previously successful interventions have repeatedly been observed in weight management approaches and seem to be a common phenomenon that should be taken into account in large intervention trials with promising feasibility pre-phases (McCrabb et al. 2019).

5.3 Outlook and implications for future approaches

While the FeLIPO pilot trial was terminated after a follow-up period lasting 12 months from delivery on, for the GeliS trial, a long pp observation phase was planned a priori. Mothers and their children are currently followed-up for 5 years and undergo extensive written and telephonic interviews about pp weight and health development (Rauh et al. 2014). This will enable the analysis of potential long-term consequences of the lifestyle intervention, even if no notable short-term effects were observed. In the follow-up phase of the FeLIPO trial, a trend to lower offspring body weight in the group receiving antenatal lifestyle counselling was first visible one year after birth (Rauh et al. 2015). This shows that effects of lifestyle adaptations during pregnancy may arise after a certain time and supports potential benefits of a longer-term follow-up of the study participants, especially as behavioural parameters such as specific dietary aspects (Günther et al. 2019a) but also physical activity parameters (Hoffmann et al. 2019b) have been adapted in the IV of the GeliS study.

After an extensive data collection during pregnancy via maternity and birth records, additional blood tests and questionnaires, a comprehensive acquisition of data about offspring weight, health and behaviour is performed in the first years of life (Rauh et al. 2014). Thus, next to a further evaluation of potential intervention effects, the GeliS cohort provides a rich data pool offering diverse opportunities for cohort analyses. In the above-mentioned analyses, some dietary aspects have been shown to be associated with the amount of GWG as well as birth weight of the offspring (Günther et al. 2019a; Günther et al. 2019b). Nevertheless, effect sizes

were rather modest and the clinical relevance of these observations is questionable. Small differences in body weight could however be amplified over time. Analysis of associations between the maternal diet during pregnancy and offspring weight over a span of numerous years will allow to address this. Beyond that, data on multiple further health and behavioural parameters are collected in the follow-up phase and will be subject to future analyses, including development of allergies, diabetes and other chronic diseases, intake of antibiotics as well as dietary and physical habits during early childhood.

Analysis of these data will provide further evidence for the antenatal lifestyle factors that impact offspring health and could thus help to identify which components of lifestyle counselling should receive more emphasis in intervention approaches. Multiple lifestyle intervention concepts have been developed over the last decade and have been shown to be modestly effective in reducing excessive GWG (i-WIP 2017). However, the large majority of these studies have been conducted in academic settings. Especially in real-life settings outside of academic centres, behavioural changes are difficult to achieve and only a limited number of pregnancy intervention studies have faced this challenge (Harrison et al. 2013; Rauh et al. 2013; Kinnunen et al. 2008; Kunath et al. 2019). Successful counselling approaches that are feasible within routine prenatal care remain to be developed, as the integration into exiting settings is crucial for such concepts to be implementable at the population level. As suggested by the results of the GeliS and the FeLIPO trials, cooperation of health care professionals with dietary and physical activity experts as well as implementation of profound counselling techniques to induce changes in behaviour could strengthen the prospects of success in future approaches (Rauh et al. 2013; Kunath et al. 2019). This could be an important step in convincing women to adopt a healthy lifestyle in order to enable the next generation a healthy start in life.

6 Conclusion

Lifestyle counselling has previously been shown to be modestly effective in reducing excessive GWG if conducted within controlled research settings. In the FeLIPO and the GeliS trials, an intervention concept providing information on a healthy antenatal diet and the importance of regular physical activity in combination with monitoring of maternal weight gain, was implemented in the routine care system. In the pilot study, lifestyle counselling conducted by a dietary expert effectively reduced excessive GWG, but could only by trend show an influence on pp weight development of mothers in the first 12 months pp. After scaling-up the intervention to a large sample size and recruiting pregnant women in multiple regions of Bavaria in the GeliS study, counselling carried out by trained health-care professionals could not significantly reduce the proportion of pregnant women showing excessive GWG or pregnancy and obstetric complications. Cooperation with experts in lifestyle counselling, as done in the case of the FeLIPO trial, may improve the quality of the delivered intervention, thereby increasing the potential to achieve effects on maternal weight and health, and should thus be considered in future approaches. Nevertheless, the GeliS intervention was effective in modifying a number of dietary parameters, including the consumed amount of vegetables, fish and soft drinks. These adaptions were, however, insufficient to influence overall dietary quality, albeit there was evidence for an effect on the HEI in some subgroups. Maternal energy intake could not be significantly influenced by lifestyle counselling, and no effect on the amount of GWG was achieved. More emphasis should thus be put on a moderate energy intake in future counselling concepts. Furthermore, cohort analyses of the GeliS participants showed positive associations between a number of food groups and GWG, including mainly animal products, fast food, sweets and snacks. Offspring birth weight within the normal range seemed to be promoted by components of a healthy diet such as fruit and vegetables. If these findings can be repeated by further research, they will help to specify dietary advice provided in future counselling concepts. Potential long-term effects of the GeliS intervention are currently assessed in a 5-year pp follow-up of mothers and infants. Evaluation of the follow-up data of this well-defined cohort will provide further insights into weight development after lifestyle counselling and offers comprehensive potential to analyse relations between pregnancy lifestyle parameters and offspring health in the first years of life.

References

Abu-Saad, K. and Fraser, D. (2010). Maternal nutrition and birth outcomes. *Epidemiologic reviews* 32, 5–25.

ACOG (2014). Committee Opinion No. 614: Management of pregnant women with presumptive exposure to Listeria monocytogenes. *Obstetrics and gynecology* 124(6), 1241–1244.

ACOG (2015). Committee Opinion No. 650: Physical Activity and Exercise During Pregnancy and the Postpartum Period. *Obstetrics and gynecology* 126(6), e135-42.

Agha, M., Agha, R. A., Sandall, J. and Sandell, J. (2014). Interventions to reduce and prevent obesity in pre-conceptual and pregnant women: a systematic review and meta-analysis. *PloS one* 9(5), e95132.

Althuizen, E., van der Wijden, C. L., van Mechelen, W., Seidell, J. C. and van Poppel, M. N. M. (2013). The effect of a counselling intervention on weight changes during and after pregnancy: a randomised trial. *BJOG* 120(1), 92–99.

Amorim, A. R., Rössner, S., Neovius, M., Lourenço, P. M. and Linné, Y. (2007). Does excess pregnancy weight gain constitute a major risk for increasing long-term BMI? *Obesity (Silver Spring, Md.)* 15(5), 1278–1286.

Ancri, G., Morse, E. H. and Clarke, R. P. (1977). Comparison of the nutritional status of pregnant adolescents with adult pregnant women. III. Maternal protein and calorie intake and weight gain in relation to size of infant at birth. *The American journal of clinical nutrition* 30(4), 568–572.

Arenz, S., Rückerl, R., Koletzko, B. and Kries, R. von (2004). Breast-feeding and childhood obesity – a systematic review. *International journal of obesity and related metabolic disorders* 28(10), 1247–1256.

Asci, O. and Rathfisch, G. (2016). Effect of lifestyle interventions of pregnant women on their dietary habits, lifestyle behaviors, and weight gain: a randomized controlled trial. *Journal of health, population, and nutrition* 35, 7.

Bain, E., Crane, M., Tieu, J., Han, S., Crowther, C. A. and Middleton, P. (2015). Diet and exercise interventions for preventing gestational diabetes mellitus. *The Cochrane database of systematic reviews*(4), CD010443.

Baker, J. L., Gamborg, M., Heitmann, B. L., Lissner, L., Sørensen, T. I. A. and Rasmussen, K. M. (2008). Breastfeeding reduces postpartum weight retention. *The American journal of clinical nutrition* 88(6), 1543–1551.

Bakker, R., Steegers, E. A. P., Obradov, A., Raat, H., Hofman, A. and Jaddoe, V. W. V. (2010). Maternal caffeine intake from coffee and tea, fetal growth, and the risks of adverse birth outcomes: the Generation R Study. *The American journal of clinical nutrition* 91(6), 1691–1698.

Bärebring, L., Brembeck, P., Lof, M., Brekke, H. K., Winkvist, A. and Augustin, H. (2016). Food intake and gestational weight gain in Swedish women. *SpringerPlus* 5, 377.

Bech, B. H., Obel, C., Henriksen, T. B. and Olsen, J. (2007). Effect of reducing caffeine intake on birth weight and length of gestation: randomised controlled trial. *BMJ (Clinical research ed.)* 334(7590), 409.

Bechtel-Blackwell, D. A. (2002). Computer-assisted self-interview and nutrition education in pregnant teens. *Clinical nursing research* 11(4), 450–462.

Becker, S. and Schmid, D. (2013). Verwendung von Nährstoffsupplementen vor und während der Schwangerschaft. *Ernährungsumschau* 11, 36–41.

Bergmann, K. E., Bergmann, R. L., Ellert, U. and Dudenhausen, J. W. (2007). Perinatal risk factors for long-term health. Results of the German Health Interview and Examination Survey for Children and Adolescents (KiGGS). *Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz* 50(5-6), 670–676.

Bezard, J., Blond, J. P., Bernard, A. and Clouet, P. (1994). The metabolism and availability of essential fatty acids in animal and human tissues. *Reproduction nutrition development* 34(6), 539–568.

Black, M. H., Sacks, D. A., Xiang, A. H. and Lawrence, J. M. (2013). The relative contribution of prepregnancy overweight and obesity, gestational weight gain, and IADPSG-defined gestational diabetes mellitus to fetal overgrowth. *Diabetes care* 36(1), 56–62.

Blumfield, M. L., Schreurs, M., Rollo, M. E., MacDonald-Wicks, L. K., Kokavec, A. and Collins, C. E. (2016). The association between portion size, nutrient intake and gestational weight gain: a secondary analysis in the WATCH study 2006/7. *Journal of human nutrition and dietetics* 29(3), 271–280.

Borg, G. (1962). *Physical performance and perceived exertion*. Lund, Sweden: Gleerup.

Bosaeus, M., Hussain, A., Karlsson, T., Andersson, L., Hulthén, L., Svelander, C., Sandberg, A.-S., Larsson, I., Ellegård, L. and Holmäng, A. (2015). A randomized longitudinal dietary intervention study during pregnancy: effects on fish intake, phospholipids, and body composition. *Nutrition journal* 14.

Bothwell, T. H. (2000). Iron requirements in pregnancy and strategies to meet them. *The American journal of clinical nutrition* 72(1 Suppl), 257–264.

Brantsæter, A. L., Olafsdottir, A. S., Forsum, E., Olsen, S. F. and Thorsdottir, I. (2012). Does milk and dairy consumption during pregnancy influence fetal growth and infant birthweight? A systematic literature review. *Food & nutrition research* 56.

Brunner, H. L. R. (2007). Validity of self-reported height and weight in women of reproductive age. *Maternal and child health journal* 11(2), 137–144.

Brunner, S., Stecher, L., Ziebarth, S., Nehring, I., Rifas-Shiman, S. L., Sommer, C., Hauner, H. and Kries, R. von (2015). Excessive gestational weight gain prior to glucose screening and the risk of gestational diabetes: a meta-analysis. *Diabetologia* 58(10), 2229–2237.

Butte, N. F. and King, J. C. (2005). Energy requirements during pregnancy and lactation. *Public health nutrition* 8(7A), 1010–1027.

Canda, M. T., Sezer, O. and Demir, N. (2011). An audit of seafood consumption awareness during pregnancy and its association with maternal and fetal outcomes in a Turkish population. *Journal of obstetrics and gynaecology* 31(4), 293–297.

CARE Study Group (2008). Maternal caffeine intake during pregnancy and risk of fetal growth restriction. A large prospective observational study. *BMJ (Clinical research ed.)* 337, a2332.

Changamire, F. T., Mwiru, R. S., Msamanga, G. I., Spiegelman, D., Urassa, W., Hertzmark, E., Fawzi, W. W. and Peterson, K. E. (2014). Macronutrient and sociodemographic determinants of gestational weight gain among HIV-negative women in Tanzania. *Food and nutrition bulletin* 35(1), 43–50.

Chasan-Taber, L. (2012). Physical activity and dietary behaviors associated with weight gain and impaired glucose tolerance among pregnant Latinas. *Advances in nutrition (Bethesda, Md.)* 3(1), 108–118.

Chatzi, L., Mendez, M., Garcia, R., Roumeliotaki, T., Ibarluzea, J., Tardón, A., Amiano, P., Lertxundi, A., Iñiguez, C., Vioque, J. et al. (2012). Mediterranean diet adherence during pregnancy and fetal growth. INMA (Spain) and RHEA (Greece) mother-child cohort studies. *The British journal of nutrition* 107(1), 135–145.

Chia, A.-R., Seymour, J. V. de, Colega, M., Chen, L.-W., Chan, Y.-H., Aris, I. M., Tint, M.-T., Quah, P. L., Godfrey, K. M., Yap, F. et al. (2016). A vegetable, fruit, and white rice dietary pattern during pregnancy is associated with a lower risk of preterm birth and larger birth size in a multiethnic Asian cohort. The Growing Up in Singapore Towards healthy Outcomes (GUSTO) cohort study. *The American journal of clinical nutrition* 104(5), 1416–1423.

Chong, M. F.-F., Chia, A.-R., Colega, M., Tint, M.-T., Aris, I. M., Chong, Y.-S., Gluckman, P., Godfrey, K. M., Kwek, K., Saw, S.-M. et al. (2015). Maternal Protein Intake during Pregnancy Is Not Associated with Offspring Birth Weight in a Multiethnic Asian Population. *The Journal of nutrition* 145(6), 1303–1310.

Chooi, Y. C., Ding, C. and Magkos, F. (2019). The epidemiology of obesity. *Metabolism* 92, 6–10.

Clapp, J. F. 3. (2000). Exercise during pregnancy. A clinical update. *Clinics in sports medicine* 19(2), 273–286.

Coelho, N. d. L. P., Cunha, D. B., Esteves, A. P. P., Lacerda, E. M. d. A. and Theme Filha, M. M. (2015). Dietary patterns in pregnancy and birth weight. *Revista de saude publica* 49, 62.

Coletta, J. M., Bell, S. J. and Roman, A. S. (2010). Omega-3 Fatty acids and pregnancy. *Reviews in obstetrics & gynecology* 3(4), 163–171.

Colón-Ramos, U., Racette, S. B., Ganiban, J., Nguyen, T. G., Kocak, M., Carroll, K. N., Völgyi, E. and Tylavsky, F. A. (2015). Association between dietary patterns during pregnancy and birth size measures in a diverse population in Southern US. *Nutrients* 7(2), 1318–1332.

Cosson, E., Cussac-Pillegand, C., Benbara, A., Pharisien, I., Nguyen, M. T., Chiheb, S., Valensi, P. and Carbillon, L. (2016). Pregnancy adverse outcomes related to pregravid body mass index and gestational weight gain, according to the presence or not of gestational diabetes mellitus: A retrospective observational study. *Diabetes & metabolism* 42(1), 38–46.

Crume, T. L., Brinton, J. T., Shapiro, A., Kaar, J., Glueck, D. H., Siega-Riz, A. M. and Dabelea, D. (2016). Maternal dietary intake during pregnancy and offspring body composition. The Healthy Start Study. *American journal of obstetrics and gynecology* 215(5), 609.e1-609.e8.

Cucó, G., Arija, V., Iranzo, R., Vilà, J., Prieto, M. T. and Fernández-Ballart, J. (2006). Association of maternal protein intake before conception and throughout pregnancy with birth weight. *Acta obstetricia et gynecologica Scandinavica* 85(4), 413–421.

D-A-CH (2001). *Referenzwerte für die Nährstoffzufuhr*. Frankfurt: Umschau/Braus.

D-A-CH (2015). *Referenzwerte für die Nährstoffzufuhr*. Neustadt an der Weinstraße: Neuer Umschau Buchverlag.

Dalrymple, K. V., Martyni-Orenowicz, J., Flynn, A. C., Poston, L. and O'Keeffe, M. (2018). Can antenatal diet and lifestyle interventions influence childhood obesity? A systematic review. *Maternal & child nutrition* 14(4), e12628.

Deierlein, A. L., Siega-Riz, A. M. and Herring, A. (2008). Dietary energy density but not glycemic load is associated with gestational weight gain. *The American journal of clinical nutrition* 88(3), 693–699.

DGE (2017). Deutsche Gesellschaft für Ernährung e.V. Vollwertig essen und trinken nach den 10 Regeln der DGE [http://www.dge.de/fileadmin/public/doc/fm/10-Regeln-der-DGE.pdf].

