# Gender differences in bodyweight change following COVID-19 lockdown measures in the Netherlands. A prospective study


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# Gender differences in bodyweight change following COVID-19 lockdown measures in the Netherlands A prospective study

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**Keywords:** health behaviour; gender; longitudinal analysis; overweight; body mass index

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## Abstract

*Background:* The current study aimed to prospectively assess bodyweight change following the implementation of lockdown measures to contain the COVID-19 pandemic in the Netherlands, and to explore the potentially moderating role of gender in this association. Results of prior work on the links between lockdown measures and bodyweight change should be interpreted with caution, because this work was typically cross-sectional or retrospective, mostly used non-probability samples, and tended to overlook potential gender differences in the bodyweight implications of lockdown measures.

*Design:* Using Dutch DNB Household Survey panel data collected between 1993 and 2020, we estimated fixed-effects regression models of bodyweight change. Models were stratified by gender and formal tests of gender differences in coefficient estimates were performed.

*Participants:* 4,365 women and 4,583 men aged 18-65 were included in the study. The total number of observations was 41,330.

*Outcome measures:* Self-reported bodyweight in kilograms. Additional analyses were performed using body mass index as the outcome.

*Results:* The implementation of Dutch lockdown measures in 2020 was associated with bodyweight gain of approximately 800 grams in working age women compared to the three prior years. Bodyweight gain in 2020 relative to prior years was significantly stronger for women than for men significant ($F(4, 8947)=3.9$, $p < .01$). No evidence of bodyweight gain in working age men was found.

*Conclusion:* Results indicate that bodyweight gain following COVID-19 lockdown measures in the Netherlands was more pronounced among women than among men. Although necessary to contain the COVID-19 pandemic, lockdown measures may contribute to a different public health challenge in the rising prevalence of overweight and obesity.

## Strengths and limitations of this study

- In contrast to most prior work, the current study uses a prospective approach and data from a random national sample to assess bodyweight change following the implementation of lockdown measures to contain the COVID-19 pandemic among Dutch men and women.
- The current study acknowledges that the bodyweight implications of lockdown measures may differ between men and women by estimating models stratified by gender and performing formal tests of gender differences in coefficient estimates.
- A limitation of the current study is that the measure of bodyweight is self-reported.

## Data statement

Access to the data used can be requested via www.dhsdata.nl.

## Contributors

TvdB originally conceived the study. The research questions and analysis plan were agreed by TvdB and MF. TvdB undertook the analyses and TvdB and MF drafted the manuscript. Both authors approved the final draft.

## Funding statement

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

## Ethics statement

This study was assessed and approved by the Research Ethics Review Committee of the Erasmus School of Health Policy & Management at Erasmus University Rotterdam (Reference: 21-030).

## Conflict of interest

None.

# Introduction

On March 11th, 2020, the World Health Organization declared the novel corona virus SARS-COV2, also known as COVID-19, as a pandemic. Almost immediately, countries started implementing so-called lockdown measures, such as closures of schools and gastronomy and urgent calls to work from whenever possible, in an effort to slow down the spread of the disease. Although necessary to contain the pandemic, these measures also affected people's daily activities in a way that may compromise health, for instance through adverse lifestyle changes.

Shortly after the introduction of the first lockdown measures, scholars already specifically expressed concerns that such measures may result in bodyweight gain [1,2]. Although initial evidence suggests that these concerns are justified (for a review, see Bennett et al., 2021 [3]), results of the work hitherto conducted should be interpreted with caution for multiple reasons. Firstly, most earlier work was cross-sectional or retrospective [3], which makes estimates of bodyweight change prone to recall bias [4]. Secondly, existing studies have drawn almost exclusively on non-probability samples [3], and consequently results cannot be generalized [5]. Thirdly, only few studies have explored potential gender differences in the bodyweight implications of the measures to contain the COVID-19 pandemic. This is unfortunate, because, as described in further detail later, such differences may be expected given the central role of stress in the presumed mechanism linking the measures to contain the COVID-19 pandemic to changes in bodyweight.

The current study assesses the impact of the measures to contain the COVID-19 pandemic on the bodyweight of working age adults in the Netherlands. It extends existing work on the links between the implementation of lockdown measures and bodyweight change (1) by adopting a prospective approach, (2) by drawing on data from a random national sample, and (3) by acknowledging that the bodyweight implications of lockdown measures may differ between men and women.

## Background and hypotheses

In March 2020 the Dutch government announced the first general measures to contain the COVID-19 pandemic. Mid-March, the Netherlands went into a so-called intelligent lockdown that included closure of gastronomy, schools and sports clubs, and a travel ban. The government also made an urgent appeal to work from home whenever possible. These measures were extended through April. During the months of May and June the previously taken lockdown measures were relaxed somewhat and the testing policy got expanded. Over the course of July and August, the numbers of new COVID-19 cases started rising again, but no new measures were taken yet. At the end of September, however, the Dutch government decided that, because of the growing number of infections, additional measures were needed again and a second lockdown was announced in October 2020. Measures of the first intelligent lockdown were reintroduced. On top of this non-essential shops had to close. The second lockdown was extended until early 2021. During this period wearing masks in public places became mandatory and a curfew was introduced. Measured remained in place until February 2021 when the implemented lockdown measures started gradually being relaxed. It is important to note that rules and urgent guidelines regarding hygiene, keeping distance, group formation, and working from home as much as possible had continuously remained in place since March 2020 and were emphasized time and again by the government.

The implemented measures  had considerable implications for the personal lives of adults in the Netherlands, particularly among those of working age. In a survey commissioned by the Dutch ministry of Ministry of Health, Welfare and Sport collected among Dutch adults in the spring of 2020, the majority of working age respondents reported substantial changes to their personal situation in the wake of the measures implemented to contain the COVID-19 pandemic [6]. One in three working age respondents reported having started to work from home and one in nine working age respondents reported that the measures to contain the pandemic precluded them from performing their job altogether. One sixth of the working age respondents moreover reported taking care of children as schools and nurseries were closed. In contrast to respondents of working age, 89% of respondents aged 65 years and older reported that little had changed in their daily lives [6].

The changes in the daily lives of the working age population may be expected to have detrimental lifestyle implications. In the spring of 2020, Bhutani and Cooper [1] already speculated "that increases in stress, anxiety, and boredom on a daily basis during the pandemic may be contributing to higher energy intake, sleep disturbances, and less exercise" (p. 1576), which could ultimately result in bodyweight gain. Similarly, Mattioli et al. warned that stress resulting from quarantine and isolation measures may lead to unhealthy dietary choices and reduced physical activity [2]. Consistent with this reasoning, research suggests that Dutch adults were more likely to be physically inactive in the spring of 2020 than in a typical spring [6]. In an online survey collected among a nationally representative sample in April 2020, 22% of respondents moreover reported an increased consumption of snacks and sweets since lockdown measures were in place and 14% reported eating more frequently overall [7]. These findings from the Netherlands are in line with results of studies conducted in other contexts, e.g., the United States [8], Spain [9] and France [10]. We therefore hypothesize that bodyweight increased among working age women and men following the implementation of COVID-19 lockdown measures in the Netherlands.

