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Exploring impact on eating behaviour, exercise and well-being during COVID-19 restrictions in the Netherlands

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ABSTRACT

Many studies address the effect of the COVID-19 restrictions on food consumption and health, focusing on one or two measurements. Whether or not any effects are permanent or change over a longer period of restrictions has not been assessed in such studies. This study presented a survey containing questions on food consumption, exercise and self-assessed physical and mental health, repeatedly for six times over a 20-week period (July to November 2020) to a representative sample of 258 Dutch consumers. The majority of consumers reported no change in food consumption compared to before the COVID-19 restrictions, two smaller groups report a change to a more, or a less, healthy choice. This trend appears stable over the course of the measurements. The 'healthy changers' seem to couple a healthy and more diverse diet to healthy exercise habits, in contrast to the 'unhealthy changers'. No change was observed in self-assessed physical health over the measurements. Overall a decline in time spent exercising showed, as well as a decline in self-assessed mental health.

Clearly a lockdown situation affects food choice, exercise habits and (self-assessed) mental health. The fact that habits are able to suddenly change, for better or for worse, and that a decrease in mental health was reported, suggests that such insights need to be further explored to help individual consumers retain a healthy diet and lifestyle, and governments devise effective public health recommendations.

1. Introduction

A COVID-19 pandemic was declared by the WHO on March 11th, 2020. Many governments proclaimed a lockdown situation, of different severities and durations. In the Netherlands, the so-called first wave of the infections, with resulting lockdown measures, took place in March 2020. Living in a lockdown situation has a large impact on people's lifestyle, and as a result also on their food consumption patterns and mental and physical wellbeing. Working at home has become the norm, for those professions that allow for it, starting March 15, 2020. For an overview of the Dutch measures against the spread of the COVID-19 virus see Government of the Netherlands (2021).

Several studies have pointed out that an unhealthy physical condition may be a risk factor to the severity of contracted COVID-19 symptoms (Malik et al., 2020). When a lockdown leads to unhealthy dietary patterns and less exercise, a resulting increase of Body Mass Index (BMI) (Pellegrini et al., 2020; Robinson et al., 2020) may contribute to a rise in COVID-19 victims (de Frei et al., 2020; Gao et al., 2021). This study investigated the effects of the lockdown measures in the Netherlands onto food and exercise habits in relation to physical and mental well-being.

Several studies in different countries have investigated effects of the local COVID-19 lockdown situations. As there are no two lockdown measures alike, and most studies have different aims, comparing them is not straightforward. What most studies share is a focus on one or two moments in time to compare a before lockdown situation with the situation during the lockdown. The current study ran from July to November 2020, and compares six measurements of self-reported consumption, exercise and health, during the first Dutch lockdown period.

In the Netherlands, studies have shown different effects of the

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COVID-19 measures onto food consumption. GFT (2020) points to an increase in consumption of fruit and vegetables (12% in volume for vegetables, 7% for fruit), based on sales data, in a study during 'corona time', as their factsheet states. Poelman et al. (2021) showed that 83% of their sample of Dutch consumers reported no change in their eating habits, 10% ate more healthily, and 8% reported less healthy eating during the COVID-19 lockdown period (study carried out April 22nd–28th).

A Spanish study indicated that dietary patterns after the Spanish containment measures (starting March 14th, 2020) resulted in a larger energy intake and a lower nutritional quality of the ingested meals (Batlle-Bayer et al., 2020). Another study (Laguna et al., 2020), employing an online survey among 362 Spanish consumers, showed increased purchasing of pasta and vegetables, which the authors attribute to health motivations. They also report an increase in nuts, cheese and chocolate consumption, which they relate to mood improvement. A decrease was seen in purchase of short shelf-life foods and unhealthy foods like sugary baked goods and deserts.

In Italy, Bracale and Vaccaro (2020) used sales data (from February 23rd until March 29th, 2020) and showed an increased consumption of pasta, flour, eggs, long-life milk and frozen foods and a reduced consumption of fresh food. They report higher sales of ingredients for home making of bread, pizza's etc. and relate this to a need to support the family in the difficult circumstances that the lockdown situation presents. The study by Pellegrini et al. (2020) lists a number of effects of the lockdown onto food and health in a sample of obese individuals in Northern Italy. A mean self-reported weight gain of 1.5 kg was found over March–April, which was associated with lower exercise, self-reported boredom/solitude, anxiety/depression, enhanced eating, consumption of snacks, unhealthy foods, cereals and sweets. Self-reported anxiety/depression appeared to result in an average 2.1 kg weight gain, indicating the importance of attention for mental well-being in the COVID-19 lockdown situation.

In France, Marty et al. (2021) found a lower diet nutrition quality during the lockdown period (data collected on April 30th/May 1st), compared to the month before the lockdown and the first month of the lockdown period. This was partly attributed to an increase in the importance of mood, being negatively related to nutritional quality. A positive relation was obtained of nutritional quality with an increase in the importance of weight control as a food choice motive.

A USA-based study using self-reports of 381,564 citizens (Mitchell et al., 2020) showed an overall decrease in consumption of fresh products, and an increase in red meat and starchy vegetables, and no change in snack or alcoholic beverage intake.

All of the above mentioned studies were carried out at the beginning of the COVID pandemic, between February 17th and May 1st, in or just after a local or national lockdown. Note that the different countries used very different ways they imposed a lockdown period, which makes it impossible to strictly compare results over countries. In addition studies were carried out on different consumer groups, with rather different sample sizes. This makes it difficult, if not impossible, to draw concrete conclusions.