DHHS (2008). *Department of Health and Human Services - Physical activity guidelines for Americans*. Washington, DC: DHHS.

Diemert, A., Lezius, S., Pagenkemper, M., Hansen, G., Drozdowska, A., Hecher, K., Arck, P. and Zyriax, B. C. (2016). Maternal nutrition, inadequate gestational weight gain and birth weight. Results from a prospective birth cohort. *BMC pregnancy and childbirth* 16, 224.

Dodd, J. M., Cramp, C., Sui, Z., Yelland, L. N., Deussen, A. R., Grivell, R. M., Moran, L. J., Crowther, C. A., Turnbull, D., McPhee, A. J. et al. (2014a). The effects of antenatal dietary and lifestyle advice for women who are overweight or obese on maternal diet and physical activity: the LIMIT randomised trial. *BMC medicine* 12, 161.

Dodd, J. M., Grivell, R. M., Crowther, C. A. and Robinson, J. S. (2010). Antenatal interventions for overweight or obese pregnant women: a systematic review of randomised trials. *BJOG* 117(11), 1316–1326.

Dodd, J. M., Turnbull, D., McPhee, A. J., Deussen, A. R., Grivell, R. M., Yelland, L. N., Crowther, C. A., Wittert, G., Owens, J. A. and Robinson, J. S. (2014b). Antenatal lifestyle advice for women who are overweight or obese: LIMIT randomised trial. *BMJ (Clinical research ed.)* 348, g1285.

Donner, A. and Klar, N. (2000). *Design and analysis of cluster randomization trials in health research*. Chichester: Wiley & Sons.

EFSA (2010). Scientific Opinion on Dietary Reference Values for water. *EFSA Journal* 8(3), 1459.

Ensenauer, R., Chmitorz, A., Riedel, C., Fenske, N., Hauner, H., Nennstiel-Ratzel, U. and Kries, R. von (2013). Effects of suboptimal or excessive gestational weight gain on childhood overweight and abdominal adiposity. Results from a retrospective cohort study. *International journal of obesity (2005)* 37(4), 505–512.

Eskenazi, B., Stapleton, A. L., Kharrazi, M. and Chee, W. Y. (1999). Associations between maternal decaffeinated and caffeinated coffee consumption and fetal growth and gestational duration. *Epidemiology (Cambridge, Mass.)* 10(3), 242–249.

FAO/WHO/UNU (2004). *Human energy requirements. Report of a joint FAO/WHO/UNU expert consultation Rome, 17 - 24 October 2001*. Rome: United Nations University.

Fekete, K., Berti, C., Trovato, M., Lohner, S., Dullemeijer, C., Souverein, O. W., Cetin, I. and Decsi, T. (2012). Effect of folate intake on health outcomes in pregnancy: a systematic review and meta-analysis on birth weight, placental weight and length of gestation. *Nutrition journal* 11, 75.

Ferrari, N., Mallmann, P., Brockmeier, K., Strüder, H. K. and Graf, C. (2014). Secular trends in pregnancy weight gain in German women and their influences on foetal outcome: a hospital-based study. *BMC pregnancy and childbirth* 14, 228.

Flynn, A. C., Dalrymple, K., Barr, S., Poston, L., Goff, L. M., Rogozińska, E., van Poppel, M. N. M., Rayanagoudar, G., Yeo, S., Barakat Carballo, R. et al. (2016). Dietary interventions in overweight and obese pregnant women: a systematic review of the content, delivery, and outcomes of randomized controlled trials. *Nutrition reviews* 74(5), 312–328.

Flynn, A. C., Schneeberger, C., Seed, P. T., Barr, S., Poston, L. and Goff, L. M. (2015). The Effects of the UK Pregnancies Better Eating and Activity Trial Intervention on Dietary Patterns in Obese Pregnant Women Participating in a Pilot Randomized Controlled Trial. *Nutrition and metabolic insights* 8(Suppl 1), 79–86.

Gaillard, R., Durmus, B., Hofman, A., Mackenbach, J. P., Steegers, E. A. P. and Jaddoe, V. W. V. (2013). Risk factors and outcomes of maternal obesity and excessive weight gain during pregnancy. *Obesity (Silver Spring, Md.)* 21(5), 1046–1055.

Gardner, B., Wardle, J., Poston, L. and Croker, H. (2011). Changing diet and physical activity to reduce gestational weight gain: a meta-analysis. *Obesity reviews* 12(7), e602-20.

Godfrey, K., Robinson, S., Barker, D. J., Osmond, C. and Cox, V. (1996). Maternal nutrition in early and late pregnancy in relation to placental and fetal growth. *BMJ* 312(7028), 410–414.

Goldstein, R., Teede, H., Thangaratinam, S. and Boyle, J. (2016). Excess Gestational Weight Gain in Pregnancy and the Role of Lifestyle Intervention. *Seminars in reproductive medicine* 34(2), e14-21.

Gore, S. A., Della Brown, M. and West, D. S. (2003). The role of postpartum weight retention in obesity among women: a review of the evidence. *Annals of behavioral medicine* 26(2), 149–159.

Gray-Donald, K., Robinson, E., Collier, A., David, K., Renaud, L. and Rodrigues, S. (2000). Intervening to reduce weight gain in pregnancy and gestational diabetes mellitus in Cree communities: an evaluation. *Canadian Medical Association journal* 163(10), 1247–1251.

Gresham, E., Collins, C. E., Mishra, G. D., Byles, J. E. and Hure, A. J. (2016). Diet quality before or during pregnancy and the relationship with pregnancy and birth outcomes. The Australian Longitudinal Study on Women's Health. *Public health nutrition* 19(16), 2975–2983.

Grieger, J. A. and Clifton, V. L. (2014). A review of the impact of dietary intakes in human pregnancy on infant birthweight. *Nutrients* 7(1), 153–178.

Grundt, J. H., Eide, G. E., Brantsaeter, A.-L., Haugen, M. and Markestad, T. (2017). Is consumption of sugar-sweetened soft drinks during pregnancy associated with birth weight? *Maternal & child nutrition* 13(4).

Guelinckx, I., Devlieger, R., Mullie, P. and Vansant, G. (2010). Effect of lifestyle intervention on dietary habits, physical activity, and gestational weight gain in obese pregnant women: a randomized controlled trial. *The American journal of clinical nutrition* 91(2), 373–380.

Guilloty, N. I., Soto, R., Anzalota, L., Rosario, Z., Cordero, J. F. and Palacios, C. (2015). Diet, Pre-pregnancy BMI, and Gestational Weight Gain in Puerto Rican Women. *Maternal and child health journal* 19(11), 2453–2461.

Guldner, L., Monfort, C., Rouget, F., Garlantezec, R. and Cordier, S. (2007). Maternal fish and shellfish intake and pregnancy outcomes. A prospective cohort study in Brittany, France. *Environmental health* 6, 33.

Gunderson, E. P. and Abrams, B. (1999). Epidemiology of gestational weight gain and body weight changes after pregnancy. *Epidemiologic reviews* 21(2), 261–275.

Günther, J., Hoffmann, J., Kunath, J., Spies, M., Meyer, D., Stecher, L., Rosenfeld, E., Kick, L., Rauh, K. and Hauner, H. (2019a). Effects of a Lifestyle Intervention in Routine Care on Prenatal Dietary Behavior-Findings from the Cluster-Randomized GeliS Trial. *Journal of clinical medicine* 8(7).

Günther, J., Hoffmann, J., Spies, M., Meyer, D., Kunath, J., Stecher, L., Rosenfeld, E., Kick, L., Rauh, K. and Hauner, H. (2019b). Associations between the prenatal diet and neonatal outcomes – a secondary analysis of the cluster-randomised GeliS trial. *Nutrients* 11(8).

Haftenberger, M., Heuer, T., Heidemann, C., Kube, F., Krems, C. and Mensink, G. B. M. (2010). Relative validation of a food frequency questionnaire for national health and nutrition monitoring. *Nutrition journal* 9, 36.

Hallberg, L. (1988). Iron Balance in Pregnancy. In *Vitamins and Minerals in Pregnancy and Lactation* (ed. Berger H). New York: Raven Press.

Halldorsson, T. I., Meltzer, H. M., Thorsdottir, I., Knudsen, V. and Olsen, S. F. (2007). Is high consumption of fatty fish during pregnancy a risk factor for fetal growth retardation? A study of 44,824 Danish pregnant women. *American journal of epidemiology* 166(6), 687–696.

Han, Z., Mulla, S., Beyene, J., Liao, G. and McDonald, S. D. (2011). Maternal underweight and the risk of preterm birth and low birth weight: a systematic review and meta-analyses. *International journal of epidemiology* 40(1), 65–101.

Harder, T., Bergmann, R., Kallischnigg, G. and Plagemann, A. (2005). Duration of breastfeeding and risk of overweight: a meta-analysis. *American journal of epidemiology* 162(5), 397–403.

Harrison, C. L., Lombard, C. B., Strauss, B. J. and Teede, H. J. (2013). Optimizing healthy gestational weight gain in women at high risk of gestational diabetes: a randomized controlled trial. *Obesity (Silver Spring, Md.)* 21(5), 904–909.

Hawkins, M., Chasan-Taber, L., Marcus, B., Stanek, E., Braun, B., Ciccolo, J. and Markenson, G. (2014). Impact of an exercise intervention on physical activity during pregnancy: the behaviors affecting baby and you study. *American journal of public health* 104(10), 81.

Hedderson, M. M., Gunderson, E. P. and Ferrara, A. (2010). Gestational weight gain and risk of gestational diabetes mellitus. *Obstetrics and gynecology* 115(3), 597–604.

Heery, E., Kelleher, C. C., Wall, P. G. and McAuliffe, F. M. (2015). Prediction of gestational weight gain - a biopsychosocial model. *Public health nutrition* 18(8), 1488–1498.

Hegaard, H. K., Pedersen, B. K., Nielsen, B. B. and Damm, P. (2007). Leisure time physical activity during pregnancy and impact on gestational diabetes mellitus, pre-eclampsia, preterm delivery and birth weight: a review. *Acta obstetricia et gynecologica Scandinavica* 86(11), 1290–1296.

Heppe, D. H. M., van Dam, R. M., Willemsen, S. P., den Breeijen, H., Raat, H., Hofman, A., Steegers, E. A. P. and Jaddoe, V. W. V. (2011). Maternal milk consumption, fetal growth, and the risks of neonatal complications: the Generation R Study. *The American journal of clinical nutrition* 94(2), 501–509.

Hesse, V., Voigt, M., Sälzler, A., Steinberg, S., Friese, K., Keller, E., Gausche, R. and Eisele, R. (2003). Alterations in height, weight, and body mass index of newborns, children, and young adults in eastern Germany after German reunification. *The Journal of pediatrics* 142(3), 259–262.

Hill, B., Bergmeier, H., McPhie, S., Fuller-Tyszkiewicz, M., Teede, H., Forster, D., Spiliotis, B. E., Hills, A. P. and Skouteris, H. (2017). Is parity a risk factor for excessive weight gain during pregnancy and postpartum weight retention? A systematic review and meta-analysis. *Obesity reviews* 18(7), 755–764.

Hill, J. O. and Peters, J. C. (1998). Environmental contributions to the obesity epidemic. *Science (New York, N.Y.)* 280(5368), 1371–1374.

Hillesund, E. R., Bere, E., Haugen, M. and Øverby, N. C. (2014). Development of a New Nordic Diet score and its association with gestational weight gain and fetal growth - a study performed in the Norwegian Mother and Child Cohort Study (MoBa). *Public health nutrition* 17(9), 1909–1918.

Hoffmann, J., Günther, J., Geyer, K., Stecher, L., Kunath, J., Meyer, D., Spies, M., Rosenfeld, E., Kick L., Rauh, K. et al. (2019a). Effects of prenatal physical activity on neonatal and obstetric outcomes – findings from the cluster-randomised GeliS trial. *BMC Pregnancy and Childbirth [under review]*.

Hoffmann, J., Günther, J., Geyer, K., Stecher, L., Rauh, K., Kunath, J., Meyer, D., Sitzberger, C., Spies, M., Rosenfeld, E. et al. (2019b). Effects of a lifestyle intervention in routine care on prenatal physical activity – findings from the cluster-randomised GeliS trial. *BMC Pregnancy and Childbirth [under review]*.

Hoffmann, J., Günther, J., Stecher, L., Spies, M., Meyer, D., Kunath, J., Raab, R., Rauh, K. and Hauner, H. (2019c). Effects of a Lifestyle Intervention in Routine Care on Short- and Long-Term Maternal Weight Retention and Breastfeeding Behavior - 12 Months Follow-up of the Cluster-Randomized GeliS Trial. *Journal of clinical medicine* 8(6), 876.

Hollis, J. L., Crozier, S. R., Inskip, H. M., Cooper, C., Godfrey, K. M., Harvey, N. C., Collins, C. E. and Robinson, S. M. (2017). Modifiable risk factors of maternal postpartum weight retention: an analysis of their combined impact and potential opportunities for prevention. *International journal of obesity (2005)* 41(7), 1091–1098.

Horan, M. K., McGowan, C. A., Gibney, E. R., Byrne, J., Donnelly, J. M. and McAuliffe, F. M. (2016). Maternal Nutrition and Glycaemic Index during Pregnancy Impacts on Offspring Adiposity at 6 Months of Age – Analysis from the ROLO Randomised Controlled Trial. *Nutrients* 8(1).

Hrolfsdottir, L., Rytter, D., Hammer Bech, B., Brink Henriksen, T., Danielsen, I., Steingrimsdottir, L., Olsen, S. F. and Halldorsson, T. I. (2013). Maternal milk consumption, birth size and adult height of offspring. A prospective cohort study with 20 years of follow-up. *European journal of clinical nutrition* 67(10), 1036–1041.

Hsu, W.-Y., Wu, C.-H., Hsieh, C. T.-C., Lo, H.-C., Lin, J.-S. and Kao, M.-D. (2013). Low body weight gain, low white blood cell count and high serum ferritin as markers of poor nutrition and increased risk for preterm delivery. *Asia Pacific journal of clinical nutrition* 22(1), 90–99.

Hui, A., Back, L., Ludwig, S., Gardiner, P., Sevenhuysen, G., Dean, H., Sellers, E., McGavock, J., Morris, M., Bruce, S. et al. (2012). Lifestyle intervention on diet and exercise reduced excessive gestational weight gain in pregnant women under a randomised controlled trial. *BJOG* 119(1), 70–77.

Hui, A. L., Back, L., Ludwig, S., Gardiner, P., Sevenhuysen, G., Dean, H. J., Sellers, E., McGavock, J., Morris, M., Jiang, D. et al. (2014). Effects of lifestyle intervention on dietary intake, physical activity level, and gestational weight gain in pregnant women with different pre-pregnancy Body Mass Index in a randomized control trial. *BMC pregnancy and childbirth* 14, 331.

Hui, A. L., Ludwig, S., Gardiner, P., Sevenhuysen, G., Murray, R., Morris, M. and Shen, G. X. (2006). Community-based Exercise and Dietary Intervention During Pregnancy. A Pilot Study. *Canadian Journal of Diabetes* 30(2), 1–7.

Hytten, F. E. and Leitch, I. (1971). *The physiology of human pregnancy*. Oxford: Blackwell Scientific Publications.

Imdad, A. and Bhutta, Z. A. (2011). Effect of balanced protein energy supplementation during pregnancy on birth outcomes. *BMC public health* 11 Suppl 3, S17.

Imhoff-Kunsch, B., Briggs, V., Goldenberg, T. and Ramakrishnan, U. (2012). Effect of n-3 long-chain polyunsaturated fatty acid intake during pregnancy on maternal, infant, and child health outcomes: a systematic review. *Paediatric and perinatal epidemiology* 26 Suppl 1, 91–107.

IOM (1990). *Nutrition During Pregnancy: Part I Weight Gain: Part II Nutrient Supplements*. Washington (DC).

IOM, ed. (2009). *Weight gain during pregnancy. Reexamining the guidelines*: The National Academic Press. Washington (DC).

i-WIP (2017). Effect of diet and physical activity based interventions in pregnancy on gestational weight gain and pregnancy outcomes: meta-analysis of individual participant data from randomised trials. *BMJ (Clinical research ed.)* 358, j3119.