Given that stress arguably plays an important role in linking lockdown measures to poorer dietary choices and decreased physical activity [1,2], gender differences in bodyweight gain following the implementation of measures to contain the pandemic may be expected. This is because these measures may elicit a stronger stress response among women than among men [8,11]. Moreover, stress has been found to be more strongly associated with bodyweight gain among women than among men [12,13]. We therefore hypothesize that bodyweight change following the implementation of COVID-19 lockdown measures in the Netherlands was more pronounced for women than for men.

# Data and methods

## Sample

We draw on anonymized public release data from the DNB Household Survey [14,15] (see www.dhsdata.nl), a panel survey collected annually among a random national sample of Dutch households by CentERdata at Tilburg University in the Netherlands. Data have been collected online since 1993. A basic computer and an internet connection were provided to sampled households without a computer or internet access. Currently, 28 waves of data are available.

We restricted the sample to observations of men and women of working age (18-65) who provided valid information on all variables of interest (i.e., bodyweight, age, partner status, primary activity status) in at least two waves. These inclusion criteria resulted in an analytical sample of 19,468 observations nested in 4,365 women and 21,862 observations nested in 4,583 men.

## Patient and public involvement

The DNB Household Survey is collected among the general population of the Netherlands. The panel members provided consent via a multi-stage agreement including the initial recruitment as well as the activation of an account (after login only) in the panel environment. Since the introduction of the General Data Protection Regulation (GDPR) in 2018, panel members who already participated and newly recruited panel members, have been asked to give an explicit informed consent via a web form to (continue) taking part in research projects in the panel, among which the DNB Household Survey. Only respondents who complied could continue to participate in the panels [15].

## Measures

Our outcome of interest is self-reported bodyweight in kilograms. Consistent with earlier studies [16], we considered values below 25 kilograms implausibly low and excluded observations with such values (n=122) from our sample.

The main explanatory variable, i.e., whether or not lockdown measures were in place, was derived from the year of data collection. We compare observations from 2020 (the lockdown year) with observations from, respectively, 2019 (pre-lockdown year), 2018 (2 years before lockdown), 2017 (3 years before lockdown) and 1993-2016 (4+ years before lockdown). Consistent with prior years, the 2020 data collection took place between week 15 and week 41 when lockdown measures were in place.

Controls included in the models are age (continuous, centred on 45), age squared, primary activity (in paid employment; unemployed; student; homemaker; retired; disabled; other) and presence of a partner in the household (yes; no). An overview of sample characteristics is provided in Table 1.

<Table 1 here>

### Statistical analysis

We performed fixed-effects regression analyses of intra-individual bodyweight change [17], in which within-person means over time are subtracted from scores in each observation for both outcome and explanatory variables. Consequently, all time-invariant characteristics, regardless of whether observed, are accounted for and omitted variable bias issues are limited to time-varying factors. We regressed within-person bodyweight change on the year of observation, and adjusted for the aforementioned controls.

Models were stratified by gender. In order to assess whether coefficient estimates significantly differed between women and men, we additionally estimated a pooled model with interaction terms to allow the slopes of all explanatory variables to vary as a function of gender [18]. All models were estimated with robust standard errors to account for the nested nature of the data.

## Results

<Table 2 here>

Results of our fixed-effects analyses are presented in Table 2. As hypothesized, the fixed-effects model adjusted for age, age squared, partner status and primary activity indicated that women's bodyweight increased significantly in the COVID-lockdown year of 2020 relative to 2019, 2018, 2017 and the period 2016 and earlier. The estimated magnitude of the adjusted bodyweight increase in women in 2020 relative to the three preceding years was approximately 800 grams.

For men, no significant differences between the year 2020 and the three preceding years were found. Interestingly, however, the year 2020 was associated with a significant bodyweight decrease relative to the period 2016 and earlier, but this decrease could not be attributed to the lockdown measures of 2020, because it already manifested itself in 2019, 2018 and 2017. The analyses thus did not provide support for the hypothesized bodyweight weight gain in men following the implementation of the Dutch lockdown measures.

The finding of a significant bodyweight gain in women but not in men is insufficient to conclude that the bodyweight gain in women was significantly stronger than in men [19]. We therefore performed formal tests of differences between the coefficient estimates in the model for women and those in the model for men. As shown in the final columns of Table 2, the results indicated that bodyweight change between 2020 relative to, respectively, 2019, 2017 and the period 2016 and earlier was significantly stronger for women than for men. The gender difference in the estimated bodyweight change between 2018 and 2020 was marginally significant ($p=.07$). The combined gender differences in the estimates of the year effects were statistically significant ($F(4, 8947)=3.9$, $p<.01$). These results are consistent with our hypothesis that bodyweight gain following the implementation of the Dutch lockdown measures was more pronounced among women than among men.

## Discussion

The current study extends prior work on the bodyweight implications of measures to contain the COVID-19 pandemic by adopting a prospective approach, by drawing on data from a random national household sample and by acknowledging that the bodyweight implications of lockdown may differ between men and women. Our analyses indicate that the Dutch lockdown measures were associated with bodyweight gain of approximately 800 grams in working age women. The effects of lockdown measures on the bodyweight in working age men were less pronounced. In fact, no significant evidence that the measures were associated with bodyweight gain in men was found.

We presented results of analyses of weight change in kilograms, because the interpretation of this outcome measure is highly intuitive. It could be argued, however, that a similar bodyweight gain in kilograms is more meaningful for shorter persons than for their taller counterparts. We therefore also estimated models with body mass index (weight in kilograms divided by height in meters squared) as the outcome measure. Results of these analyses (see Appendix A) are substantively similar to the results of the analyses of bodyweight in kilograms presented in Table 2.

An important limitation of the current study is that our measure of bodyweight was self-reported. Self-reports of bodyweight are, on average, lower than measured bodyweight [16]. However, given that the extent to which people underreport their weight tends to be stable over time, within-person changes in self-reported bodyweight – such as analysed here – have been found to only have minor discrepancies with changes in measured bodyweight [20].

Overweight and obesity currently account for almost four percent of the total burden of disease in the Netherlands [21]. Given that the prevalence of overweight and obesity is projected to increase in the next decades [21], this percentage may be expected to rise even further. Our results suggest that the Dutch measures to contain the COVID-19 pandemic may aggravate this trend. This would particularly be the case if, as suspected by Bhutani and Cooper [1], the relatively small short-term bodyweight changes reported here result in substantial, permanent weight gain over time. Future studies could extend the current study by analysing data from upcoming DNB Household Survey data waves to test whether concerns about the persistence of bodyweight gain related to the implementation of lockdown measures are justified [22].

