

# Impact of physical activity on COVID-19-related symptoms and perception of physical performance, fatigue and exhaustion during stay-at-home orders

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## ABSTRACT

**Objectives** The measures used to contain the COVID-19 pandemic led to a significant reduction in physical activity. Due to the health benefits of exercise, recommendations were made for lockdown restrictions. Within the CoCo-Fakt study (Cologne-Corona counselling and support for index and contacts during the quarantine period), we aimed to determine how these recommendations were implemented, especially by individuals who were officially quarantined due to an infected persons (IPs) or as close contacts (CPs), and how this affected their physical and psychological condition.

**Methods** From 12 December 2020 to 6 January 2021, all IPs and CPs registered by Cologne's public health department up to the survey period were surveyed online. Of 10 547 people in the CoCo-Fakt sample, 8102 were integrated into the current analysis. In addition to demographic data, information regarding COVID-19-specific and persistent symptoms or conditions and their association with the amount and type of exercise and screen time before and during the quarantine were collected.

**Results** Before quarantine, 66.9% of IPs and 69% of CPs were physically active; during quarantine, this decreased by 49.4% in IPs depending on the course of the disease and by 30.6% in CPs. Physically active IPs and CPs felt less exhausted and more fit during their quarantine periods than those who were inactive, with active IPs significantly less likely to report prolonged physical and psychological symptoms than their more sedentary counterparts.

**Conclusion** Given the acute and long-term positive effects of exercise on quarantined individuals, corresponding recommendations should be communicated to those affected, especially CPs. Recommendations for IPs depend on their health status.

## INTRODUCTION

The COVID-19 pandemic has had an enormous impact on human life worldwide, with considerable economic, health and psychosocial consequences.<sup>1</sup> In the absence of possible therapeutic countermeasures and

## Key messages

### What is already known

⇒ Physical activity is considered a protective factor for non-communicable diseases, but due to the restrictions of daily life, less physical activity was observed during the pandemic.

### What this study adds

⇒ Physical activity decreased during stay-at-home orders by 49.4% in infected persons and 30.6% in contact persons. People who were active during quarantine felt fitter, less tired and less exhausted during this period.

### How this study might affect research, practice or policy

⇒ The benefits of exercise should be repeatedly emphasised during subsequent medical care, and people should be encouraged to exercise or exercise more.

vaccinations that only became available in Germany at the end of 2020, various contact restrictions and curfews were imposed to protect high-risk groups and prevent an overload of the health system. Due to these restrictions, the pandemic has had an enormous impact on the general population's daily lives and mental health. Several studies described an increase in loneliness, symptoms of anxiety and depression.<sup>2,3</sup> Physical activity is an important measure for maintaining mental health.<sup>4</sup> Therefore, during a lockdown or political regulations that restricted contact in public and private spaces, especially during an individual quarantine ordered by the authorities, exercise and physical activity were and remained advised.<sup>4</sup> Faulkner *et al*<sup>5</sup> showed that people who exercised more during the initial COVID-19-related restrictions had better mental health and well-being than those who



did not. Sallis *et al*<sup>6</sup> also showed that physically inactive infected individuals had a more severe disease course than active ones. Inevitably, however, the lockdown has led to a reduction in physical activity in various ways; this is due in part to the closure of gyms, swimming pools and club facilities, although everyday activities have also been affected. Data from more than 450 000 people from 187 countries indicated a 27% reduction in daily steps, equivalent to a 1432-step decrease.<sup>7</sup> Parallel to the reduction in physical activity, increased media time was observed in various studies.<sup>8,9</sup> However, numerous recommendations regarding physical activity have been made (eg, by the WHO), which can and should be (implemented at home<sup>10–12</sup>) to counteract the negative effects of lockdown or quarantine measures (online supplemental table S1). Naturally, infected persons (IPs) are assumed to be not or less active. However, the symptomatology in the context of COVID-19 disease is very heterogeneous. Ma *et al*<sup>13</sup> showed in a recent meta-analysis covering 29 776 306 individuals undergoing testing that the pooled percentage of asymptomatic infections among the confirmed population was 40.5%.

So far, however, there have been no studies of the type, frequency or intensity of exercise undertaken by individuals in officially ordered quarantine like IPs and their close contacts (CPs). A stay-at-home order restricts the radius of affected persons even more. Moreover, such a requirement may be even more psychologically stressful than general lockdown measures. In addition, a violation of this order in Germany was punishable by severe financial penalties.<sup>14</sup> Therefore, the Cologne-Corona (CoCo)-Fakt study<sup>15</sup> (CoCo counselling and support for IPs and CPs during the quarantine period; author's translation) analysed physical activity before and meanwhile officially ordered quarantine among IPs or CPs and how this affected their subjective perceptions of physical performance, fatigue and exhaustion during this time, and the (long-term) symptoms of IPs.

## METHODS

### Study design

Since detecting the first COVID-19 infection in Cologne at the end of February 2020, all laboratories have reported all those who have tested positive for SARS-CoV-2 to the Cologne public health department. These people were contacted, registered in DiKoMa,<sup>16</sup> the Cologne Health Department's software tool, questioned in a standardised manner regarding, among others, possible routes of infection, pre-existing conditions and other risk factors. In addition, CPs were identified so that they could also be quarantined. In the survey period of this study, CPs were defined according to criteria established by the German Robert Koch Institute and European Centre for Disease Prevention and Control, among others, as individuals who had had contact with an IP for more than 10–15 min at a distance of less than 2 m and without sufficient protection.<sup>17</sup> Based on the German Infection Protection Act, the quarantine period during the survey period was

usually 10–14 days from the onset of symptoms or the positive test in IPs and from the last contact in CPs.