There are studies, some of them longitudinal, that compare the situation before (during) with that during (after) a lockdown period. In Spain, a survey among 693 respondents compared the situation during (March 2020) and after (April/May 2020) the COVID-19 lockdown period (Martínez-de-Quel et al., 2021). This study showed a significant, negative (*i.e.* unhealthy) impact on (self-reported) physical activity levels, sleep quality and well-being, with the exception of the development of eating disorders, which did not increase. In the UK, Robertson et al. (2021), on the contrary, report an increase in exercise (and in thinking about exercise) in a group of 243 citizens, in an online survey between May and June 2020. They also report an increase in a preoccupation with food and eating, an increased difficulty to regulate/control eating, and a greater concern with the way one looks. Their sample was mostly female (78%). Also in the UK, Buckland et al. (2021) report an increased consumption of high energy dense food types, which the authors connect to a low craving control as measured by the craving control subscale of the control of eating questionnaire (Dalton et al. 2015, 2017).

The current study is of an exploratory nature, as the diverse findings from the literature precluded posing clear hypotheses to test, other than that a lockdown affects food choice, and exercise behaviour. The main aim of this study is to explore to what extent, and how exactly these are affected, and what the effects on self-assessed physical health, mental health and the quality of one's diet are.

2. Method

In order to pick up changes in health and exercise routines over the course of the COVID-19 lockdown period in the Netherlands, six online survey measurements were carried out, once every four weeks from July 1st until November 18th, 2020 (see Fig. 1). Initially, 402 respondents filled out the first survey after being contacted by a research agency (MSI-ACI, The Netherlands), constituting a demographically representative group of Dutch consumers. The research agency was commissioned to program the survey into an online version. They distributed it to 402 consumers using their own consumer panel. Inclusion criteria based on gender, age, region and education level were selected such that a nationally representative sample was obtained. The researchers received the total set of obtained data from the agency for subsequent data cleaning, checking for completeness, and analyses. The agency had no part in selecting parts of the data, nor in any of the analyses. Out of the 402 participants, 258 completed all six online measurements and were included in the analysis.

The respondents needed approximately 10 min time to complete the survey every four weeks. The survey could be filled out using a (laptop) computer, a tablet or a smartphone. Several sets of food, exercise and health related questions were asked. An overview of the questions from the survey, analysed in this paper, is available as supplementary material. Some of the questions, like the psychological traits surveys (not presented in this paper), were asked once, others on all six occasions (see further details below). These latter questions specifically address food consumption, self-assessed health and exercise.

2.1. Health, food intake and exercise questions in the survey and variables for the analysis

Self-assessment of physical health, mental health and an estimate of the healthiness of one's diet, were inquired through asking:

- *How would you estimate your physical health to be at this moment?*
- *How would you estimate your mental health to be at this moment?*
- *How would you estimate the healthiness of your food regime this month?*

These questions were asked at each measurement occasion, the answer was given on a 7-point scale ranging from 'very unhealthy' (score 1), to 'very healthy' (score 7). To obtain an estimate of the -self-reported- healthiness of the diet, compared to *before* the COVID-measures, the following question was asked:

- *Compared to before the Corona crisis, I now eat . …*

which was to be answered using a 7-point scale ranging from 1 ('much less healthily'), via 4 ('equally healthily') to 7 ('much more healthily').

The survey containing the above questions was developed by the current authors especially to probe food and exercise related behaviour in the COVID-19 lockdown period. It was not subjected to a thorough scale validation exercise. There was no time for this as at the moment of execution of the survey the expectation was that the lockdown would last no longer than a few months. The survey was informally pre-tested

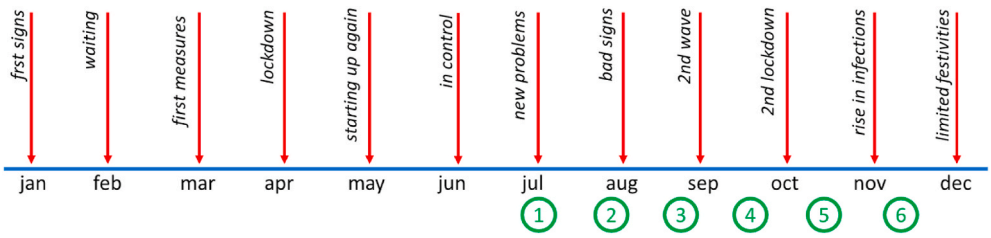

Fig. 1. Overview of Dutch COVID-19 measures and the study timelines (red arrows: short description of the COVID-19 situation in 2020; green circles: the 6 measurements in this study). . (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

among a group of colleagues of the authors who filled it out and commented. It showed to be understood and the items were judged feasible to answer. Unfortunately, some items did raise some confusion in respondents, as will be explained later.

Every four weeks, questions were asked concerning the consumption of 18 different food types, *i.e.* on how many days during the previous week they were consumed. For the analysis the 18 food types were divided into two categories, one containing basic food products essential for a normal healthy daily diet, and a group with non-essential food products that are consumed extra to a normal diet (often as a snack). We will refer to these two categories as 'essential', and 'non-essential', respectively:

essential: fruit, vegetables (*e.g.* raw, cooked, stir fried), pulses (*e.g.* kidney beans, chick peas), eggs, rice, potatoes, bread or breakfast cereals, dairy products (*e.g.* milk, milk products, cheese (spread)), meat (products, meats), seafood, nuts and olives, dairy substitutes, meat substitutes (*e.g.* vegetable burger, 'vegetarian' minced meat),

non-essential: alcoholic drinks, cookies/pastries/muesli bars, savoury snacks (*e.g.* crisps, cocktail nuts, croquette), candy/chocolate/sweet toppings.