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Table 1. Sample characteristics

| | Women | | Men | |
|---|---|---|---|---|
| | Mean / % | (N) | Mean / % | (N) |
| Mean bodyweight in kilograms | 72.0 | | 84.1 | |
| (Standard deviation) | (15.1) | | (13.6) | |
| Year of observation: | | | | |
| 2020 (Covid-year) | 3.9% | (768) | 3.4% | (746) |
| 2019 (pre-Covid year) | 4.3% | (845) | 3.7% | (808) |
| 2018 (2 years pre-Covid) | 3.7% | (714) | 3.2% | (709) |
| 2017 (3 years pre-Covid) | 4.1% | (805) | 3.5% | (769) |
| 2016 and prior | 83.9% | (16,336) | 86.1% | (18,830) |
| Mean age [a] | 44.4 | | 46.3 | |
| (Standard deviation) | (12.1) | | (11.7) | |
| Lives with partner | 77.3% | (15,040) | 79.9% | (17,472) |
| Primary activity status: | | | | |
| In paid employment | 54.8% | (10,666) | 77.3% | (16,906) |
| Unemployed | 2.7% | (516) | 2.7% | (600) |
| Student | 7.3% | (1,412) | 3.0% | (653) |
| Homemaker | 21.2% | (4,119) | 1.2% | (255) |
| Retired | 4.0% | (774) | 8.1% | (1,778) |
| Disabled | 4.4% | (864) | 4.3% | (933) |
| Other | 5.7% | (1,117) | 3.4% | (737) |
| Number of observations | 19,468 | | 21,862 | |
| Number of persons | 4,365 | | 4,583 | |

Notes: Data are from the DNB Household Survey 1993-2020;
[a] based on values before centring

Table 2. Results of fixed-effects analyses predicting bodyweight change

| | Women | | Men | | Women vs men | |
|---|---|---|---|---|---|---|
| | b | (SE) | b | (SE) | Δb | (SE) |
| Year: | | | | | | |
| 2020 (Covid-year) | Ref. | | Ref. | | Ref. | |
| 2019 (pre-Covid year) | -0.804** | (0.265) | 0.043 | (0.242) | -0.847* | (0.359) |
| 2018 (2 years pre-Covid) | -0.799* | (0.359) | -0.028 | (0.235) | -0.771† | (0.429) |
| 2017 (3 years pre-Covid) | -0.816* | (0.341) | 0.250 | (0.259) | -1.067* | (0.429) |
| 2016 and prior | -1.133** | (0.423) | 0.883** | (0.310) | -2.016*** | (0.525) |
| Time-variant controls: | | | | | | |
| Age [a] | 0.255*** | (0.029) | 0.363*** | (0.025) | -0.108** | (0.039) |
| Age [a] (squared) | -0.003* | (0.001) | -0.007*** | (0.001) | 0.003† | (0.002) |
| Lives with partner | 0.944† | (0.513) | 0.489 | (0.498) | 0.455 | (0.715) |
| Primary activity status: | | | | | | |
| In paid employment | Ref. | | Ref. | | Ref. | |
| Unemployed | 0.064 | (0.395) | -0.182 | (0.346) | 0.246 | (0.525) |
| Student | 0.247 | (0.299) | -0.368 | (0.495) | 0.616 | (0.578) |
| Homemaker | -0.073 | (0.267) | -0.713 | (0.735) | 0.640 | (0.782) |
| Retired | 0.022 | (0.346) | -0.704† | (0.399) | 0.727 | (0.528) |
| Disabled | -0.218 | (0.553) | -0.390 | (0.455) | 0.173 | (0.716) |
| Other | -0.038 | (0.347) | -0.119 | (0.328) | 0.081 | (0.478) |
| Number of observations | 19,468 | | 21,862 | | | |
| Number of persons | 4,365 | | 4,583 | | | |

Notes: Data are from the DNB Household Survey 1993-2020; [a] centred on age 45; † $p < .1$, * $p < .05$, ** $p < .01$, *** $p < 0.001$

Appendix A. Results of fixed-effects analyses predicting body mass index change

| | Women | | Men | | Women vs men | |
|---|---|---|---|---|---|---|
| | b | (SE) | b | (SE) | Δb | (SE) |
| Year: | | | | | | |
| 2020 (Covid-year) | Ref. | | Ref. | | Ref. | |
| 2019 (pre-Covid year) | -0.267*** | (0.068) | -0.049 | (0.060) | -0.217* | (0.090) |
| 2018 (2 years pre-Covid) | -0.310*** | (0.087) | -0.021 | (0.068) | -0.289** | (0.110) |
| 2017 (3 years pre-Covid) | -0.264** | (0.098) | 0.060 | (0.074) | -0.325** | (0.123) |
| 2016 and prior | -0.331** | (0.115) | 0.203* | (0.088) | -0.534*** | (0.145) |
| Time-variant controls: | | | | | | |
| Age [a] | 0.093*** | (0.010) | 0.108*** | (0.007) | -0.015 | (0.012) |
| Age [a] (squared) | -0.001† | (0.000) | -0.002*** | (0.000) | 0.001 | (0.001) |
| Lives with partner | 0.350* | (0.173) | 0.139 | (0.133) | 0.211 | (0.218) |
| Primary activity status: | | | | | | |
| In paid employment | Ref. | | Ref. | | Ref. | |
| Unemployed | -0.044 | (0.101) | -0.083 | (0.083) | 0.038 | (0.131) |
| Student | 0.152 | (0.099) | -0.061 | (0.145) | 0.212 | (0.176) |
| Homemaker | 0.072 | (0.086) | -0.055 | (0.213) | 0.127 | (0.230) |
| Retired | 0.088 | (0.110) | -0.161† | (0.094) | 0.249 | (0.145) |
| Disabled | -0.064 | (0.177) | -0.114 | (0.105) | 0.050 | (0.206) |
| Other | 0.040 | (0.102) | -0.024 | (0.081) | 0.064 | (0.130) |
| Number of observations | 19,416 | | 21,806 | | | |
| Number of persons | 4,357 | | 4,574 | | | |

Notes: Data are from the DNB Household Survey 1993-2020; [a] centered on age 45; † $p < .1$, * $p < .05$, ** $p < .01$, *** $p < 0.001$

**STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology***

**Checklist for cohort, case-control, and cross-sectional studies (combined)**

| Section/Topic | Item # | Recommendation | Reported on page # |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1, 2 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 5 |
| Objectives | 3 | State specific objectives, including any pre-specified hypotheses | 5-7 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 5, 8-9 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 5 |
| Participants | 6 | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls<br>*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants | 5 |
| | | (*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study*—For matched studies, give matching criteria and the number of controls per case | |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 8-9 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 8-9 |
| Bias | 9 | Describe any efforts to address potential sources of bias | 9 |
| Study size | 10 | Explain how the study size was arrived at | 8 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 8-9 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 9 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | 9 |
| | | (*c*) Explain how missing data were addressed | 8 |
| | | (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed<br>*Case-control study*—If applicable, explain how matching of cases and controls was addressed | |

| | | | |
|---|---|---|---|
| | | *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy | |
| | | (*e*) Describe any sensitivity analyses | 11 |
| **Results** | | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | |
| | | (b) Give reasons for non-participation at each stage | |
| | | (c) Consider use of a flow diagram | |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 14 |
| | | (b) Indicate number of participants with missing data for each variable of interest | |
| | | (c) *Cohort study*—Summarise follow-up time (eg, average and total amount) | 14 |
| Outcome data | 15* | *Cohort study*—Report numbers of outcome events or summary measures over time | 14 |
| | | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure | |
| | | *Cross-sectional study*—Report numbers of outcome events or summary measures | |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | 9-10, 15 |
| | | (*b*) Report category boundaries when continuous variables were categorized | |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | 11 |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 10-11 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 11 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 10, 11 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 11 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 4 |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

# Gender differences in bodyweight change following COVID-19 lockdown measures in the Netherlands. A prospective longitudinal study

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# Gender differences in bodyweight change following COVID-19 lockdown measures in the Netherlands. A prospective longitudinal study

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# Abstract

*Background:* The current study aimed to prospectively assess bodyweight change following the implementation of lockdown measures to contain the COVID-19 pandemic in the Netherlands, and to explore the potentially moderating role of gender in this association.

*Design:* Using Dutch DNB Household Survey panel data collected between 1993 and 2020, we estimated fixed-effects regression models of bodyweight change. Models were stratified by gender and formal tests of gender differences in coefficient estimates were performed.

*Participants:* 4,365 women and 4,583 men aged 18-65 were included in the study. The total number of observations was 41,330.

*Outcome measures:* Self-reported bodyweight in kilograms. Additional analyses were performed using body mass index (self-reported weight in kilograms divided by self-reported height in meters squared) as the outcome.

*Results:* The implementation of Dutch lockdown measures in 2020 was associated with bodyweight gain of approximately 800 grams in working age women compared to the three prior years. Bodyweight gain in 2020 relative to prior years was significantly stronger for women than for men ($F(4, 8947) = 3.9$, $p < .01$). No evidence of bodyweight gain in working age men was found.

*Conclusion:* Results indicate that bodyweight gain following COVID-19 lockdown measures in the Netherlands was more pronounced among women than among men. Although necessary to contain the COVID-19 pandemic, lockdown measures may contribute to a different public health challenge in the rising prevalence of overweight and obesity.

## Strengths and limitations of this study

- In contrast to most prior work, the current study uses a prospective approach and data from a random national sample to assess bodyweight change following the implementation of lockdown measures to contain the COVID-19 pandemic among Dutch men and women.
- The current study acknowledges that the bodyweight implications of lockdown measures may differ between men and women by estimating models stratified by gender and performing formal tests of gender differences in coefficient estimates.
- A limitation of the current study is that the measure of bodyweight is self-reported.

## Data statement

Access to the data used can be requested via www.dhsdata.nl.

## Contributors

TvdB originally conceived the study. The research questions and analysis plan were agreed by TvdB and MF. TvdB undertook the analyses and TvdB and MF drafted the manuscript. Both authors approved the final draft. Research assistance of Izel Yildirim, who made an overview of the timing of the measures to contain the spread of COVID-19 in the Netherlands, is gratefully acknowledged.

## Funding statement

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

## Ethics statement

This study was assessed and approved by the Research Ethics Review Committee of the Erasmus School of Health Policy & Management at Erasmus University Rotterdam (Reference: 21-030).

## Conflict of interest

None.

# Introduction

On March 11th, 2020, the World Health Organization declared the novel corona virus SARS-COV2, also known as COVID-19, as a pandemic. Almost immediately, countries started implementing so-called lockdown measures, such as closures of schools and gastronomy and urgent calls to work from home whenever possible, in an effort to slow down the spread of the disease. Although necessary to contain the pandemic, these measures also affected people's daily activities in a way that may compromise health, for instance through adverse lifestyle changes.

Shortly after the introduction of the first lockdown measures, scholars already specifically expressed concerns that such measures may result in bodyweight gain [1,2]. Although initial evidence suggests that these concerns are justified (for reviews, see Bennett et al., 2021 [3] and Khan et al., 2021 [4]), results of the work hitherto conducted should be interpreted with caution for multiple reasons. Firstly, most earlier work was cross-sectional or retrospective [3,4], which makes estimates of bodyweight change prone to recall bias [5]. Secondly, existing studies have drawn almost exclusively on non-probability samples [3,4], and consequently results cannot be generalized [6,7]. Thirdly, only few studies have explored potential gender differences in the bodyweight implications of the measures to contain the COVID-19 pandemic. This is unfortunate, because, as described in further detail later, such differences may be expected given the central role of stress in the presumed mechanism linking the measures to contain the COVID-19 pandemic to changes in bodyweight.

The current study assesses the impact of the measures to contain the COVID-19 pandemic on the bodyweight of working age women and men in the Netherlands. It extends existing work on the links between the implementation of lockdown measures and bodyweight change (1) by adopting a prospective approach, (2) by drawing on data from a random national sample, and (3) by acknowledging that the bodyweight implications of lockdown measures may differ between women and men.

## Background and hypotheses

In March 2020 the Dutch government announced the first general measures to contain the COVID-19 pandemic. Mid-March, the Netherlands went into a so-called intelligent lockdown that included closure of gastronomy, schools and sports clubs, and a travel ban. The government also made an urgent appeal to work from home whenever possible. These measures were extended through April. During the months of May and June the previously taken lockdown measures were relaxed somewhat and the testing policy got expanded. Over the course of July and August, the numbers of new COVID-19 cases started rising again, but no new measures were taken yet. At the end of September, however, the Dutch government decided that, because of the rising number of infections, additional measures were needed again and a second lockdown was announced in October 2020. Measures of the first intelligent lockdown were reintroduced. On top of this, non-essential shops had to close. The second lockdown was extended until early 2021. During this period, wearing masks in public places became mandatory and a curfew was introduced. Measures remained in place until February 2021 when the implemented lockdown measures started gradually being relaxed. In response to rising infection rates and the emergence of the SARS-CoV-2 Omicron variant, restrictive measures were reimplemented from November 2021 onwards, and a complete lockdown, including closures of non-essential shops, was announced mid-December. It is important to note that rules and urgent guidelines regarding hygiene, keeping distance, group formation, and working from home as much as possible had continuously remained in place since March 2020 and were emphasized time and again by the government.