### Sampling and study population

From this dataset, all people registered in DiKoMa up to 9 December 2020 (n=36 498) were extracted; people under 16 years of age, people with missing informed consent forms, non-compliant individuals, deceased patients and those who were in medical or nursing facilities or quarantined for other reasons (eg, travel returnees) were excluded. The detailed study design has already been published.<sup>15</sup> From 12 December 2020 to 6 January 2021, the link to the online survey was sent via email to 33 699 people, 13 057 of whom responded by clicking. Twice, after 5 and 7 days, a reminder was sent asking for participation in the survey.<sup>15</sup> After the data were cleaned, only individuals for whom information on pre-pandemic physical activity behaviour was available were integrated into this evaluation (n=8102; [figure 1](#)). On average, the quarantine period was over for 99.6 days (SD=87.5; see [table 1](#)). 17.7% (n=1278) participants were in quarantine during the first pandemic wave in Germany (February to April 2020), 17.0% (n=1228) between May and September and 65.4% (n=4632) during the second pandemic wave (October to December 2020; missing n=864).

### Survey items

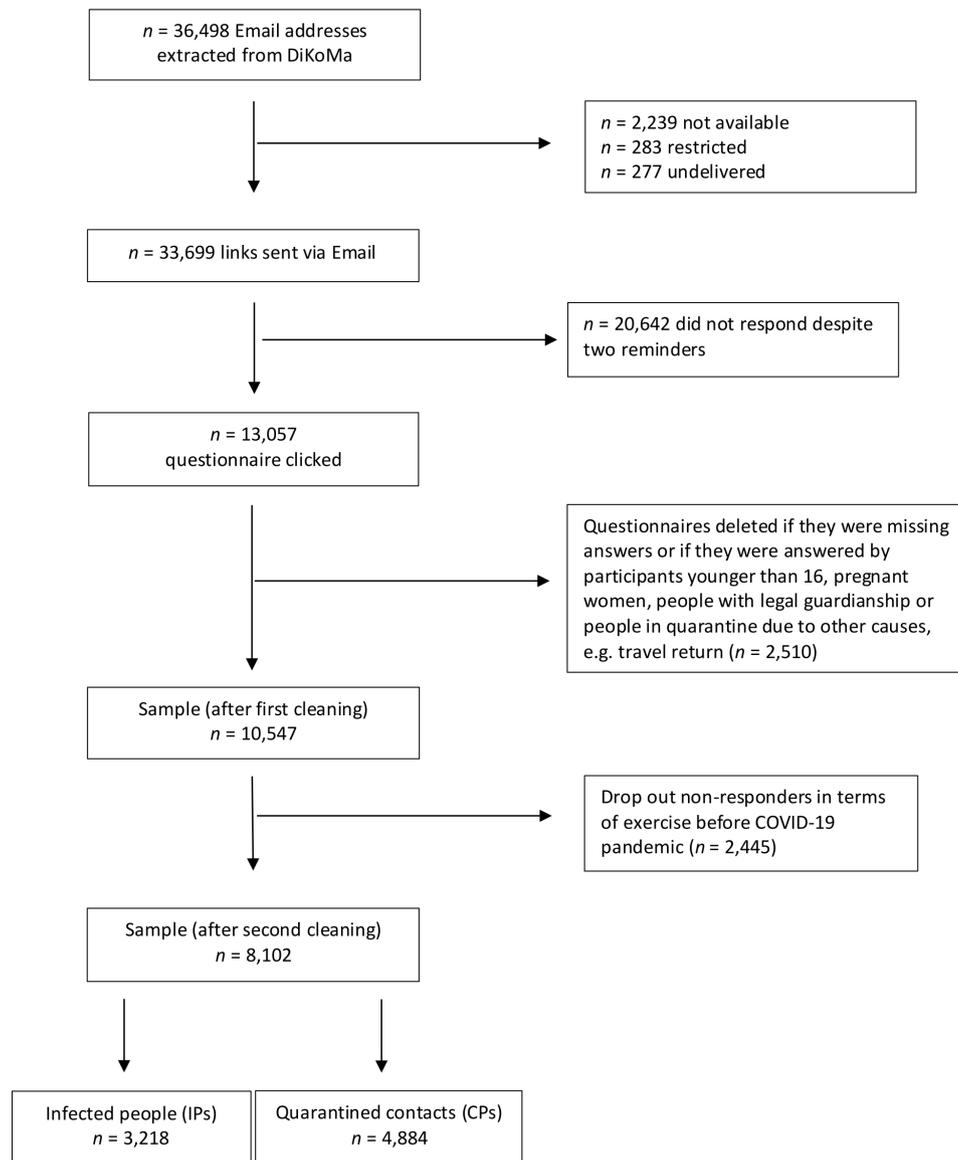
The following demographic data were assessed and included in this analysis: age, sex, presence or absence of chronic diseases (diabetes, cardiovascular diseases, orthopaedic disorders, etc), living situation (whether it had a balcony or garden) and family/household structure (partnership, married; children). We designated participants' socioeconomic status (SES) as high, middle or low based on the categorisation in the German Health Update 2009.<sup>18</sup> Those who spoke a language other than German at home were classed as having a migrant background.

### Patient and public involvement

The research questions and methods were developed based on the literature.<sup>5,6,15,19</sup> To optimise the survey and align it according to the research questions, affected persons from the personal environment were first approached and asked to answer and assess the draft. From this collective, 20 additional affected persons were recruited by snowball sampling, and the feasibility and duration were tested. Since the online survey is anonymised, no individual results are given to the patients. However, the results and the recommendations or support systems developed from them will be communicated via the press and the city's homepage and the health department. Therefore, future quarantined persons will benefit from our study if our recommendations are considered in settings that influence their individual needs, worries and coping strategies.