Jackson, R. A., Stotland, N. E., Caughey, A. B. and Gerbert, B. (2011). Improving diet and exercise in pregnancy with Video Doctor counseling: a randomized trial. *Patient education and counseling* 83(2), 203–209.

Jebeile, H., Mijatovic, J., Louie, J. C. Y., Prvan, T. and Brand-Miller, J. C. (2016). A systematic review and metaanalysis of energy intake and weight gain in pregnancy. *American journal of obstetrics and gynecology* 214(4), 465–483.

Jedrychowski, W., Perera, F. P., Tang, D., Stigter, L., Mroz, E., Flak, E., Spengler, J., Budzyn-Mrozek, D., Kaim, I. and Jacek, R. (2012). Impact of barbecued meat consumed in pregnancy on birth outcomes accounting for personal prenatal exposure to airborne polycyclic aromatic hydrocarbons. Birth cohort study in Poland. *Nutrition* 28(4), 372–377.

Johnson, J. L., Farr, S. L., Dietz, P. M., Sharma, A. J., Barfield, W. D. and Robbins, C. L. (2015). Trends in gestational weight gain: the Pregnancy Risk Assessment Monitoring System, 2000-2009. *American journal of obstetrics and gynecology* 212(6), 806.e1-8.

Kapadia, M. Z., Gaston, A., van Blyderveen, S., Schmidt, L., Beyene, J., McDonald, H. and McDonald, S. D. (2015). Psychological antecedents of excess gestational weight gain. A systematic review. *BMC pregnancy and childbirth* 15, 107.

Khoury, J., Henriksen, T., Christophersen, B. and Tonstad, S. (2005). Effect of a cholesterol-lowering diet on maternal, cord, and neonatal lipids, and pregnancy outcome: a randomized clinical trial. *American journal of obstetrics and gynecology* 193(4), 1292–1301.

Kieffer, E. C., Welmerink, D. B., Sinco, B. R., Welch, K. B., Rees Clayton, E. M., Schumann, C. Y. and Uhley, V. E. (2014). Dietary outcomes in a Spanish-language randomized controlled diabetes prevention trial with pregnant Latinas. *American journal of public health* 104(3), 526–533.

Kinnunen, T. I., Aittasalo, M., Koponen, P., Ojala, K., Mansikkamäki, K., Weiderpass, E., Fogelholm, M. and Luoto, R. (2008). Feasibility of a controlled trial aiming to prevent excessive pregnancy-related weight gain in primary health care. *BMC pregnancy and childbirth* 8, 37.

Kinnunen, T. I., Pasanen, M., Aittasalo, M., Fogelholm, M., Hilakivi-Clarke, L., Weiderpass, E. and Luoto, R. (2007). Preventing excessive weight gain during pregnancy - a controlled trial in primary health care. *European journal of clinical nutrition* 61(7), 884–891.

Kinnunen, T. I., Puhkala, J., Raitanen, J., Ahonen, S., Aittasalo, M., Virtanen, S. M. and Luoto, R. (2014). Effects of dietary counselling on food habits and dietary intake of Finnish pregnant women at increased risk for gestational diabetes - a secondary analysis of a cluster-randomized controlled trial. *Maternal & child nutrition* 10(2), 184–197.

Kizirian, N. V., Markovic, T. P., Muirhead, R., Brodie, S., Garnett, S. P., Louie, J. C. Y., Petocz, P., Ross, G. P. and Brand-Miller, J. C. (2016). Macronutrient Balance and Dietary Glycemic Index in Pregnancy Predict Neonatal Body Composition. *Nutrients* 8(5).

Kjøllesdal, M. K. R. and Holmboe-Ottesen, G. (2014). Dietary Patterns and Birth Weight-a Review. *AIMS public health* 1(4), 211–225.

Kleinwechter, H., Schäfer-Graf, U., Bührer, C., Hoesli, I., Kainer, F., Kautzky-Willer, A., Pawlowski, B., Schunck, K., Somville, T. and Sorger, M. (2016). Gestationsdiabetes mellitus (GDM) –Diagnostik, Therapie und Nachsorge. *Diabetologie und Stoffwechsel* 11(S 02), S182-S194.

Knudsen, V. K., Heitmann, B. L., Halldorsson, T. I., Sørensen, T. I. A. and Olsen, S. F. (2013). Maternal dietary glycaemic load during pregnancy and gestational weight gain, birth weight and postpartum weight retention. A study within the Danish National Birth Cohort. *The British journal of nutrition* 109(8), 1471–1478.

Knudsen, V. K., Orozova-Bekkevold, I. M., Mikkelsen, T. B., Wolff, S. and Olsen, S. F. (2008). Major dietary patterns in pregnancy and fetal growth. *European journal of clinical nutrition* 62(4), 463–470.

Koivusalo, S. B., Rono, K., Klemetti, M. M., Roine, R. P., Lindstrom, J., Erkkola, M., Kaaja, R. J., Poyhonen-Alho, M., Tiitinen, A., Huvinen, E. et al. (2016). Gestational Diabetes Mellitus Can Be Prevented by Lifestyle Intervention: The Finnish Gestational Diabetes Prevention Study (RADIEL): A Randomized Controlled Trial. *Diabetes care* 39(1), 24–30.

Koletzko, B., Bauer, C. P., Bung, P., Cremer, M., Flothkotter, M., Hellmers, C., Kersting, M., Krawinkel, M., Przyrembel, H., Rasenack, R. et al. (2013). German national consensus recommendations on nutrition and lifestyle in pregnancy by the 'Healthy Start - Young Family Network'. *Annals of nutrition & metabolism* 63(4), 311–322.

Koletzko, B., Cetin, I. and Brenna, J. T. (2007). Dietary fat intakes for pregnant and lactating women. *The British journal of nutrition* 98(5), 873–877.

Koletzko, B., Cremer, M., Flothkötter, M., Graf, C., Hauner, H., Hellmers, C., Kersting, M., Krawinkel, M., Przyrembel, H., Röbl-Mathieu, M. et al. (2018). Diet and Lifestyle Before and During Pregnancy - Practical Recommendations of the Germany-wide Healthy Start - Young Family Network. *Geburtshilfe und Frauenheilkunde* 78(12), 1262–1282.

Kolip, P., Nolting, H.-D. and Zich, K. (2012). Faktencheck Gesundheit. Kaiserschnittgeburten - Entwicklung und regionale Verteilung. 1st ed. https://faktencheck-gesundheit.de/fileadmin/files/BSt/Publikationen/GrauePublikationen/GP_Faktencheck_Gesundheit_Kaiserschnitt.pdf, Accessed August 19, 2019.

Kolu, P., Raitanen, J., Puhkala, J., Tuominen, P., Husu, P. and Luoto, R. (2016). Effectiveness and Cost-Effectiveness of a Cluster-Randomized Prenatal Lifestyle Counseling Trial: A Seven-Year Follow-Up. *PloS one* 11(12), e0167759.

Kuhn, D.-A. (2017). *Entwicklung eines Index zur Bewertung der Ernährungsqualität in der Studie zur Gesundheit Erwachsener in Deutschland (DEGS1), German ("Development of a dietary quality index in the German Health Examination Survey for Adults"),* Master's Thesis, Robert Koch Institute.

Kunath, J., Günther, J., Rauh, K., Hoffmann, J., Stecher, L., Rosenfeld, E., Kick, L., Ulm, K. and Hauner, H. (2019). Effects of a lifestyle intervention during pregnancy to prevent excessive gestational weight gain in routine care - the cluster-randomised GeliS trial. *BMC medicine* 17(1), 5.

Lagiou, P., Tamimi, R. M., Mucci, L. A., Adami, H.-O., Hsieh, C.-C. and Trichopoulos, D. (2004). Diet during pregnancy in relation to maternal weight gain and birth size. *European journal of clinical nutrition* 58(2), 231–237.

Lamichhane, D. K., Leem, J.-H., Kim, H.-C., Lee, J.-Y., Park, M.-S., Jung, D.-Y., Ko, J. K., Ha, M., Kim, Y., Hong, Y.-C. et al. (2016). Impact of prenatal exposure to polycyclic aromatic hydrocarbons from maternal diet on birth outcomes. A birth cohort study in Korea. *Public health nutrition* 19(14), 2562–2571.

Lamminpää, R., Vehviläinen-Julkunen, K. and Schwab, U. (2018). A systematic review of dietary interventions for gestational weight gain and gestational diabetes in overweight and obese pregnant women. *European journal of nutrition* 57(5), 1721–1736.

Langley-Evans, A. J. and Langley-Evans, S. C. (2003). Relationship between maternal nutrient intakes in early and late pregnancy and infants weight and proportions at birth. Prospective cohort study. *The journal of the Royal Society for the Promotion of Health* 123(4), 210–216.

Larsen, S. C., Angquist, L., Laurin, C., Morgen, C. S., Jakobsen, M. U., Paternoster, L., Smith, G. D., Olsen, S. F., Sorensen, T. I. A. and Nohr, E. A. (2016). Association between Maternal Fish Consumption and Gestational Weight Gain. Influence of Molecular Genetic Predisposition to Obesity. *PloS one* 11(3), e0150105.

Larsson, L. and Lindqvist, P. G. (2005). Low-impact exercise during pregnancy – a study of safety. *Acta obstetricia et gynecologica Scandinavica* 84(1), 34–38.

Lassi, Z. S., Salam, R. A., Haider, B. A. and Bhutta, Z. A. (2013). Folic acid supplementation during pregnancy for maternal health and pregnancy outcomes. *The Cochrane database of systematic reviews*(3), CD006896.

Ledikwe, J. H., Blanck, H. M., Kettel Khan, L., Serdula, M. K., Seymour, J. D., Tohill, B. C. and Rolls, B. J. (2006). Dietary energy density is associated with energy intake and weight status in US adults. *The American journal of clinical nutrition* 83(6), 1362–1368.

Lenders, C. M., Hediger, M. L., Scholl, T. O., Khoo, C. S., Slap, G. B. and Stallings, V. A. (1997). Gestational age and infant size at birth are associated with dietary sugar intake among pregnant adolescents. *The Journal of nutrition* 127(6), 1113–1117.

Leventakou, V., Roumeliotaki, T., Martinez, D., Barros, H., Brantsaeter, A.-L., Casas, M., Charles, M.-A., Cordier, S., Eggesbø, M., van Eijsden, M. et al. (2014). Fish intake during pregnancy, fetal growth, and gestational length in 19 European birth cohort studies. *The American journal of clinical nutrition* 99(3), 506–516.

Linné, Y., Dye, L., Barkeling, B. and Rössner, S. (2004). Long-term weight development in women: a 15-year follow-up of the effects of pregnancy. *Obesity research* 12(7), 1166–1178.

Liu, Y., Dai, W., Dai, X. and Li, Z. (2012). Prepregnancy body mass index and gestational weight gain with the outcome of pregnancy: a 13-year study of 292,568 cases in China. *Archives of gynecology and obstetrics* 286(4), 905–911.

Louie, J. C. Y., Markovic, T. P., Perera, N., Foote, D., Petocz, P., Ross, G. P. and Brand-Miller, J. C. (2011). A randomized controlled trial investigating the effects of a low-glycemic index diet on pregnancy outcomes in gestational diabetes mellitus. *Diabetes care* 34(11), 2341–2346.

Lu, M.-S., Chen, Q.-Z., He, J.-R., Wei, X.-L., Lu, J.-H., Li, S.-H., Wen, X.-X., Chan, F.-F., Chen, N.-N., Qiu, L. et al. (2016). Maternal Dietary Patterns and Fetal Growth. A Large Prospective Cohort Study in China. *Nutrients* 8(5).

Luoto, R., Kinnunen, T. I., Aittasalo, M., Kolu, P., Raitanen, J., Ojala, K., Mansikkamäki, K., Lamberg, S., Vasankari, T., Komulainen, T. et al. (2011). Primary prevention of gestational diabetes mellitus and large-for-gestational-age newborns by lifestyle counseling: a cluster-randomized controlled trial. *PLoS medicine* 8(5), e1001036.

Makrides, M., Crosby, D. D., Bain, E. and Crowther, C. A. (2014). Magnesium supplementation in pregnancy. *The Cochrane database of systematic reviews*(4), CD000937.

Mamluk, L., Edwards, H. B., Savović, J., Leach, V., Jones, T., Moore, T. H. M., Ijaz, S., Lewis, S. J., Donovan, J. L., Lawlor, D. et al. (2017). Low alcohol consumption and pregnancy

and childhood outcomes: time to change guidelines indicating apparently 'safe' levels of alcohol during pregnancy? A systematic review and meta-analyses. *BMJ open* 7(7), e015410.

Mamun, A. A., Kinarivala, M., O'Callaghan, M. J., Williams, G. M., Najman, J. M. and Callaway, L. K. (2010). Associations of excess weight gain during pregnancy with long-term maternal overweight and obesity: evidence from 21 y postpartum follow-up. *The American journal of clinical nutrition* 91(5), 1336–1341.

Mamun, A. A., Mannan, M. and Doi, S. A. R. (2014). Gestational weight gain in relation to offspring obesity over the life course: a systematic review and bias-adjusted meta-analysis. *Obesity reviews* 15(4), 338–347.

Mannan, M., Doi, S. A. R. and Mamun, A. A. (2013). Association between weight gain during pregnancy and postpartum weight retention and obesity: a bias-adjusted meta-analysis. *Nutrition reviews* 71(6), 343–352.

Mannion, C. A., Gray-Donald, K. and Koski, K. G. (2006). Association of low intake of milk and vitamin D during pregnancy with decreased birth weight. *Canadian Medical Association journal* 174(9), 1273–1277.

Margerison Zilko, C. E., Rehkopf, D. and Abrams, B. (2010). Association of maternal gestational weight gain with short- and long-term maternal and child health outcomes. *American journal of obstetrics and gynecology* 202(6), 574.e1-8.

Maslova, E., Halldorsson, T. I., Astrup, A. and Olsen, S. F. (2015). Dietary protein-to-carbohydrate ratio and added sugar as determinants of excessive gestational weight gain. A prospective cohort study. *BMJ open* 5(2), e005839.

Mathews, F., Yudkin, P. and Neil, A. (1999). Influence of maternal nutrition on outcome of pregnancy. Prospective cohort study. *BMJ (Clinical research ed.)* 319(7206), 339–343.

McCrabb, S., Lane, C., Hall, A., Milat, A., Bauman, A., Sutherland, R., Yoong, S. and Wolfenden, L. (2019). Scaling-up evidence-based obesity interventions: A systematic review assessing intervention adaptations and effectiveness and quantifying the scale-up penalty. *Obesity reviews* 20(7), 964–982.

McGowan, C. A. and McAuliffe, F. M. (2012). Maternal nutrient intakes and levels of energy underreporting during early pregnancy. *European journal of clinical nutrition* 66(8), 906–913.

Melchior, H., Kurch-Bek, D. and Mund, M. (2017). The Prevalence of Gestational Diabetes. *Deutsches Arzteblatt international* 114(24), 412–418.

Melnik, B. C., John, S. M. and Schmitz, G. (2015). Milk consumption during pregnancy increases birth weight, a risk factor for the development of diseases of civilization. *Journal of translational medicine* 13, 13.

Meltzer, H. M., Brantsaeter, A. L., Ydersbond, T. A., Alexander, J. and Haugen, M. (2008). Methodological challenges when monitoring the diet of pregnant women in a large study: experiences from the Norwegian Mother and Child Cohort Study (MoBa). *Maternal & child nutrition* 4(1), 14–27.

Melzer, K., Schutz, Y., Boulvain, M. and Kayser, B. (2010). Physical activity and pregnancy: cardiovascular adaptations, recommendations and pregnancy outcomes. *Sports medicine* 40(6), 493–507.

Mensink, G. B. M., Schienkiewitz, A., Haftenberger, M., Lampert, T., Ziese, T. and Scheidt-Nave, C. (2013). Overweight and obesity in Germany: results of the German Health Interview and Examination Survey for Adults (DEGS1). *Bundesgesundheitsblatt, Gesundheitsforschung, Gesundheitsschutz* 56(5-6), 786–794.

Metzger, B. E., Gabbe, S. G., Persson, B., Buchanan, T. A., Catalano, P. A., Damm, P., Dyer, A. R., Leiva, A. de, Hod, M., Kitzmiler, J. L. et al. (2010). International association of diabetes and pregnancy study groups recommendations on the diagnosis and classification of hyperglycemia in pregnancy. *Diabetes care* 33(3), 676–682.