The implemented measures had considerable implications for the personal lives of adults in the Netherlands, particularly among those of working age. In a survey commissioned by the Dutch ministry of Ministry of Health, Welfare and Sport collected among Dutch adults in the spring of 2020, the majority of working age respondents reported substantial changes to their personal situation in the wake of the measures implemented to contain the COVID-19 pandemic [8]. One in three working age respondents reported having started to work from home and one in nine working age respondents reported that the measures to contain the pandemic precluded them from performing their job altogether. One sixth of the working age respondents moreover reported taking care of children as schools and nurseries were closed. In contrast to respondents of working age, 89% of respondents aged 65 years and older reported that little had changed in their daily lives [8].

The changes in the daily lives of the working age population may be expected to have detrimental lifestyle implications. In the spring of 2020, Bhutani and Cooper [1] already speculated "that increases in stress, anxiety, and boredom on a daily basis during the pandemic may be contributing to higher energy intake, sleep disturbances, and less exercise" (p. 1576), which could ultimately result in bodyweight gain. Similarly, Mattioli et al. warned that stress resulting from quarantine and isolation measures may lead to unhealthy dietary choices and reduced physical activity [2]. Consistent with this reasoning, research suggests that Dutch adults were more likely to be physically inactive in the spring of 2020 than in a typical spring [8]. In an online survey collected among a nationally representative sample in April 2020, 22% of respondents moreover reported an increased consumption of snacks and sweets since lockdown measures were in place and 14% reported eating more frequently overall [9]. These findings from the Netherlands are in line with results of studies conducted in other contexts [10], e.g., the United States [11,12], Canada [13], the United Kingdom [14], Germany [15,16], France [17], Denmark [18], Spain [19], China [20] and Japan [21]. We therefore hypothesize that bodyweight increased among working age women and men following the implementation of COVID-19 lockdown measures in the Netherlands.

Given that stress arguably plays an important role in linking lockdown measures to poorer dietary choices and decreased physical activity [1,2], gender differences in bodyweight gain following the implementation of measures to contain the pandemic may be expected. This is because these measures may elicit a stronger stress response among women than among men [11,22]. Moreover, stress has been found to be more strongly associated with suboptimal dietary choices and bodyweight gain among women than among men [23–25]. We therefore hypothesize that bodyweight change following the implementation of COVID-19 lockdown measures in the Netherlands was more pronounced for women than for men.

## Data and methods

### Sample

We draw on anonymized public release data from the DNB Household Survey [26–28] (see www.dhsdata.nl), a panel survey collected annually among a random national sample of Dutch households by CentERdata at Tilburg University in the Netherlands. Data have been collected online since 1993. A basic computer and an internet connection were provided to sampled households without a computer or internet access. Currently, 28 waves of data are available.

We restricted the sample to observations of men and women of working age (18-65) who provided valid information on all variables of interest (i.e., bodyweight, age, partner status, primary activity status) in at least two waves. These inclusion criteria resulted in an analytical sample of 19,468 observations nested in 4,365 women and 21,862 observations nested in 4,583 men.

### Patient and public involvement

The DNB Household Survey is collected among the general population of the Netherlands. The panel members provided consent via a multi-stage agreement including the initial recruitment as well as the activation of an account (after login only) in the panel environment. Since the introduction of the General Data Protection Regulation (GDPR) in 2018, panel members who already participated and newly recruited panel members, have been asked to give an explicit informed consent via a web form to (continue) taking part in research projects in the panel, among which the DNB Household Survey. Only respondents who complied could continue to participate in the panels [28].

Panel respondents have the possibility to comment on the questionnaire online, or they may call the free helpdesk with any comments. This helpdesk is open during regular office hours. In case of (technical) problems related to the completion of the questionnaires or the need for further assistance, a member of CentERdata will visit the household upon appointment to help them solve the issue at hand [27].

## Measures

Our outcome of interest is self-reported bodyweight in kilograms. Consistent with earlier studies [29,30], we considered values below 25 kilograms implausibly low and excluded observations with such values (n=122) from our sample.

The main explanatory variable, i.e., whether or not lockdown measures were in place, was derived from the year of data collection. We compare observations from 2020 (the lockdown year) with observations from, respectively, 2019 (pre-lockdown year), 2018 (2 years before lockdown), 2017 (3 years before lockdown) and 1993-2016 (4+ years before lockdown). Consistent with prior years, the 2020 data collection took place between week 15 and week 41 when lockdown measures were in place.

Controls included in the models are age (continuous, centred on 45), age squared, primary activity (in paid employment; unemployed; student; homemaker; retired; disabled; other) and presence of a partner in the household (yes; no). A brief overview of sample characteristics is provided in Table 1. Descriptive statistics stratified by period of data collection (2020; 2019; 2018; 2017; 2016 and prior) are presented in Appendix A.

<Table 1 here>

## Statistical analysis

We performed fixed-effects regression analyses of intra-individual bodyweight change [31], in which within-person means over time are subtracted from scores in each observation for both outcome and explanatory variables. Consequently, all time-invariant characteristics, regardless of whether observed, are accounted for and omitted variable bias issues are limited to time-varying factors. We regressed within-person bodyweight change on the year of observation, and adjusted for the aforementioned controls.

Models were stratified by gender. In order to assess whether coefficient estimates significantly differed between women and men, we additionally estimated a pooled model with interaction terms to allow the slopes of all explanatory variables to vary as a function of gender [32]. All models were estimated with robust standard errors to account for the nested nature of the data.

## Results

Results of our fixed-effects analyses are presented in Table 2. As hypothesized, the fixed-effects model adjusted for age, age squared, partner status and primary activity indicated that women's bodyweight increased significantly in the COVID-lockdown year of 2020 relative to 2019, 2018, 2017 and the period 2016 and earlier. The estimated magnitude of the adjusted bodyweight increase in women in 2020 relative to the three preceding years was approximately 800 grams.

For men, no significant differences between the year 2020 and the three preceding years were found. Interestingly, however, the year 2020 was associated with a significant bodyweight decrease relative to the period 2016 and earlier, but this decrease could not be attributed to the lockdown measures of 2020, because it already manifested itself in 2019, 2018 and 2017. The analyses thus did not provide support for the hypothesized bodyweight weight gain in men following the implementation of the Dutch lockdown measures.