### Quarantine-specific situation

The assessment of the quarantine-specific situation on physical performance and fitness and state of



**Figure 1** Study population flow chart.

exhaustion and/or fatigue (tiredness) was recorded with the following questions:

- ▶ I feel/felt limited in my physical performance.
- ▶ I feel/felt exhausted.
- ▶ I feel/felt tired.
- ▶ I always feel/felt physically fit.

Responses ranged from ‘not applicable at all’ (1) to ‘fully applicable’ (6) and were grouped into yes (1, 2), no (5, 6), partly (3, 4).

### Symptoms

The assessment of COVID-19-specific and postinfection symptoms was recorded only in IPs, who were asked to describe the course of their disease according to the following options:

#### Physical symptoms

- ▶ Completely symptom-free, clustered as asymptomatic.
- ▶ Mild symptoms, clustered as mild progression.

- ▶ 1–3 days of clear symptoms clustered as a moderate course.
- ▶ A severe feeling of illness, clustered as a severe course.

#### Psychological symptoms

- ▶ Illness-related anxiety, psychological symptoms.

#### Free-text answers

- ▶ Responses from this category were assigned to the clusters as mentioned above. For example, anxiety is related to the ‘psychological symptoms’ category, and hospitalisation is related to the ‘severe course’ category.

At the time of the survey, no uniform definition of long COVID-19 was available.<sup>20</sup> Therefore, assessments of long-lasting and persistent symptoms (eg, weeks of reduced performance, fatigue, reduced concentration, memory disorders, permanent loss of smell and taste, hair loss and so on were based on the free responses).

**Table 1** Population characteristics

|   | Total       | IP          | CP           | Differences between IPs and CPs/p value |
|---|-------------|-------------|--------------|---|
| Sample n (%)  | 8102 (100)  | 3218 (39.7) | 4884 (60.3)  |   |
| Sex n (%)   |             |             |              |   |
| Male  | 3081 (38.4) | 1351 (42.5) | 1730 (35.7)  | <0.001*                                 |
| Female  | 4939 (61.6) | 1828 (57.5) | 3111 (64.3)  |   |
| Mean age (years; mean and SD)†  | 41.7 (14.3) | 42.8 (14.3) | 41.0 (14.2)  | <0.001‡                                 |
| Migration background n (%)  |             |             |              |   |
| No  | 7573 (95.0) | 2936 (93.3) | 4637 (96.1)  | <0.001*                                 |
| Yes   | 399 (5.0)   | 211 (6.7)   | 188 (3.9)    |   |
| Education n (%)†  |             |             |              |   |
| High  | 6504 (80.8) | 2537 (79.4) | 3967 (81.7)  | 0.011*                                  |
| Middle  | 1478 (18.4) | 623 (17.6)  | 855 (17.6)   |   |
| Low   | 70 (0.9)    | 36 (1.1)    | 34 (0.7)     |   |
| Family/household structure n (%)  |             |             |              |   |
| Live alone  | 2264 (28.6) | 860 (27.4)  | 1405 (29.4)  |   |
| No of adults (mean and SD)  | 1.60 (0.95) | 1.56 (0.93) | 1.62 (0.94)  | 0.027‡                                  |
| Partnership/married   | 5661 (71.4) | 2282 (72.6) | 3379 (70.6)  | 0.054*                                  |
| Children yes (%)  | 2534 (43.8) | 1465 (45.7) | 2069 (42.5)  | 0.004*                                  |
| No of children aged <3 years (mean and SD)                                | 1.16 (0.39) | 1.16 (0.43) | 1.16 (0.36)  | 0.824‡                                  |
| No of children aged 3 to <6 years (mean and SD)                           | 1.16 (0.39) | 1.17 (0.40) | 1.15 (0.39)  | 0.484‡                                  |
| No of children aged 6 to <10 years (mean and SD)                          | 1.23 (0.47) | 1.21 (0.45) | 1.24 (0.49)  | 0.609‡                                  |
| No of children aged 10 to <14 years (mean and SD)                         | 1.18 (0.40) | 1.18 (0.38) | 1.18 (0.41)  | 0.877‡                                  |
| No of children aged 14 to <16 years (mean and SD)                         | 1.10 (0.30) | 1.07 (0.28) | 1.10 (0.32)  | 0.310‡                                  |
| Living situation with garden and/or balcony (%)                           |             |             |              |   |
| Yes   | 6841 (84.7) | 2746 (85.6) | 4095 (84.1)  | 0.067*                                  |
| No  | 1239 (15.3) | 463 (14.4)  | 776 (15.9)   |   |
| Chronic diseases yes, n (%)   | 1781 (22.8) | 750 (24.2%) | 1031 (21.8)  | 0.016*                                  |
| Quarantine duration days mean (SD)  | 11.8 (4.6)  | 12.1 (4.9)  | 11.6 (4.3)   | <0.001‡                                 |
| Period between quarantine and answering the questionnaire, days mean (SD) | 99.6 (87.6) | 97.1 (87.5) | 101.4 (86.1) | 0.036‡                                  |
| * $\chi^2$ test.  |             |             |              |   |
| †Rounding error.  |             |             |              |   |
| ‡Unpaired t-test.   |             |             |              |   |
| CP, contact person; IP, infected person.                                  |             |             |              |   |

### Physical activity

Lifestyle was recorded in physical activity and sedentary behaviour pre-pandemic and during the mandated quarantine period in both IP and CP.