Note that we decided to exclude the category 'non-alcoholic drinks' from the analysis as apparently numerous subjects had overlooked coffee, tea or water. Many reported to consume this category on zero days in the previous week.

The food consumption variable used for further analyses is created by the number of days -in the past week-that a participant reported to consume items from a specific food category. Next the number of days, for the products in the essential and non-essential food groups, were added and divided by the number of food types in each of these two categories. This gives an estimate of the average number of days -in the past week-a participant consumed essential and non-essential food products. In the essential food category, dairy substitutes and meat substitutes were left out, as only few consumers reported to have consumed these products; the many zero number of days would have resulted in an unduly low average number.

At the first measurement occasion an additional question about the consumption of the 18 food types referred to 'compared to before the Corona crisis, I consumed this product', with the answer categories 'less often', 'equally often' or 'more often' (scored as 1, 2 and 3 respectively). The scores were averaged over the items in the two food categories ('essential' and 'non-essential'), and given the labels 'less often', 'equally often' and 'more often', based on the average score being <2, $=2$ and >2, respectively. This variable thus gives an indication of the lockdown-related change in consumption amount at the first measurement.

In addition to these food consumption variables, a 'dietary diversity' variable was computed (Kennedy et al., 2013). The diversity score was calculated as the number of different foods from the 'essential foods' category consumed in the past week, and is available for the six measurements. This variable did include the food types dairy substitutes and meat substitutes, which were left out from the food consumption variable. The dietary diversity measure only concerns binary data (consumed yes or no), and hence is not so sensitive to the many zeroes for these food types.

A number of questions concerning physical exercise were also included at six measurement occasions. Eight different types of exercise were presented, for which participants indicated how many days they performed this exercise during the past week. In addition an estimate of how long each exercise lasted on average (in minutes), was asked. The exercise question posed was:

- *Which physical activities have you employed in the previous week, irrespective of your daily household or shopping activities (more answers allowed).*

The following categories were indicated: walking, bicycling, running/jogging, swimming, fitness, yoga/Pilates, other individual sports (*e.g.* tennis, golf, judo, badminton), team sports (*e.g.* soccer, hockey, basketball). The next two questions probed the frequency and duration of the indicated activities:

- *How often did you partake in this activity?*
- *How much time did you spend doing this activity (average number of minutes per occasion)?*

The first question was to be answered by a number of days in the previous week, the second demanded a number of minutes to be indicated. The exercise variable is created by multiplying the reported number of days, in the week prior to filling the form out, that a specific exercise is performed with the estimated number of minutes the exercise lasted. This results in a number of minutes per week, per exercise type. Adding these over all the specific exercise types, the exercise variable contains the total number of minutes spent exercising in the week before filling out the survey. This variable is also available for each of the six measurements.

2.2. Outliers

Concerning the four variables computed we encountered several outliers. Outliers may have resulted from extremely sporty individuals who exercise an extreme amount or from respondents who may not have paid attention to the fact that the consumption question ranged over one week previously, not over the full four-week period since the last survey was received. As an example we mention the fact that some respondents of the latter type reported having consumed vast amounts of potatoes, several kilograms per day. In total, 12 such outliers have been removed, leaving 246 participants' data to analyse. One additional subject did not provide any data on the 6th measurement moment, so the 6th measurement contains one subject less than the other measurements.

Further, outlying individual scores have been removed when they were 1.5 times an Inter Quartile Range over (under) the upper (lower) quartile of the distribution of scores for each individual question and measurement moment.

2.3. Statistical analyses

Results were deemed to be statistically significant when $p < 0.05$. A

Bonferroni correction was applied to counteract problems of multiple comparisons when performing multiple pairwise tests. For tests that proved not significant, only the *p*-values are reported. For the linear mixed effects regression analyses, model χ^2-values are reported, along with their *p*-value and the resulting differences when present. *F*-values are presented for the analyses of variance carried out, alongside the *p*-values of *post-hoc* tests. Comparisons of differences between the number of participants in several (crossed) groups, are carried out using χ^2-tests, the value of the χ^2 and the corresponding *p*-value will be given. In some cases the standardised residuals are presented.

The computations and analyses were performed in R version 3.6.1 (R core team, 2018).

2.4. Description of the participants

After removal of the outliers from the database 246 respondents remained (50% female), the average age was 49.6 year (SD 17.2 year). The sample of participants in this study was mainly of high education (49%), from 2-person households (41%) and with moderate (35% from 1.500 to 3.000 €/month) to high (34% from 3.000 to 7.500 €/month) income. Most participants (42%) report a healthy weight, and no weight change (45%) since early 2020, the pre-COVID-19 situation.

3. Results

3.1. Change groups

The question concerning the consumption situation before the COVID-lockdown shows three groups of respondents. The three groups will be referred to as 'healthy changers' (scoring 1, 2 or 3; 22% of respondents), 'no changers' (scoring 4; 66%), and 'unhealthy changers' (scoring 5, 6 or 7; 12%), and will be referred to as 'change groups' in the remainder of the paper.

A one-factor (change group) ANOVA, despite overall significant, did not reveal any age differences in the *post hoc t*-tests between the change groups. χ^2-tests (level of education, household size, net monthly income group) did not show any differences between the change groups either (Table 1, columns 'unhealthy changers', 'no-changers', 'healthy changers'). A χ^2-test revealed a significant association between change group and BMI group $\chi^2(6) = 12.6$, $p = 0.049$); this was predominantly driven by the group of healthy changers, where the number of respondents with a healthy BMI was higher than expected ($z = 1.82$), and the number of obese respondents was lower than expected ($N = 6$, $z = -1.84$). Note that the absolute values of the standardised residuals do not exceed 1.96, so they would list as not significant.

