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WEIGHT LOSS AND SEXUAL ACTIVITY IN ADULT OBESE INDIVIDUALS: ESTABLISHING A CAUSAL LINK

February 28, 2015

Abstract

Obesity may not only be linked to undesirable health outcomes but also to limitations in sexual life. The present paper aims to assess whether there is a relationship between weight change and sexual activity in obese individuals. To address the endogeneity of weight loss that is likely to result in biased estimation results, the analysis is based on data from a randomized controlled trial. In this experiment financial weight-loss rewards were randomly offered to a subgroup of participants and can be used as exogenous source of weight variation in an instrumental variables approach. Estimation results indicate that for obese males losing weight increases both the probability for being involved in a sexual relationship. Conditional on having already lost some weight, a further reduction of obesity also increases the frequency of sexual intercourse.

JEL codes: I12, J12, J13

Keywords: obesity, sexual partnership, frequency of intercourse, randomized trial, weight-loss incentives.

1 Introduction

A close link of a fulfilling sex life and general life satisfaction is well documented in the literature (e.g. Woloski-Wruble et al., 2010; Schafer et al., 2013) and also represents a commonplace of everyday's life experience. Impairments in sexual life therefore are likely to have a strong negative impact on individual happiness and life satisfaction. One possible reason for limitations in sexual life is obesity; see Larsen et al. (e.g. 2007) for a review of the medical literature focussing on the association of obesity and sexual dysfunction such as erectile dysfunction. Though the majority of analyses reviewed by Larsen et al. (2007) find a positive association, the evidence is still mixed.¹ Taking a less physiological oriented perspective, Kolotkin et al. (2006) list 'lack of enjoyment', 'lack of desire', difficulties with performance', and 'avoidance of sexual encounters' as examples for obesity related impairments of sexual live. Thus, obesity may not only be linked to undesirable general health outcomes, but may also have a more direct detrimental effect on happiness and life satisfaction that operates through an unsatisfactory sex life.

Somewhat surprisingly the non-medical, health-economics oriented literature has taken a quite different view on the link of body weight to sexual live. To our knowledge, this rather small literature (Cawley, 2001; Halpern et al., 2005; Cawley et al., 2006; Sabia and Rees, 2011; Ali et al., 2014; Neymotin and Downing-Matibag, 2014) focuses on individuals of very young age, adolescents in particular. Due to the focus on this special age group, sexual activity is not primarily interpreted as one facet of a happy and fruitful life. It is rather associated with premature initiation to sex, potentially exerting detrimental effects on adolescents' later lives. For female adolescents Sabia and Rees (2008) find a causal and detrimental effect of early sexual intercourse on psychological well-being. Ali et al. (2014) refer to disease and pregnancy risks teenagers run if having sex early in their lives, suggesting that a postponed intonation to sexual activities may be a positive side-effect of teenage overweight.

The contribution of the present paper is to (i) conduct an analysis that focusses on adult individuals, for whom the above line of argument does not apply and whose sexual behavior, most likely, fundamentally differs from the behavior of the age group studied by the above cited literature. Moreover, unlike the majority of the medical literature, our focus is (ii) on (self-reported) sexual activity rather than specific sexual dysfunctions such as erectile dysfunction. This is important as obesity related limitations in sex life may often be unrelated to any physiological deficit but can possibly be attributed to social and psychological body-weight related factors, such as

¹Especially for women, for which 'sexual dysfunction' is less clearly defined than for man and for which the number of studies is much smaller, several analyses fail in establishing an association of sexual dysfunction and body weight (e.g. Adolfsson et al., 2004; Kolotkin et al., 2006).

'being less attractive to a potential partner', 'being less self confidence when dating', or 'less enjoyment in and desire for sex'. Finally, the present analysis contributes to the existing evidence by (iii) establishing a causal effect of weight-loss on sexual activity as opposed to finding a mere correlation in the data.

Focussing on the non-medical strand of the literature, causality in the link between body weight and sex life has not always attracted much attention. Halpern et al. (2005), for instance, estimate that one BMI unit less increases the probability of being involved in a romantic relationship (with or without sexual intercourse) by 6-7 percent in adolescent girls. Based on Add Health (National Longitudinal Survey of Adolescent Health; Harris, 2013) data, a US longitudinal school-based survey – but not when alternatively using the NLSY – Cawley et al. (2006) find that for obese girls the odds of initiation to sexual intercourse are just 32 percent of the odds of normal-weight girls. However, both analyses do not take account of unobserved heterogeneity. Hence, the striking results may well be attributed to unobserved confounding factors, such as personal character traits, that are relevant for both obesity related behavior (eating habits, physical activity) and mating behavior. Numerous studies from the medical literature, likewise cannot rule out that confounding factors drive the observed correlation of overweight and impairments in sex life.

More recent papers from the field of health economics address possible endogeneity by the use of instrumental variables (IV) estimation. Sabia and Rees (2011), analyzing data from the National Longitudinal Study of Adolescent Health and using siblings' BMI and mother's obesity status as instruments for the respondents' body weight, find that a one unit increase in BMI reduces the probability of being sexually active by 3.5 percentage points in girls aged 14 to 17. In contrast, no significant effect is found for boys. Rather, the point estimate for boys bears the opposite sign in several specifications. Ali et al. (2014) take a similar approach by instrumenting body weight by maternal obesity status. For white girls – but not for blacks – they find that higher body weight or being obese significantly lowers the probability of having had sex or having been involved in a romantic relationship. Though both papers carefully discuss the validity of the instruments used and argue that including a wide range of covariates does capture any possible direct effects from mother's body weight to the child's sexual behavior, one may still doubt whether mother's – and other relatives' – body weight is a valid instrument. One concern is that not only body weight but also sexual behavior – or at least attitudes towards it – may be intergenerationally transmitted from the mother to her children (e.g. Taris, 2000). If so, mother's own sexual behavior represents another channel through which maternal body weight influences children's sex life, given that body weight matters for sexual behavior. Another concern with respect to instrument

validity is the social environment children share with their mothers and siblings. It may strongly influence both body weight and attitudes towards sex for both mothers and children and, most likely, cannot entirely be controlled for by including covariates in the analysis.

While we follow Sabia and Rees (2011) and Ali et al. (2014) in relying on instrumental variables in establishing a causal link between body-weight and sexual behavior, we do not use maternal body weight as instrumental variable. Rather in our analysis identification rests on exogenous variation in BMI that was artificially induced in a randomized field experiment. More precisely, we use data that originate from a randomized trial that was conducted to evaluate the effectiveness of financial incentives for weight loss (Augurzký et al., 2012, 2014). In this experiment individuals in the intervention groups were exposed to financial incentive for losing body weight, while control group members were not. Hence following Reichert (2015) treatment status can serve as an instrument for the change in body weight. Besides of using different instruments and focussing on adult individuals, our analysis materially deviates from Sabia and Rees (2011) and Ali et al. (2014) by only considering obese individuals. That is, the empirical analysis is not concerned with the question of whether being overweight, or even obese, has adverse effects on sex life. Rather, we are interested in the question of whether – even moderate – weight loss in obese individuals makes a difference for their sexual lives.

The strategy for identification of the present analysis is related to the approach of Esposito et al. (2004). This medical study also relies on data from a randomized field experiment with obese participants. In this study the intervention was not exposition to financial incentives but guidance on how to lose weight combined with weight monitoring through monthly group sessions. Yet, rather than identifying a causal effect weight loss, Esposito et al. (2004) estimate a reduced form effect by comparing post-intervention IIEF (International Index of Erectile Function) scores between intervention and control group. The statistically significant advantage in IIEF found for the intervention group nevertheless provides striking evidence for a reduction of body-weight mattering for sexual dysfunctions in obese. However, by focussing on erectile dysfunction alone, Esposito et al. (2004) may miss out other obesity related impairments of sexual life. By considering two different measures of sexual activity our analysis takes a broader perspective in the link between obesity and sex life.

The remainder of this paper is organized as follows. The subsequent section 2 introduces the data and describes the experiment the data originates from. Section 3 discusses the econometric model and section 4 presents the estimation results for the basic model. In section 5 alternative model specifications and estimation results are discussed. Section 6 summarizes the main findings and concludes.

2 Data

2.1 The Experiment

The data used in this analysis originate from a large scale randomized field experiment that is described in more detail elsewhere in the literature (Augurzky et al., 2012). The experiment was conducted between March 2010 and July 2013. Roughly 700 obese individuals were recruited in the period March 2010 to August 2011. Recruitment took place in four rehabilitation clinics in south-west Germany (Bad Mergentheim, Bad Kissingen, Isny, and Glottertal). Only for a minor group of participant obesity was the immediate reason for their rehab stay. Yet, many were sent to the clinic because of health deficits that are connected with over-weight or obesity such as chronic back pain, for instance. The participating rehab clinics are operated by the German Pension Insurance (DRV), Baden-Württemberg section. For this reason all patients are insured with DRV and the ultimate aim of treatment at the rehab clinics is either to preserve or to restore patients' workableness. Shortly after clinic admission the physician in charge approached all patient who had a BMI of 30 or above and complied with the further admission criteria² and ask them for participation in the experiment. Shortly before discharge from the clinic, after a typically three weeks stay, the participants were set an individual weight-loss target by the physician in charge, that they were prompted to realize within four months. The physicians were advised to choose a weight-reduction target of six to eight percent of current body weight, but were free in setting a target they regarded medically appropriate given the specific case. Subsequently, participants were randomly assigned to two incentive groups (*incentive 150₁₋₄* and *incentive 300₁₋₄*)³ and one control group (*incentive 0₁₋₄*). Members of the former two groups were promised € 300 and € 150, respectively, for realizing (or exceeding) their individual weight-loss target within four months, while members of the control group were not exposed to any financial incentives for reducing body weight. Members of *incentive 300₁₋₄* and *incentive 150₁₋₄* who fail in fully complying with the scheduled weight loss but managed to reduce their body weight by at least 50 percent of the contractual target were awarded proportionally to the degree of target achievement. That is a member of *incentive 300₁₋₄* with body weight of 100 kg at clinic discharge and a weight-loss target of 7 kg would not have received a financial reward if she were weighed more than 96.5 kg at the

²An age between 18 and 75, being resident of Baden-Württemberg, having sufficient German language skills, not being pregnant, not exhibiting psychological and eating disorders, no substance abuse, not being seriously ill (specified list diseases).

³To keep notation simple we omit the index i indicating individuals. Numerical subscripts refer to months since rehab discharge. Thus, variables indexed with a simple numerical subscript refer to a certain point in time; e.g. BMI_0 denotes BMI measured at rehab discharge while BMI_4 denotes BMI measured four months later, i.e. by the end of the weight-loss phase. Variables indexed with a bipartite numerical subscript separated by a short hyphen refer to a time span; e.g. for *incentive 300₁₋₄* the observation period is month 1 to month 4 (including month 1 and 4), i.e. the entire four months weight-reduction phase.

end of the weight-reduction phase. She would have received the full premium of €300 if they were weighed 93 kg or less. If she were weighed w kg, with $93 < w \leq 96.5$, she would have received $\text{€}300 \cdot (100-w)/7$.