- Were you active in sports before the pandemic period/during the quarantine period?
- Yes/no.

If yes

- Type of exercise.
- How often per week.
- For how many minutes per activity.
- Independently.
- In a club.
- In a gym/with a coach.
- Media/online based.
- Other.

**Table 2** Types of exercise and classifications

| Classification                         | Example  |
|--|--|
| (1) Endurance                          | Triathlon, water fitness, hiking, Nordic walking         |
| (2) Strength training (plus endurance) | Fitness, circuit training, boxing, karate, rowing        |
| (3) Ball sports                        | Soccer, volleyball, Spikeball                            |
| (4) Coordination and flexibility       | Hot Yoga, Pilates, dancing, Zumba, Hula Hoop, gymnastics |
| (5) Body and mind                      | Meditation/yoga, wing-tsun, tai chi                      |
| (6) Activities of daily living         | Household, dog walking, gardening                        |
| (7) Others                             | Archery, chess, horse riding, surfing                    |

First, binary variables were formed based on whether participants engaged in sporting activities before the pandemic and during the quarantine period and whether they achieved the recommended 150 min of moderate activity per week. In addition, a qualitative analysis of the forms of exercise and types of sport performed was carried out based on the classifications defined by Ainsworth *et al* (table 2).<sup>21</sup>

### Sedentary activities

The survey recorded sedentary activities in minutes per week in professional and private spheres. The survey also explicitly asked about media time. In the context of the present analysis, only screen time in the private context was used.

- ▶ How many hours per week did you usually spend sitting before the COVID-19 pandemic/during the quarantine period? (eg, in the car, on the sofa, while watching television and so on).
  - At work
    - Office work without screen work.
    - Office work with screen work (eg, computer work).
    - Driving a car.
    - Other.
  - In your private environment
    - Computer/phone/tablet.
    - TV.
    - Driving a car.
    - Reading/writing
    - Hobbies (sewing, handicrafts, etc).
    - Other.

### Statistics

For the descriptive statistics, absolute and relative frequencies for categorical variables and mean values (M) and SDs for continuous variables were calculated. Associations between participants' characteristics (eg,

age, gender) and outcomes were examined using  $\chi^2$  tests and independent t-tests.

Binary and multiple logistic regressions were used to analyse predictors of subjective feelings in IPs and CPs during isolation and long-lasting symptoms in IPs. For this purpose, ORs and 95% CIs of potential determinants of subjective perceptions/symptoms were calculated, taking age, gender, the presence of chronic diseases and level of prepandemic physical activity and screen time into account. Other variables, such as migration background, family/household structure, residential situation, SES, duration of quarantine, the period between quarantine and answering the questionnaire, were excluded from the models if they were not significant. Model fits were checked using pseudo R<sup>2</sup> (Nagelkerke R<sup>2</sup>). The level of significance ( $\alpha$ ) was set at=0.05. The analyses were carried out with the statistical software SPSS V.27.0 (IBM).

## MAIN ANALYSIS

### Subjects

A total of 3218 IPs and 4,884 CPs could be integrated into this analysis. The study population had a mean age of 41.7 years (SD=14.3) and was 61.6% female (table 1). On average, the duration of quarantine was 11.8 (SD=4.6) days, which varied based on differences in the applicable guideline. The data for the entire group and subdivided according to IP and CP are shown in table 1.

### Physical activity/screen time

Before the pandemic, 5522 people (68.2%) reported being physically active. 66.4% reached the 150 min of moderate activity or more per week recommended by the guidelines. During quarantine, only 2439 (30.1%) were physically active. 46.3% reported reaching the guidelines. IPs were significantly less active during quarantine than CPs (17.5% vs 38.4%, respectively;  $p<0.001$ ; table 3). In both groups, those who were already regularly active before the pandemic were more active during quarantine ( $p<0.001$  in each case).

Overall screen time increased from 3.0 (SD 2.8) hours per day to 3.4 (SD 3.3; table 3). There was a significant increase in both groups, which was more pronounced in the CP group (table 3,  $p<0.05$  in each case).

### Types of exercise

Before the pandemic, endurance sports were the most common type of exercise participants engaged in, followed by strength sports/strength endurance (see table 4). During the quarantine, there was a reduction in overall time spent exercising and a clear shift from endurance sports towards strength and coordination training (see table 4). Even though online workouts were not high overall, they were used more frequently by CPs (n.s., table 4).

### Subjective perceptions during the quarantine period

A total of 1684 people (23.0%) stated that they always felt fit during quarantine; 4554 (61.4%) felt limited in their