Michel, S., Raab, R., Drabsch, T., Günther, J., Stecher, L. and Hauner, H. (2019). Do lifestyle interventions during pregnancy have the potential to reduce long-term postpartum weight retention? A systematic review and meta-analysis. *Obesity reviews* 20(4), 527–542.

Moore, V. M., Davies, M. J., Willson, K. J., Worsley, A. and Robinson, J. S. (2004). Dietary composition of pregnant women is related to size of the baby at birth. *The Journal of nutrition* 134(7), 1820–1826.

Moran, L. J., Flynn, A. C., Louise, J., Deussen, A. R. and Dodd, J. M. (2017). The effect of a lifestyle intervention on pregnancy and postpartum dietary patterns determined by factor analysis. *Obesity (Silver Spring, Md.)* 25(6), 1022–1032.

Moses, R. G., Barker, M., Winter, M., Petocz, P. and Brand-Miller, J. C. (2009). Can a low-glycemic index diet reduce the need for insulin in gestational diabetes mellitus? A randomized trial. *Diabetes care* 32(6), 996–1000.

Moses, R. G., Casey, S. A., Quinn, E. G., Cleary, J. M., Tapsell, L. C., Milosavljevic, M., Petocz, P. and Brand-Miller, J. C. (2014). Pregnancy and Glycemic Index Outcomes study: effects of low glycemic index compared with conventional dietary advice on selected pregnancy outcomes. *The American journal of clinical nutrition* 99(3), 517–523.

Moses, R. G., Luebcke, M., Davis, W. S., Coleman, K. J., Tapsell, L. C., Petocz, P. and Brand-Miller, J. C. (2006). Effect of a low-glycemic-index diet during pregnancy on obstetric outcomes. *The American journal of clinical nutrition* 84(4), 807–812.

Moussa, H. N., Hosseini Nasab, S., Haidar, Z. A., Blackwell, S. C. and Sibai, B. M. (2016). Folic acid supplementation: what is new? Fetal, obstetric, long-term benefits and risks. *Future science OA* 2(2), FSO116.

MRI (2008a). German National Consumption Survey II (Nationale Verzehrsstudie II), Part 1 (Ergebnisbericht Teil 1).

MRI (2008b). German National Consumption Survey II (Nationale Verzehrsstudie II), Part 2 (Ergebnisbericht Teil 2).

MRI 2018. Consumption patterns of selected food items from the German National Consumption Survey II (Verzehrsmengen ausgewählter Lebensmittel aus der Nationalen Verzehrsstudie II). Personal communication 11.07.2018. Max Rubner Institute, Federal Research Institute of Nutrition and Food (Bundesforschungsinstitut für Ernährung und Lebensmittel), Karlsruhe, Germany (MRI).

Mukherjee, R. A. S., Hollins, S., Abou-Saleh, M. T. and Turk, J. (2005). Low level alcohol consumption and the fetus. *BMJ (Clinical research ed.)* 330(7488), 375–376.

Muktabhant, B., Lawrie, T. A., Lumbiganon, P. and Laopaiboon, M. (2015). Diet or exercise, or both, for preventing excessive weight gain in pregnancy. *The Cochrane database of systematic reviews*(6), CD007145.

Murphy, M. M., Stettler, N., Smith, K. M. and Reiss, R. (2014). Associations of consumption of fruits and vegetables during pregnancy with infant birth weight or small for gestational age births: a systematic review of the literature. *International journal of women's health* 6, 899–912.

Mustila, T., Raitanen, J., Keskinen, P., Saari, A. and Luoto, R. (2012). Lifestyle counseling during pregnancy and offspring weight development until four years of age: follow-up study of a controlled trial. *Journal of negative results in biomedicine* 11, 11.

Nehring, I., Lehmann, S. and Kries, R. von (2013). Gestational weight gain in accordance to the IOM/NRC criteria and the risk for childhood overweight: a meta-analysis. *Pediatric obesity* 8(3), 218–224.

Nehring, I., Schmoll, S., Beyerlein, A., Hauner, H. and Kries, R. von (2011). Gestational weight gain and long-term postpartum weight retention: a meta-analysis. *The American journal of clinical nutrition* 94(5), 1225–1231.

Ng, S.-K., Cameron, C. M., Hills, A. P., McClure, R. J. and Scuffham, P. A. (2014). Socioeconomic disparities in prepregnancy BMI and impact on maternal and neonatal outcomes and postpartum weight retention: the EFHL longitudinal birth cohort study. *BMC pregnancy and childbirth* 14, 314.

O'Brien, C. M., Grivell, R. M. and Dodd, J. M. (2016). Systematic review of antenatal dietary and lifestyle interventions in women with a normal body mass index. *Acta obstetricia et gynecologica Scandinavica* 95(3), 259–269.

Ohlin, A. and Rössner, S. (1990). Maternal body weight development after pregnancy. *International journal of obesity* 14(2), 159–173.

Oken, E., Kleinman, K. P., Olsen, S. F., Rich-Edwards, J. W. and Gillman, M. W. (2004). Associations of seafood and elongated n-3 fatty acid intake with fetal growth and length of gestation: results from a US pregnancy cohort. *American journal of epidemiology* 160(8), 774–783.

Okubo, H., Miyake, Y., Sasaki, S., Tanaka, K., Murakami, K., Hirota, Y., Kanzaki, H., Kitada, M., Horikoshi, Y., Ishiko, O. et al. (2012). Maternal dietary patterns in pregnancy and fetal growth in Japan. The Osaka Maternal and Child Health Study. *The British journal of nutrition* 107(10), 1526–1533.

Olafsdottir, A. S., Skuladottir, G. V., Thorsdottir, I., Hauksson, A. and Steingrimsdottir, L. (2006). Maternal diet in early and late pregnancy in relation to weight gain. *International journal of obesity (2005)* 30(3), 492–499.

Olsen, S. F., Halldorsson, T. I., Willett, W. C., Knudsen, V. K., Gillman, M. W., Mikkelsen, T. B. and Olsen, J. (2007). Milk consumption during pregnancy is associated with increased infant size at birth: prospective cohort study. *The American journal of clinical nutrition* 86(4), 1104–1110.

Olsen, S. F. and Secher, N. J. (2002). Low consumption of seafood in early pregnancy as a risk factor for preterm delivery. Prospective cohort study. *BMJ (Clinical research ed.)* 324(7335), 447.

Olson, C. M. and Strawderman, M. S. (2003). Modifiable behavioral factors in a biopsychosocial model predict inadequate and excessive gestational weight gain. *Journal of the American Dietetic Association* 103(1), 48–54.

Oteng-Ntim, E., Varma, R., Croker, H., Poston, L. and Doyle, P. (2012). Lifestyle interventions for overweight and obese pregnant women to improve pregnancy outcome: systematic review and meta-analysis. *BMC medicine* 10, 47.

Papadopoulou, E., Caspersen, I. H., Kvalem, H. E., Knutsen, H. K., Duarte-Salles, T., Alexander, J., Meltzer, H. M., Kogevinas, M., Brantsæter, A. L. and Haugen, M. (2013). Maternal dietary intake of dioxins and polychlorinated biphenyls and birth size in the Norwegian Mother and Child Cohort Study (MoBa). *Environment international* 60, 209–216.

Pathirathna, M. L., Sekijima, K., Sadakata, M., Fujiwara, N., Muramatsu, Y. and Wimalasiri, K. M. S. (2017). Impact of Second Trimester Maternal Dietary Intake on Gestational Weight Gain and Neonatal Birth Weight. *Nutrients* 9(6).

Peña-Rosas, J. P., De-Regil, L. M., Garcia-Casal, M. N. and Dowswell, T. (2015). Daily oral iron supplementation during pregnancy. *The Cochrane database of systematic reviews*(7), CD004736.

Pereira-da-Silva, L., Cabo, C., Moreira, A. C., Virella, D., Guerra, T., Camoes, T., Silva, A. R., Neves, R. and Ferreira, G. C. (2014). The adjusted effect of maternal body mass index, energy and macronutrient intakes during pregnancy, and gestational weight gain on body composition of full-term neonates. *American journal of perinatology* 31(10), 875–882.

Phelan, S., Hart, C., Phipps, M., Abrams, B., Schaffner, A., Adams, A. and Wing, R. (2011a). Maternal behaviors during pregnancy impact offspring obesity risk. *Experimental diabetes research* 2011, 985139.

Phelan, S., Phipps, M. G., Abrams, B., Darroch, F., Schaffner, A. and Wing, R. R. (2011b). Randomized trial of a behavioral intervention to prevent excessive gestational weight gain: the Fit for Delivery Study. *The American journal of clinical nutrition* 93(4), 772–779.

Pirkola, J., Pouta, A., Bloigu, A., Hartikainen, A.-L., Laitinen, J., Jarvelin, M.-R. and Vaarasmaki, M. (2010). Risks of overweight and abdominal obesity at age 16 years associated with prenatal exposures to maternal prepregnancy overweight and gestational diabetes mellitus. *Diabetes care* 33(5), 1115–1121.

Pitkin, R. M. (1976). Nutritional support in obstetrics and gynecology. *Clinical obstetrics and gynecology* 19(3), 489–513.

Polley, B. A., Wing, R. R. and Sims, C. J. (2002). Randomized controlled trial to prevent excessive weight gain in pregnant women. *International journal of obesity and related metabolic disorders* 26(11), 1494–1502.

Poobalan, A. S., Aucott, L. S., Gurung, T., Smith, W. C. S. and Bhattacharya, S. (2009). Obesity as an independent risk factor for elective and emergency caesarean delivery in nulliparous women – systematic review and meta-analysis of cohort studies. *Obesity reviews : an official journal of the International Association for the Study of Obesity* 10(1), 28–35.

Poston, L., Bell, R., Croker, H., Flynn, A. C., Godfrey, K. M., Goff, L., Hayes, L., Khazaezadeh, N., Nelson, S. M., Oteng-Ntim, E. et al. (2015). Effect of a behavioural intervention in obese pregnant women (the UPBEAT study). A multicentre, randomised controlled trial. *The Lancet Diabetes & Endocrinology* 3(10), 767–777.

Poston, L., Briley, A. L., Barr, S., Bell, R., Croker, H., Coxon, K., Essex, H. N., Hunt, C., Hayes, L., Howard, L. M. et al. (2013). Developing a complex intervention for diet and activity behaviour change in obese pregnant women (the UPBEAT trial); assessment of behavioural change and process evaluation in a pilot randomised controlled trial. *BMC pregnancy and childbirth* 13, 148.

Poudevigne, M. S. and O'Connor, P. J. (2006). A review of physical activity patterns in pregnant women and their relationship to psychological health. *Sports medicine* 36(1), 19–38.

Prentice, A. (2003). Micronutrients and the bone mineral content of the mother, fetus and newborn. *The Journal of nutrition* 133(5 Suppl 2), 1693–1699.

Quinlivan, J. A., Lam, L. T. and Fisher, J. (2011). A randomised trial of a four-step multidisciplinary approach to the antenatal care of obese pregnant women. *The Australian & New Zealand journal of obstetrics & gynaecology* 51(2), 141–146.

Ramón, R., Ballester, F., Aguinagalde, X., Amurrio, A., Vioque, J., Lacasaña, M., Rebagliato, M., Murcia, M. and Iñiguez, C. (2009). Fish consumption during pregnancy, prenatal

mercury exposure, and anthropometric measures at birth in a prospective mother-infant cohort study in Spain. *The American journal of clinical nutrition* 90(4), 1047–1055.

Rauh, K., Gabriel, E., Kerschbaum, E., Schuster, T., Kries, R. von, Amann-Gassner, U. and Hauner, H. (2013). Safety and efficacy of a lifestyle intervention for pregnant women to prevent excessive maternal weight gain: a cluster-randomized controlled trial. *BMC pregnancy and childbirth* 13, 151.

Rauh, K., Günther, J., Kunath, J., Stecher, L. and Hauner, H. (2015). Lifestyle intervention to prevent excessive maternal weight gain: mother and infant follow-up at 12 months postpartum. *BMC pregnancy and childbirth* 15, 265.

Rauh, K., Kunath, J., Rosenfeld, E., Kick, L., Ulm, K. and Hauner, H. (2014). Healthy living in pregnancy: a cluster-randomized controlled trial to prevent excessive gestational weight gain - rationale and design of the GeliS study. *BMC pregnancy and childbirth* 14, 119.

Ren, M., Li, H., Cai, W., Niu, X., Ji, W., Zhang, Z., Niu, J., Zhou, X. and Li, Y. (2018). Excessive gestational weight gain in accordance with the IOM criteria and the risk of hypertensive disorders of pregnancy. A meta-analysis. *BMC pregnancy and childbirth* 18(1), 281.

Renault, K. M., Carlsen, E. M., Norgaard, K., Nilas, L., Pryds, O., Secher, N. J., Olsen, S. F. and Halldorsson, T. I. (2015a). Intake of Sweets, Snacks and Soft Drinks Predicts Weight Gain in Obese Pregnant Women. Detailed Analysis of the Results of a Randomised Controlled Trial. *PloS one* 10(7), e0133041.

Renault, K. M., Carlsen, E. M., Nørgaard, K., Nilas, L., Pryds, O., Secher, N. J., Cortes, D., Jensen, J.-E. B., Olsen, S. F. and Halldorsson, T. I. (2015b). Intake of carbohydrates during pregnancy in obese women is associated with fat mass in the newborn offspring. *The American journal of clinical nutrition* 102(6), 1475–1481.

Restall, A., Taylor, R. S., Thompson, J. M. D., Flower, D., Dekker, G. A., Kenny, L. C., Poston, L. and McCowan, L. M. E. (2014). Risk factors for excessive gestational weight gain in a healthy, nulliparous cohort. *Journal of obesity* 2014, 148391.

Rhodes, E. T., Pawlak, D. B., Takoudes, T. C., Ebbeling, C. B., Feldman, H. A., Lovesky, M. M., Cooke, E. A., Leidig, M. M. and Ludwig, D. S. (2010). Effects of a low-glycemic load diet in overweight and obese pregnant women: a pilot randomized controlled trial. *The American journal of clinical nutrition* 92(6), 1306–1315.

RKI (2018). Mensink, Gert B. M., Robert Koch Institute. Personal communication.

Rodrigues, P. L., Lacerda, E. M. d. A., Schlussel, M. M., Spyrides, M. H. C. and Kac, G. (2008). Determinants of weight gain in pregnant women attending a public prenatal care facility in Rio de Janeiro, Brazil: a prospective study, 2005-2007. *Cadernos de saude publica* 24 Suppl 2, S272-84.

Rodríguez-Bernal, C. L., Rebagliato, M., Iñiguez, C., Vioque, J., Navarrete-Muñoz, E. M., Murcia, M., Bolumar, F., Marco, A. and Ballester, F. (2010). Diet quality in early pregnancy and its effects on fetal growth outcomes: the Infancia y Medio Ambiente (Childhood and Environment) Mother and Child Cohort Study in Spain. *The American journal of clinical nutrition* 91(6), 1659–1666.

Rohatgi, K. W., Tinius, R. A., Cade, W. T., Steele, E. M., Cahill, A. G. and Parra, D. C. (2017). Relationships between consumption of ultra-processed foods, gestational weight gain and neonatal outcomes in a sample of US pregnant women. *PeerJ* 5.

Ronnberg, A., Hanson, U., Ostlund, I. and Nilsson, K. (2016). Effects on postpartum weight retention after antenatal lifestyle intervention - a secondary analysis of a randomized controlled trial. *Acta obstetricia et gynecologica Scandinavica* 95(9), 999–1007.

Ronnberg, A. K. and Nilsson, K. (2010). Interventions during pregnancy to reduce excessive gestational weight gain: a systematic review assessing current clinical evidence using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) system. *BJOG* 117(11), 1327–1334.

Ronnberg, A.-K., Hanson, U. and Nilsson, K. (2017). Effects of an antenatal lifestyle intervention on offspring obesity - a 5-year follow-up of a randomized controlled trial. *Acta obstetricia et gynecologica Scandinavica* 96(9), 1093–1099.

Rooney, B. L. and Schauberger, C. W. (2002). Excess pregnancy weight gain and long-term obesity: one decade later. *Obstetrics and gynecology* 100(2), 245–252.

Sagedal, L. R., Overby, N. C., Bere, E., Torstveit, M. K., Lohne-Seiler, H., Smastuen, M., Hillesund, E. R., Henriksen, T. and Vistad, I. (2016). Lifestyle intervention to limit gestational weight gain: the Norwegian Fit for Delivery randomised controlled trial. *BJOG*.