The weigh-in at the end of the weight-reduction phase – and all further weigh-ins – were carried out at assigned pharmacies. Though it was tried to find a pharmacy close to the participants place of residence, the test persons could not actively influence to which particular pharmacy they were sent. Thus, the location of weigh-in was exogenous to the participants but might influence attrition and participation. All participants received a show-up fee of €25 for attending the weigh-in and (partially) successful incentive group members received the respective reward. Shortly after the weigh-in, all participant – irrespective of group membership in the weight-reduction phase and irrespective of success – were prompted to comply with their target weight by the end of a subsequent six months weight-maintenance phase.⁴ Yet, conditional on success in the weight reduction phase, a second randomization took place at the same time. Participants who had lost at least 50 percent of their contractual weight-loss target were randomly assigned to two intervention groups (*incentive 250*₅₋₁₀, *incentive 500*₅₋₁₀) and one control group (*incentive 0*₅₋₁₀). The former two could gain up to €250 and €500, respectively, if they were weighed their target weight or less ten months after rehab discharge. For those who did not fully comply with the target weight, the actual reward was calculated using the same rule as described above. No rewards were promised to members of the control group. Individuals who were not successful in the weight-reduction phase were hence effectively assigned to the control group.

Six month later, i.e. ten months after rehab discharge, another weigh-in took place under identical conditions. Yet, at this point in time the incentive scheme was terminated and no further randomization took place. However, all participants were still requested to comply with their target weight and another weigh-in was announced to take place after another twelve months. This final year serves the follow-up phase. See Figure 1 for the time line of the entire experiment.

By the end of each of the four phases, the participants had to answer a detailed questionnaire. The final one, which was send to the participants 22 months after rehab discharge, is of major importance to the present analysis as it is the only one that includes questions concerning the participants sex life. Yet, only for participants with even identification number – i.e. for a fifty percent random sample⁵ – the questionnaire included these delicate questions. The reason for this was to reduce the risk of losing many individuals if being asked – possibly displeasing – questions about their sex lives made people drop out. However, this concern proved immaterial as the

⁴For not unsuccessful individuals the ‘weight-maintenance phase’ was effectively another weight-reduction phase.

⁵As the individual identifiers were issued as clinic specific, sequential numbers, for each participant the odds for an even or an odd id were fifty-fifty.

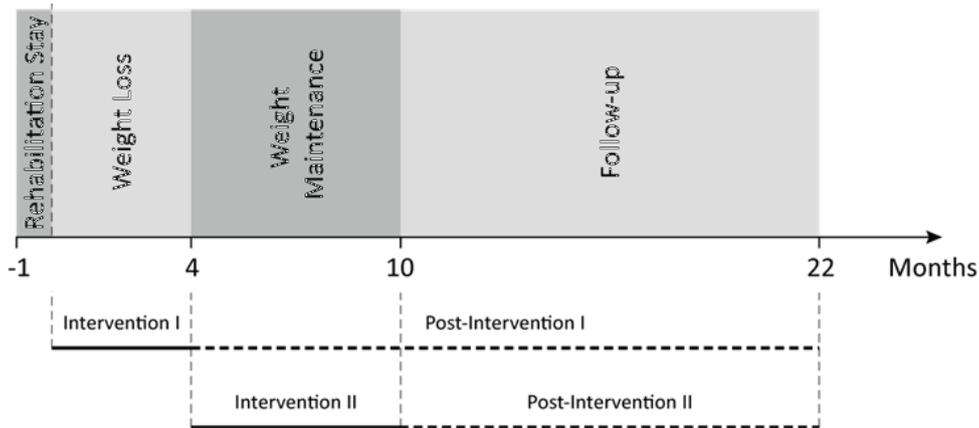


Figure 1: Time line of the experiment.

drop out rate virtually did not differ between individuals with even and with odd identification number.

The experiment population is subject to significant sample attrition. 697 individuals started the weight-reduction phase after rehab discharge. Out of these six denied information about their sex and cannot be considered in the present analysis. 176 participants dropped out during the weight-reduction phase, i.e. they did not show up at the weigh-in after four months, leading to only 521 individuals who entered the weight-maintenance phase. In this phase another 109 individuals dropped out. The follow-up phase was also subject to some sample attrition reducing the number of individuals for whom weight information is available by the end of the experiment to 316. Among these 174 were asked questions regarding sex life. Only 17 denied of any kind of information on their sex lives. This corresponds to a rate of item-non-response of less than 10 percent, which is very low compared to many surveys addressing sexual behavior (cf. Fenton et al., 2001).

2.2 Variables

In the final questionnaire, which participants had to fill in 22 months after rehab discharge, they were asked two questions regarding their sex lives, (i) whether being involved in a sexual relationship and (ii) how frequently they have sexual intercourse. Both questions refer to the previous twelve month that is the follow-up phase of the experiment. While the first question had to be answered by yes or no, the latter allowed for answers on a five categories scale, more precisely 'never', 'occasionally', 'at least once a month', 'at least once a week', '(almost) daily'. Hence we can use two different measures of sexual activity as dependent variables, a binary indicator (*sexpartner*₁₁₋₂₂) and an ordered categorical one (*sexfrequency*₁₁₋₂₂). 156 and 152, respectively, par-

Table 1: **Distribution of dependent variables**

| | frequency of sexual intercourse | | | | | marginal distribution ⁺ | | |
|-----------------------------------------------|---------------------------------|--------------|-----------|-----------|----------|------------------------------------|-------|---------|
| | never | occasionally | monthly | weekly | daily | all | males | females |
| sexual relationship: no | 32 | 9 | 1 | 0 | 0 | 45 | 20 | 25 |
| yes | 0 | 25 | 32 | 48 | 4 | 111 | 83 | 28 |
| marginal distribution⁺: all | 32 | 35 | 33 | 48 | 4 | 157 | 103 | 53 |
| males | 11 | 26 | 22 | 37 | 3 | 99 | | |
| females | 21 | 9 | 11 | 11 | 1 | 53 | | |

Notes: ⁺ due to item non response, values do not exactly sum up. 157 responses to (at least) one of the two questions regarding sex life; 156 responses to question about sexual relationship; 152 responses to question about frequency of intercourse.

ticipants answered these questions.⁶ Table 1 displays the joint distribution of both measures. The information regarding the two measures seems to be mutually consistent, as no respondent who reports not to have had sex in the previous year, reports having been involved in a sexual partnership for the same period. The data indicates that the respondents distinguish between living together with a partner and having a sexual relationship. Though both variables are highly positively correlated, roughly one in ten of those who live with a partner report not to live in a sexual partnership. None of these individuals reports having sex more often than occasionally.

The dependent variables are observed for the final phase of the experiment (month 11 to month 22). We measure the key explanatory variables prior to this and use the change in BMI measured between rehab discharge and the end of the weight maintenance phase, denoted ΔBMI_{1-10} , as key explanatory variable.⁷

The small number of observations precludes specifying a rich regression model with numerous controls. Hence only age and sex as basic socioeconomic characteristics enter the model. Besides these, BMI at rehab discharge (BMI_0) and an indicator for living together with a partner at the time of rehab discharge ($together_0$) enter the regression model. The former we include to capture the effect of pre-intervention body weight which is most likely endogenous and for which no instruments are available.⁸ The latter we include as the closest substitute available for pre-intervention values of the dependent variable, which is not observed in the data. Table 2 displays key descriptives for the explanatory variables.

The key concern to the present analysis is the possible endogeneity of both body weight and its change over time. The validity of estimates obtained from naively regressing measures of sexual activity on body weight are subject to concern of endogeneity bias for several reasons. First,

⁶While a single individual answered the question concerning the frequency of sexual intercourse but provided no information on involvement in a sexual relationship, for five individuals the provision of information exhibits the reverse pattern.

⁷One may think of using the level of the BMI (at the end of the maintenance phase) instead its change. Yet, as long as BMI at rehab discharge is controlled for, both model variants are fully equivalent.

⁸For this reason, the coefficient of BMI_0 is most likely estimated with bias. Yet, as our instruments for ΔBMI_{1-10} are orthogonal to BMI_0 , the bias does not carry over to the coefficient of primary interest.

Table 2: Descriptive Statistics for Estimation Sample

| | Mean | S.D. | Median | Min. | Max. |
|-----------------------------------------------------|--------|-------|--------|---------|--------|
| all | | | | | |
| dependent variables: | | | | | |
| <i>sexpartner</i> ₁₁₋₂₂ | 0.712 | 0.455 | 1.000 | 0.000 | 1.000 |
| <i>sexfrequency</i> ₁₁₋₂₂ | 2.717 | 1.193 | 3.000 | 1.000 | 5.000 |
| <i>together</i> ₂₂ ⁺ | 0.637 | 0.482 | 1.000 | 0.000 | 1.000 |
| explanatory variables: | | | | | |
| Δ <i>BMI</i> ₁₋₁₀ | -1.229 | 2.596 | -1.130 | -15.347 | 3.774 |
| Δ <i>BMI</i> ₅₋₁₀ ⁺ | 0.448 | 1.604 | 0.362 | -8.424 | 4.181 |
| <i>age</i> | 50.166 | 7.982 | 51.000 | 21.000 | 68.000 |
| <i>female</i> | 0.338 | 0.474 | 0.000 | 0.000 | 1.000 |
| <i>together</i> ₀ | 0.675 | 0.470 | 1.000 | 0.000 | 1.000 |
| <i>BMI</i> ₀ | 35.831 | 5.087 | 34.816 | 28.441 | 60.221 |
| <i>together</i> ₄ ⁺ | 0.656 | 0.477 | 1.000 | 0.000 | 1.000 |
| <i>BMI</i> ₄ ⁺ | 34.154 | 5.149 | 33.391 | 22.857 | 60.672 |
| instrumental variables: | | | | | |
| <i>incentive 150</i> ₁₋₄ | 0.312 | 0.465 | 0.000 | 0.000 | 1.000 |
| <i>incentive 300</i> ₁₋₄ | 0.357 | 0.481 | 0.000 | 0.000 | 1.000 |
| <i>incentive 250</i> ₅₋₁₀ | 0.204 | 0.404 | 0.000 | 0.000 | 1.000 |
| <i>incentive 500</i> ₅₋₁₀ | 0.236 | 0.426 | 0.000 | 0.000 | 1.000 |
| <i>pharmacy nearby</i> ₁₋₂₂ ⁺ | 0.682 | 0.467 | 1.000 | 0.000 | 1.000 |
| males | | | | | |
| dependent variables: | | | | | |
| <i>sexpartner</i> ₁₁₋₂₂ | 0.806 | 0.397 | 1.000 | 0.000 | 1.000 |
| <i>sexfrequency</i> ₁₁₋₂₂ | 2.949 | 1.101 | 3.000 | 1.000 | 5.000 |
| <i>together</i> ₂₂ ⁺ | 0.683 | 0.468 | 1.000 | 0.000 | 1.000 |
| explanatory variables: | | | | | |
| Δ <i>BMI</i> ₁₋₁₀ | -1.256 | 2.676 | -1.162 | -15.347 | 3.774 |
| Δ <i>BMI</i> ₅₋₁₀ ⁺ | 0.498 | 1.573 | 0.393 | -8.424 | 4.181 |
| <i>age</i> | 50.183 | 7.601 | 50.000 | 21.000 | 68.000 |
| <i>female</i> | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| <i>together</i> ₀ | 0.731 | 0.446 | 1.000 | 0.000 | 1.000 |
| <i>BMI</i> ₀ | 35.164 | 4.793 | 34.414 | 28.441 | 50.039 |
| <i>together</i> ₄ ⁺ | 0.692 | 0.464 | 1.000 | 0.000 | 1.000 |
| <i>BMI</i> ₄ ⁺ | 33.411 | 4.634 | 32.747 | 22.857 | 48.001 |
| instrumental variables: | | | | | |
| <i>incentive 150</i> ₁₋₄ | 0.308 | 0.464 | 0.000 | 0.000 | 1.000 |
| <i>incentive 300</i> ₁₋₄ | 0.327 | 0.471 | 0.000 | 0.000 | 1.000 |
| <i>incentive 250</i> ₅₋₁₀ | 0.173 | 0.380 | 0.000 | 0.000 | 1.000 |
| <i>incentive 500</i> ₅₋₁₀ | 0.279 | 0.451 | 0.000 | 0.000 | 1.000 |
| <i>pharmacy nearby</i> ₁₋₂₂ ⁺ | 0.663 | 0.475 | 1.000 | 0.000 | 1.000 |
| females | | | | | |
| dependent variables: | | | | | |
| <i>sexpartner</i> ₁₁₋₂₂ | 0.528 | 0.504 | 1.000 | 0.000 | 1.000 |
| <i>sexfrequency</i> ₁₁₋₂₂ | 2.283 | 1.246 | 2.000 | 1.000 | 5.000 |
| <i>together</i> ₂₂ ⁺ | 0.547 | 0.503 | 1.000 | 0.000 | 1.000 |
| explanatory variables: | | | | | |
| Δ <i>BMI</i> ₁₋₁₀ | -1.177 | 2.455 | -0.830 | -7.249 | 3.048 |
| Δ <i>BMI</i> ₅₋₁₀ ⁺ | 0.351 | 1.676 | 0.137 | -3.366 | 4.147 |
| <i>age</i> | 50.132 | 8.757 | 51.000 | 21.000 | 63.000 |
| <i>female</i> | 1.000 | 0.000 | 1.000 | 1.000 | 1.000 |
| <i>together</i> ₀ | 0.566 | 0.500 | 1.000 | 0.000 | 1.000 |
| <i>BMI</i> ₀ | 37.140 | 5.429 | 35.417 | 29.714 | 60.221 |
| <i>together</i> ₄ ⁺ | 0.585 | 0.497 | 1.000 | 0.000 | 1.000 |
| <i>BMI</i> ₄ ⁺ | 35.611 | 5.808 | 34.297 | 27.690 | 60.672 |
| instrumental variables: | | | | | |
| <i>incentive 150</i> ₁₋₄ | 0.321 | 0.471 | 0.000 | 0.000 | 1.000 |
| <i>incentive 300</i> ₁₋₄ | 0.415 | 0.497 | 0.000 | 0.000 | 1.000 |
| <i>incentive 250</i> ₅₋₁₀ | 0.264 | 0.445 | 0.000 | 0.000 | 1.000 |
| <i>incentive 500</i> ₅₋₁₀ | 0.151 | 0.361 | 0.000 | 0.000 | 1.000 |
| <i>pharmacy nearby</i> ₁₋₂₂ ⁺ | 0.717 | 0.455 | 1.000 | 0.000 | 1.000 |