<Table 2 here>

The finding of a significant bodyweight gain in women but not in men is insufficient to conclude that the bodyweight gain in women was significantly stronger than in men [33]. We therefore performed formal tests of differences between the coefficient estimates in the model for women and those in the model for men. As shown in the final columns of Table 2, the results indicated that bodyweight change in 2020 relative to, respectively, 2019, 2017 and the period 2016 and earlier was significantly stronger for women than for men. The gender difference in the estimated bodyweight change between 2018 and 2020 was marginally significant ($p$ = .07). The combined gender differences in the estimates of the year effects were statistically significant ($F(4, 8947) = 3.9$, $p < .01$). These results are consistent with our hypothesis that bodyweight gain following the implementation of the Dutch lockdown measures was more pronounced among women than among men.

## Discussion

The current study extends prior work on the bodyweight implications of measures to contain the COVID-19 pandemic by adopting a prospective approach, by drawing on data from a random national household sample and by acknowledging that the bodyweight implications of lockdown may differ between men and women. Our analyses indicate that the Dutch lockdown measures were associated with bodyweight gain of approximately 800 grams in working age women. The effects of lockdown measures on the bodyweight in working age men were significantly less pronounced. In fact, no statistically significant evidence that the measures were associated with bodyweight gain in men was found.

We presented results of analyses of weight change in kilograms, because the interpretation of this outcome measure is highly intuitive. It could be argued, however, that a similar bodyweight gain in kilograms is more meaningful for shorter persons than for their taller counterparts. We therefore also estimated models with body mass index (self-reported weight in kilograms divided by self-reported height in meters squared) as the outcome measure. Results of these analyses (see Appendix B) were substantively similar to the results of the analyses of bodyweight in kilograms presented in Table 2.

The results presented here are consistent with our hypotheses built on prior work showing that both the stress response to the pandemic [11,22] and the association between stress and bodyweight gain [23,24] were stronger in women than in men. However, given the absence of a stress measure in the data used, we cannot be conclusive that stress indeed plays a central role in the mechanism underlying bodyweight increases following the COVID-19 lockdown measures in the Netherlands. Such bodyweight gains could arguably also be related to losing the exercise associated with a physically demanding job, which may be ruled out via lockdown. However, we estimated additional models in which we dichotomized primary activity status (in paid employment versus not in paid employment) and allowed the lockdown effects to vary as a function of whether one was employed or not. The results of these analyses did not provide evidence that bodyweight gain was more pronounced for persons who were in paid employment than for their counterparts who were not (See Appendix C). Moreover, in 2020 approximately 20% of male workers in the Netherlands had a physically demanding job versus approximately 15% of female workers [34]. If bodyweight gain following the lockdown measures implemented in the Netherlands were attributable to loss of the exercise that comes with having physically demanding jobs, one might therefore have expected more pronounced effects for men than for women. Yet, the opposite pattern was found in our analyses.

An important limitation of the current study is that our measure of bodyweight was self-reported. Self-reports of bodyweight are, on average, lower than measured bodyweight [29,35]. However, given that the extent to which people underreport their weight tends to be stable over time, within-person changes in self-reported bodyweight – such as analysed here – have been found to only have minor discrepancies with changes in measured bodyweight [36].

Overweight and obesity currently account for almost four percent of the total burden of disease in the Netherlands [37]. Given that the prevalence of overweight and obesity is projected to increase in the next decades [37], this percentage may be expected to rise even further. Our results suggest that the Dutch measures to contain the COVID-19 pandemic may aggravate this trend. Research has shown that short-term weight gain, for instance during the holiday season, often tends to be retained, and that it is a major contributor to long-term excess bodyweight [38]. Working age adults typically gain bodyweight with every additional year of age. For instance, Peeters et al. [39] reported an average annual bodyweight increase of 0.34 kilograms among Australian adults and Orpana et al. [40] found that Canadian men gained 0.74 kg and women 0.57 kg over two years. These estimates are approximately similar to our estimates of annual bodyweight gain in Dutch working age women (0.26 kg/m2 at age 45 (See Table 2); 95% CI: 0.20,0.31) and men (0.36 kg/m2 at age 45 (See Table 2); 95% CI: 0.31,041). It is worth noting that the additional estimated bodyweight gain in women associated with the COVID-19 lockdown measures was three times larger than the estimated bodyweight gain associated with a one-year age increase. Differently put, our model suggests that women's increase in bodyweight between 2019 and 2020 was approximately equivalent to what they in non-COVID-19 times would have gained over four years rather than one year. Restrictive measures furthermore remained in place after the period analysed here. Future studies could extend the current study by analysing data from upcoming DNB Household Survey data waves to test whether concerns about the persistence of bodyweight gain related to the implementation of lockdown measures are justified [41].

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Table 1. Sample characteristics for women and men.

| | Women | | Men | |
|---|---|---|---|---|
| | Mean / % | (N) | Mean / % | (N) |
| Mean bodyweight in kilograms | 72.0 | | 84.1 | |
| (Standard deviation) | (15.1) | | (13.6) | |
| Year of observation: | | | | |
| 2020 (Covid-year) | 3.9% | (768) | 3.4% | (746) |
| 2019 (pre-Covid year) | 4.3% | (845) | 3.7% | (808) |
| 2018 (2 years pre-Covid) | 3.7% | (714) | 3.2% | (709) |
| 2017 (3 years pre-Covid) | 4.1% | (805) | 3.5% | (769) |
| 2016 and prior | 83.9% | (16,336) | 86.1% | (18,830) |
| Mean age [a] | 44.4 | | 46.3 | |
| (Standard deviation) | (12.1) | | (11.7) | |
| Lives with partner | 77.3% | (15,040) | 79.9% | (17,472) |
| Primary activity status: | | | | |
| In paid employment | 54.8% | (10,666) | 77.3% | (16,906) |
| Unemployed | 2.7% | (516) | 2.7% | (600) |
| Student | 7.3% | (1,412) | 3.0% | (653) |
| Homemaker | 21.2% | (4,119) | 1.2% | (255) |
| Retired | 4.0% | (774) | 8.1% | (1,778) |
| Disabled | 4.4% | (864) | 4.3% | (933) |
| Other | 5.7% | (1,117) | 3.4% | (737) |
| Number of observations | 19,468 | | 21,862 | |
| Number of persons | 4,365 | | 4,583 | |

Notes: Data are from the DNB Household Survey 1993-2020;
[a] based on values before centring

Table 2. Results of fixed-effects analyses predicting bodyweight change in women and men; coefficient estimates with 95% confidence intervals.