Sagedal, L. R., Sanda, B., Øverby, N. C., Bere, E., Torstveit, M. K., Lohne-Seiler, H., Hillesund, E. R., Pripp, A. H., Henriksen, T. and Vistad, I. (2017). The effect of prenatal lifestyle intervention on weight retention 12 months postpartum: results of the Norwegian Fit for Delivery randomised controlled trial. *BJOG* 124(1), 111–121.

Samura, T., Steer, J., Michelis, L. D., Carroll, L., Holland, E. and Perkins, R. (2016). Factors Associated With Excessive Gestational Weight Gain. Review of Current Literature. *Global advances in health and medicine* 5(1), 87–93.

Scholl, T. O. (2004). The Dietary Glycemic Index during Pregnancy. Influence on Infant Birth Weight, Fetal Growth, and Biomarkers of Carbohydrate Metabolism. *American journal of epidemiology* 159(5), 467–474.

Scott, J., Kirke, P., Molloy, A., Daly, L. and Weir, D. (1994). The role of folate in the prevention of neural-tube defects. *Proceedings of the Nutrition Society* 53(3), 631–636.

Sengpiel, V., Elind, E., Bacelis, J., Nilsson, S., Grove, J., Myhre, R., Haugen, M., Meltzer, H. M., Alexander, J., Jacobsson, B. et al. (2013). Maternal caffeine intake during pregnancy is associated with birth weight but not with gestational length: results from a large prospective observational cohort study. *BMC medicine* 11, 42.

Shepherd, E., Gomersall, J. C., Tieu, J., Han, S., Crowther, C. A. and Middleton, P. (2017). Combined diet and exercise interventions for preventing gestational diabetes mellitus. *The Cochrane database of systematic reviews* 11, CD010443.

Shieh, C., Cullen, D. L., Pike, C. and Pressler, S. J. (2018). Intervention strategies for preventing excessive gestational weight gain: systematic review and meta-analysis. *Obesity reviews* 19(8), 1093–1109.

Shin, D., Bianchi, L., Chung, H., Weatherspoon, L. and Song, W. O. (2014). Is gestational weight gain associated with diet quality during pregnancy? *Maternal and child health journal* 18(6), 1433–1443.

Shin, D., Lee, K. W. and Song, W. O. (2016). Dietary Patterns During Pregnancy are Associated with Gestational Weight Gain. *Maternal and child health journal* 20(12), 2527–2538.

Simmons, D., Devlieger, R., van Assche, A., Jans, G., Galjaard, S., Corcoy, R., Adelantado, J. M., Dunne, F., Desoye, G., Harreiter, J. et al. (2017). Effect of Physical Activity and/or Healthy Eating on GDM Risk: The DALI Lifestyle Study. *The Journal of clinical endocrinology and metabolism* 102(3), 903–913.

Skouteris, H., Hartley-Clark, L., McCabe, M., Milgrom, J., Kent, B., Herring, S. J. and Gale, J. (2010). Preventing excessive gestational weight gain: a systematic review of interventions. *Obesity reviews* 11(11), 757–768.

Sloan, N. L., Lederman, S. A., Leighton, J., Himes, J. H. and Rush, D. (2001). The effect of prenatal dietary protein intake on birth weight. *Nutrition Research* 21(1-2), 129–139.

Sokol, R. J., Delaney-Black, V. and Nordstrom, B. (2003). Fetal alcohol spectrum disorder. *JAMA* 290(22), 2996–2999.

Starling, A. P., Sauder, K. A., Kaar, J. L., Shapiro, A. L., Siega-Riz, A. M. and Dabelea, D. (2017). Maternal Dietary Patterns during Pregnancy Are Associated with Newborn Body Composition. *The Journal of nutrition* 147(7), 1334–1339.

Streuling, I., Beyerlein, A. and Kries, R. von (2010). Can gestational weight gain be modified by increasing physical activity and diet counseling? A meta-analysis of interventional trials. *The American journal of clinical nutrition* 92(4), 678–687.

Streuling, I., Beyerlein, A., Rosenfeld, E., Schukat, B. and Kries, R. von (2011). Weight gain and dietary intake during pregnancy in industrialized countries – a systematic review of observational studies. *Journal of perinatal medicine* 39(2), 123–129.

Stuebe, A. M., Oken, E. and Gillman, M. W. (2009). Associations of diet and physical activity during pregnancy with risk for excessive gestational weight gain. *American journal of obstetrics and gynecology* 201(1), 58.e1-8.

Tanentsapf, I., Heitmann, B. L. and Adegboye, A. R. A. (2011). Systematic review of clinical trials on dietary interventions to prevent excessive weight gain during pregnancy among normal weight, overweight and obese women. *BMC pregnancy and childbirth* 11, 81.

Tanvig, M., Vinter, C. A., Jørgensen, J. S., Wehberg, S., Ovesen, P. G., Lamont, R. F., Beck-Nielsen, H., Christesen, H. T. and Jensen, D. M. (2014). Anthropometrics and Body Composition by Dual Energy X-Ray in Children of Obese Women: A Follow-Up of a Randomized Controlled Trial (the Lifestyle in Pregnancy and Offspring LiPO Study). *PloS one* 9(2).

Tenter, A. M., Heckeroth, A. R. and Weiss, L. M. (2000). Toxoplasma gondii: from animals to humans. *International journal for parasitology* 30(12-13), 1217–1258.

Thame, M., Wilks, R. J., McFarlane-Anderson, N., Bennett, F. I. and Forrester, T. E. (1997). Relationship between maternal nutritional status and infant's weight and body proportions at birth. *European journal of clinical nutrition* 51(3), 134–138.

Thangaratinam, S., Rogozinska, E., Jolly, K., Glinkowski, S., Roseboom, T., Tomlinson, J. W., Kunz, R., Mol, B. W., Coomarasamy, A. and Khan, K. S. (2012). Effects of interventions in pregnancy on maternal weight and obstetric outcomes: meta-analysis of randomised evidence. *BMJ (Clinical research ed.)* 344, e2088.

Tie, H.-T., Xia, Y.-Y., Zeng, Y.-S., Zhang, Y., Dai, C.-L., Guo, J. J. and Zhao, Y. (2014). Risk of childhood overweight or obesity associated with excessive weight gain during pregnancy: a meta-analysis. *Archives of gynecology and obstetrics* 289(2), 247–257.

Tielemans, M. J., Garcia, A. H., Peralta, S. A., Bramer, W. M., Luksa, N., Luvizotto, M. J., Moreira, E., Topi, G., Jonge, E. A. de, Visser, T. L. et al. (2016). Macronutrient composition and gestational weight gain. A systematic review. *The American journal of clinical nutrition* 103(1), 83–99.

Timmermans, S., Steegers-Theunissen, R. P., Vujkovic, M., den Breeijen, H., Russcher, H., Lindemans, J., Mackenbach, J., Hofman, A., Lesaffre, E. E., Jaddoe, V. V. et al. (2012). The Mediterranean diet and fetal size parameters. The Generation R Study. *The British journal of nutrition* 108(8), 1399–1409.

Torloni, M. R., Betran, A. P., Horta, B. L., Nakamura, M. U., Atallah, A. N., Moron, A. F. and Valente, O. (2009). Prepregnancy BMI and the risk of gestational diabetes: a systematic review of the literature with meta-analysis. *Obesity reviews* 10(2), 194–203.

Uusitalo, U., Arkkola, T., Ovaskainen, M.-L., Kronberg-Kippila, C., Kenward, M. G., Veijola, R., Simell, O., Knip, M. and Virtanen, S. M. (2009). Unhealthy dietary patterns are associated with weight gain during pregnancy among Finnish women. *Public health nutrition* 12(12), 2392–2399.

Valkama, A., Koivusalo, S., Lindstrom, J., Meinila, J., Kautiainen, H., Stach-Lempinen, B., Rono, K., Klemetti, M., Poyhonen-Alho, M., Tiitinen, A. et al. (2016). The effect of dietary counselling on food intakes in pregnant women at risk for gestational diabetes: a secondary analysis of a randomised controlled trial RADIEL. *European journal of clinical nutrition* 70(8), 912–917.

Vesco, K. K., Leo, M. C., Karanja, N., Gillman, M. W., McEvoy, C. T., King, J. C., Eckhardt, C. L., Smith, K. S., Perrin, N. and Stevens, V. J. (2016). One-year postpartum outcomes following a weight management intervention in pregnant women with obesity. *Obesity (Silver Spring, Md.)* 24(10), 2042–2049.

Voerman, E., Jaddoe, V. W. V., Gishti, O., Hofman, A., Franco, O. H. and Gaillard, R. (2016). Maternal caffeine intake during pregnancy, early growth, and body fat distribution at school age. *Obesity (Silver Spring, Md.)* 24(5), 1170–1177.

Walsh, J. M., McGowan, C. A., Mahony, R., Foley, M. E. and McAuliffe, F. M. (2012). Low glycaemic index diet in pregnancy to prevent macrosomia (ROLO study): randomised control trial. *BMJ (Clinical research ed.)* 345, e5605.

Wang, C., Wei, Y., Zhang, X., Zhang, Y., Xu, Q., Sun, Y., Su, S., Zhang, L., Liu, C., Feng, Y. et al. (2017). A randomized clinical trial of exercise during pregnancy to prevent gestational diabetes mellitus and improve pregnancy outcome in overweight and obese pregnant women. *American journal of obstetrics and gynecology* 216(4), 340–351.

Wen, L. M., Simpson, J. M., Rissel, C. and Baur, L. A. (2013). Maternal "junk food" diet during pregnancy as a predictor of high birthweight. Findings from the healthy beginnings trial. *Birth* 40(1), 46–51.

Wen, S. W., Chen, X.-K., Rodger, M., White, R. R., Yang, Q., Smith, G. N., Sigal, R. J., Perkins, S. L. and Walker, M. C. (2008). Folic acid supplementation in early second trimester and the risk of preeclampsia. *American journal of obstetrics and gynecology* 198(1), 45.e1-7.

Williamson, C. S. (2006). Nutrition in pregnancy. *Nutrition Bulletin* 31(1), 28–59.

Wolff, C. B. and Wolff, H. K. (1995). Maternal eating patterns and birth weight of Mexican American infants. *Nutrition and health* 10(2), 121–134.

Wolff, S., Legarth, J., Vangsgaard, K., Toubro, S. and Astrup, A. (2008). A randomized trial of the effects of dietary counseling on gestational weight gain and glucose metabolism in obese pregnant women. *International journal of obesity (2005)* 32(3), 495–501.

Wrottesley, S. V., Pisa, P. T. and Norris, S. A. (2017). The Influence of Maternal Dietary Patterns on Body Mass Index and Gestational Weight Gain in Urban Black South African Women. *Nutrients* 9(7).

Xue, F., Willett, W. C., Rosner, B. A., Forman, M. R. and Michels, K. B. (2008). Parental characteristics as predictors of birthweight. *Human reproduction* 23(1), 168–177.

Yu, Z., Han, S., Zhu, J., Sun, X., Ji, C. and Guo, X. (2013). Pre-pregnancy body mass index in relation to infant birth weight and offspring overweight/obesity: a systematic review and meta-analysis. *PloS one* 8(4), e61627.

Zhang, R., Han, S., Chen, G.-C., Li, Z.-N., Silva-Zolezzi, I., Parés, G. V., Wang, Y. and Qin, L.-Q. (2016). Effects of low-glycemic-index diets in pregnancy on maternal and newborn outcomes in pregnant women. A meta-analysis of randomized controlled trials. *European journal of nutrition* 57(1), 167–177.

Zhu, Y., Olsen, S. F., Mendola, P., Halldorsson, T. I., Rawal, S., Hinkle, S. N., Yeung, E. H., Chavarro, J. E., Grunnet, L. G., Granström, C. et al. (2017). Maternal consumption of artificially sweetened beverages during pregnancy, and offspring growth through 7 years of age. A prospective cohort study. *International journal of epidemiology* 46(5), 1499–1508.

Zulyniak, M. A., Souza, R. J. d., Shaikh, M., Desai, D., Lefebvre, D. L., Gupta, M., Wilson, J., Wahi, G., Subbarao, P., Becker, A. B. et al. (2017). Does the impact of a plant-based diet during pregnancy on birth weight differ by ethnicity? A dietary pattern analysis from a prospective Canadian birth cohort alliance. *BMJ open* 7(11), e017753.

Appendix

A1 Food frequency questionnaire applied for the dietary assessment in the GeliS study (German version).

GeliS Gesund leben in der Schwangerschaft

Teilnehmer ID _ _ _ _ _ _ _ _ _ _ Praxis ID _ _ _ _ _

Fragebogen zur Ernährung

- Sie werden gefragt, **wie oft** und **in welcher Menge** Sie in den letzten vier Wochen verschiedene Lebensmittel gegessen haben. Denken Sie dabei auch an Mahlzeiten, die Sie außer Haus (z. B. im Restaurant, in der Kantine) eingenommen haben.
- Bitte beantworten Sie **jede** Frage. Wenn Sie sich nicht sicher sind, dann schätzen Sie. Eine ungefähre Schätzung ist besser als gar keine Antwort.
- Denken Sie bitte nur an Ihre Ernährung **in den letzten vier Wochen!**
- Es kommt vielleicht vor, dass Sie bestimmte Sachen nicht essen oder trinken. Kreuzen Sie dann bitte »nie« an und gehen weiter zur nächsten Frage.
- Bei den Mengenangaben geht es um die **durchschnittliche** Menge.
- Bitte bei jeder Frage nur **eine Antwort** ankreuzen.

Beispiel:
Sie essen morgens 1 Vollkornbrötchen und abends 3 Scheiben Vollkornbrot. Bitte kreuzen Sie dann wie unten »2 Mal am Tag« und als Menge »2 Scheiben« (den Durchschnitt) an:

18	Wie oft haben Sie Vollkornbrot oder Vollkornbrötchen gegessen?		18a	Wenn Sie Vollkornbrot oder Vollkornbrötchen essen, wie viel essen Sie davon meistens?
	☐ Nie → Bitte weiter mit Frage 19			☐ ½ Scheibe oder ½ Brötchen (oder weniger)
	☐ 1 Mal im Monat	☐ 1 Mal am Tag		☐ 1 Scheibe oder 1 Brötchen
	☐ 2–3 Mal im Monat	☒ 2 Mal am Tag		☒ 2 Scheiben oder 2 Brötchen
	☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag		☐ 3 Scheiben oder 3 Brötchen
	☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag		☐ 4 Scheiben (oder mehr)
	☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

14 Fragebogen zur Ernährung 1

Gesund leben in der Schwangerschaft GeliS

1 Wie oft haben Sie **Milch** (einschließlich Milch für Kaffee, Müsli) getrunken?

- ☐ Nie → Bitte weiter mit Frage 2
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

1a Wenn Sie **Milch** trinken, wie viel trinken Sie davon meistens?

- ☐ ½ Glas (oder weniger)
- ☐ 1 Glas (200 ml)
- ☐ 2 Gläser
- ☐ 3 Gläser
- ☐ 4 Gläser (oder mehr)

1b Welche Art von **Milch** trinken Sie meistens?

- ☐ Vollmilch (mindestens 3.5 % Fett)
- ☐ Fettarme Milch (1.5 % Fett)
- ☐ Magermilch (max. 0.3 % Fett)
- ☐ Sojamilch
- ☐ Laktosefreie Milch
- ☐ Andere

2 Wie oft haben Sie **zuckerhaltige Erfrischungsgetränke** (z. B. Cola, Limonade, Eistee, Malzbier) getrunken? Nicht gemeint sind Light-Getränke.

- ☐ Nie → Bitte weiter mit Frage 3
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

2a Wenn Sie **zuckerhaltige Erfrischungsgetränke** trinken, wie viel trinken Sie davon meistens?

- ☐ ½ Glas (oder weniger)
- ☐ 1 Glas (200 ml)
- ☐ 2 Gläser
- ☐ 3 Gläser
- ☐ 4 Gläser (oder mehr)

3 Wie oft haben Sie **Energydrinks** getrunken?

- ☐ Nie → Bitte weiter mit Frage 4
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

3a Wenn Sie **Energydrinks** trinken, wie viel trinken Sie davon meistens?