A significant association between change group and self-reported weight change was also found ($\chi^2(6) = 14.0$, $p = 0.030$). Specifically, the number of unhealthy changers who gained weight was higher than expected (see Table 2, $N = 12$, $z = 1.79$), and the number of healthy changers who lost weight was lower than expected ($N = 19$, $z = 1.92$). Note that the absolute values of the standardised residuals do not exceed 1.96, so they would list as not significant.

Table 1
Basic demographics of the sample of 246 respondents in the data set, for the three change groups separately. No significant differences exist between the three change groups (χ^2-tests, ANOVA for age).

	Unhealthy changers	No-changers	Healthy changers
Sample *N* (%)	30 (12)	163 (66)	53 (22)
GENDER *N (%) female*	17 (57)	83 (51)	23 (43)
AGE *M-/+SD*	44.7 −/+17.9	51.5 −/+16.7	46.4 −/+17.4
LEVEL OF EDUCATION *N* (%)			
Low	2 (7)	34 (21)	5 (9)
Middle	15 (50)	50 (31)	19 (36)
High	13 (43)	79 (48)	29 (55)
HOUSEHOLD *N* (%)			
1-person household	6 (20)	39 (24)	18 (34)
2-person household	12 (40)	67 (41)	21 (40)
3-person household	5 (17)	26 (16)	6 (11)
4-person household	6 (20)	24 (15)	5 (9)
5-person household	0 (0)	6 (4)	2 (4)
6-person household	1 (3)	1 (1)	1 (2)
NET MONTHLY INCOME *N* (%)			
<1500 EUR	6 (20)	18 (11)	7 (13)
1500–3000 EUR	8 (27)	59 (36)	20 (38)
3000–7500 EUR	11 (37)	57 (35)	16 (30)
> 7500 EUR	0 (0)	1 (1)	2 (4)
(unknown)	5 (17)	28 (17)	8 (15)

3.2. Product-specific consumption behavior change

The consumption frequency of essential and non-essential products before the COVID-19 lockdown, compared to during the lockdown, is shown in Fig. 2, separately for the three change groups. A χ^2-test on the combination of the three change categories (unhealthy changers, no-changers, healthy changers) and the 'before the crisis'-consumption categories (eating the food types less often, equally often, more often than before the crisis), for the essential products, shows significant differences between the numbers ($\chi^2(4) = 74.2$, $p < 0.001$). Similarly, a χ^2-test for the non-essential products shows a significant effect as well ($\chi^2(4) = 66.3$, $p < 0.001$). Within the group of no-changers, most respondents report to eat essential and non-essential food products equally often as before the crisis. Very few no-changers consume both essential and non-essential products more often compared to before the COVID-19 lockdown. Among unhealthy changers, the majority report to consume non-essential products more often than before the crisis, only one respondent indicated to eat non-essential foods less often. As for the essential food category, the majority of unhealthy changers indicate to eat these products less often. For healthy changers, the pattern is opposite, the majority indicate to eat essential products more often, whereas the proportion of healthy changers who more often consume non-essential products is lowest.

The self-reported change behaviour shows to be reflected in the consumption of essential and non-essential products. These differential findings in consumption patterns for the three change groups support the validity of the existence of these groups in the study.

Table 2
Health and food consumption related description of the participant sample, for the three change groups. Significant deviations from expected counts are in bold (according to χ^2-testing, see section 3.1 for details).

	Unhealthy changers	No-Changers	Healthy changers
BMI *M-/+SD* (measured at 6th measurement)	27.3−/+6.6	26.7−/+5.2	25.3−/+4.4
BMI-group *N* (%)			
Underweight (<18.5)	0 (0)	6 (4)	0 (0)
Healthy weight (18.5–24.9)	12 (40)	61 (37)	**31 (58)**
Overweight (25–29.9)	8 (27)	54 (33)	16 (30)
Obese (>30)	10 (33)	42 (26)	**6 (11)**
self-reported weight change since early 2020 *N* (%)			
My weight did not change	12 (40)	82 (50)	16 (30)
I gained weight	**12 (40)**	33 (20)	14 (26)
I lost weight	5 (17)	33 (20)	**19 (36)**
I don't know	1 (3)	15 (9)	4 (8)

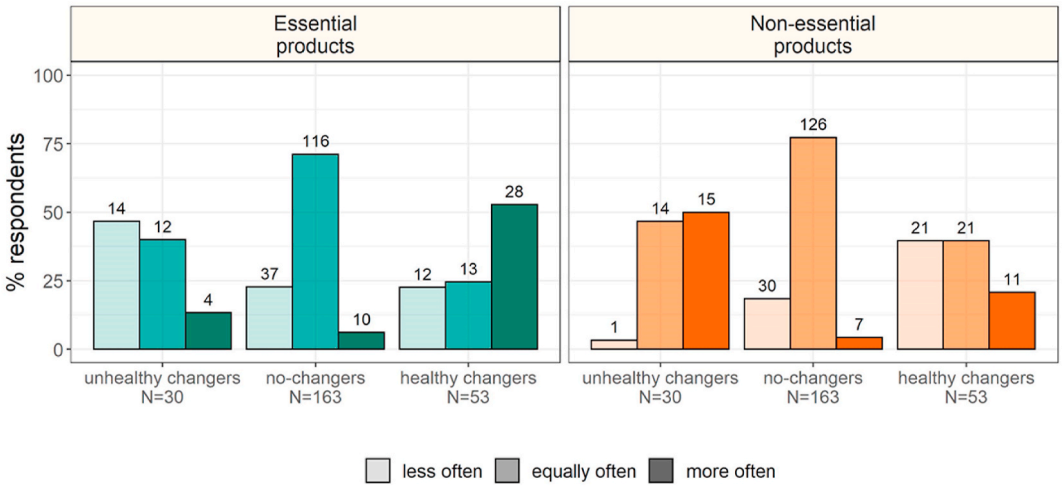

Fig. 2. Comparison of the consumption at the first measurement occasion (less often, equally often, more often), of essential and non-essential food products, with before the COVID-measures, by the three change groups. Shown, along the ordinate, is the percentage of respondents for the different combinations, the bars contain the absolute numbers of respondents.