| | Women | | Men | | Women vs men | |
|---|---|---|---|---|---|---|
| | b | [95% CI] | b | [95% CI] | Δb | [95% CI] |
| Year: | | | | | | |
| 2020 (Covid-year) | Ref. | | Ref. | | Ref. | |
| 2019 (pre-Covid year) | -0.804** | [-1.322,-0.285] | 0.043 | [-0.432,0.518] | -0.847* | [-1.550,-0.144] |
| 2018 (2 years pre-Covid) | -0.799* | [-1.504,-0.095] | -0.028 | [-0.489,0.432] | -0.771† | [-1.612,0.071] |
| 2017 (3 years pre-Covid) | -0.816* | [-1.485,-0.148] | 0.250 | [-0.258,0.758] | -1.067* | [-1.906,-0.227] |
| 2016 and prior | -1.133** | [-1.962,-0.303] | 0.883** | [0.274,1.492] | -2.016*** | [-3.044,-0.987] |
| Time-variant controls: | | | | | | |
| Age [a] | 0.255*** | [0.197,0.312] | 0.363*** | [0.313,0.412] | -0.108** | [-.184,-0.032] |
| Age [a] (squared) | -0.003* | [-0.006,-0.001] | -0.007*** | [-0.009,-0.004] | 0.003† | [-0.000,0.007] |
| Lives with partner | 0.944† | [-0.061,1.949] | 0.489 | [-0.487,1.465] | 0.455 | [-0.956,1.856] |
| Primary activity status: | | | | | | |
| In paid employment | Ref. | | Ref. | | Ref. | |
| Unemployed | 0.064 | [-0.710,0.838] | -0.182 | [-0.860,0.495] | 0.246 | [-0.782,1.274] |
| Student | 0.247 | [-0.338,0.833] | -0.368 | [-1.339,0.602] | 0.616 | [-0.518,1.749] |
| Homemaker | -0.073 | [-0.596,0.450] | -0.713 | [-2.154,0.729] | 0.640 | [-0.893,2.173] |
| Retired | 0.022 | [-0.656,0.700] | -0.704† | [-1.486,0.078] | 0.727 | [-0.308,1.761] |
| Disabled | -0.218 | [-1.302,0.867] | -0.390 | [-1.283,0.502] | 0.173 | [-1.231,1.577] |
| Other | -0.038 | [-0.718,0.643] | -0.119 | [-0.762,0.525] | 0.081 | [-0.856,1.017] |
| Number of observations | 19,468 | | 21,862 | | | |
| Number of persons | 4,365 | | 4,583 | | | |

Notes: Data are from the DNB Household Survey 1993-2020; [a] centred on age 45;
† $p < .1$, * $p < .05$, ** $p < .01$, *** $p < 0.001$

Appendix A. Sample characteristics; stratified by gender and period of observation.

| | Women | | | | | Men | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2016 and prior | 2017 | 2018 | 2019 | 2020 | 2016 and prior | 2017 | 2018 | 2019 | 2020 |
| Mean age [a] | 44.4 | 44.1 | 44.3 | 44.6 | 45.4 | 46.2 | 46.5 | 46.6 | 47.5 | 48.3 |
| (Standard deviation) | (12.0) | (12.6) | (12.8) | (12.6) | (12.4) | (11.7) | (12.0) | (12.3) | (12.0) | (11.9) |
| Lives with partner | 79.2% | 67.3% | 64.8% | 67.2% | 68.4% | 81.7% | 71.1% | 67.0% | 68.9% | 68.1% |
| Primary activity status: | | | | | | | | | | |
| In paid employment | 52.8% | 63.6% | 64.8% | 65.2% | 66.7% | 76.9% | 81.5% | 79.5% | 80.8% | 79.2% |
| Unemployed | 2.7% | 2.4% | 1.8% | 2.1% | 2.7% | 2.7% | 3.3% | 2.5% | 2.5% | 3.8% |
| Student | 7.6% | 5.5% | 6.7% | 6.2% | 4.4% | 2.8% | 3.8% | 5.9% | 4.5% | 3.8% |
| Homemaker | 22.9% | 13.0% | 11.8% | 12.2% | 12.1% | 1.2% | 0.9% | 1.0% | 1.2% | 1.7% |
| Retired | 4.5% | 1.5% | 1.3% | 0.8% | 1.2% | 9.0% | 2.3% | 2.3% | 2.7% | 3.1% |
| Disabled | 3.7% | 8.8% | 9.1% | 7.6% | 8.2% | 4.0% | 5.2% | 5.8% | 5.6% | 6.0% |
| Other | 5.9% | 5.2% | 4.5% | 5.9% | 4.7% | 3.5% | 3.0% | 3.0% | 2.7% | 2.4% |
| Mean bodyweight in kilograms | 71.3 | 74.8 | 75.2 | 74.9 | 76.1 | 83.7 | 86.8 | 86.5 | 86.5 | 86.9 |
| (Standard deviation) | (14.5) | (16.8) | (17.5) | (16.8) | (17.6) | (13.4) | (14.7) | (14.5) | (15.2) | (15.1) |
| Mean Body Mass Index (BMI) | 25.0 | 26.0 | 26.2 | 26.1 | 26.5 | 25.5 | 26.0 | 26.0 | 26.1 | 26.3 |
| (Standard deviation) | (4.6) | (5.5) | (5.8) | (5.5) | (5.7) | (3.6) | (4.0) | (4.0) | (4.1) | (4.1) |
| BMI Category: | | | | | | | | | | |
| Not overweight (< 25 kg/m2) | 57.2% | 49.2% | 48.5% | 49.7% | 47.6% | 49.7% | 47.2% | 46.9% | 47.0% | 45.2% |
| Overweight (25-30 kg/m2) | 29.6% | 32.2% | 31.5% | 30.2% | 29.5% | 41.1% | 38.1% | 38.3% | 37.7% | 38.7% |
| Obese (>= 30 kg/m2) | 13.1% | 18.6% | 20.1% | 20.0% | 22.9% | 9.1% | 14.7% | 14.8% | 15.4% | 16.1% |
| Number of observations | 16,336 | 805 | 714 | 845 | 768 | 18,830 | 769 | 709 | 808 | 746 |
| Number of observations with complete BMI information | 16,298 | 803 | 712 | 843 | 765 | 18,787 | 769 | 708 | 807 | 744 |

Notes: Data are from the DNB Household Survey 1993-2020;
[a] based on values before centring

Appendix B. Results of fixed-effects analyses predicting bod mass index in women and men; coefficient estimates with 95% confidence intervals.