**Table 3** Physical activity (PA), exercise and screen time before the COVID-19 pandemic and during quarantine

|   | Total (n=8102) | IP (n=3218) | CP (n=4884) | Differences between IPs and CPs/p value |
|---|----------------|-------------|-------------|---|
| Exercise before COVID-19 19 pandemic n (%) <sup>*</sup>                       |                |             |             |   |
| Yes   | 5522 (68.2)    | 2153 (66.9) | 3369 (69.0) | 0.050†                                  |
| No  | 2580 (31.6)    | 1065 (33.1) | 1515 (31.0) |   |
| Exercise during quarantine n (%)  |                |             |             |   |
| Yes   | 2439 (30.1)    | 563 (17.5)  | 1876 (38.4) | <0.001†                                 |
| No  | 5043 (62.2)    | 2445 (76.0) | 2598 (53.2) |   |
| No information  | 620 (7.7)      | 210 (6.5)   | 410 (8.4)   |   |
| Differences between prepandemic and quarantine exercise/p value <sup>*</sup>  | <0.001         | <0.001      | <0.001      |   |
| Meet PA guidelines before COVID-19 19 pandemic n (%)‡                         |                |             |             |   |
| Yes   | 3453 (66.4)    | 1332 (65.8) | 2121 (67.7) | 0.514†                                  |
| No  | 1749 (33.6)    | 691 (34.2)  | 1058 (33.)  |   |
| Meet PA guidelines during quarantine n (%)§                                   |                |             |             |   |
| Yes   | 885 (46.3)     | 203 (44.8)  | 682 (46.8)  | 0.457†                                  |
| No  | 1025 (53.7)    | 250 (55.2)  | 775 (53.2)  |   |
| Differences between prepandemic and quarantine findings/p value†              | <0.001         | <0.001      | <0.001      |   |
| Screen time before COVID-19 19 pandemic                                       |                |             |             |   |
| Screen time h/day mean (SD)   | 3.0 (2.8)      | 2.8 (2.8)   | 3.0 (2.8)   | 0.016¶                                  |
| Screen time during quarantine   |                |             |             |   |
| Screen time h/day mean (SD)   | 3.4 (3.3)      | 3.0 (3.1)   | 3.7 (3.4)   | <0.001¶                                 |
| Differences between prepandemic and quarantine findings/p value <sup>**</sup> | <0.001         | <0.001      | <0.001      |   |
| Number of values in variables with missing data.                              |                |             |             |   |
| *Rounding error.  |                |             |             |   |
| † $\chi^2$ test.  |                |             |             |   |
| ‡n=2,900.   |                |             |             |   |
| §n=6,192.   |                |             |             |   |
| ¶Unpaired t-test.   |                |             |             |   |
| **Paired t-test.  |                |             |             |   |
| CP, contact person; IP, infected person.                                      |                |             |             |   |

physical performance, 3271 (44.4%) felt exhausted and 3563 (48.4%) felt tired. IPs differed significantly from the CPs in all areas (table 5).

Responses ranged from 'not applicable at all' (1) to 'fully applicable' (6) and were grouped into yes (1, 2), no (5, 6), partly (3, 4).

For both groups, the analysis showed that those who were physically active during quarantine felt physically fitter, less limited in their physical performance, less tired and less exhausted than those who were physically inactive during quarantine. This was influenced by age, sex, pre-existing conditions and sports participation before the pandemic; for IPs, this was also influenced by whether symptoms were present. A detailed table of regression results appears in online supplemental material S3 (figure 2A,B).

### Symptoms

Of the IPs, 503 (18.4%) reported being asymptomatic, 848 (31.1%) were mildly symptomatic, and 835 (30.6%) were moderately symptomatic. Severe symptoms were reported by 19.9% (n=544). Psychological symptoms were reported by 11.6% of IPs (n=407); these included disease-related anxiety and depressed mood. At least 139 IPs (4.0%) reported long-term complaints at the time of the survey, including exhaustion, loss of taste and smell, impaired performance, lack of concentration and persistent headaches (table 6).

Considering the cross-sectional design, physical activity was found to predict the severity of physical symptoms and the occurrence of psychological and persistent symptoms. Physically active IPs were less likely to display COVID-19-induced symptoms during quarantine (see figure 3). The effect

**Table 4** Prepandemic sport types and exercise during quarantine; multiple answers were possible

| Type of exercise                       | Prepandemic    | During quarantine | Prepandemic    | During quarantine |
|--|----------------|-------------------|----------------|-------------------|
|  | IP nomination  |                   | CP nomination  |                   |
|  | Total 3210 (%) | Total 542 (%)     | Total 5071 (%) | Total 1820 (%)    |
| (1) Endurance                          | 1.290 (40.2)   | 122 (22.5)        | 1.906 (37.6)   | 364 (20)          |
| (2) Strength training (plus endurance) | 908 (28.3)     | 183 (33.8)        | 1.368 (27)     | 700 (38.5)        |
| (3) Ball sports                        | 343 (10.7)     | 11 (2)            | 580 (11.4)     | 40 (2.2)          |
| (4) Coordination and flexibility       | 533 (16.6)     | 215 (39.7)        | 1.009 (19.9)   | 677 (37.2)        |
| (5) Body and mind                      | 3 (0.1)        | 1 (0.2)           | 9 (0.2)        | 0 (0)             |
| (6) Activities of daily living         | 33 (1)         | 4 (0.7)           | 42 (0.8)       | 24 (1.3)          |
| (7) Other(s)                           | 100 (3.1)      | 6 (1.1)           | 157 (3.1)      | 15 (0.8)          |
| Online exercise programmes/workouts    |                |                   |                |                   |
| Nomination                             | Total 3225 (%) | Total 642 (%)     | Total 5230 (%) | Total 2183 (%)    |
| Yes                                    | 141 (4.3)      | 130 (20.2)        | 225 (4.3)      | 496 (22.7)        |

CP, contact person; IP, infected person.

increased with symptom severity. Thus, active IPs were 34% less likely to have mild physical symptoms, 61% less likely to have moderate physical symptoms and 74% less likely to have severe physical symptoms than inactive IPs. Active IPs were 52% less likely to have psychological symptoms and 76% less likely to have persistent symptoms (figure 3).