- ☐ 1/2 Dose (oder weniger)
- ☐ 1 Dose (250 ml)
- ☐ 2 Dosen
- ☐ 3 Dosen
- ☐ 4 Dosen (oder mehr)

GeliS Gesundheit in der Schwangerschaft

4 Wie oft haben Sie kalorienreduzierte Erfrischungsgetränke (z. B. Light-Getränke) getrunken?

- ☐ Nie → Bitte weiter mit Frage 5
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

4a Wenn Sie kalorienreduzierte Erfrischungsgetränke trinken, wie viel trinken Sie davon meistens?

- ☐ ½ Glas (oder weniger)
- ☐ 1 Glas (200 ml)
- ☐ 2 Gläser
- ☐ 3 Gläser
- ☐ 4 Gläser (oder mehr)

5 Wie oft haben Sie Fruchtsaft (z. B. Orangen-, Apfel-, Kirschsaft) getrunken? Gemeint ist auch verdünnter Fruchtsaft.

- ☐ Nie → Bitte weiter mit Frage 6
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

5a Wenn Sie Fruchtsaft trinken, wie viel trinken Sie davon meistens?

- ☐ ½ Glas (oder weniger)
- ☐ 1 Glas (200 ml)
- ☐ 2 Gläser
- ☐ 3 Gläser
- ☐ 4 Gläser (oder mehr)

5b Wie trinken Sie Ihren Fruchtsaft meistens?

- ☐ Unverdünnt
- ☐ Etwa ¼ Saft und ¾ Wasser
- ☐ Etwa ½ Saft und ½ Wasser
- ☐ Etwa ¾ Saft und ¼ Wasser

6 Wie oft haben Sie Gemüsesaft (z. B. Tomaten-, Karottensaft) getrunken? Gemeint ist auch verdünnter Gemüsesaft.

- ☐ Nie → Bitte weiter mit Frage 7
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

6a Wenn Sie Gemüsesaft trinken, wie viel trinken Sie davon meistens?

- ☐ ½ Glas (oder weniger)
- ☐ 1 Glas (200 ml)
- ☐ 2 Gläser
- ☐ 3 Gläser
- ☐ 4 Gläser (oder mehr)

6b Wie trinken Sie Ihren Gemüsesaft meistens?

- ☐ Unverdünnt
- ☐ Etwa ¼ Saft und ¾ Wasser
- ☐ Etwa ½ Saft und ½ Wasser
- ☐ Etwa ¾ Saft und ¼ Wasser

Gesund leben in der Schwangerschaft GeliS

7 Wie oft haben Sie Wasser (Leitungswasser, Mineralwasser, aromatisiertes Wasser) getrunken?

- ☐ Nie → Bitte weiter mit Frage 8
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

7a Wenn Sie Wasser trinken, wie viel trinken Sie davon meistens?

- ☐ ½ Glas (oder weniger)
- ☐ 1 Glas (200 ml)
- ☐ 2 Gläser
- ☐ 3 Gläser
- ☐ 4 Gläser (oder mehr)

8 Wie oft haben Sie Früchte- oder Kräutertee getrunken?

- ☐ Nie → Bitte weiter mit Frage 9
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

8a Wenn Sie Früchte- oder Kräutertee trinken, wie viel trinken Sie davon meistens?

- ☐ ½ Tasse (oder weniger)
- ☐ 1 Tasse (150 ml)
- ☐ 2 Tassen
- ☐ 3 Tassen
- ☐ 4 Tassen (oder mehr)

8b Nehmen Sie üblicherweise Zucker in Ihren Früchte- oder Kräutertee? Nicht gemeint sind Süßstoffe.

- ☐ Nein
- ☐ Ja, etwa 1 Teelöffel pro Tasse
- ☐ Ja, 2 Teelöffel pro Tasse
- ☐ Ja, 3 Teelöffel (oder mehr) pro Tasse

9 Wie oft haben Sie schwarzen oder grünen Tee getrunken?

- ☐ Nie → Bitte weiter mit Frage 10
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

9a Wenn Sie schwarzen oder grünen Tee trinken, wie viel trinken Sie davon meistens?

- ☐ ½ Tasse (oder weniger)
- ☐ 1 Tasse (150 ml)
- ☐ 2 Tassen
- ☐ 3 Tassen
- ☐ 4 Tassen (oder mehr)

9b Nehmen Sie üblicherweise Zucker in Ihren schwarzen oder grünen Tee? Nicht gemeint sind Süßstoffe.

- ☐ Nein
- ☐ Ja, etwa 1 Teelöffel pro Tasse
- ☐ Ja, 2 Teelöffel pro Tasse
- ☐ Ja, 3 Teelöffel (oder mehr) pro Tasse

GeliS Gesundheit in der Schwangerschaft

10	Wie oft haben Sie Kaffee (auch Cappuccino, Latte Macchiato, Espresso) getrunken?
☐	Nie → Bitte weiter mit Frage 11
☐	1 Mal im Monat
☐	2–3 Mal im Monat
☐	1–2 Mal pro Woche
☐	3–4 Mal pro Woche
☐	5–6 Mal pro Woche
☐	1 Mal am Tag
☐	2 Mal am Tag
☐	3 Mal am Tag
☐	4–5 Mal am Tag
☐	Öfter als 5 Mal am Tag

10a	Wenn Sie Kaffee trinken, wie viel trinken Sie davon meistens?
☐	½ Tasse (oder weniger)
☐	1 Tasse (150 ml)
☐	2 Tassen
☐	3 Tassen
☐	4 Tassen (oder mehr)

10b	Nehmen Sie üblicherweise Zucker in Ihren Kaffee? Nicht gemeint sind Süßstoffe.
☐	Nein
☐	Ja, etwa 1 Teelöffel pro Tasse
☐	Ja, 2 Teelöffel pro Tasse
☐	Ja, 3 Teelöffel (oder mehr) pro Tasse

10c	Trinken Sie in der Regel Kaffee mit oder ohne Koffein?
☐	mit Koffein
☐	ohne Koffein

11	Wie oft haben Sie Bier (alkoholhaltig) getrunken?
☐	Nie → Bitte weiter mit Frage 12
☐	1 Mal im Monat
☐	2–3 Mal im Monat
☐	1–2 Mal pro Woche
☐	3–4 Mal pro Woche
☐	5–6 Mal pro Woche
☐	1 Mal am Tag
☐	2 Mal am Tag
☐	3 Mal am Tag
☐	4–5 Mal am Tag
☐	Öfter als 5 Mal am Tag

11a	Wenn Sie Bier trinken, wie viel trinken Sie davon meistens?
☐	½ Flasche (oder weniger)
☐	1 Flasche (330 ml)
☐	2 Flaschen
☐	3 Flaschen
☐	4 Flaschen (oder mehr)

12	Wie oft haben Sie alkoholfreies Bier getrunken?
☐	Nie → Bitte weiter mit Frage 13
☐	1 Mal im Monat
☐	2–3 Mal im Monat
☐	1–2 Mal pro Woche
☐	3–4 Mal pro Woche
☐	5–6 Mal pro Woche
☐	1 Mal am Tag
☐	2 Mal am Tag
☐	3 Mal am Tag
☐	4–5 Mal am Tag
☐	Öfter als 5 Mal am Tag

12a	Wenn Sie alkoholfreies Bier trinken, wie viel trinken Sie davon meistens?
☐	½ Flasche (oder weniger)
☐	1 Flasche (330 ml)
☐	2 Flaschen
☐	3 Flaschen
☐	4 Flaschen (oder mehr)

Gesund leben in der Schwangerschaft GeliS

13	Wie oft haben Sie Wein, Sekt oder Obstwein getrunken?		13a	Wenn Sie Wein, Sekt oder Obstwein trinken, wie viel trinken Sie davon meistens?
☐	Nie → Bitte weiter mit Frage 14		☐	1 Glas (125 ml oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	2 Gläser
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	3 Gläser
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	4 Gläser
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	5 Gläser (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

14	Wie oft haben Sie Cocktails oder andere alkoholische Mischgetränke getrunken?		14a	Wenn Sie Cocktails oder andere alkoholische Mischgetränke trinken, wie viel trinken Sie davon meistens?
☐	Nie → Bitte weiter mit Frage 15		☐	½ Getränk (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	1 Getränk
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	2 Getränke
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	3 Getränke
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	4 Getränke (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

15	Wie oft haben Sie hochprozentige alkoholische Getränke (z.B. Rum, Weinbrand, Likör, klare Schnäpse) getrunken?		15a	Wenn Sie hochprozentige alkoholische Getränke trinken, wie viel trinken Sie davon meistens?
☐	Nie → Bitte weiter mit Frage 16		☐	½ Glas (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	1 Glas (2 cl)
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	2 Gläser
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	3 Gläser
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	4 Gläser (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

16	Wie oft haben Sie Cornflakes (auch z.B. Choco Pops, Nougat Bits, Fruit Rings) gegessen?		16a	Wenn Sie Cornflakes essen, wie viel essen Sie davon meistens? Mengenangabe bitte ohne Milch.
☐	Nie → Bitte weiter mit Frage 17		☐	¼ Schale (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	½ Schale
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	1 Schale
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	2 Schalen
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	3 Schalen (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		Gemeint ist eine Dessertschale von 150 ml.

GeliS Gesund leben in der Schwangerschaft

17	Wie oft haben Sie **Müsli** gegessen?	
	☐ Nie → Bitte weiter mit Frage 18	
	☐ 1 Mal im Monat	☐ 1 Mal am Tag
	☐ 2–3 Mal im Monat	☐ 2 Mal am Tag
	☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag
	☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag
	☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

17a	Wenn Sie **Müsli** essen, wie viel essen Sie davon meistens? Mengenangabe bitte ohne Milch.
	☐ ¼ Schale (oder weniger)
	☐ ½ Schale
	☐ 1 Schale
	☐ 2 Schalen
	☐ 3 Schalen (oder mehr)
	Gemeint ist eine Dessertschale von 150 ml.

18	Wie oft haben Sie **Vollkornbrot oder Vollkornbrötchen** gegessen?	
	☐ Nie → Bitte weiter mit Frage 19	
	☐ 1 Mal im Monat	☐ 1 Mal am Tag
	☐ 2–3 Mal im Monat	☐ 2 Mal am Tag
	☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag
	☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag
	☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

18a	Wenn Sie **Vollkornbrot oder Vollkornbrötchen** essen, wie viel essen Sie davon meistens?
	☐ ½ Scheibe oder ½ Brötchen (oder weniger)
	☐ 1 Scheibe oder 1 Brötchen
	☐ 2 Scheiben oder 2 Brötchen
	☐ 3 Scheiben oder 3 Brötchen
	☐ 4 Scheiben (oder mehr)

19	Wie oft haben Sie **Graubrot oder Mischbrot** gegessen?	
	☐ Nie → Bitte weiter mit Frage 20	
	☐ 1 Mal im Monat	☐ 1 Mal am Tag
	☐ 2–3 Mal im Monat	☐ 2 Mal am Tag
	☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag
	☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag
	☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

19a	Wenn Sie **Graubrot oder Mischbrot** essen, wie viel essen Sie davon meistens?
	☐ ½ Scheibe oder ½ Brötchen (oder weniger)
	☐ 1 Scheibe oder 1 Brötchen
	☐ 2 Scheiben oder 2 Brötchen
	☐ 3 Scheiben oder 3 Brötchen
	☐ 4 Scheiben (oder mehr)

20	Wie oft haben Sie **Weißbrot oder Brötchen** (auch Laugenbrötchen, Fladenbrot) gegessen?	
	☐ Nie → Bitte weiter mit Frage 21	
	☐ 1 Mal im Monat	☐ 1 Mal am Tag
	☐ 2–3 Mal im Monat	☐ 2 Mal am Tag
	☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag
	☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag
	☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

20a	Wenn Sie **Weißbrot oder Brötchen** essen, wie viel essen Sie davon meistens?
	☐ ½ Scheibe oder ½ Brötchen (oder weniger)
	☐ 1 Scheibe oder 1 Brötchen
	☐ 2 Scheiben oder 2 Brötchen
	☐ 3 Scheiben oder 3 Brötchen
	☐ 4 Scheiben (oder mehr)

21 Wie oft haben Sie Butter oder Margarine (auf Brot etc.) gegessen?

- ☐ Nie → Bitte weiter mit Frage 22
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

21a Wenn Sie Butter oder Margarine essen, wie viel essen Sie davon meistens?

- ☐ ½ Teelöffel (oder weniger)
- ☐ 1 Teelöffel (gestrichen)
- ☐ 2 Teelöffel (gestrichen)
- ☐ 3 Teelöffel (gestrichen)
- ☐ 4 Teelöffel (oder mehr)

22 Wie oft haben Sie Frischkäse (z. B. Philadelphia, Hüttenkäse) gegessen?

- ☐ Nie → Bitte weiter mit Frage 23
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

22a Wenn Sie Frischkäse essen, wie viel essen Sie davon meistens?

- ☐ ½ Esslöffel (oder weniger)
- ☐ 1 Esslöffel (gestrichen)
- ☐ 2 Esslöffel (gestrichen)
- ☐ 3 Esslöffel (gestrichen)
- ☐ 4 Esslöffel (oder mehr)

22b Essen Sie fettarmen Frischkäse?

- ☐ Selten oder nie
- ☐ Etwa zur Hälfte
- ☐ Überwiegend
- ☐ Weiß ich nicht

23 Wie oft haben Sie Käse (Weich-, Schnitt- oder Hartkäse) gegessen?

- ☐ Nie → Bitte weiter mit Frage 24
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

23a Wenn Sie Käse essen, wie viel essen Sie davon meistens?

- ☐ ½ Scheibe oder ½ Portion (oder weniger)
- ☐ 1 Scheibe oder 1 Portion
- ☐ 2 Scheiben oder 2 Portionen
- ☐ 3 Scheiben oder 3 Portionen
- ☐ 4 Scheiben oder 4 Portionen (oder mehr)

1 Scheibe oder 1 Portion sind ca. 30 g.

23b Essen Sie fettarmen Käse?

- ☐ Selten oder nie
- ☐ Etwa zur Hälfte
- ☐ Überwiegend
- ☐ Weiß ich nicht

GeliS Gesund leben in der Schwangerschaft

24 Wie oft haben Sie Quark, Joghurt oder Dickmilch gegessen?

- ☐ Nie → Bitte weiter mit Frage 25
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

24a Wenn Sie Quark, Joghurt oder Dickmilch essen, wie viel essen Sie davon meistens?

- ☐ ½ Becher (oder weniger)
- ☐ 1 Becher (200 g)
- ☐ 2 Becher
- ☐ 3 Becher
- ☐ 4 Becher

24b Essen Sie fettarmen Quark, Joghurt oder fettarme Dickmilch?

- ☐ Selten oder nie
- ☐ Etwa zur Hälfte
- ☐ Überwiegend
- ☐ Weiß ich nicht

25 Wie oft haben Sie Honig oder Marmelade (auch Sirup) gegessen?

- ☐ Nie → Bitte weiter mit Frage 26
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

25a Wenn Sie Honig oder Marmelade essen, wie viel essen Sie davon meistens?

- ☐ 1 Teelöffel (oder weniger)
- ☐ 2 Teelöffel (gehäuft)
- ☐ 3 Teelöffel (gehäuft)
- ☐ 4 Teelöffel (gehäuft)
- ☐ 5 Teelöffel (oder mehr)

26 Wie oft haben Sie Nuss-Nougatcreme gegessen?

- ☐ Nie → Bitte weiter mit Frage 27
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

26a Wenn Sie Nuss-Nougatcreme essen, wie viel essen Sie davon meistens?

- ☐ 1 Teelöffel (oder weniger)
- ☐ 2 Teelöffel (gehäuft)
- ☐ 3 Teelöffel (gehäuft)
- ☐ 4 Teelöffel (gehäuft)
- ☐ 5 Teelöffel (oder mehr)

27 Wie oft haben Sie **Eier** (z. B. Spiegelei, Rührei, gekochtes Ei) gegessen?

- ☐ Nie → Bitte weiter mit Frage 28
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

27a Wenn Sie **Eier** essen, wie viel essen Sie davon meistens?

- ☐ ½ Ei (oder weniger)
- ☐ 1 Ei
- ☐ 2 Eier
- ☐ 3 Eier
- ☐ 4 Eier (oder mehr)

28 Wie oft haben Sie **Geflügel** (z. B. Hähnchen, Chicken Nuggets) gegessen?

- ☐ Nie → Bitte weiter mit Frage 29
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

28a Wenn Sie **Geflügel** essen, wie viel essen Sie davon meistens?