3.3. Absolute consumption frequency over time

An ANOVA is carried out for the essential and non-essential food category separately. The change groups show a difference in total consumption of essential food products (F (2,243) = 6.03, $p < 0.01$). The healthy changers ($M = 3.81$ day/wk) consume more essential products than the unhealthy changers ($M = 3.27$ day/wk, $p < 0.05$) according to a *post-hoc* pairwise comparison t-test. The no-changers ($M = 3.57$ day/wk) did not differ from the healthy changers, nor from the unhealthy-changers (for both, $p > 0.07$). A similar ANOVA for the non-essential products showed no significant differences ($p = 0.43$) between the average number of days per week the food items in this category are consumed.

The consumption of essential and non-essential food types has been reported for a longer period of time, over six occasions. Fig. 3 shows the patterns for the three change groups. A linear mixed effects regression analysis was performed, predicting the number of days/wk from the change group membership (3 change groups), measurement occasion (6 moments in time) and their interaction, separately for essential and non-essential foods. For the essential foods the model shows a significant main effect of change group ($\chi^2(2) = 8.6$, $p < 0.05$). *Post-hoc* pairwise group comparisons show that healthy changers ($M = 3.74$ day/wk) continue to eat essential foods more often than unhealthy changers ($M = 3.36$ day/wk, $p < 0.05$). The no-change group ($M = 3.54$ day/wk) did not differ from either other group (in both cases $p > 0.09$). No evidence was found for changes in essential food consumption frequency over the six measurement occasions ($p = 0.85$), nor for an interaction between the change group and measurement occasion ($p = 0.66$).

A similar analysis for the non-essential food category did not produce significant main effects (for change group $p = 0.51$, measurement occasion $p = 0.052$), nor a significant interaction between the two ($p = 0.69$).

3.4. Dietary diversity in essential food products, per change group

In addition to consumption frequency, a dietary diversity variable (see section 2.1) was computed on the essential food category. A one-factor (change group) ANOVA shows a significant effect of change group (F (2,243) = 3.35, $p < 0.05$). The healthy changers' diet is more diverse ($M = 10.8$) than that of the no-changers ($M = 10.1$, $p < 0.05$). The unhealthy changers ($M = 10.3$) do not differ from either group (for both cases $p > 0.59$).

The change of dietary diversity over the six measurement occasions is shown in Fig. 4. A linear mixed effects regression model predicting the dietary score on the basis of change group, measurement occasion and their interaction shows a significant effect of change group ($\chi^2(2) = 7.0$, $p < 0.05$). *Post-hoc* pairwise group comparisons show that essential food diets of healthy changers are more diverse ($M = 10.7$) than that of no-changers ($M = 10.1$, $p < 0.05$). Differences between unhealthy changers ($M = 10.2$) and the two other change groups are not significant (in both cases $p > 0.29$). No changes in dietary diversity over time showed up ($p = 0.57$), nor an interaction of measurement occasion and

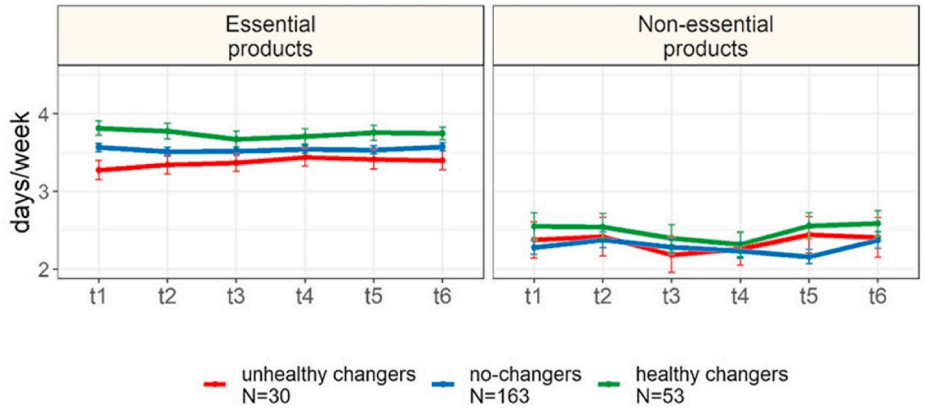

Fig. 3. Absolute consumption frequency of essential and non-essential foods per change group over the six measurement occasions.

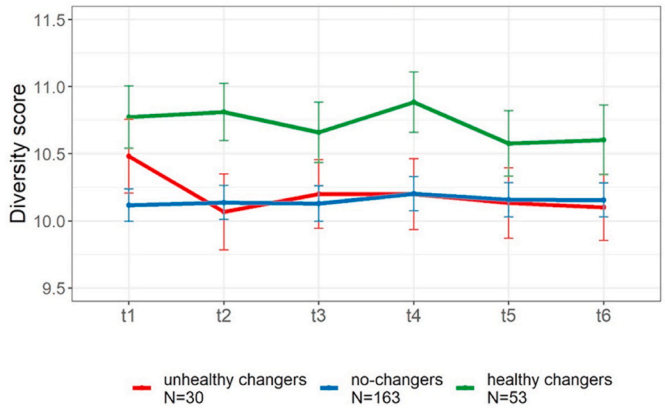

Fig. 4. Mean dietary diversity scores over time, for the three change groups.

change group ($p = 0.74$), indicating that dietary patterns of healthy changers continue to be the more diverse over the six measurements.