## DISCUSSION

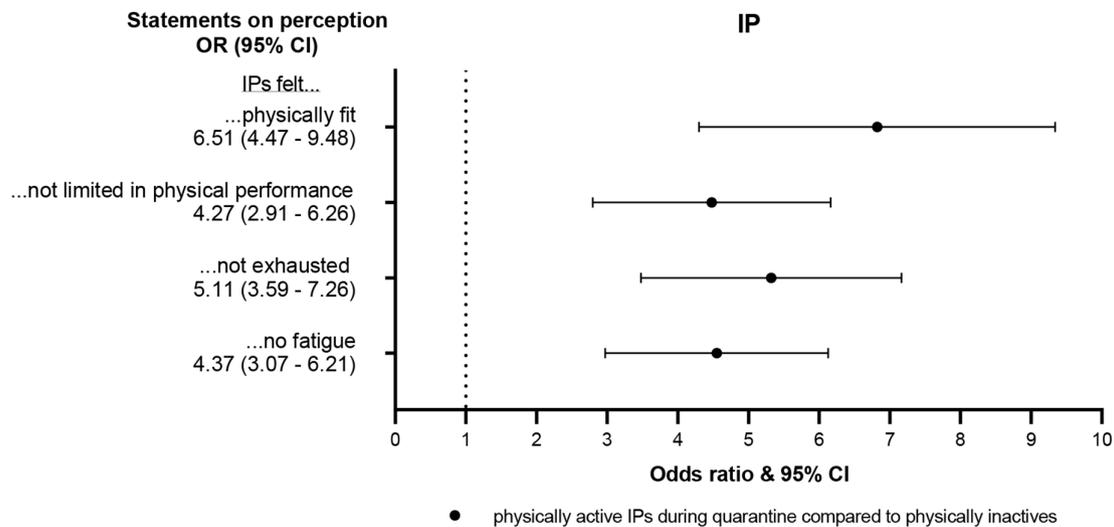
### Main findings

This is the first study to analyse the associations between subjective perceptions of physical fitness, exhaustion and fatigue in IPs and CPs under legally enforced quarantine

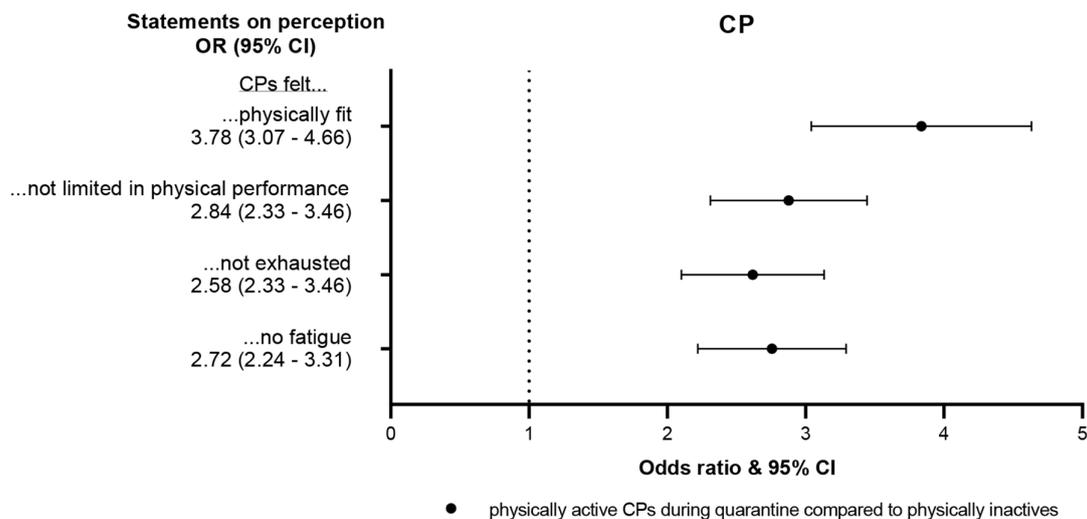
**Table 5** Subjective perceptions during the quarantine period

|  | Total (n=8102) | IP (n=3218)  | CP (n=4884)  | Differences between IPs and CPs / p value |
|--|----------------|--------------|--------------|---|
| 'I always feel/felt physically fit.**†             |                |              |              |   |
| Yes  | 1684 (23.0%)   | 343 (11.8%)  | 1341 (30.5%) | <0.001‡                                   |
| Partly   | 2191 (30.0%)   | 563 (19.3%)  | 1628 (37.0%) |   |
| No   | 3438 (47.0%)   | 2012 (69.0%) | 1426 (32.4%) |   |
| 'I feel/felt limited in my physical performance.‡§ |                |              |              |   |
| Yes  | 4554 (61.4%)   | 2237 (74.9%) | 2317 (52.3%) | <0.001‡                                   |
| Partly   | 1393 (18.8%)   | 412 (13.8%)  | 981 (22.1%)  |   |
| No   | 1468 (19.8%)   | 336 (11.3%)  | 1132 (25.6%) |   |
| 'I feel/felt exhausted.**¶                         |                |              |              |   |
| Yes  | 3271 (44.4%)   | 2026 (68.3%) | 1245 (28.3%) | <0.001‡                                   |
| Partly   | 1691 (23.0%)   | 478 (16.1%)  | 1213 (27.5%) |   |
| No   | 2406 (32.7%)   | 461 (15.5%)  | 1945 (44.2%) |   |
| 'I feel/felt tired.**                              |                |              |              |   |
| Yes  | 3563 (48.4%)   | 2064 (69.8%) | 1499 (34.1%) | <0.001‡                                   |
| Partly   | 1685 (22.9%)   | 477 (16.1%)  | 1208 (27.5%) |   |
| No   | 2106 (28.6%)   | 417 (14.1%)  | 1689 (38.4%) |   |
| *Rounding error.                                   |                |              |              |   |
| †n=789.  |                |              |              |   |
| ‡ $\chi^2$ test.                                   |                |              |              |   |
| §n=687.  |                |              |              |   |
| ¶n=734.  |                |              |              |   |
| **n=748.   |                |              |              |   |
| CP, contact person; IP, infected person.           |                |              |              |   |