Notes: Statistics for 157 individuals who provide information on *sexpartner*₁₁₋₂₂ or *sexfrequency*₁₁₋₂₂. ⁺ Variable used in alternative model specification/robustness check.

unobserved individual characteristics may have an effect on either variable. One may hypothesise that individuals with high self esteem are more successful in finding a partner and are also less vulnerable to overeating and obesity. Second, reverse causality may also be a source of endo-

geneity bias. One such channel is sexual frustration-induced overeating. Yet, one may also argue that being satisfied with his or her sex life reduces the pressure to comply with ideals of beauty rendering obesity less costly in psychological terms.

As we observe the dependent variables for only once, fixed effects estimation is no option for eliminating unobserved heterogeneity. Moreover, addressing reverse causality via regressing *sexpartner*₁₁₋₂₂ and *sexfrequency*₁₁₋₂₂ on lagged measures of body weight is also hampered. While using a lagged regressor evidently rules out direct reverse causality, lagged body weight may still be influenced by past sex life, which, given that it exhibits some kind of persistency, is directly linked to the observed values of the dependent variables. Given the lack of information about how the respondents' sex life develop over time, instrumental variables estimation is the first choice for identifying a causal relation. As the data used in this analysis originate from a randomized field experiment described in section 2.1, it includes variables well suited for being used as instrumental variables. More precisely, these variables are *incentive 150*₁₋₄, *incentive 300*₁₋₄, *incentive 250*₅₋₁₀, and *incentive 500*₅₋₁₀, i.e. the indicators for randomly assigned group membership in the two intervention phases of the experiment. While exogeneity is guaranteed by the experimental design⁹, explanatory power for the endogenous regressor ΔBMI_{1-10} has been established elsewhere in the literature (Augurzky et al., 2012, 2014). In other words, the analyses cited above clearly find that being exposed to financial incentives for weight loss makes obese individuals losing body weight. Table 2 displays descriptive statistics for the group indicators. Though the randomization design allocated equal probability to each experimental group, the mean values deviate substantially from 1/3. This can be explained by two reasons: (i) Drop out from the experiment was – for obvious reason – more frequent in the control groups where no financial rewards can be earned. (ii) Individuals who did not (sufficiently) comply with contractual the weight loss after four months were – without randomization – directly assigned to the no incentive group in the weight maintenance phase.

3 The Estimation Procedure

The econometric model rests on a linear equation that links a latent dependent variable to the key regressor ΔBMI_{1-10} , the control variables, and a normally distributed error.¹⁰ This leads to a con-

⁹See section 5 for further discussion of instrument validity.

¹⁰These latent counterparts to *sexpartner*₁₁₋₂₂ and *sexfrequency*₁₁₋₂₂ could be labelled 'inclination and opportunity to live in sexual relationship' and 'inclination and opportunity to have sexual intercourse', respectively. It is important to note that, unlike other behavior, it is not just individual desire for sex that makes an individual sexually active but also his or her attractiveness to potential partners (and the availability of the latter). Since we cannot distinguish between both in the empirical analysis, we abstain from formulating a more complex econometric model that explicitly takes account of these different aspects.

ventional probit model for explaining $sexpartner_{11-22}$ and an ordered probit model for explaining $sexfrequency_{11-22}$. As discussed above, the potential endogeneity of ΔBMI_{1-10} is the key challenge to the empirical analysis that is addressed via the use of instrumental variables. Since the latent dependent variables are not observed, conventional linear instrumental variables estimation, such as two-step least squares, is not applicable.¹¹ For this reason we rely on the assumption of joint normality for identification and specify a control function model. The control function is equivalent to the instrumental equation in the linear IV-model besides that we explicitly assume joint normality. This allows for joint estimation all model parameters using maximum likelihood (ML). That means, estimation is carried out in a single step. Deriving a log-likelihood function that is easily dealt with in the optimization procedure rests on expressing the joint likelihood as the product of (i) the probability of the observed outcome conditional on the endogenous regressor and (ii) the density of the endogenous regressor conditional on the instruments. See Wooldridge (2002, p. 476) for ML estimation of the binary probit model with an endogenous regressor. This control function approach is straight forward generalized to related models such as ordered probit required for estimating the model variant with $sexfrequency_{11-22}$ on the left-hand-side. Moreover, due to joint estimation, individuals for which the dependent variables are not observed but the endogenous regressor is observed contribute to the log-likelihood function and enter the estimation sample. Roodman (2011) discusses various control function models that involve a linear index and jointly normal errors and introduces a software component that implements these models.¹²

4 Estimation Results for the Basic Model

In this section we discuss estimation results for the model described above. Table 3 displays results for the model variant that uses $sexpartner_{11-22}$ as dependent variable, while Table 4 displays results for the model that explains $sexfrequency_{11-22}$. Besides a pooled model that considers men and women, we discuss results for a stratified specification, as the determinants of sex life are likely to differ substantially between both genders. Starting with the question of what renders a sexual relationship more likely for males, Table 3 (upper panel, first column) indicates that age does not have a significant effect. Not surprisingly, those who lived with a partner at time zero (experiment start) are more likely to have a sexual partner one or two years later. Estimation results yield also a significantly negative association with initial BMI. Yet, this coefficient does not isolate a causal relationship but is likely to also capture the influence of unobserved indi-

¹¹For the model explaining $sexpartner_{11-22}$ one may estimate a IV-linear probability model, which yields a similar pattern of estimated coefficients as the preferred nonlinear specification.

¹²This Stata[®] ado-file, called *cmp* (conditional mixed process), is used in the present application.

vidual heterogeneity. The key coefficient is rather attached to ΔBMI_{1-10} and is highly significant (p -value: 0.025) and negative. This indicates that – conditional on initial weight and initial relationship status – loosing body weight increases the likelihood of being involved in a sexual relationship. The point estimate corresponds to an effect of substantial size. At its maximum value ($\hat{\beta}_{\Delta BMI_{1-10}} \cdot \phi(0)$) the corresponding marginal effect is as high as -0.077 . That is one BMI unit reduction in body weight increases the probability of having a sexual partner by 7.7 percentage points. The mean marginal effect in the estimation sample is still 4.1 percentage points.

The estimated error correlation is 0.536 and is statistically significant. From a purely technical perspective, this does not take one by surprise. Since the bivariate descriptive analysis yields a very weak correlation of BMI_{1-10} and $sexpartner_{11-22}$ while control function approach yields a strong negative effect, something needs to balance the latter for consistency of both results. Yet, from a non technical perspective, it somewhat conflicts with our earlier reasoning that unobserved heterogeneity matters for both being successful in loosing weight and being sexually active. One possible explanation is that the desire for physical pleasure is a major source of unobserved heterogeneity. In other words, those who have a great desire for such pleasures are more likely to have sex but are less likely to reduce overeating. In any case, the estimate for ρ indicates that the endogeneity of ΔBMI_{1-10} is an issue worth to be addressed in the estimation procedure. Interpreting the estimated coefficient in terms of a causal effect critically relies on appropriate instruments that only is on variables that only enter the control function and have substantial explanatory power. Table 3 indicates that the indicators for the experimental groups for are indeed strong predictors for the endogenous regressor weight change. The p -value for the test on joint significant is smaller than 0.000 and each indicator is individually significant in statistical terms. That is, financial incentives do have a strong effect on success in weight loss, as established elsewhere in the literature (Volpp et al., 2008; John et al., 2011; Augurzky et al., 2012; Cawley and Price, 2013; Augurzky et al., 2014), and there is no reason for being concerned about weak instruments.¹³

In order to dig deeper into the interdependence of body weight and sexual activity we re-estimated the model with an indicator for living together with a partner ($together_0$) as alternative dependent variable, see Appendix Table 9. There, we find virtually no effect of a change in body weight. In other words it is not the relationship status per se but its sexual in nature that is significantly affected by loosing body weight. In the light of this result one would expect to find also an effect of a change in body weight on the frequency of sexual intercourse. Yet, Table 4 indicates that this does not apply. The point estimate is virtually zero and is accompanied by a large standard error. This also holds if we reduce the number of categories in $sexfrequency_{11-22}$ to three (never,

¹³In terms of the corresponding linear model the relevant F -statistic is 17.56 for males.