3.5. Physical activity over time, per change group

Fig. 5 shows the average number of minutes spent doing physical exercise, during the week prior to receiving the survey, per each of the six measurement occasions. A linear mixed effects regression showed a main effect of change group (χ^2 (2) = 8.8, $p < 0.05$), indicating that healthy changers ($M = 287$ min/wk) exercise more than no-changers ($M = 210$ min/wk, $p < 0.05$). The time unhealthy changers spend exercising ($M = 204$ min/wk) does not differ significantly from that of the healthy and no-change groups (in both cases $p > 0.09$).

A main effect of measurement occasion was also found ($\chi^2(5) = 21.3$, $p < 0.001$), *post-hoc* pairwise comparisons showed that more time was spent on physical exercise at the second measurement ($M = 257$ min/wk) relative to the third ($M = 226$ min/wk, $p = 0.015$) and fifth measurement ($M = 216$ min/wk, $p < 0.001$). No evidence was found for a change group by measurement interaction ($p = 0.18$).

3.6. Self-assessed health per change group

The self-assessed physical health, mental health, and dietary health, per change group and over the six measurement occasions, are shown in Fig. 6. A linear mixed effects regression analysis of physical health scores (including change group, measurement time and their interaction) revealed no evidence for an effect of measurement ($p = 0.66$), change group ($p = 0.18$), or of their interaction ($p = 0.31$).

For mental health, a main effect was found for change group ($\chi^2(2) = 21.7$, $p < 0.001$) as well as for measurement occasion ($\chi^2(5) = 28.2$, $p < 0.001$). There was no significant interaction ($p = 0.23$). The no-changers ($M = 5.36$) had a higher self-reported mental health than both unhealthy changers ($M = 4.81$, $p < 0.025$) and healthy changers ($M = 4.57$, $p < 0.001$). The unhealthy changers did not differ from the healthy changers ($p = 0.864$).

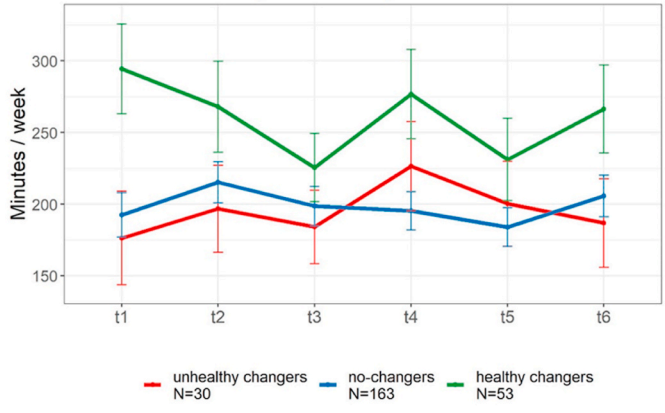

Fig. 5. Physical activity (average minutes/week) for the three change groups, and the six measurement occasions.

Pairwise differences between the six measurements indicate a difference between both the 1st and 2nd measurement (that do not differ from each other, for both $M = 5.04$, $p = 1.00$) and the 6th measurement ($M = 4.73$, for both $p < 0.001$), suggesting some slow decline in self-assessed mental health over the duration of the lockdown period.

The scores for the self-assessed healthiness of participants' food regime did show differences between measurement occasions ($\chi^2(5) = 12.4$, $p < 0.05$), however pairwise post hoc testing did not reveal any pairwise differences after Bonferroni correction for multiple testing. Differences between change groups ($\chi^2(2) = 18.7$, $p < 0.001$) showed that the unhealthy changers ($M = 4.52$) had a lower rating on healthiness of their food regime than the no-changers ($M = 5.22$, $p < 0.001$) and the healthy changers ($M = 5.13$, $p = 0.003$). The no-changers did not differ from the healthy changers ($p = 1.00$). The interaction between change group and measurement occasion proved not significant ($p = 0.09$).

4. Discussion

The aim of this study was to add a dynamic view to the impact of the COVID-19 lockdown measures on food consumption, exercise and health in the Netherlands. Many studies thus far have reported consumption and health effects, but the extent to which these effects are short lived or permanent remained unknown. In this study six measurements were performed, one each four weeks, collecting data on food consumption, exercise and self-assessed health. In addition some demographics of the participants were collected to assist with the characterisation of the sample population.

4.1. Consumption

We found that a majority of our respondents (66%) report no change in their healthy eating compared to before the lockdown period. Much smaller groups reported they started eating healthier (22%) or less healthy (12%). These two smaller groups show that they changed their eating behaviour for essential and non-essential products. We observed the unhealthy changers consuming fewer essential and more non-essential products, the reverse shows for the healthy changers. Furthermore, for all three groups, there is no indication of a change of consumption frequency of products, over the six measurement occasions.