A



B



**Figure 2** Impact of physical activity on IPs (A) and CPs (B) subjective perceptions; multiple logistic regression, adjusted for age, gender, chronic disease status, physical activity before quarantine and screen time. CPs, close contacts; IPs, infected persons.

imposed by the health department. In our cohort, screen time increased by about 10% among IPs and about 20% among CPs during the quarantine period. Overall, only about one-third of participants reported being physically active during this period, regardless of family, respectively, household structure or the presence of a garden or balcony (data not shown). Due to infection with COVID-19 and the associated symptoms, IPs were less active during the quarantine period (only about 18%, compared with about 67% before the pandemic) than

the CPs (about 39%, compared with about 69% before the pandemic). While the reduction in physical activity was related to symptoms in the IPs, there were no disease-related restrictions for CPs. Active CPs, however, clearly benefited during the quarantine period with regard to their subjective perceptions: they felt fitter, less restricted in their ability to perform, less exhausted and less tired than inactive CPs. They mainly used riding exercise bikes, strength training with home dumbbells or dancing as forms of exercise. There was an overall

**Table 6** Symptoms of IPs during and after quarantine

|                        |              | Frequency (%) |
|------------------------|--------------|---------------|
| Somatic symptoms*      | Asymptomatic | 503 (18.4)    |
|                        | Mild         | 848 (31.1)    |
|                        | Moderate     | 835 (30.6)    |
|                        | Severe       | 544 (19.9)    |
|                        | Total        | 2730†         |
| Psychological symptoms | Yes          | 341 (11.6)    |
|                        | No           | 2391 (88.4)   |
|                        | Total        | 2732‡         |
| Persistent symptoms    | Yes          | 118 (4.0)     |
|                        | No           | 2612 (96.0)   |
|                        | Total        | 2730§         |

Number of values in variables with missing data.  
 \*Rounding error.  
 †n=488.  
 ‡n=486.  
 §n=488.  
 IP, infected person.

shift from endurance sports pre-pandemic to strength and flexibility exercises that can be done at home during the pandemic. Surprisingly few participants used online exercise programmes.

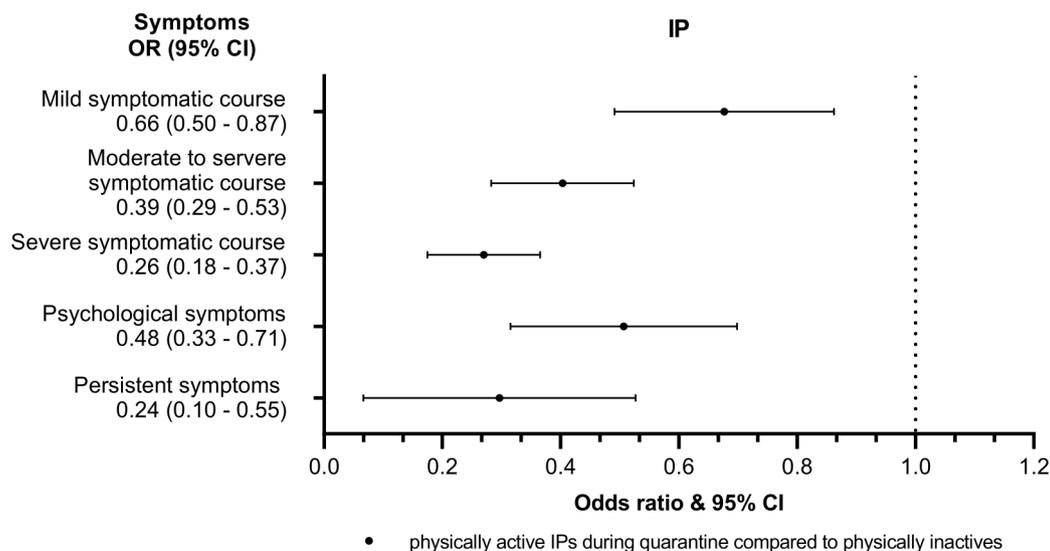
Regarding the benefits of home-based exercise on physical fitness in healthy older adults, Chaabene *et al*<sup>22</sup> described improvements in muscle strength, muscular endurance and balance in a systematic review. More frequent training sessions (>3 per week) and longer sessions (>30 min per session) had greater effects. Due to the positive correlations with mental health, CPs without

symptoms should be advised to exercise regularly and limit media use/screen time.<sup>23 24</sup>

IPs who had symptoms were understandably less active during the quarantine period. Active IPs reported fewer limitations such as lesser physical performance, exhaustion, fatigue and persistent symptoms than IPs who were not active during the quarantine period. These two aspects are, of course, mutually dependent so that no causal association can be concluded. Thus, based on cross-sectional analysis, we can only speculate about a possible preventive effect of exercise in the context of Long COVID-19.<sup>25</sup> In addition, it must be decided individually and, depending on the severity of the disease, to what extent IPs should be advised to exercise during the quarantine period.<sup>26</sup> Acute infections are generally a contraindication to physical activity. Asymptomatic patients can be advised to do very light physical exercises, such as yoga and flexibility exercises. To prevent complications such as myocarditis or postacute COVID-19 syndrome, symptomatic patients should start light exercise again about 7 days after symptoms have subsided, depending on their severity.<sup>26</sup> If symptoms reoccur, exercise should be discontinued, and medical advice sought if necessary.