- ☐ ¼ Portion (oder weniger)
- ☐ ½ Portion
- ☐ 1 Portion
- ☐ 2 Portionen
- ☐ 3 Portionen (oder mehr)

Mit einer Portion sind etwa 1 Hähnchenschenkel oder 8 Nuggets gemeint.

28b Wie oft war das **Geflügel** paniert oder frittiert (z. B. Nuggets)?

- ☐ (Fast) nie
- ☐ Etwa ¼ des Verzehrs
- ☐ Etwa ½ des Verzehrs
- ☐ Etwa ¾ des Verzehrs
- ☐ (Fast) immer

29 Wie oft haben Sie **Hamburger oder Döner Kebab** gegessen?

- ☐ Nie → Bitte weiter mit Frage 30
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

29a Wenn Sie **Hamburger oder Döner Kebab** essen, wie viel essen Sie davon meistens?

- ☐ ½ Stück (oder weniger)
- ☐ 1 Stück
- ☐ 2 Stück
- ☐ 3 Stück
- ☐ 4 Stück (oder mehr)

GeliS Gesund leben in der Schwangerschaft

30 Wie oft haben Sie **Bratwurst oder Currywurst** gegessen?

- ☐ Nie → Bitte weiter mit Frage 31
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

30a Wenn Sie **Bratwurst oder Currywurst** essen, wie viel essen Sie davon meistens?

- ☐ ½ Stück (oder weniger)
- ☐ 1 Stück
- ☐ 2 Stück
- ☐ 3 Stück
- ☐ 4 Stück (oder mehr)

31 Wie oft haben Sie **Fleisch** (z. B. Schweinefleisch, Rindfleisch, Wildfleisch) gegessen? Nicht gemeint sind Wurst oder Geflügel.

- ☐ Nie → Bitte weiter mit Frage 32
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

31a Wenn Sie **Fleisch** essen, wie viel essen Sie davon meistens?

- ☐ ¼ Portion (oder weniger)
- ☐ ½ Portion
- ☐ 1 Portion
- ☐ 2 Portionen
- ☐ 3 Portionen (oder mehr)

Mit einer Portion ist etwa 1 Kotelett, 1 Steak oder 1 Schnitzel gemeint.

31b Wie oft war das **Fleisch** paniert (z. B. Wiener Schnitzel)?

- ☐ (Fast) nie
- ☐ Etwa ¼ des Verzehrs
- ☐ Etwa ½ des Verzehrs
- ☐ Etwa ¾ des Verzehrs
- ☐ (Fast) immer

32 Wie oft haben Sie **Wurst** (z. B. Salami, Leberwurst) gegessen? Nicht gemeint ist Schinken.

- ☐ Nie → Bitte weiter mit Frage 33
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

32a Wenn Sie **Wurst** essen, wie viel essen Sie davon meistens?

- ☐ ½ Scheibe
- ☐ 1 Scheibe
- ☐ 2 Scheiben
- ☐ 3 Scheiben
- ☐ 4 Scheiben (oder mehr)

32b Essen Sie **fettarme Wurst**?

- ☐ Selten oder nie
- ☐ Etwa zur Hälfte
- ☐ Überwiegend
- ☐ Weiß ich nicht

Gesund leben in der Schwangerschaft GeliS

33 Wie oft haben Sie Schinken gegessen?

- ☐ Nie → Bitte weiter mit Frage 34

☐ 1 Mal im Monat	☐ 1 Mal am Tag
☐ 2–3 Mal im Monat	☐ 2 Mal am Tag
☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag
☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag
☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

33a Wenn Sie Schinken essen, wie viel essen Sie davon meistens?

- ☐ ½ Scheibe
- ☐ 1 Scheibe
- ☐ 2 Scheiben
- ☐ 3 Scheiben
- ☐ 4 Scheiben (oder mehr)

34 Wie oft haben Sie kalten Fisch (z. B. Räucherlachs, Matjes, Thunfisch) gegessen?

- ☐ Nie → Bitte weiter mit Frage 35

☐ 1 Mal im Monat	☐ 1 Mal am Tag
☐ 2–3 Mal im Monat	☐ 2 Mal am Tag
☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag
☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag
☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

34a Wenn Sie kalten Fisch essen, wie viel essen Sie davon meistens?

- ☐ ¼ Portion (oder weniger)
- ☐ ½ Portion
- ☐ 1 Portion
- ☐ 2 Portionen
- ☐ 3 Portionen (oder mehr)

Mit einer Portion ist etwa die Menge eines Brotbelages gemeint.

35 Wie oft haben Sie Fisch als warme Mahlzeit (z. B. Seelachs, Forelle) gegessen?

- ☐ Nie → Bitte weiter mit Frage 36

☐ 1 Mal im Monat	☐ 1 Mal am Tag
☐ 2–3 Mal im Monat	☐ 2 Mal am Tag
☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag
☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag
☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

35a Wenn Sie Fisch als warme Mahlzeit essen, wie viel essen Sie davon meistens?

- ☐ ¼ Portion (oder weniger)
- ☐ ½ Portion
- ☐ 1 Portion
- ☐ 2 Portionen
- ☐ 3 Portionen (oder mehr)

Mit einer Portion sind 1 Fischfilet oder 4 Fischstäbchen gemeint.

35b Wie oft war der Fisch paniert oder frittiert?

- ☐ (Fast) nie
- ☐ Etwa ¼ des Verzehrs
- ☐ Etwa ½ des Verzehrs
- ☐ Etwa ¾ des Verzehrs
- ☐ (Fast) immer

GeliS Gesundheit in der Schwangerschaft

36	Wie oft haben Sie frisches Obst (z. B. Apfel, Banane) gegessen?	36a	Wenn Sie frisches Obst essen, wie viel essen Sie davon meistens?
☐	Nie → Bitte weiter mit Frage 37	☐	½ Stück oder ½ Schale (oder weniger)
☐	1 Mal im Monat	☐	1 Stück oder 1 Schale
☐	2–3 Mal im Monat	☐	2 Stück oder 2 Schalen
☐	1–2 Mal pro Woche	☐	3 Stück oder 3 Schalen
☐	3–4 Mal pro Woche	☐	4 Stück oder 4 Schalen (oder mehr)
☐	5–6 Mal pro Woche		1 Stück ist z. B. 1 Apfel oder 1 Banane. Mit Schale ist eine kleine Dessertschale von 150 ml mit z. B. Erdbeeren oder Kirschen gemeint.
☐	1 Mal am Tag		
☐	2 Mal am Tag		
☐	3 Mal am Tag		
☐	4–5 Mal am Tag		
☐	Öfter als 5 Mal am Tag		

37	Wie oft haben Sie gegartes Obst (z. B. Kompott, Konservenobst) gegessen?	37a	Wenn Sie gegartes Obst essen, wie viel essen Sie davon meistens?
☐	Nie → Bitte weiter mit Frage 38	☐	¼ Schale (oder weniger)
☐	1 Mal im Monat	☐	½ Schale
☐	2–3 Mal im Monat	☐	1 Schale
☐	1–2 Mal pro Woche	☐	2 Schalen
☐	3–4 Mal pro Woche	☐	3 Schalen (oder mehr)
☐	5–6 Mal pro Woche		Gemeint ist eine Dessertschale von 150 ml.
☐	1 Mal am Tag		
☐	2 Mal am Tag		
☐	3 Mal am Tag		
☐	4–5 Mal am Tag		
☐	Öfter als 5 Mal am Tag		

38	Wie oft haben Sie rohes Gemüse (z. B. Kopfsalat, Rohkost) gegessen?	38a	Wenn Sie rohes Gemüse essen, wie viel essen Sie davon meistens?
☐	Nie → Bitte weiter mit Frage 39	☐	¼ Portion (oder weniger)
☐	1 Mal im Monat	☐	½ Portion
☐	2–3 Mal im Monat	☐	1 Portion
☐	1–2 Mal pro Woche	☐	2 Portionen
☐	3–4 Mal pro Woche	☐	3 Portionen (oder mehr)
☐	5–6 Mal pro Woche		Gemeint ist eine Beilagenportion von etwa 150 g.
☐	1 Mal am Tag		
☐	2 Mal am Tag		
☐	3 Mal am Tag		
☐	4–5 Mal am Tag		
☐	Öfter als 5 Mal am Tag		

39	Wie oft haben Sie Hülsenfrüchte (z. B. Bohnen, Erbsen, Linsen) gegessen?	39a	Wenn Sie Hülsenfrüchte essen, wie viel essen Sie davon meistens?
☐	Nie → Bitte weiter mit Frage 40	☐	¼ Portion (oder weniger)
☐	1 Mal im Monat	☐	½ Portion
☐	2–3 Mal im Monat	☐	1 Portion
☐	1–2 Mal pro Woche	☐	2 Portionen
☐	3–4 Mal pro Woche	☐	3 Portionen (oder mehr)
☐	5–6 Mal pro Woche		Gemeint ist eine Beilagenportion von etwa 150 g.
☐	1 Mal am Tag		
☐	2 Mal am Tag		
☐	3 Mal am Tag		
☐	4–5 Mal am Tag		
☐	Öfter als 5 Mal am Tag		

Gesund leben in der Schwangerschaft GeliS

40 Wie oft haben Sie gegartes Gemüse gegessen?

- ☐ Nie → Bitte weiter mit Frage 41

☐ 1 Mal im Monat	☐ 1 Mal am Tag
☐ 2–3 Mal im Monat	☐ 2 Mal am Tag
☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag
☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag
☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

40a Wenn Sie gegartes Gemüse essen, wie viel essen Sie davon meistens?

- ☐ ¼ Portion (oder weniger)
- ☐ ½ Portion
- ☐ 1 Portion
- ☐ 2 Portionen
- ☐ 3 Portionen (oder mehr)

Gemeint ist eine Beilagenportion von etwa 150 g.

40b Wenn Sie gegartes Gemüse essen, dann ist das üblicherweise:

- ☐ Frisch (roh) eingekauft
- ☐ Tiefkühlgemüse
- ☐ Konservengemüse
- ☐ Weiß ich nicht

41 Wie oft haben Sie Nudeln (z. B. Spaghetti, Spätzle, Ravioli, Lasagne) gegessen?

- ☐ Nie → Bitte weiter mit Frage 42

☐ 1 Mal im Monat	☐ 1 Mal am Tag
☐ 2–3 Mal im Monat	☐ 2 Mal am Tag
☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag
☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag
☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

41a Wenn Sie Nudeln essen, wie viel essen Sie davon meistens?

- ☐ ¼ Teller (oder weniger)
- ☐ ½ Teller
- ☐ 1 Teller
- ☐ 2 Teller
- ☐ 3 Teller (oder mehr)

42 Wie oft haben Sie Reis (auch Couscous, Bulgur) gegessen?

- ☐ Nie → Bitte weiter mit Frage 43

☐ 1 Mal im Monat	☐ 1 Mal am Tag
☐ 2–3 Mal im Monat	☐ 2 Mal am Tag
☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag
☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag
☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

42a Wenn Sie Reis (auch Couscous, Bulgur) essen, wie viel essen Sie davon meistens?

- ☐ ¼ Portion (oder weniger)
- ☐ ½ Portion
- ☐ 1 Portion
- ☐ 2 Portionen
- ☐ 3 Portionen (oder mehr)

Gemeint ist eine Beilagenportion von etwa 150 g.

GeliS Gesund leben in der Schwangerschaft

43	Wie oft haben Sie gekochte Kartoffeln (z. B. Salzkartoffeln, Pellkartoffeln, Kartoffelklöße) gegessen?		43a	Wenn Sie gekochte Kartoffeln essen, wie viel essen Sie davon meistens?
☐	Nie → Bitte weiter mit Frage 44		☐	½ Portion oder 1 Kartoffel (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	1 Portion oder 2 Kartoffeln
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	1 ½ Portionen oder 3 Kartoffeln
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	2 Portionen oder 4 Kartoffeln
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	2 ½ Portionen oder 5 Kartoffeln (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		Gemeint sind mittelgroße Kartoffeln.

44	Wie oft haben Sie gebratene Kartoffeln (auch Kroketten oder Kartoffelpuffer) gegessen? Nicht gemeint sind Pommes.		44a	Wenn Sie gebratene Kartoffeln essen, wie viel essen Sie davon meistens?
☐	Nie → Bitte weiter mit Frage 45		☐	¼ Teller (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	½ Teller
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	1 Teller
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	2 Teller
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	3 Teller (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

45	Wie oft haben Sie Pommes Frites gegessen?		45a	Wenn Sie Pommes Frites essen, wie viel essen Sie davon meistens?
☐	Nie → Bitte weiter mit Frage 46		☐	¼ Portion (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	½ Portion
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	1 Portion
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	2 Portionen
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	3 Portionen (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		Gemeint ist eine mittlere Portion am Imbissstand.

46	Wie oft haben Sie Pizza gegessen?		46a	Wenn Sie Pizza essen, wie viel essen Sie davon meistens?
☐	Nie → Bitte weiter mit Frage 47		☐	¼ Portion (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	½ Portion
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	1 Portion
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	2 Portionen
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	3 Portionen (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		Mit einer Portion ist eine Tiefkühlpizza von etwa 350 g gemeint.

Gesund leben in der Schwangerschaft GeliS

47	Wie oft haben Sie Kuchen, Torten oder süße Backwaren (auch Muffins, Apfeltaschen, Baklava) gegessen?		47a	Wenn Sie Kuchen, Torten oder süße Backwaren essen, wie viel essen Sie davon meistens?
☐	Nie → Bitte weiter mit Frage 48		☐	½ Stück (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	1 Stück
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	2 Stück
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	3 Stück
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	4 Stück (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

48	Wie oft haben Sie Kekse (z. B. Butterkekse, Plätzchen) gegessen?		48a	Wenn Sie Kekse essen, wie viel essen Sie davon meistens?
☐	Nie → Bitte weiter mit Frage 49		☐	2 Kekse (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	3 Kekse
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	4 Kekse
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	5 Kekse
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	6 Kekse (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

49	Wie oft haben Sie Schokolade oder Schokoriegel (auch Pralinen) gegessen?		49a	Wenn Sie Schokolade oder Schokoriegel essen, wie viel essen Sie davon meistens?
☐	Nie → Bitte weiter mit Frage 50		☐	¼ kleinen Schokoriegel (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	¼ Tafel oder 1 kleinen Schokoriegel
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	½ Tafel oder 1 großen Schokoriegel
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	1 Tafel oder 2 große Schokoriegel
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	2 Tafeln (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		Gemeint ist eine Tafel von 100 g.

50	Wie oft haben Sie Süßigkeiten (z. B. Bonbons, Fruchtgummi, Hustenbonbons, Lakritz) gegessen?		50a	Wenn Sie Süßigkeiten essen, wie viel essen Sie davon meistens?
☐	Nie → Bitte weiter mit Frage 51		☐	1 Stück
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	2–5 Stück
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	6–10 Stück
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	11–20 Stück
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	21 Stück (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

GeliS Gesund leben in der Schwangerschaft

51	Wie oft haben Sie Eis gegessen?	
	☐ Nie → Bitte weiter mit Frage 52	
	☐ 1 Mal im Monat	☐ 1 Mal am Tag
	☐ 2–3 Mal im Monat	☐ 2 Mal am Tag
	☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag
	☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag
	☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

51a	Wenn Sie Eis essen, wie viel essen Sie davon meistens?
	☐ ½ Kugel (oder weniger)
	☐ 1 Kugel
	☐ 2 Kugeln oder 1 Eis am Stiel
	☐ 3 Kugeln
	☐ 4 Kugeln (oder mehr)

52	Wie oft haben Sie Kartoffelchips gegessen?	
	☐ Nie → Bitte weiter mit Frage 53	
	☐ 1 Mal im Monat	☐ 1 Mal am Tag
	☐ 2–3 Mal im Monat	☐ 2 Mal am Tag
	☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag
	☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag
	☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

52a	Wenn Sie Kartoffelchips essen, wie viel essen Sie davon meistens?
	☐ ¼ Schale (oder weniger)
	☐ ½ Schale
	☐ 1 Schale
	☐ 2 Schalen
	☐ 3 Schalen (oder mehr)
	Gemeint ist eine Dessertschale von 150 ml.