The fact that the change groups report to eat more (unhealthy changers), or less (healthy changers), non-essential products (Fig. 2), does not show in the results about the consumption of non-essential foods as reported at the first measurement occasion (as can be seen in the right panel of Fig. 3, at t1). This may mean that either the consumption of non-essential products by healthy changers before the lockdown was higher than that of the unhealthy changers, or that self-reported consumption behaviour is not completely reliable. The percentage of no-changers in our study is lower than the 83.0% no change in eating behaviour, and 73.3% no change in food purchases as reported by Poelman et al. (2020), although the no-change groups are clearly the largest in both studies. The self-reported behaviour change in the current study can be corroborated by some of the findings of the reported consumption (Fig. 3). It shows that the no-change group indeed reports to consume both essential and non-essential products equally often as before the lockdown period. These findings lend credibility to the validity of the three change groups in our study.

Further, the overall pattern of reporting having eaten less than, more than or equal amounts as before the lockdown, split between 'healthy'

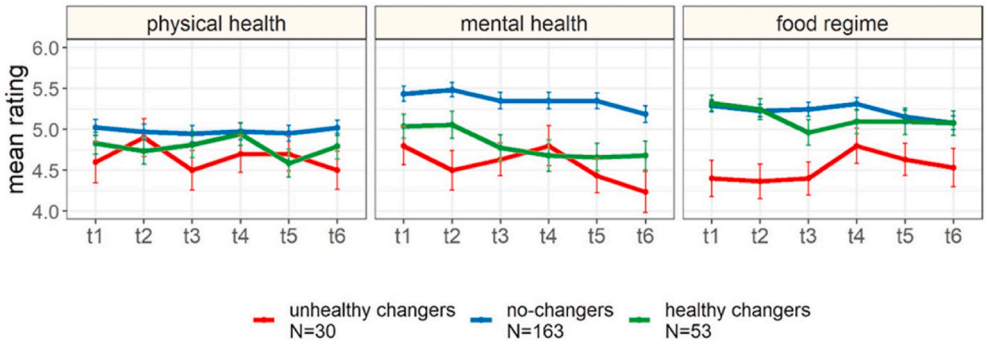

Fig. 6. Self-assessed physical health, mental health, and health of one's food regime, per change group and over the six measurement occasions.

and 'unhealthy' products by Poelman et al. (2020) or 'essential' and 'non-essential' products in the current survey, is similar. We therefore like to conclude that both studies rely on a comparably representative sample of Dutch consumers.

Concerning the amount eaten (in our case the average number of days per week that items from a food category were consumed, in the week prior to the measurement occasion) shows a differential increase in consumption of essential products for the three change groups. A comparison to the pre-lockdown situation can only be made based on the answers given at the first measurement occasion, as then the survey explicitly inquired about the pre-lockdown situation. Results are shown in Fig. 2, albeit for the three change groups separately. What it does show, is that we find a much lower percentage of participants that report to consume (essential or non-essential) products 'more often', than before the lockdown, *viz*. 17% and 13% respectively. This is low in comparison to Buckland et al. (2021) who report 48% of their participants increasing their food intake as a response to the COVID-19 lockdown in the UK.

Robinson et al. (2020) list that 56% of their sample report to increase their snacking during the lockdown in the UK, and 23% reducing it. If we equate our 'non-essential' food category to snacks, we see 21% of our sample reducing, and 12% increasing (Fig. 2). Robinson et al. (2020) also point at an increased difficulty in accessing, and a lack of motivation and control to obtaining, healthy food, particularly for their respondents with higher BMI.

The lack of evidence for a change in essential food consumption frequency over the six measurement occasions, and for an interaction between the change group and measurement occasion (Fig. 3), suggests that differences between change groups in their consumption habits do not develop gradually over time, but seem to appear rather sudden after the onset of the lockdown, and remain stable for the duration of the measurements.

The healthy changers showed to consume a more diverse diet, compared to the no-changers and the unhealthy changers. This greater diversity may have made an adaptation to the lockdown circumstances easier, resulting in a change of diet into a more healthy direction. It is easier to leave out, say, the unhealthy parts from a diverse diet (and thereby change to a more healthy diet), than it is to leave out unhealthy parts from a less diverse diet and still have a healthy diet.

4.2. Physical activity

We observed a certain decline in physical activity on the 3rd and 5th measurement (226 min/wk and 216 min/wk, respectively, compared to 257 min/wk in the 2nd measurement). Further, healthy changers were found to exercise more overall compared to the no-changers (287 min/wk vs. 210 min/wk, respectively). An effect on physical exercise is also reported in a Spanish study by Martínez-de-Quel et al. (2021), where respondents who reported to be active before the lockdown period report less activity during. In addition, this active group also reported a negative impact on sleep quality and well-being. Inactive participants reported no such effects. Speculatively one may pose that the latter group may live with a lower bodily awareness than the former, resulting in them not noticing any effects, or they simply don't bother. It is not straightforward, if at all possible, to compare these Spanish results on activity, as they are given in METmin/wk (MET: Metabolic Equivalent of Task, the approximate ratio of the energy used during a task to the energy expended at rest), with our findings concerning physical activity (in min/wk). Also, a distinction between three change groups, as in our study, is not made by Martínez-de-Quel et al. (2021), rendering further comparison rather speculative.

The study by Robertson et al. (2021) reports an increase in exercise, which is in contrast with the above findings. They also report an increase in *thinking* about exercise, so one may wonder if their respondents may have confused these two measures. In our study we see some overall decrease in exercise as a main effect. In our analyses of the exercise data we observe no interaction between change group and our six measurement occasions, so it looks like the results for any of our change groups are not in line with the reported increase in exercise by Robertson et al. (2021). One difference between our sample and that of Robertson et al. (2021) is that the latter surveyed mainly women (78% of their sample), while our sample contains 50% women.

Overall, the healthy change group appears to display a more healthy lifestyle, and the unhealthy changers an unhealthy lifestyle. This need not be a result of the lockdown, it may have been a property of the respondents in those groups, irrespective of the circumstances.