Table 3: Involved in a Sexual Relationship (estimated coefficients)

| | Males | | Females | | All | |
|--------------------------------------------------------------------|---------------------|-------|------------|-------|---------------------|-------|
| | Est. Coef. | S.E. | Est. Coef. | S.E. | Est. Coef. | S.E. |
| main equation (dependent variable: $sexpartner_{11-22}$) | | | | | | |
| ΔBMI_{1-10} | -0.193* | 0.086 | -0.011 | 0.212 | -0.166 ⁺ | 0.095 |
| <i>age</i> | 0.009 | 0.020 | -0.010 | 0.023 | -0.007 | 0.015 |
| <i>female</i> | - | - | - | - | -0.674* | 0.254 |
| <i>together₀</i> | 1.312* | 0.382 | 1.523* | 0.549 | 1.506* | 0.281 |
| BMI_0 | -0.053 ⁺ | 0.030 | 0.002 | 0.036 | -0.045 ⁺ | 0.025 |
| <i>constant</i> | 1.209 | 1.534 | -0.382 | 1.748 | 1.676 | 1.193 |
| control function (dependent variable: ΔBMI_{1-10}) | | | | | | |
| <i>incentive 150₁₋₄</i> | -0.707 ⁺ | 0.412 | -0.745 | 0.517 | -0.742* | 0.330 |
| <i>incentive 300₁₋₄</i> | -0.959* | 0.410 | -1.160* | 0.492 | -1.052* | 0.324 |
| <i>incentive 250₅₋₁₀</i> | -2.753* | 0.415 | -1.313* | 0.499 | -2.294* | 0.324 |
| <i>incentive 500₅₋₁₀</i> | -2.060* | 0.405 | -1.874* | 0.538 | -1.914* | 0.330 |
| <i>age</i> | 0.004 | 0.021 | -0.006 | 0.023 | 0.001 | 0.016 |
| <i>female</i> | - | - | - | - | 0.057 | 0.273 |
| <i>together₀</i> | -0.489 | 0.386 | 0.241 | 0.421 | -0.179 | 0.292 |
| BMI_0 | -0.082* | 0.028 | 0.011 | 0.030 | -0.047* | 0.021 |
| <i>constant</i> | 3.515* | 1.646 | -0.167 | 1.644 | 2.061 ⁺ | 1.198 |
| ancillary parameters | | | | | | |
| σ (control function error S.D.) | 2.663* | 0.115 | 2.258* | 0.135 | 2.563* | 0.090 |
| ρ (error correlation) | 0.536* | 0.248 | -0.438 | 0.435 | 0.269 | 0.276 |
| # of observations (overall) | 269 | | 140 | | 409 | |
| # of observations (main equation) | 103 | | 53 | | 156 | |
| log likelihood | -680.2 | | -337.4 | | -1028.1 | |
| instrument relevance (joint sig. instruments, p -value) | 0.000 | | 0.000 | | 0.000 | |
| sample split (LR-test, p -value) | - | | - | | 0.070 | |

Notes: * significant at 5%; ⁺ significant at 10%.

irregularly, regularly) and even to two (never, not never). This raises some concerns with respect to our earlier result of a significant effect on $sexpartner_{11-22}$.

Turning to the results for females, the estimated effect of ΔBMI_{1-10} on $sexpartner_{11-22}$ is statistically insignificant. Though the point estimate bears the same sign as its counterparts for males, it is very small and is accompanied by a rather large standard error. One cannot rule out that the effect of body weight on sexual activity is of qualitatively different nature for females as compared to males. Yet, a more trivial explanation for the heterogeneity in results across genders is the small size of the female sample. It includes only includes 53 individuals for which information on sexual activity is available and, hence, provides a rather weak basis establishing a causal relationship. Hence it does not take one by surprise that for females significant effects of ΔBMI_{1-10} are also neither found on $sexfrequency_{11-22}$ nor on $together_0$. That for females, the estimate for ρ exhibits the opposite sign but is statistically insignificant raises further doubts with respect to the reliability of the results found for women.

In order to base the econometric analysis on a larger sample, one may think of pooling males and females. Re-estimating the model using the pooled model yields results which are very close and qualitatively equivalent to what is found for males, which dominate the pooled sample in numbers. However, likelihood ratio tests (p -values: 0.070, 0.014 and 0.222) argue against the hypothesis that the dependent variables are determined by models that are uniform across genders.

Table 4: Frequency of Sexual Intercourse (estimated coefficients)

| | Males | | Females | | All | |
|--------------------------------------------------------------------|------------|-------|------------|-------|---------------------|-------|
| | Est. Coef. | S.E. | Est. Coef. | S.E. | Est. Coef. | S.E. |
| main equation (dependent variable: $sexfrequency_{11-22}$) | | | | | | |
| ΔBMI_{1-10} | -0.016 | 0.080 | -0.103 | 0.185 | -0.064 | 0.071 |
| <i>age</i> | -0.029* | 0.015 | -0.026 | 0.021 | -0.024* | 0.011 |
| <i>female</i> | - | - | - | - | -0.471* | 0.191 |
| <i>together</i> ₀ | 0.564* | 0.255 | 1.378* | 0.366 | 0.870* | 0.204 |
| BMI_0 | -0.049* | 0.024 | -0.023 | 0.034 | -0.044* | 0.019 |
| control function (dependent variable: ΔBMI_{1-10}) | | | | | | |
| <i>incentive 150</i> ₁₋₄ | -0.817* | 0.413 | -0.650 | 0.568 | -0.763* | 0.328 |
| <i>incentive 300</i> ₁₋₄ | -1.004* | 0.415 | -1.118* | 0.505 | -1.072* | 0.323 |
| <i>incentive 250</i> ₅₋₁₀ | -2.687* | 0.425 | -1.383* | 0.504 | -2.260* | 0.325 |
| <i>incentive 500</i> ₅₋₁₀ | -2.068* | 0.411 | -1.862* | 0.545 | -1.935* | 0.329 |
| <i>age</i> | 0.004 | 0.021 | -0.007 | 0.023 | 0.001 | 0.016 |
| <i>female</i> | - | - | - | - | 0.058 | 0.273 |
| <i>together</i> ₀ | -0.496 | 0.386 | 0.251 | 0.421 | -0.181 | 0.292 |
| BMI_0 | -0.083* | 0.028 | 0.011 | 0.030 | -0.047* | 0.021 |
| <i>constant</i> | 3.601* | 1.646 | -0.169 | 1.644 | 2.081 ⁺ | 1.197 |
| ancillary parameters | | | | | | |
| <i>threshold 1</i> | -4.072* | 1.267 | -1.543 | 1.587 | -3.219* | 0.933 |
| <i>threshold 2</i> | -3.061* | 1.244 | -0.954 | 1.590 | -2.414* | 0.924 |
| <i>threshold 3</i> | -2.450* | 1.233 | -0.291 | 1.586 | -1.796 ⁺ | 0.917 |
| <i>threshold 4</i> | -0.751 | 1.236 | 1.220 | 1.608 | 2.563* | 0.090 |
| σ (control function error S.D.) | 2.663* | 0.115 | 2.257* | 0.135 | 2.563* | 0.090 |
| ρ (error correlation) | 0.141 | 0.235 | 0.029 | 0.467 | 0.157 | 0.200 |
| # of observations (over all) | 269 | | 140 | | 409 | |
| # of observations (main equation) | 99 | | 53 | | 152 | |
| log likelihood | -776.3 | | -376.8 | | -1165.7 | |
| instrument relevance (<i>p</i> -value, joint sig. instruments) | 0.000 | | 0.000 | | 0.000 | |
| sample split (<i>p</i> -value LR-test) | - | | - | | 0.014 | |

Notes: * significant at 5%; ⁺ significant at 10%.

5 Model Extensions and Robustness Checks

5.1 Analysis Conditional on Success in Weight-Loss Phase

Though the parametric control function model is non-linear, non-linearity is not sufficient for identification which still rests on valid exclusion restrictions. In the above section, we argued that group membership is purely random and exerts effects on sex life only through the change in body weight. While randomness by experimental design applies to group membership in the weight-loss phase, one may put randomness into question with respect to the group membership in the weight-maintenance phase that is for the indicators *incentive 250*₅₋₁₀ and *incentive 500*₅₋₁₀. This is due to the experimental design that conditions assignment to the intervention groups of this phase on success in the preceding one. In other words, one may argue that the effect of unobserved confounding factors may not be completely be eliminated by using *incentive 150*₁₋₄, *incentive 300*₁₋₄, *incentive 250*₅₋₁₀, and *incentive 500*₅₋₁₀ as instruments, since the latter two are potentially affected by these factors through being successful in losing body weight during the months one to four.

One obvious approach to deal with this issue is to use only *incentive 150*₁₋₄ and *incentive 300*₁₋₄

as instruments for ΔBMI_{1-10} . However, as compared to *incentive 250*₅₋₁₀ and *incentive 500*₅₋₁₀, group membership in the weight-loss phase has just limited explanatory power for the endogenous regressor. The p -value for the test of joint significance is just 0.067. That is, group membership in the weight-reduction phase is just a weak instrument for weight loss over the entire intervention period of the experiment. This is not that much of a surprise since long-term effects of financial incentives – if existent – are well known to be much smaller than short-term effects (Augurzky et al., 2014).

For this reason we take a different approach to tackle the potential endogeneity of the instruments by confining the analysis to those individuals who did successfully loose weight in the weigh-loss phase and, hence, are eligible for the second randomization. Within this sub-sample group membership from month 5 to month 10 is purely random and, in turn, *incentive 250*₅₋₁₀ and *incentive 500*₅₋₁₀ are purely exogenous with respect to weight change over the weight maintenance phase (ΔBMI_{5-10}). This does not hold with respect to weight change over the entire intervention period (ΔBMI_{1-10}). For this reason, in the alternative model that only considers individuals who were successful in the first intervention period ΔBMI_{5-10} serves as key regressor and *incentive 250*₅₋₁₀ and *incentive 500*₅₋₁₀ as instruments for it. Since *incentive 150*₁₋₄ and *incentive 300*₁₋₄ are no valid instruments one may think of skipping them from the model. One cannot, however, firmly rule out long run effects of exposition to financial incentives in the weight-reduction phase. Hence, we let *incentive 150*₁₋₄ and *incentive 300*₁₋₄ enter the regression model as further controls. Moreover, as in this variant of the model identification rests exclusively on weight variation over the maintenance phase, we condition on the values of the control variables (initial BMI, relationship status) four months after experiment start. Confining the analysis to individuals who are eligible to the second randomization reduces the size of the estimation sample considerably. This creates problems in particular for estimation the model with *sexfrequency*₁₁₋₂₂ as dependent variable because some of its categories are observed for very few individuals. For this reason, we reduced the number of categories to three (never, occasionally, regularly) where the latter category combines having sex monthly, weekly or (almost) daily.