53	Wie oft haben Sie Salzgebäck oder Cracker (z. B. Salzstangen) gegessen?	
	☐ Nie → Bitte weiter mit Frage 54	
	☐ 1 Mal im Monat	☐ 1 Mal am Tag
	☐ 2–3 Mal im Monat	☐ 2 Mal am Tag
	☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag
	☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag
	☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

53a	Wenn Sie Salzgebäck oder Cracker essen, wie viel essen Sie davon meistens?
	☐ ¼ Schale (oder weniger)
	☐ ½ Schale
	☐ 1 Schale
	☐ 2 Schalen
	☐ 3 Schalen (oder mehr)
	Gemeint ist eine Dessertschale von 150 ml.

54	Wie oft haben Sie Nüsse (z. B. Erdnüsse, Walnüsse, Haselnüsse) gegessen?	
	☐ Nie → Bitte weiter mit Frage 55	
	☐ 1 Mal im Monat	☐ 1 Mal am Tag
	☐ 2–3 Mal im Monat	☐ 2 Mal am Tag
	☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag
	☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag
	☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

54a	Wenn Sie Nüsse essen, wie viel essen Sie davon meistens?
	☐ ¼ Portion (oder weniger)
	☐ ½ Portion
	☐ 1 Portion
	☐ 2 Portionen
	☐ 3 Portionen (oder mehr)
	Mit einer Portion ist eine Handvoll von ca. 25 g gemeint.

55	Welches Fett verwenden Sie bei der Zubereitung von Fleisch oder Fisch hauptsächlich?
	☐ Butter, Margarine
	☐ Olivenöl
	☐ Rapsöl
	☐ Pflanzliches Kochfett (z. B. Biskin, Palmin)
	☐ Tierisches Kochfett (z. B. Schmalz)
	☐ Sonnenblumen-, Distel-, Keimöl etc.
	☐ Weiß ich nicht
	☐ Kein

56	Welches Fett verwenden Sie bei der Zubereitung von Gemüse hauptsächlich?
	☐ Butter, Margarine
	☐ Olivenöl
	☐ Rapsöl
	☐ Pflanzliches Kochfett (z. B. Biskin, Palmin)
	☐ Tierisches Kochfett (z. B. Schmalz)
	☐ Sonnenblumen-, Distel-, Keimöl etc.
	☐ Weiß ich nicht
	☐ Kein

57	Essen Sie üblicherweise vegetarisch?
	☐ Nein → Bitte weiter mit Frage 58
	☐ Ja

57a	Welche der folgenden Lebensmitteln essen Sie nicht? Mehrfachangaben möglich.
	☐ Fleisch, Geflügel und Wurst
	☐ Fisch
	☐ Milch und Milchprodukte
	☐ Eier

58	Wie häufig in der Woche bereiten Sie aus Grundzutaten/ frischen Lebensmitteln eine warme Mahlzeit (Mittag- oder Abendessen) selbst zu?
	☐ Täglich
	☐ 5–6 Mal pro Woche
	☐ 3–4 Mal pro Woche
	☐ 1–2 Mal pro Woche
	☐ Nie

59	Rauchen Sie zurzeit?
	☐ Ja, regelmäßig
	☐ Ja, gelegentlich (< 1 Zigarette pro Tag)
	☐ Nein, nicht mehr
	☐ Habe noch nie geraucht

59a	Wenn Sie rauchen, wie viele Zigaretten rauchen Sie pro Tag?
	_____ Zigaretten

Quelle: modifiziert nach Ernährungsfragebogen der Studie zur Gesundheit Erwachsener in Deutschland (DEGS) des Robert Koch Instituts, Berlin, 2008

A2 Approval for the publication-based dissertation.

Einverständniserklärung zur publikationsbasierten Promotion[1]

Anlage 6 (für § 6 Abs. 2)

Hiermit erkläre ich mein Einverständnis, dass die Dissertation von

Frau/Herrn Julia Katharina Günther

als publikationsbasierte Dissertation eingereicht wird. Sie erfüllt die nachfolgenden Kriterien:

1. Einleitungs- und Methodenteil (20 Seiten). Ein themenübergreifender Diskussionsteil mit Reflexion zur bestehenden Literatur.

2. Kumulative Einbindung von mindestens zwei akzeptierten Erstautorenveröffentlichungen (full paper in einem englischsprachigen, international verbreiteten Publikationsorgan, peer reviewed)

3. Die eingebundenen Veröffentlichungen müssen federführend vom Doktoranden abgefasst sein.

4. Eingebunden muss sein: je eine einseitige Zusammenfassung der jeweiligen Veröffentlichungen unter Hervorhebung der individuellen Leistungsbeiträge des Kandidaten.

5. Einbindung von ausgewählten Originalveröffentlichungen nur mit einem separaten schriftlichen „Erlaubnisschreiben des jeweiligen Verlags". Alle anderen Originalveröffentlichungen werden unter Nennung der bibliografischen Angaben aufgelistet. In den Exemplaren für die Mitglieder der Prüfungskommission sind alle Originalveröffentlichungen separat dazu abzugeben.

5. 8. 2015 — Datum

Unterschrift betreuender ~~Prof.~~

[1] Zur Vorlage bei der Einreichung der Dissertation.

Acknowledgement

Zuallererst möchte ich meinem Doktorvater Prof. Dr. med. Hans Hauner für die Möglichkeit danken, im Rahmen des GeliS-Projekts zu promovieren. Herzlichen Dank für das mir entgegengebrachte Vertrauen und die engagierte Unterstützung. Weiterhin gilt mein Dank Prof. Dr. med. Ensenauer für die Zweitbetreuung der Arbeit und Prof. Dr. Klingenspor für die Übernahme des Prüfungsvorsitzes.

Herzlich möchte ich auch meiner Mentorin Dr. Paula Singmann danken, die immer ein offenes Ohr für Anliegen jeglicher Art hatte. Vielen Dank an Dr. Lynne Stecher für ihre tolle Unterstützung bei Statistik-Fragen – danke, dass du dir sogar während deiner Elternzeit immer Zeit für meine Anliegen genommen hast.

Ganz besonderen Dank gilt natürlich dem besten Team aller Zeiten – Team GeliS. Durch euch hat Team-Arbeit für mich eine ganz neue Bedeutung bekommen. Danke an Dr. Kathrin Rauh, meine inoffizielle Doktormutter, und die KErn-Damen Eva Rosenfeld und Luzia Kick für aufregende und lehrreiche Zeiten, anregende Diskussionen, heitere Momente und Zusammenhalt bei schweren Rückschlägen. Herzlichen Dank an Julia Kunath, die Pilotin des GeliS-Mobils, für unzählige gemeinsame Stunden zwischen Schreibtisch und Doppelbett auf den Fahrten durch unsere bayrischen Studienregionen. Deine wunderbare positive Art hat meine Zeit am Institut sehr bereichert. Meinem Gegenüber Julia Hoffmann danke ich für ihre endlose Geduld in unseren Diskussionen zur Datenauswertung, die fachliche und mentale Unterstützung bei Fragen aller Art und vor allem für ihren grenzenlosen Team-Geist und ihr ansteckendes Strahlen.

Auch den liebgewonnenen Kolleginnen Monika Spies und Dora Meyer, sowie dem GeliS-Nachwuchs Roxana Raab und Kristina Geyer danke ich ganz herzlich für ihre Bereicherung des Teams – bei euch ist das GeliS-Projekt in guten Händen. Danke für euer tolles Engagement, eure Herzlichkeit – und die Aufrechterhaltung meines Blutzucker- und Koffeinspiegels.

Meinen Kolleginnen und Kollegen am Lehrstuhl für Ernährungsmedizin in Freising und München möchte ich für die schöne gemeinsame Zeit und die vielen Erlebnisse in und abseits der Arbeit danken. Mittagspausen auf der Münchner Dachterrasse, Seerunden in Freising, Campusläufe, Biergarten- und Wiesnabende, unvergessliche Kongressbesuche, gemeisterte Challenges und so viel mehr.

Ein ganz besonders herzliches Danke geht an meine Eltern, meine Schwestern und an meine Freunde – insbesondere an Jakob, Gina, Kiki, Alex und Jamson – die mir immer Rückhalt und unglaublich viel Kraft gegeben haben, und durch ihr großes Interesse teilweise selbst zu Experten bzgl. Ernährung in der Schwangerschaft geworden sind.

List of publications and congress contributions

Publications

Rauh K* & **Günther J***, Kunath J, Stecher L, Hauner H. Lifestyle intervention to prevent excessive maternal weight gain: mother and infant follow-up at 12 months postpartum. BMC Pregnancy Childbirth. 2015; 15, 265.

Kunath J* & **Günther J***, Rauh K, Hoffmann J, Stecher L, Rosenfeld E, Kick L, Ulm K, Hauner H. Effects of a lifestyle intervention during pregnancy to prevent excessive gestational weight gain in routine care – the cluster-randomised GeliS trial. BMC Med. 2019, 17, 5.

Günther J, Hoffmann J, Kunath J, Spies M, Meyer D, Stecher L, Rosenfeld E, Kick L, Rauh K, Hauner H. Effects of a Lifestyle Intervention in Routine Care on Prenatal Dietary Behaviour – Findings from the Cluster-Randomised GeliS Trial. J. Clin. Med. 2019, 8(7), 960.

Hoffmann J, **Günther J**, Stecher L, Spies M, Meyer D, Kunath J, Raab R, Rauh K, Hauner H. Effects of a Lifestyle Intervention in Routine Care on Short- and Long-Term Maternal Weight Retention and Breastfeeding Behaviour – 12 Months Follow-up of the Cluster-Randomised GeliS Trial. J. Clin. Med. 2019, 8(6), 876.

Michel S* & Raab R*, Drabsch T, **Günther J**, Stecher L, Hauner H. Do lifestyle interventions during pregnancy have the potential to reduce long-term postpartum weight retention? A systematic review and meta-analysis. Obes. Rev. 2019, 20(4), 527.

Günther J, Hoffmann J, Spies M, Meyer D, Kunath J, Stecher L, Rosenfeld E, Kick L, Rauh K, Hauner H. Effects of the prenatal diet on neonatal outcomes – findings from the cluster-randomised GeliS trial. Nutrients 2019 [accepted].

Hoffmann* & **Günther J***, Geyer K, Stecher L, Rauh K, Kunath J, Meyer D, Sitzberger C, Spies M, Rosenfeld E, Kick L, Oberhoffer R, Hauner H. Effects of a lifestyle intervention in routine care on prenatal physical activity – findings from the cluster-randomised GeliS trial. BMC Pregnancy Childbirth 2019 [under review].

Hoffmann J, **Günther J**, Geyer K, Stecher L, Kunath J, Meyer D, Spies M, Rosenfeld E, Kick L, Rauh K, Hauner H. Effects of prenatal physical activity on neonatal and obstetric outcomes – findings from the cluster-randomised GeliS trial. BMC Pregnancy Childbirth 2019 [under review].

* The first two authors contributed equally to this work.

Articles in German

Rosenfeld E, Rauh K, Kick L, Kunath J, **Günther J**, Hauner H. Gesund leben in der Schwangerschaft (GeliS) – gesundheitsförderliche Ernährung von Schwangeren. Gesundheitswesen. 2015, 77:656.

Günther J, Kunath J, Wessels B, Rauh K, Hauner H. Foetale Prägung und frühkindliche Ernährung – ist eine Primärprävention von Adipositas möglich? Adipositas. 2015; 4.

Kunath J, **Günther J**, Kick L, Rauh K, Rosenfeld E, Hauner H. GeliS – Gesund leben in der Schwangerschaft. Eine Studie zur Ernährung und Bewegung in der Schwangerschaft. Die Hebamme. 2016, 29:354.

Günther J* & Hoffmann J*, Spies M, Hauner H. Lebensstil und Gewichtszunahme in der Schwangerschaft – Bedeutung für die Gesundheit von Mutter und Kind. Ernährung & Medizin 2019, 34:20.

* The first two authors contributed equally to this work.

Congress talks

Günther J. „Gesund leben in der Schwangerschaft“ /healthy living in pregnancy – a lifestyle intervention project in 10 regions of Bavaria, Germany. 25th European Congress on Obesity, 23.–26.05.2018, Vienna, Austria.

Günther J. Diet and gestational diabetes – risk factors and prevention strategies. 40th ESPEN Congress on Clinical Nutrition & Metabolism, 01.–04.09.2018, Madrid, Spain.

Günther J, Hoffmann J, Kunath J, Rauh K, Spies M, Kick L, Rosenfeld E, Stecher L, Hauner H. „Gesund leben in der Schwangerschaft“ – Ergebnisse der GeliS-Lebensstilinterventionsstudie in zehn bayrischen Regionen. 56. Wissenschaftlicher Kongress der DGE (Deutsche Gesellschaft für Ernährung e.V.), 19.-21.03.2019, Gießen, Germany.

Günther J, Kunath J, Rauh K, Hoffmann J, Stecher L, Rosenfeld E, Kick L, Ulm K, Hauner H. Lebensstilintervention in der Schwangerschaft – Ergebnisse der „Gesund leben in der Schwangerschaft“ (GeliS)-Studie. 10. Update Ernährungsmedizin, 18.-19.10.2019, Munich, Germany.

Posters

Kunath J & **Günther J**, Rauh K, Rosenfeld E, Kick L, Hauner H. Healthy living in pregnancy: a cluster-randomised controlled trial to prevent excessive gestational weight gain – design and current status of the GeliS study. Liesel Beckmann Symposium, 27.11.2015, Munich, Germany.

Kunath J, **Günther J**, Rauh K, Rosenfeld E, Kick L, Hauner H. GeliS – A lifestyle intervention trial to prevent excessive weight gain during pregnancy. The Power of Programming, 13.–15.10.2016, Munich, Germany.

Rauh K, Hoffmann J, Kunath J, **Günther J**, Kick L, Rosenfeld E, Hauner H. Evaluation der Beratungsgespräche des Lebensstilinterventions-Programms „Gesund leben in der Schwangerschaft“ (GeliS). 53. Wissenschaftlicher Kongress der DGE (Deutsche Gesellschaft für Ernährung e.V.), 02.–04.03.2018, Fulda, Germany.

Günther J, Kunath J, Rauh K, Kick L, Rosenfeld E, Hauner H. Evaluation des Lebensstilinterventions-Programms „Gesund leben in der Schwangerschaft“ (GeliS) – ein Erfahrungsbericht aus Sicht der Lebensstilberater. 54. Wissenschaftlicher Kongress der DGE (Deutsche Gesellschaft für Ernährung e.V.), 01.–03.03.2017, Kiel, Germany.

Hoffmann J, **Günther J**, Kunath J, Rauh K, Bär L, Spies M, Kick L, Rosenfeld E, Stecher L, Hauner H. „Gesund leben in der Schwangerschaft“ – Evaluation der GeliS-Lebensstilintervention. 56. Wissenschaftlicher Kongress der DGE (Deutsche Gesellschaft für Ernährung e.V.), 19.–21.03.2019, Gießen, Germany.

Günther J, Hoffmann J, Rauh K, Kunath K, Rosenfeld E, Kick L, Stecher L, Hauner H. The effect of lifestyle counselling on dietary behaviour of pregnant women – secondary results of the randomised controlled GeliS trial. 26th European Congress on Obesity, 28.04.–01.05.2019, Glasgow, Scotland.

Hoffmann J, **Günther J**, Rauh K, Kunath J, Rosenfeld E, Kick L, Stecher L, Hauner H. Effect of prenatal lifestyle counselling in routine care on gestational weight gain and the risk of gestational diabetes – results of the cluster-randomised GeliS trial. DIP 2019 – 10th International Symposium on Diabetes, Hypertension, Metabolic Syndrome and Pregnancy, 29.05.–01.06.2019, Florence, Italy.

Günther J, Kunath J, Rauh K, Hoffmann J, Stecher L, Rosenfeld E, Kick L, Hauner H. The Healthy living in pregnancy (GeliS) trial – a large-scaled public health approach for the prevention of excessive gestational weight gain and pregnancy complications. International Society for Developmental Origins of Health and Disease – World Congress 2019, 20.10.–23.10.2019, Melbourne, Australia.

Hoffmann J, **Günther J**, Kunath J, Rauh K, Stecher L, Rosenfeld E, Kick L, Geyer K, Spies M, Meyer D, Hauner H. Effects of prenatal lifestyle counselling on diet and physical activity in the cluster-randomised controlled GeliS (“Gesund leben in der Schwangerschaft”/Healthy living in pregnancy) trial. International Society for Developmental Origins of Health and Disease – World Congress 2019, 20.10.–23.10.2019, Melbourne, Australia.