4.3. Self-assessed health

The attested decrease in self-assessed mental health over the course of the six measurements is noteworthy, and suggests that the extended COVID-19 lockdown period takes its toll on one's psychological well-being. The trending decline in mental health (Fig. 6) may be compared with the findings by Martínez-de-Quel et al. (2021), who report a significant increase in sleep problems and a significant decrease in self-perceived well-being in their sample (containing mostly university students), albeit that our finding shows in a significant decline (0.67 scale points on a 7-point scale) only between both the first two measurements and the last. Although different measures are used, both studies seem to signal an overall decrease in mental health/mental well-being as a result of the prolonged lockdown measures.

Note that the no-change group in our sample reported a higher mental health than the two change groups throughout the measurement period. One could speculate that a general 'no-change' attitude may point at some sort of underlying psychological stability, expressed in behaviour (food choice) as well as in mental health (albeit self-assessed). In this light, both healthy and unhealthy changers may be viewed as psychologically less stable individuals, who are similarly affected by the lockdown circumstances, but have opposite coping strategies: those who take the lockdown as a motivation for making healthier food choices

(healthy changers) vs. those who use the lockdown as an excuse for making less healthy food choices (unhealthy changers). The difference between healthy and unhealthy changers, then, may speculatively be related to a personal characteristic that has also been linked to the lockdown circumstances. Robertson et al. (2021) found that respondents reported greater difficulty in control (e.g. in controlling one's eating behaviour), Buckland et al., 2021 identified craving control (Dalton, Finlayson and Blundell, 2015) as an important predictor of the increase in the consumption of high energy dense foods. Together, these findings suggest that there may be a common denominator related to behavioural (self) control that could lead to a less healthy food choice under the lockdown circumstances.

4.4. Limitations of the study

The fact that the study completely relies on self-reported consumption, exercise activities and health has to be mentioned. We acknowledge that any form of observational data is always to be preferred, and provides greater validity. However, self-reported data are not uncommon in this field of research, and -particularly under COVID-19 restrictions-often necessary. The construction of the survey, of the online administration, and the strict deletion of outliers that showed extreme scores, results in the trustworthy data set that we used for the analyses in this paper.

We have collected self-reports on six measurement occasions, and from these conclude whether or not any specific behaviour changed over time. The *change* itself was not self-reported, which may increase its validity compared to when the *change* itself would have been self-reported.

There were relatively low numbers of respondents in the 'unhealthy changers' and 'healthy changers' group, showing that the majority of the respondents reported no change. This means that conclusions concerning these groups are not very strong. They serve as an indication that some of the findings reported may need future studies to focus on.

The way the questions were posed to the respondents appears to have led to some confusion, as inferred from a zero reporting of drinks and as further indicated in section 2.3. As a result, we had to delete some questions from the data set. This suggests that it is vital to always pose very clear, understandable questions, in particular in a long survey like this one. In particular when one relies on respondents to give rather detailed answers concerning food categories, amounts consumed or exercise types and durations.

Some comparisons to respondents' pre-COVID-19 situation cannot be made, other than by speculation. In particular the lack of information concerning the consumption of (non) essential products before the lockdown period casts doubt on some of the potential findings.

5. Conclusion

The Dutch COVID-19 lockdown has effects onto food choice, exercising and health, although the picture that arises from the analyses is rather complicated. No effects on self-assessed physical health were found, which may cast some doubt on this measurement probing anything other than 'self-assessed health'.

Comparison with studies in other countries shows results that sometimes point in the same, sometimes in other directions. This is likely a result of differences in the severity of the type of lockdown imposed, and possibly too of differences in sample characteristics and the specific ways the data were collected.

Overall the healthy change group seems to couple a healthy diet to healthy exercise habits. We cannot know if this group already displayed a healthy lifestyle pre-lockdown or that they changed into a healthier lifestyle upon the start of the lockdown. Further research will have to elucidate this. Knowing what drives a healthy lifestyle, or a change to a healthy lifestyle, by this group, may help to set up measures or advice to counter a decrease in healthy lifestyle of other groups.

An advice to health authorities, based on this and other studies, to prepare for future effects of a lockdown onto food consumption, and exercising and possibly through that onto health, seems worthwhile. In particular the overall finding of a decline in self-assessed mental health, calls for such preparation. It also calls for more research into the mental effects of a lockdown.

Findings as from this study can be important when developing public health recommendations to increase healthy food choice during lockdown -or in other situations producing psychological stress. Additional analyses and additional studies will be needed to reveal hitherto hidden or unexpected relationships between respondents' psychology, lifestyle, consumption patterns and health.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2021.105720.

Author contributions

All authors jointly devised the study; GvB performed most of the statistical analysis; GD and GvB drafted the paper; GD wrote most of the paper; RdW, EZ, DK, MV provided relevant input to parts of the paper; MV supervised the research project this study is part of.

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Declaration of interest

Authors GD, GvB, RdW, MV do not report any competing interest. EHZ is employee of Unilever Foods Innovation Centre Wageningen, The Netherlands, a company which produces and markets food, home and personal care products. DK is employee of Kikkoman Research, Europe, Wageningen, The Netherlands, a company which produces and markets food products.

Ethical statement

The data collection was not invasive (online survey) and is in line with the ethical standards of Wageningen University and Research. Therefore, data collection has been performed in accordance with the declaration of Helsinki. After explaining the study details, participants could participate in the online survey which was not invasive and anonymous. Participants provided consent before starting with the first of the six questionnaires. Participants could stop filling in their answers at any moment during a survey, or during the running time of the study.

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