| | Women | | Men | | Women vs men | |
|---|---|---|---|---|---|---|
| | b | [95% CI] | b | [95% CI] | Δb | [95% CI] |
| Year: | | | | | | |
| 2020 (Covid-year) | Ref. | | Ref. | | Ref. | |
| 2019 (pre-Covid year) | -0.267*** | [-0.399,-0.134] | -0.049 | [-0.166,0.067] | -0.217* | [-0.394,-0.041] |
| 2018 (2 years pre-Covid) | -0.310*** | [-0.481,-0.140] | -0.021 | [-0.153,0.112] | -0.289** | [-0.505,-0.073] |
| 2017 (3 years pre-Covid) | -0.264** | [-0.457,-0.072] | 0.060 | [-0.084,0.205] | -0.325** | [-0.565,-0.084] |
| 2016 and prior | -0.331** | [-0.557,-0.105] | 0.203* | [0.031,0.375] | -0.534*** | [-0.818,-0.250] |
| Time-variant controls: | | | | | | |
| Age [a] | 0.093*** | [0.074,0.113] | 0.108*** | [0.094,0.122] | -0.015 | [-0.039,0.009] |
| Age [a] (squared) | -0.001† | [-0.002,0.000] | -0.002*** | [-0.002,-0.001] | 0.001 | [-0.000,0.002] |
| Lives with partner | 0.350* | [0.010,0.690] | 0.139 | [-0.121,0.399] | 0.211 | [-0.216,0.639] |
| Primary activity status: | | | | | | |
| In paid employment | Ref. | | Ref. | | Ref. | |
| Unemployed | -0.044 | [-0.242,0.154] | -0.083 | [-0.245,0.080] | 0.038 | [-0.218,0.294] |
| Student | 0.152 | [-0.043,0.346] | -0.061 | [-0.345,0.224] | 0.212 | [-0.132,0.556] |
| Homemaker | 0.072 | [-0.097,0.241] | -0.055 | [-0.472,0.362] | 0.127 | [-0.323,0.577] |
| Retired | 0.088 | [-0.128,0.304] | -0.161† | [-0.344,0.023] | 0.249† | [-0.035,0.532] |
| Disabled | -0.064 | [-0.410,0.283] | -0.114 | [-0.321,0.093] | 0.050 | [-0.353,0.453] |
| Other | 0.040 | [-0.159,0.239] | -0.024 | [-0.182,0.134] | 0.064 | [-0.191,0.318] |
| Number of observations | 19,416 | | 21,806 | | | |
| Number of persons | 4,357 | | 4,574 | | | |

Notes: Data are from the DNB Household Survey 1993-2020; [a] centred on age 45;
† $p < .1$, * $p < .05$, ** $p < .01$, *** $p < 0.001$

Appendix C. Results of fixed-effects analyses predicting bodyweight change in women and men; coefficient estimates with 95% confidence intervals.

| | Women | | Men | | Women vs men | |
|---|---|---|---|---|---|---|
| | b | [95% CI] | b | [95% CI] | Δb | [95% CI] |
| Year: | | | | | | |
| 2020 (Covid-year) | Ref. | | Ref. | | Ref. | |
| 2019 (pre-Covid year) | -0.760** | [-1.241,-0.280] | -0.131 | [-0.577,0.314] | -0.629† | [-1.285,0.026] |
| 2018 (2 years pre-Covid) | -0.905** | [-1.558,-0.252] | -0.073 | [-0.573,0.428] | -0.832* | [-1.654,-0.010] |
| 2017 (3 years pre-Covid) | -0.781* | [-1.463,-0.099] | 0.296 | [-0.276,0.869] | -1.078* | [-1.968,-0.187] |
| 2016 and prior | -1.111* | [-1.962,-0.261] | 0.935** | [0.285,1.584] | -2.046*** | [-3.116,-0.977] |
| Time-variant controls: | | | | | | |
| Age [a] | 0.259*** | [0.202,0.316] | 0.362*** | [0.313,0.411] | -0.103** | [-0.178,-0.028] |
| Age [a] (squared) | -0.003* | [-0.006,-0.001] | -0.007*** | [-0.010,-0.005] | 0.004† | [-0.000,0.007] |
| Lives with partner | 0.932† | [-0.076,1.941] | 0.487 | [-0.491,1.465] | 0.445 | [-0.959,1.850] |
| Not in paid employment | -0.166 | [-1.986,1.654] | -0.063 | [-1.503,1.377] | -0.103 | [-2.423,2.217] |
| 2019 (pre-Covid year) x not in paid employment | -0.091 | [-1.504,1.323] | 0.931 | [-0.813,2.674] | -1.022 | [-3.266,1.223] |
| 2018 (2 years pre-Covid) x not in paid employment | 0.361 | [-1.505,2.228] | 0.199 | [-1.100,1.498] | 0.162 | [-2.111,2.436] |
| 2017 (3 years pre-Covid) x not in paid employment | -0.010 | [-1.663,1.643] | -0.312 | [-1.665,1.042] | 0.302 | [-1.835,2.438] |
| 2016 and prior x not in paid employment | 0.183 | [-1.619,1.984] | -0.417 | [-1.868,1.034] | 0.600 | [-1.713,2.913] |
| Number of observations | 19,468 | | 21,862 | | | |
| Number of persons | 4,365 | | 4,583 | | | |

Notes: Data are from the DNB Household Survey 1993-2020; [a] centred on age 45;
† $p < .1$, * $p < .05$, ** $p < .01$, *** $p < 0.001$

**STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology***

**Checklist for cohort, case-control, and cross-sectional studies (combined)**

| Section/Topic | Item # | Recommendation | Reported on page # |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1, 2 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 5 |
| Objectives | 3 | State specific objectives, including any pre-specified hypotheses | 5-8 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 5, 8-10 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 8 |
| Participants | 6 | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls<br>*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants | 8 |
| | | (*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study*—For matched studies, give matching criteria and the number of controls per case | N/A |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 9 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 9 |
| Bias | 9 | Describe any efforts to address potential sources of bias | 9-10 |
| Study size | 10 | Explain how the study size was arrived at | 8 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 8-10 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 9-10 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | 9-10 |
| | | (*c*) Explain how missing data were addressed | 8-9 |
| | | (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed<br>*Case-control study*—If applicable, explain how matching of cases and controls was addressed | N/A |

| | | | |
|---|---|---|---|
| | | *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy | |
| | | (*e*) Describe any sensitivity analyses | 11-12 |
| **Results** | | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 8 |
| | | (b) Give reasons for non-participation at each stage | 8 |
| | | (c) Consider use of a flow diagram | N/A |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 14 |
| | | (b) Indicate number of participants with missing data for each variable of interest | Appendix A |
| | | (c) *Cohort study*—Summarise follow-up time (eg, average and total amount) | 14 |
| Outcome data | 15* | *Cohort study*—Report numbers of outcome events or summary measures over time | 14 |
| | | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure | N/A |
| | | *Cross-sectional study*—Report numbers of outcome events or summary measures | N/A |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | 9-11, 17-18 |
| | | (*b*) Report category boundaries when continuous variables were categorized | 9 |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | N/A |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | 11-12 |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 11 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 11 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 11-13 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 11 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 4 |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.