Tables 5 and 6 display estimation results for the variant of the model discussed above. As before, besides estimating a pooled model, we estimate the model stratified by gender. Here, the females' regression clearly does not yield reliable results for the causal effect of body weight on women's sex life. The reason for this is the very low explanatory power the instruments have for ΔBMI_{5-10} . The p -value for the test on joint significant is as high as 0.677 indicating that the incentive indicators are weak instruments in the females' sub-sample. Thus, the puzzling positive and – in the regression explaining *sexpartner*₁₁₋₂₂ – significant coefficient of ΔBMI_{5-10} represents

Table 5: Sexual Relationship (est. coefficients, cond. on success in weight-loss phase)

| | Males | | Females | | All | |
|--------------------------------------------------------------------------------|--------------------|-------|---------------------|-------|--------------------|-------|
| | Est. Coef. | S.E. | Est. Coef. | S.E. | Est. Coef. | S.E. |
| main equation (dependent variable: <i>sexpartner</i> ₁₁₋₂₂) | | | | | | |
| ΔBMI_{5-10} | -0.422* | 0.078 | 0.398* | 0.165 | -0.369* | 0.154 |
| <i>incentive</i> 150 ₁₋₄ | -0.531 | 0.367 | 0.015 | 0.620 | -0.357 | 0.385 |
| <i>incentive</i> 300 ₁₋₄ | -0.360 | 0.368 | -0.451 | 0.699 | -0.413 | 0.343 |
| <i>age</i> | -0.003 | 0.015 | 0.027 ⁺ | 0.016 | -0.014 | 0.014 |
| <i>female</i> | - | - | - | - | -0.344 | 0.326 |
| <i>together</i> ₄ | 0.652 ⁺ | 0.369 | 0.335 | 1.139 | 1.141* | 0.480 |
| <i>BMI</i> ₄ | -0.041 | 0.031 | -0.060 | 0.048 | -0.050 | 0.036 |
| <i>constant</i> | 2.142 | 1.451 | 0.854 | 1.813 | 2.776 ⁺ | 1.509 |
| control function (dependent variable: ΔBMI_{5-10}) | | | | | | |
| <i>incentive</i> 250 ₅₋₁₀ | -1.342* | 0.407 | -0.275 | 0.492 | -1.032* | 0.327 |
| <i>incentive</i> 500 ₅₋₁₀ | -1.034* | 0.369 | -0.533 | 0.593 | -0.780* | 0.327 |
| <i>incentive</i> 150 ₁₋₄ | -0.276 | 0.431 | 0.416 | 0.768 | -0.221 | 0.377 |
| <i>incentive</i> 300 ₁₋₄ | -0.351 | 0.435 | 0.182 | 0.710 | -0.357 | 0.367 |
| <i>age</i> | 0.003 | 0.021 | -0.050 ⁺ | 0.027 | -0.014 | 0.017 |
| <i>female</i> | - | - | - | - | 0.115 | 0.297 |
| <i>together</i> ₄ | -0.123 | 0.385 | 0.742 | 0.520 | 0.246 | 0.314 |
| <i>BMI</i> ₄ | -0.033 | 0.029 | 0.081* | 0.036 | 0.009 | 0.023 |
| <i>constant</i> | 2.480 | 1.566 | -0.432 | 1.857 | 1.339 | 1.218 |
| ancillary parameters | | | | | | |
| σ (control function error S.D.) | 2.124* | 0.113 | 2.063* | 0.163 | 2.149* | 0.095 |
| ρ (error correlation) | 0.879* | 0.120 | -0.950* | 0.160 | 0.678 ⁺ | 0.353 |
| # of observations (over all) | 177 | | 80 | | 257 | |
| # of observations (main equation) | 65 | | 32 | | 97 | |
| log likelihood | -405.4 | | -182.9 | | -598.4 | |
| instrument relevance (<i>p</i> -value, joint sig. instruments) | 0.003 | | 0.667 | | 0.005 | |
| sample split (<i>p</i> -value LR-test) | - | | - | | 0.162 | |

Notes: * significant at 5%; ⁺ significant at 10%. All model equations estimated using only individuals who successfully lost body weight during month one to four.

an artifact of weak instruments.

This argument does not apply to the male's sub-sample and the pooled sample, see Tables 5 and 6. There, the tests on the joint significance of *incentive* 250₅₋₁₀ and *incentive* 500₅₋₁₀ yield much smaller *p*-values (0.003 and 0.005). The coefficients attached to ΔBMI_{5-10} – in qualitative terms – confirm what is found in the specification that uses weight change over the entire intervention period as explanatory variable. That is weight-loss significantly increases the probability for being involved in a sexual relationship for males and in the pooled sample. Yet, the coefficients are much larger in magnitude as compared to Table 3 and 4. Marginal effects on the probability of *sexpartner*₁₁₋₂₂ taking the value of one are more than two times larger, reaching the value of -0.168 at its maximum. In other words, losing one BMI unit in bodyweight makes an sexual relationship substantially more likely. Estimating the model on basis of the pooled sample yields a similar result.

Unlike the results discussed in section 4, a significant and negative effect of ΔBMI_{5-10} is also found for *sexfrequency*₁₁₋₂₂. That is, estimating the model conditional on success in the weight-loss phase yields not only the result that losing body weights makes a sexual relationship more likely but also that having actually sex becomes more frequent if obese individuals get less overweight. One may explain this finding that deviate from the results discussed in Section 4 by relying on

Table 6: Frequency of Intercourse (est. coefficients, cond. on success in weight-loss phase)

| | Males | | Females | | All | |
|--------------------------------------------------------------------|---------------------|-------|---------------------|-------|---------------------|-------|
| | Est. Coef. | S.E. | Est. Coef. | S.E. | Est. Coef. | S.E. |
| main equation (dependent variable: $sexfrequency_{11-22}$) | | | | | | |
| ΔBMI_{5-10} | -0.302* | 0.131 | 0.354 | 0.404 | -0.299 ⁺ | 0.161 |
| <i>incentive</i> 150 ₁₋₄ | -0.109 | 0.316 | -0.530 | 0.754 | -0.058 | 0.295 |
| <i>incentive</i> 300 ₁₋₄ | -0.298 | 0.308 | -0.700 | 1.202 | -0.336 | 0.268 |
| <i>age</i> | -0.024 | 0.019 | 0.014 | 0.038 | -0.025 ⁺ | 0.014 |
| <i>female</i> | - | - | - | - | -0.077 | 0.241 |
| <i>together</i> ₄ | 0.502 | 0.317 | 0.893 | 2.327 | 0.944* | 0.358 |
| <i>BMI</i> ₄ | -0.041 | 0.029 | -0.093 | 0.103 | -0.045 | 0.030 |
| control function (dependent variable: ΔBMI_{5-10}) | | | | | | |
| <i>incentive</i> 250 ₅₋₁₀ | -1.221* | 0.446 | -0.231 | 0.621 | -0.965* | 0.348 |
| <i>incentive</i> 500 ₅₋₁₀ | -1.146* | 0.362 | -0.526 | 0.611 | -0.877* | 0.310 |
| <i>incentive</i> 150 ₁₋₄ | -0.283 | 0.432 | 0.425 | 0.773 | -0.221 | 0.377 |
| <i>incentive</i> 300 ₁₋₄ | -0.377 | 0.437 | 0.198 | 0.723 | -0.359 | 0.368 |
| <i>age</i> | 0.002 | 0.021 | -0.050 ⁺ | 0.027 | -0.014 | 0.017 |
| <i>female</i> | - | - | - | - | 0.106 | 0.297 |
| <i>together</i> ₄ | -0.128 | 0.386 | 0.734 | 0.524 | 0.240 | 0.315 |
| <i>BMI</i> ₄ | -0.036 | 0.029 | 0.081* | 0.036 | 0.009 | 0.023 |
| <i>constant</i> | 2.604 ⁺ | 1.568 | -0.451 | 1.864 | 1.385 | 1.217 |
| ancillary parameters | | | | | | |
| <i>threshold</i> 1 | -3.304 ⁺ | 1.694 | -2.690 | 5.090 | -3.179* | 1.416 |
| <i>threshold</i> 2 | -2.620 ⁺ | 1.521 | -2.373 | 4.574 | -2.560* | 1.261 |
| σ (control function error S.D.) | 2.128* | 0.113 | 2.063* | 0.163 | 2.149* | 0.095 |
| ρ (error correlation) | 0.780* | 0.207 | -0.817 | 0.717 | 0.670* | 0.319 |
| # of observations (over all) | 177 | | 80 | | 257 | |
| # of observations (main equation) | 63 | | 32 | | 95 | |
| log likelihood | -433.9 | | -192.6 | | -638.1 | |
| instrument relevance (<i>p</i> -value, joint sig. instruments) | 0.003 | | 0.677 | | 0.006 | |
| sample split (<i>p</i> -value LR-test) | - | | - | | 0.057 | |

Notes: * significant at 5%; ⁺ significant at 10%. All model equations estimated using only individuals who successfully lost body weight during month one to four.

more credible exclusion restrictions. An alternative explanation could be that adjusting sex life habits (in an existing partnership) takes some time and reduced body weight comes only in effect if it is maintained for some time. Due to the ordinal nature of $sexfrequency_{11-22}$ the coefficient is not easily interpreted in qualitative terms. Yet, one may interpret the coefficient such that if the odds for having sex at least as frequent as indicated by the k th category of $sexfrequency_{11-22}$ are 50 percent, a one BMI unit reduction in body weight increases this probability by 12 percentage points. As before, the results for the pooled sample largely mirror what is found for males.

5.2 Selection Correction

One major concern about the present analysis is, as compared to the initial study population, the small size of the actual estimation sample. In other words, the experiment suffers from severe sample attrition, which may not be exogenous and, in turn, may represent a source of bias. Besides randomly removing all questions concerning sexual behavior from roughly one-half of the questionnaires – which does not challenge consistency – two distinct processes are responsible for the small number of individuals for whom information about sex life is available. As one can easily imagine, questions concerning the respondents' sexual behavior are delicate and, for this

reason, are subject to frequent item non-response. Yet, in our data the rate of denied information is smaller than 0.1, which is remarkably low compared to survey studies that ask for information on sex life (Fenton et al., 2001). This rate applies to those, who have completed the experiment and provided information about body weight at its final stage. Yet – more importantly – roughly 55 percent of the participants dropped out at some point in time and denied providing further information.¹⁴ In most cases dropping out took place without explicit notice to experimenters by not showing-up at the weigh-in and not returning the questionnaire, even after receiving reminder letters and reminder phone calls. Taken all sources of missing information together, information on sex life is available for just 22.5 percent of the original study population.

While item non response is not easily addressed in the econometric analysis, the experiment generated information that can be used to address drop-out. Since the show-up fee for attending the weigh-in is flat and does not account for the actual costs of providing the requested information, the actual net-cost of experiment continuation varies substantially across individuals. A major determinant of costs differentials is group membership as for – successful – members of the incentive groups, dropping out means foregoing financial rewards. Yet, this information is already exhausted for explaining changes in body weight and cannot be used as an instrument for compliance. However, another determinant is travel cost. Though no precise measure for this cost is available – which is highly subjective and inherently unobservable – the data include an indicator for the place of weigh-in is located within the same zip-code area as the participant's place of residence. Since the pharmacy to be visited for the weigh-in was assigned by the experimenter this variable (*pharmacy nearby*₁₋₂₂) represents an exogenous source of variation in travel cost and can be used as instrument for providing information on sex life at the final stage of the experiment.

In terms of the econometric model we augment the models discussed in section 5.1 by a selection equation that explains whether or not information on individuals *i*'s sex life is available in the data (*sexinfo*₂₂)¹⁵ and that includes *pharmacy nearby*₁₋₂₂ as additional explanatory variable. Following our previous modelling strategy, we assume joint normality with the main equation and the control function and estimate all model parameters jointly by maximum likelihood. Estimation results are displayed in the Tables 7 and 8. No results are reported for the females' sub-sample because of weak instruments, already discussed in section 5.1.

The relevant tests indicate that *pharmacy nearby*₁₋₂₂ has substantial explanatory power for *sex-*

¹⁴With respect to dropping out, body weight is the key piece of information. As providing information about body weight requires attending a weigh-in it is more costly than filling-in a questionnaire, which is sufficient for providing information concerning other variables.

¹⁵Item-non-response slightly varies between the two dependent variables *sexpartner*₁₁₋₂₂ and *sexfrequency*₁₁₋₂₂. Hence, the dependent variable of the selection equation *sexinfo*₂₂ is differently defined for the two variants of the model.

Table 7: Sexual Relationship (estimated coefficients, selection correction)

| | Males | | Females | | All | |
|--------------------------------------------------------------------------------|---------------------|-------|------------|------|---------------------|-------|
| | Est. Coef. | S.E. | Est. Coef. | S.E. | Est. Coef. | S.E. |
| main equation (dependent variable: <i>sexpartner</i> ₁₁₋₂₂) | | | | | | |
| ΔBMI_{5-10} | -0.348 ⁺ | 0.197 | - | - | -0.334* | 0.167 |
| <i>incentive</i> 150 ₁₋₄ | -0.448 | 0.492 | - | - | -0.497 | 0.373 |
| <i>incentive</i> 300 ₁₋₄ | -0.110 | 0.503 | - | - | -0.301 | 0.322 |
| <i>age</i> | 0.014 | 0.016 | - | - | 0.001 | 0.013 |
| <i>female</i> | - | - | - | - | -0.111 | 0.273 |
| <i>together</i> ₄ | 0.340 | 0.300 | - | - | 0.494* | 0.245 |
| <i>BMI</i> ₄ | -0.079 | 0.048 | - | - | -0.068 ⁺ | 0.041 |
| <i>constant</i> | 1.783 | 1.870 | - | - | 2.026 | 1.524 |
| control function (dependent variable: ΔBMI_{5-10}) | | | | | | |
| <i>incentive</i> 250 ₅₋₁₀ | -1.392* | 0.534 | - | - | -1.062* | 0.410 |
| <i>incentive</i> 500 ₅₋₁₀ | -1.066* | 0.511 | - | - | -0.785* | 0.380 |
| <i>incentive</i> 150 ₁₋₄ | -0.298 | 0.489 | - | - | -0.201 | 0.417 |
| <i>incentive</i> 300 ₁₋₄ | -0.334 | 0.531 | - | - | -0.328 | 0.427 |
| <i>age</i> | 0.007 | 0.029 | - | - | -0.012 | 0.018 |
| <i>female</i> | - | - | - | - | 0.090 | 0.364 |
| <i>together</i> ₄ | -0.130 | 0.460 | - | - | 0.230 | 0.344 |
| <i>BMI</i> ₄ | -0.034 | 0.031 | - | - | 0.009 | 0.021 |
| <i>constant</i> | 2.331 | 2.140 | - | - | 1.289 | 1.350 |
| selection equation (dependent variable: <i>sexinfo</i> ₂₂) | | | | | | |
| <i>pharmacy nearby</i> ₁₋₂₂ | 0.857* | 0.224 | - | - | 0.910* | 0.173 |
| <i>incentive</i> 250 ₅₋₁₀ | -0.229 | 0.272 | - | - | -0.003 | 0.216 |
| <i>incentive</i> 500 ₅₋₁₀ | 0.196 | 0.268 | - | - | 0.185 | 0.195 |
| <i>incentive</i> 150 ₁₋₄ | -0.317 | 0.266 | - | - | -0.541* | 0.220 |
| <i>incentive</i> 300 ₁₋₄ | -0.034 | 0.275 | - | - | -0.294 | 0.217 |
| <i>age</i> | 0.023 | 0.015 | - | - | 0.018 ⁺ | 0.010 |
| <i>female</i> | - | - | - | - | 0.113 | 0.182 |
| <i>together</i> ₄ | -0.462 | 0.283 | - | - | -0.342 | 0.215 |
| <i>BMI</i> ₄ | -0.069 | 0.029 | - | - | -0.057* | 0.019 |
| <i>constant</i> | 0.787 | 1.300 | - | - | 0.615 | 0.905 |
| ancillary parameters | | | | | | |
| σ (control function error S.D.) | 2.157* | 0.104 | - | - | 2.175* | 0.073 |
| ρ_{bmi}^{sex} | 0.617 | 0.420 | - | - | 0.582 | 0.382 |
| ρ_{info}^{sex} | 0.758 | - | - | - | 0.792 ⁺ | 0.423 |
| ρ_{bmi}^{bmi} | -0.046 | 0.148 | - | - | -0.036 | 0.109 |
| # of observations (over all) | 209 | | - | - | 302 | |
| # of observations (main equation) | 65 | | - | - | 97 | |
| log likelihood | -509.5 | | - | - | -752.0 | |
| exclusion restriction (<i>p</i> -value, selection equation) | 0.000 | | - | - | 0.000 | |
| sample split (<i>p</i> -value LR-test) | - | | - | - | 0.359 | |

Notes: * significant at 5%; ⁺ significant at 10%. All model equations estimated using only individuals who successfully lost body weight during month one to four.

*info*₂₂, i.e. identification rests on a strong exclusion restriction. This is line with missing information being predominantly due to drop out from the experiment while item-non-response plays – which should not be correlated with *pharmacy nearby*₁₋₂₂ – just a marginal role. The point estimates for the error correlation ρ_{info}^{sex} are positive, pointing to unobserved factors – such as personal traits – that make individuals sexually more active and, at the same time, more willing to reveal information about their sex lives.

While providing some confidence in the estimation results not representing an artifact of self-selection, the selection correction model confirms the previous results. In all variants of the model, the coefficients attached to ΔBMI_{5-10} bear the same sign and are of similar magnitude as their counterparts in Table 5 and Table 6. The largest deviation from the results without selection correction is found for the model explaining *sexpartner*₁₁₋₂₂ only considering males. There, the

Table 8: Frequency of Intercourse (estimated coefficients, selection correction)

| | Males | | Females | | All | |
|--------------------------------------------------------------------|------------|-------|------------|------|---------------------|-------|
| | Est. Coef. | S.E. | Est. Coef. | S.E. | Est. Coef. | S.E. |
| main equation (dependent variable: $sexfrequency_{11-22}$) | | | | | | |
| ΔBMI_{5-10} | -0.333* | 0.122 | - | - | -0.351* | 0.111 |
| <i>incentive</i> 150 ₁₋₄ | -0.166 | 0.352 | - | - | -0.248 | 0.298 |
| <i>incentive</i> 300 ₁₋₄ | -0.282 | 0.329 | - | - | -0.339 | 0.242 |
| <i>age</i> | -0.016 | 0.030 | - | - | -0.015 | 0.013 |
| <i>female</i> | - | - | - | - | 0.025 | 0.219 |
| <i>together</i> ₄ | 0.356 | 0.351 | - | - | 0.575 ⁺ | 0.299 |
| <i>BMI</i> ₄ | -0.050 | 0.042 | - | - | -0.052 | 0.034 |
| control function (dependent variable: ΔBMI_{5-10}) | | | | | | |
| <i>incentive</i> 250 ₅₋₁₀ | -1.136* | 0.516 | - | - | -0.902* | 0.388 |
| <i>incentive</i> 500 ₅₋₁₀ | -1.179* | 0.504 | - | - | -0.916* | 0.369 |
| <i>incentive</i> 150 ₁₋₄ | -0.304 | 0.469 | - | - | -0.232 | 0.406 |
| <i>incentive</i> 300 ₁₋₄ | -0.403 | 0.514 | - | - | -0.369 | 0.418 |
| <i>age</i> | 0.002 | 0.029 | - | - | -0.014 | 0.018 |
| <i>female</i> | - | - | - | - | 0.103 | 0.359 |
| <i>together</i> ₄ | -0.134 | 0.466 | - | - | 0.235 | 0.337 |
| <i>BMI</i> ₄ | -0.037 | 0.030 | - | - | 0.008 | 0.020 |
| <i>constant</i> | 2.691 | 2.074 | - | - | 1.425 | 1.295 |
| selection equation (dependent variable: $sexinfo_{22}$) | | | | | | |
| <i>pharmacy nearby</i> ₁₋₂₂ | 0.824* | 0.231 | - | - | 0.862* | 0.182 |
| <i>incentive</i> 250 ₅₋₁₀ | -0.099 | 0.314 | - | - | 0.134 | 0.226 |
| <i>incentive</i> 500 ₅₋₁₀ | 0.250 | 0.277 | - | - | 0.192 | 0.206 |
| <i>incentive</i> 150 ₁₋₄ | -0.324 | 0.275 | - | - | -0.537* | 0.226 |
| <i>incentive</i> 300 ₁₋₄ | -0.056 | 0.271 | - | - | -0.298 | 0.222 |
| <i>age</i> | 0.023 | 0.015 | - | - | 0.017 | 0.011 |
| <i>female</i> | - | - | - | - | 0.151 | 0.187 |
| <i>together</i> ₄ | -0.341 | 0.296 | - | - | -0.268 | 0.222 |
| <i>BMI</i> ₄ | -0.066 | 0.029 | - | - | -0.057* | 0.021 |
| <i>constant</i> | 0.534 | 1.406 | - | - | 0.576 | 0.926 |
| ancillary parameters | | | | | | |
| <i>threshold</i> 1 | -2.980 | 2.361 | - | - | -2.585 ⁺ | 1.473 |
| <i>threshold</i> 2 | -2.390 | 2.198 | - | - | -2.130 | 1.331 |
| σ (control function error S.D.) | 2.133* | 0.099 | - | - | 2.152* | 0.070 |
| ρ_{bmi}^{sex} | 0.826* | 0.178 | - | - | 0.777* | 0.221 |
| ρ_{info}^{sex} | 0.186 | 0.393 | - | - | 0.377 | 0.295 |
| ρ_{info}^{bmi} | -0.061 | 0.153 | - | - | -0.042 | 0.113 |
| # of observations (over all) | 209 | | - | - | 302 | |
| # of observations (main equation) | 63 | | - | - | 95 | |
| log likelihood | -541.0 | | - | - | -796.4 | |
| exclusion restriction (<i>p</i> -value, selection equation) | 0.000 | | - | - | 0.000 | |
| sample split (<i>p</i> -value LR-test) | - | | - | - | 0.124 | |

Notes: * significant at 5%; ⁺ significant at 10%. All model equations estimated using only individuals who successfully lost body weight during month one to four.

coefficient gets somewhat smaller in absolute terms while the estimated standard errors are more than twice as large if the selection equation is added to the model.¹⁶ This lets the relevant *p*-value increase to the value of 0.077. Yet, the general result that weight loss exerts – at least at the ten percent level – a significant and positive effect of substantial magnitude on both the probability of sexual relationship and the frequency of intercourse is not challenged. This also applies to a slightly different variant of the model that uses the entire sample for estimating the selection equation and not just those individuals who qualify for the second randomization, cf. Tables 10 and 11.

¹⁶In this regression the optimization algorithm encounters problems in precisely estimating the error correlation structure, with corresponds to substantially larger standard errors for the coefficient estimates.

6 Conclusion

This paper analyzed whether weight reduction in obese individuals exerts an effect on their sex lives, namely whether or not they live in a sexual partnership and how frequently they have sex. Based on data generated by a randomized field experiment, where randomization provides an exogenous source of variation in body weight that is exploited for identification, we find that obese males are substantially more likely to be involved in a sexual relationship if they get less overweight. This effect is of substantial magnitude, reaching – depending on the model specification – 8 to 17 percentage points for the most affected individual. The results are not as clear for the frequency of sexual intercourse. Yet in males who have already lost weight estimation results indicate that further weight reduction, or at least weight maintenance, results in having sex more often. For females the analysis does not yield any significant effect. This might be due to the sexes differing in what determines sex life. Yet, the small number of females in our data that significantly hampers the empirical analysis appears to be the more obvious explanation. The key result is robust to being more restrictive in choosing instruments for weight change and to correcting for dropout from the experiment by augmenting the model by a selection equation.

Since for many individuals a fulfilling sex life is an important facet of general life satisfaction and happiness, our general result may provide additional motivation for obese individuals to reduce overweight. Moreover, it provides further evidence for substantial social costs of obesity that are not necessarily linked to pathological health problems. This raises the question about the channels through which the established effects operate, which cannot be decided on basis of the data used in this study. One possibility is recovery from sexual dysfunction on which the medical literature has focussed. Yet, given strong effects of a moderate weight reduction found in the data, other channels are likely to also play a role. Greater self-confidence when initiating sexual contact, improved attractiveness to potential sexual partners, feeling more comfortable with its own body, and more desire for sex may act as such channels. One limitation of the present analysis is that it does not allow for disentangling the effect of a reduce body weight from the effect of the process of weight reduction. The strong effects found may therefore rather be attributed to being successful in meeting a major individual challenge than to weight loss itself. One possible route to address this question were to evaluate the effects of bariatric surgeries on sexual activity.

While the existing non-medical literature had a strong focus on the effect of overweight on young individuals' sex lives, our result explicitly refers to adult obese individuals. Thus the argument of overweight having the desirable side effect of counteracting premature initiation to sex does not apply. It rather provides further evidence for obesity imposing restrictions on private

lives, but also for even moderate weight reduction mitigation these limitations.

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A Appendix

A.1 Results for living with a partner as dependent variable

Table 9: Estimated Effects on Living with a Partner

| | Males | | Females | | All | |
|---------------------------------------------------------------------------|---------------------|-------|------------|-------|--------------------|-------|
| | Est. Coef. | S.E. | Est. Coef. | S.E. | Est. Coef. | S.E. |
| main equation (dependent variable: <i>together</i> ₂₂) | | | | | | |
| ΔBMI_{1-10} | 0.037 | 0.108 | 0.161 | 0.193 | 0.085 | 0.092 |
| <i>age</i> | 0.019 | 0.018 | 0.001 | 0.023 | 0.011 | 0.014 |
| <i>female</i> | – | – | – | – | –0.215 | 0.237 |
| <i>together</i> ₀ | 3.305* | 0.357 | 3.096* | 0.520 | 3.196* | 0.289 |
| <i>BMI</i> ₀ | 0.026 | 0.028 | 0.035 | 0.034 | 0.029 | 0.021 |
| <i>constant</i> | –3.471* | 1.585 | –2.808 | 1.923 | –3.077* | 1.184 |
| control function (dependent variable: ΔBMI_{1-10}) | | | | | | |
| <i>incentive 150</i> ₁₋₄ | –0.811 ⁺ | 0.416 | –0.650 | 0.525 | –0.792* | 0.327 |
| <i>incentive 300</i> ₁₋₄ | –1.006* | 0.420 | –1.108* | 0.504 | –1.084* | 0.323 |
| <i>incentive 250</i> ₅₋₁₀ | –2.702* | 0.427 | –1.393* | 0.495 | –2.252* | 0.327 |
| <i>incentive 500</i> ₅₋₁₀ | –2.048* | 0.412 | –1.865* | 0.542 | –1.925* | 0.330 |
| <i>age</i> | 0.004 | 0.021 | –0.007 | 0.023 | 0.001 | 0.016 |
| <i>female</i> | – | – | – | – | 0.060 | 0.273 |
| <i>together</i> ₀ | –0.496 | 0.386 | 0.251 | 0.421 | –0.183 | 0.292 |
| <i>BMI</i> ₀ | –0.082* | 0.028 | 0.011 | 0.030 | –0.047* | 0.021 |
| <i>constant</i> | 3.584* | 1.647 | –0.168 | 1.644 | 2.091 ⁺ | 1.197 |
| ancillary parameters | | | | | | |
| σ (control function error S.D.) | 2.663* | 0.115 | 2.257* | 0.135 | 2.563* | 0.090 |
| ρ (error correlation) | –0.062 | 0.335 | –0.147 | 0.486 | –0.149 | 0.266 |
| # of observations (over all) | 269 | | 140 | | 409 | |
| # of observations (main equation) | 206 | | 105 | | 311 | |
| log likelihood | –687.3 | | –339.5 | | –1035.0 | |
| instrument relevance (<i>p</i> -value, joint sig. instruments) | 0.000 | | 0.000 | | 0.000 | |
| sample split (<i>p</i> -value LR-test) | – | | – | | 0.222 | |

Notes: * significant at 5%; ⁺ significant at 10%.

A.2 All observation used for estimating the selection equation

Table 10: Estimated Effects on Sexual Relationship (selection correction)

| | Males | | Females | | All | |
|--------------------------------------------------------------------------------|------------|-------|------------|------|--------------------|-------|
| | Est. Coef. | S.E. | Est. Coef. | S.E. | Est. Coef. | S.E. |
| main equation (dependent variable: <i>sexpartner</i> ₁₁₋₂₂) | | | | | | |
| ΔBMI_{5-10} | -0.448* | 0.070 | - | - | -0.429* | 0.069 |
| <i>incentive 150</i> ₁₋₄ | -0.375 | 0.352 | - | - | -0.233 | 0.281 |
| <i>incentive 300</i> ₁₋₄ | -0.154 | 0.354 | - | - | -0.150 | 0.255 |
| <i>age</i> | 0.008 | 0.019 | - | - | -0.005 | 0.011 |
| <i>female</i> | - | - | - | - | -0.102 | 0.230 |
| <i>together</i> ₄ | 0.392 | 0.273 | - | - | 0.537* | 0.227 |
| <i>BMI</i> ₄ | -0.054 | 0.035 | - | - | -0.043 | 0.031 |
| <i>constant</i> | 1.374 | 1.657 | - | - | 1.446 | 1.206 |
| control function (dependent variable: ΔBMI_{5-10}) | | | | | | |
| <i>incentive 250</i> ₅₋₁₀ | -1.404* | 0.520 | - | - | -1.061* | 0.403 |
| <i>incentive 500</i> ₅₋₁₀ | -1.131* | 0.470 | - | - | -0.779* | 0.357 |
| <i>incentive 150</i> ₁₋₄ | -0.278 | 0.472 | - | - | -0.230 | 0.411 |
| <i>incentive 300</i> ₁₋₄ | -0.345 | 0.518 | - | - | -0.351 | 0.423 |
| <i>age</i> | 0.009 | 0.029 | - | - | -0.011 | 0.018 |
| <i>female</i> | - | - | - | - | 0.083 | 0.358 |
| <i>together</i> ₄ | -0.213 | 0.462 | - | - | 0.224 | 0.339 |
| <i>BMI</i> ₄ | -0.039 | 0.030 | - | - | 0.008 | 0.021 |
| <i>constant</i> | 2.510 | 2.073 | - | - | 1.326 | 1.340 |
| selection equation (dependent variable: <i>sexinfo</i> ₂₂) | | | | | | |
| <i>pharmacy nearby</i> ₁₋₂₂ | 1.228* | 0.154 | - | - | 1.197* | 0.124 |
| <i>incentive 250</i> ₅₋₁₀ | 0.021 | 0.213 | - | - | 0.211 | 0.166 |
| <i>incentive 500</i> ₅₋₁₀ | 0.463* | 0.203 | - | - | 0.433* | 0.161 |
| <i>incentive 150</i> ₁₋₄ | -0.206 | 0.186 | - | - | -0.133 | 0.146 |
| <i>incentive 300</i> ₁₋₄ | -0.067 | 0.190 | - | - | -0.032 | 0.154 |
| <i>age</i> | 0.014 | 0.009 | - | - | 0.013 ⁺ | 0.008 |
| <i>female</i> | - | - | - | - | 0.040 | 0.130 |
| <i>together</i> ₀ | -0.157 | 0.181 | - | - | -0.209 | 0.142 |
| <i>BMI</i> ₀ | -0.049 | 0.017 | - | - | -0.038* | 0.012 |
| <i>constant</i> | -0.020 | 0.894 | - | - | -0.392 | 0.640 |
| ancillary parameters | | | | | | |
| σ | 2.132* | 0.101 | - | - | 2.164* | 0.072 |
| ρ_{bmi}^{sex} | 0.846* | 0.152 | - | - | 0.812* | 0.171 |
| ρ_{info}^{sex} | 0.489 | - | - | - | 0.546 ⁺ | 0.279 |
| ρ_{info}^{bmi} | -0.050 | 0.133 | - | - | -0.045 | 0.101 |
| # of observations (over all) | 468 | | - | - | 691 | |
| # of observations (main equation) | 65 | | - | - | 97 | |
| log likelihood | -591.9 | | - | - | -881.0 | |
| exclusion restriction (<i>p</i> -value, selection equation) | 0.000 | | - | - | 0.000 | |
| sample split (<i>p</i> -value LR-test) | - | | - | - | 0.376 | |

Notes: * significant at 5%; ⁺ significant at 10%. Main equation and control function estimated using only individuals who successfully lost body weight during month one to four; selection equation estimated using the entire sample.

Table 11: Estimated Effects on Frequency of Intercourse (selection correction)

| | Males | | Females | | All | |
|--------------------------------------------------------------------|------------|-------|------------|------|---------------------|-------|
| | Est. Coef. | S.E. | Est. Coef. | S.E. | Est. Coef. | S.E. |
| main equation (dependent variable: $sexfrequency_{11-22}$) | | | | | | |
| ΔBMI_{5-10} | -0.365* | 0.086 | - | - | -0.377* | 0.082 |
| <i>incentive 150</i> ₁₋₄ | -0.158 | 0.301 | - | - | -0.137 | 0.264 |
| <i>incentive 300</i> ₁₋₄ | -0.264 | 0.290 | - | - | -0.276 | 0.235 |
| <i>age</i> | -0.013 | 0.023 | - | - | -0.017 | 0.012 |
| <i>female</i> | - | - | - | - | 0.020 | 0.210 |
| <i>together</i> ₄ | 0.305 | 0.301 | - | - | 0.587* | 0.289 |
| <i>BMI</i> ₄ | -0.045 | 0.034 | - | - | -0.042 | 0.030 |
| control function (dependent variable: ΔBMI_{5-10}) | | | | | | |
| <i>incentive 250</i> ₅₋₁₀ | -1.069* | 0.495 | - | - | -0.903* | 0.375 |
| <i>incentive 500</i> ₅₋₁₀ | -1.206* | 0.494 | - | - | -0.937* | 0.367 |
| <i>incentive 150</i> ₁₋₄ | -0.320 | 0.462 | - | - | -0.262 | 0.402 |
| <i>incentive 300</i> ₁₋₄ | -0.416 | 0.511 | - | - | -0.388 | 0.418 |
| <i>age</i> | 0.002 | 0.029 | - | - | -0.013 | 0.018 |
| <i>female</i> | - | - | - | - | 0.106 | 0.354 |
| <i>together</i> ₄ | -0.152 | 0.455 | - | - | 0.231 | 0.332 |
| <i>BMI</i> ₄ | -0.039 | 0.029 | - | - | 0.007 | 0.021 |
| <i>constant</i> | 2.734 | 2.040 | - | - | 1.490 | 1.284 |
| selection equation (dependent variable: $sexinfo_{22}$) | | | | | | |
| <i>pharmacy nearby</i> ₁₋₂₂ | 1.180* | 0.158 | - | - | 1.179* | 0.126 |
| <i>incentive 250</i> ₅₋₁₀ | 0.159 | 0.241 | - | - | 0.314 ⁺ | 0.174 |
| <i>incentive 500</i> ₅₋₁₀ | 0.499* | 0.213 | - | - | 0.417* | 0.166 |
| <i>incentive 150</i> ₁₋₄ | -0.199 | 0.188 | - | - | -0.123 | 0.149 |
| <i>incentive 300</i> ₁₋₄ | -0.077 | 0.192 | - | - | -0.038 | 0.156 |
| <i>age</i> | 0.011 | 0.010 | - | - | 0.012 | 0.008 |
| <i>female</i> | - | - | - | - | 0.079 | 0.133 |
| <i>together</i> ₀ | -0.090 | 0.187 | - | - | -0.168 | 0.145 |
| <i>BMI</i> ₀ | -0.050 | 0.017 | - | - | -0.040* | 0.012 |
| <i>constant</i> | 0.090 | 0.925 | - | - | -0.312 | 0.656 |
| ancillary parameters | | | | | | |
| <i>threshold 1</i> | -2.562 | 1.977 | - | - | -2.327 ⁺ | 1.378 |
| <i>threshold 2</i> | -2.076 | 1.837 | - | - | -1.903 | 1.241 |
| σ | 2.133* | 0.097 | - | - | 2.153* | 0.070 |
| ρ_{bmi}^{sex} | 0.883* | 0.114 | - | - | 0.836* | 0.157 |
| ρ_{info}^{sex} | 0.179 | 0.228 | - | - | 0.250 | 0.207 |
| ρ_{bmi}^{bmi} | -0.066 | 0.139 | - | - | -0.055 | 0.107 |
| # of observations (over all) | 468 | | - | | 691 | |
| # of observations (main equation) | 63 | | - | | 95 | |
| log likelihood | -622.3 | | - | | -924.7 | |
| exclusion restriction (<i>p</i> -value, selection equation) | 0.000 | | - | | 0.000 | |
| sample split (<i>p</i> -value LR-test) | - | | - | | 0.152 | |

Notes: * significant at 5%; ⁺ significant at 10%. Main equation and control function estimated using only individuals who successfully lost body weight during month one to four; selection equation estimated using the entire sample.

A.3 Complete weight-info ($compliance_{1-22}$) as dep. var. in selection equation

Table 12: Estimated Effects on Sexual Relationship (selection correction)

| | Males | | Females | | All | |
|----------------------------------------------------------------------|---------------------|-------|------------|------|---------------------|-------|
| | Est. Coef. | S.E. | Est. Coef. | S.E. | Est. Coef. | S.E. |
| main equation (dependent variable: $sexpartner_{11-22}$) | | | | | | |
| ΔBMI_{5-10} | -0.444* | 0.102 | - | - | -0.476* | 0.042 |
| <i>incentive 150</i> ₁₋₄ | -0.341 | 0.455 | - | - | -0.184 | 0.311 |
| <i>incentive 300</i> ₁₋₄ | 0.048 | 0.525 | - | - | -0.140 | 0.285 |
| <i>age</i> | 0.004 | 0.027 | - | - | -0.012 | 0.012 |
| <i>female</i> | - | - | - | - | -0.124 | 0.235 |
| <i>together</i> ₄ | 0.934 ⁺ | 0.491 | - | - | 0.708* | 0.297 |
| <i>BMI</i> ₄ | -0.057 | 0.050 | - | - | -0.033 | 0.031 |
| <i>constant</i> | 1.998 | 2.476 | - | - | 1.803 | 1.374 |
| control function (dependent variable: ΔBMI_{5-10}) | | | | | | |
| <i>incentive 250</i> ₅₋₁₀ | -1.563* | 0.517 | - | - | -1.175* | 0.393 |
| <i>incentive 500</i> ₅₋₁₀ | -1.215* | 0.478 | - | - | -0.875* | 0.354 |
| <i>incentive 150</i> ₁₋₄ | -0.391 | 0.467 | - | - | -0.293 | 0.408 |
| <i>incentive 300</i> ₁₋₄ | -0.411 | 0.526 | - | - | -0.428 | 0.425 |
| <i>age</i> | 0.003 | 0.027 | - | - | -0.013 | 0.018 |
| <i>female</i> | - | - | - | - | 0.074 | 0.358 |
| <i>together</i> ₄ | -0.210 | 0.433 | - | - | 0.262 | 0.340 |
| <i>BMI</i> ₄ | -0.036 | 0.031 | - | - | 0.009 | 0.022 |
| <i>constant</i> | 2.964 | 2.041 | - | - | 1.553 | 1.324 |
| selection equation (dependent variable: $compliance_{1-22}$) | | | | | | |
| <i>pharmacy nearby</i> ₁₋₂₂ | 2.817* | 0.303 | - | - | 3.056* | 0.284 |
| <i>incentive 250</i> ₅₋₁₀ | 0.749* | 0.230 | - | - | 0.765* | 0.191 |
| <i>incentive 500</i> ₅₋₁₀ | 0.894* | 0.248 | - | - | 0.710* | 0.197 |
| <i>incentive 150</i> ₁₋₄ | 0.038 | 0.210 | - | - | 0.206 | 0.176 |
| <i>incentive 300</i> ₁₋₄ | 0.255 | 0.199 | - | - | 0.305 ⁺ | 0.174 |
| <i>age</i> | 0.025* | 0.010 | - | - | 0.019* | 0.009 |
| <i>female</i> | - | - | - | - | 0.008 | 0.153 |
| <i>together</i> ₀ | 0.044 | 0.187 | - | - | 0.136 | 0.156 |
| <i>BMI</i> ₀ | -0.017 | 0.014 | - | - | -0.023 ⁺ | 0.012 |
| <i>constant</i> | -1.728* | 0.803 | - | - | -1.322* | 0.671 |
| ancillary parameters | | | | | | |
| σ | 2.130* | 0.101 | - | - | 2.156* | 0.072 |
| ρ_{bmi}^{sex} | 0.852* | 0.184 | - | - | 0.903* | 0.095 |
| $\rho_{compliance}^{sex}$ | 0.277 | - | - | - | 0.256 | - |
| $\rho_{compliance}^{bmi}$ | -0.268 ⁺ | 0.150 | - | - | -0.184 | 0.116 |
| # of observations (over all) | 468 | | - | | 691 | |
| # of observations (main equation) | 65 | | - | | 97 | |
| log likelihood | -574.7 | | - | | -834.9 | |

Notes: * significant at 5%; ⁺ significant at 10%. Main equation and control function estimated using only individuals who successfully lost body weight during month one to four; selection equation estimated using the entire sample.

Table 13: Estimated Effects on Frequency of Intercourse (selection correction)

| | Males | | Females | | All | |
|----------------------------------------------------------------------|--------------------|--------|------------|------|---------------------|--------|
| | Est. Coef. | S.E. | Est. Coef. | S.E. | Est. Coef. | S.E. |
| main equation (dependent variable: $sexfrequency_{11-22}$) | | | | | | |
| ΔBMI_{5-10} | -0.356* | 0.083 | - | - | -0.378* | 0.077 |
| <i>incentive</i> 150 ₁₋₄ | -0.148 | 0.311 | - | - | -0.113 | 0.267 |
| <i>incentive</i> 300 ₁₋₄ | -0.219 | 0.302 | - | - | -0.254 | 0.239 |
| <i>age</i> | -0.014 | 0.022 | - | - | -0.020 ⁺ | 0.012 |
| <i>female</i> | - | - | - | - | 0.010 | 0.213 |
| <i>together</i> ₄ | 0.301 | 0.282 | - | - | 0.637* | 0.275 |
| <i>BMI</i> ₄ | -0.044 | 0.034 | - | - | -0.040 | 0.029 |
| control function (dependent variable: ΔBMI_{5-10}) | | | | | | |
| <i>incentive</i> 250 ₅₋₁₀ | -1.318* | 0.483 | - | - | -1.057* | 0.366 |
| <i>incentive</i> 500 ₅₋₁₀ | -1.414* | 0.476 | - | - | -1.060* | 0.358 |
| <i>incentive</i> 150 ₁₋₄ | -0.422 | 0.451 | - | - | -0.306 | 0.396 |
| <i>incentive</i> 300 ₁₋₄ | -0.507 | 0.517 | - | - | -0.454 | 0.421 |
| <i>age</i> | -0.001 | 0.027 | - | - | -0.014 | 0.018 |
| <i>female</i> | - | - | - | - | 0.080 | 0.350 |
| <i>together</i> ₄ | -0.165 | 0.410 | - | - | 0.252 | 0.322 |
| <i>BMI</i> ₄ | -0.037 | 0.029 | - | - | 0.008 | 0.021 |
| <i>constant</i> | 3.213 ⁺ | 1.946 | - | - | 1.726 | 1.262 |
| selection equation (dependent variable: $compliance_{1-22}$) | | | | | | |
| <i>pharmacy nearby</i> ₁₋₂₂ | 2.822* | 0.300 | - | - | 3.074* | 0.283 |
| <i>incentive</i> 250 ₅₋₁₀ | 0.770* | 0.236 | - | - | 0.781* | 0.195 |
| <i>incentive</i> 500 ₅₋₁₀ | 0.934* | 0.250 | - | - | 0.718* | 0.199 |
| <i>incentive</i> 150 ₁₋₄ | 0.017 | 0.207 | - | - | 0.230 | 0.175 |
| <i>incentive</i> 300 ₁₋₄ | 0.262 | 0.197 | - | - | 0.341* | 0.173 |
| <i>age</i> | 0.026* | 0.010 | - | - | 0.020* | 0.009 |
| <i>female</i> | - | - | - | - | -0.007 | 0.153 |
| <i>together</i> ₀ | 0.038 | 0.189 | - | - | 0.158 | 0.158 |
| <i>BMI</i> ₀ | -0.017 | 0.014 | - | - | -0.023 ⁺ | 0.012 |
| <i>constant</i> | -1.721* | 0.814 | - | - | -1.369* | 0.689 |
| ancillary parameters | | | | | | |
| <i>threshold</i> 1 | -2.788 | 1.900 | - | - | -2.603 ⁺ | 1.390 |
| <i>threshold</i> 2 | -2.251 | 1.783 | - | - | -2.141 ⁺ | 1.264 |
| σ | 2.125* | 0.093 | - | - | 2.149* | 0.068 |
| ρ_{bmi}^{sex} | 0.873* | 0.106 | - | - | 0.836* | 0.140 |
| $\rho_{compliance}^{sex}$ | 0.035 | 0.234 | - | - | 0.146 | 0.208 |
| $\rho_{compliance}^{bmi}$ | -0.309* | 0.151 | - | - | -0.206 ⁺ | 0.117 |
| # of observations (over all) | | 468 | | - | | 691 |
| # of observations (main equation) | | 63 | | - | | 95 |
| log likelihood | | -603.9 | | - | | -878.8 |

Notes: * significant at 5%; ⁺ significant at 10%. Main equation and control function estimated using only individuals who successfully lost body weight during month one to four; selection equation estimated using the entire sample.