### Strength and limitations

A great strength of this study is a large amount of data, systematically collected by the largest health department in Germany and consisting exclusively of data on quarantined people. However, people with a significantly low proportion of education or migration background were significantly less likely to respond to these interviews despite the availability of translated questionnaires. In addition, respondents had undergone quarantine anywhere between 1 week and 9 months before the survey; the different intervals could have changed the subjective assessment and influenced the data. The majority of



**Figure 3** Impact of physical activity during quarantine on perceived symptoms of IPs; multiple logistic regression, adjusted for age, gender, chronic disease status and physical activity before the quarantine. IPs, infected persons.

participants were quarantined during the second wave of the pandemic (October–December 2020). An advantage is that they probably remember their situation more clearly; a disadvantage is that this limits the significance of possible persistent symptoms. The survey's cross-sectional nature also limits its validity. Unfortunately, inhibiting and supporting factors for movement opportunities were also not recorded; in another survey examining overweight families, space and digital equipment requirements were mentioned.<sup>14</sup> We cannot determine how these factors played a role in this survey; however, participants' living situation had no relevant influence on their exercise. Therefore, it is recommended that these factors be investigated in further surveys.

## CONCLUSION

In summary, taking selection bias and the methodological limitations of a cross-sectional analysis into account, this study showed that being physically active increases the subjective well-being of IPs and CPs and can thus contribute to their ability to positively adjust to stressful life situations such as quarantine measures due to illness or contact. However, it also became clear that the majority of both IPs and CPs were significantly less physically active during stay-at-home orders. Therefore, depending on an individual's physical condition, more exercise should be advised during the quarantine period, especially for asymptomatic CPs. Throughout the pandemic, the number of offers for exercise-related digital content and fitness training increased. It could contribute to increased exercise and associated well-being.<sup>27</sup> Therefore, such issues could be addressed during the health department's monitoring of quarantined individuals but also by general practitioners.

Because exercise is important for physical and mental health, the benefits of exercise should be repeatedly emphasised during subsequent medical care, and people should be encouraged to exercise or exercise more.

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## REFERENCES

- Rommel A, von der Lippe E, Plaß D. The COVID-19 disease burden in Germany in 2020. *Dtsch Arztebl Int* 2021;118:145–51.
- Sinanović O, Muftić M, Sinanović S. COVID-19 pandemic: neuropsychiatric comorbidity and consequences. *Psychiatr Danub* 2020;32:236–44.
- Violant-Holz V, Gallego-Jiménez MG, González-González CS, et al. Psychological health and physical activity levels during the COVID-19 pandemic: a systematic review. *Int J Environ Res Public Health* 2020;17:9419.
- Füzéki E, Groneberg DA, Banzer W. Physical activity during COVID-19 induced lockdown: recommendations. *J Occup Med Toxicol* 2020;15:25.
- Faulkner J, O'Brien WJ, McGrane B, et al. Physical activity, mental health and well-being of adults during initial COVID-19 containment strategies: a multi-country cross-sectional analysis. *J Sci Med Sport* 2021;24:320–6.
- Sallis R, Young DR, Tartof SY, et al. Physical inactivity is associated with a higher risk for severe COVID-19 outcomes: a study in 48 440 adult patients. *Br J Sports Med* 2021;55:1099–105.
- Tison GH, Avram R, Kuhar P, et al. Worldwide effect of COVID-19 on physical activity: a descriptive study. *Ann Intern Med* 2020;173:767–70.
- Di Renzo L, Gualtieri P, Pivari F, et al. Eating habits and lifestyle changes during COVID-19 lockdown: an Italian survey. *J Transl Med* 2020;18:229.
- Souza TC, Oliveira LA, Daniel MM. Lifestyle and eating habits before and during COVID-19 quarantine in Brazil. *Public Health Nutr* 2021;1–11.
- Europe WHOROF. How to stay physically active during COVID-19 self-quarantine, 2020. Available: <https://www.euro.who.int/en/health-topics/disease-prevention/physical-activity/news/news/2020/3/how-to-stay-physically-active-during-covid-19-self-quarantine>; [Accessed 02 Aug 2021].
- Polero P, Rebollo-Seco C, Adsuar JC, et al. Physical activity recommendations during COVID-19: narrative review. *Int J Environ Res Public Health* 2021;18:65.
- Schwendinger F, Pocecco E. Counteracting physical inactivity during the COVID-19 pandemic: evidence-based recommendations for home-based exercise. *Int J Environ Res Public Health* 2020;17:3909.
- Ma Q, Liu J, Liu Q, et al. Global percentage of asymptomatic SARS-CoV-2 infections among the tested population and individuals with confirmed COVID-19 diagnosis: a systematic review and meta-analysis. *JAMA Netw Open* 2021;4:e2137257.
- Chae SH, Park HJ. Effectiveness of penalties for Lockdown violations during the COVID-19 pandemic in Germany. *Am J Public Health* 2020;110:1844–9.
- Joisten C, Kossow A, Book J, et al. How to manage quarantine-adherence, psychosocial consequences, coping strategies and lifestyle of patients with COVID-19 and their confirmed contacts:

- study protocol of the CoCo-Fakt surveillance study, Cologne, Germany. *BMJ Open* 2021;11:e048001.
- 16 Neuhann F, Buess M, Wolff A, *et al.* Entwicklung einer software Zur Unterstützung Der Prozesse Im Gesundheitsamt Der Stadt köln in Der SARS-CoV-2-Pandemie, Digitales Kontaktmanagement (DiKoMa). *Epidemiologisches Bulletin* 2020;2020:3–11.
  - 17 Ermittlung von Kontaktpersonen: Umgang des Gesundheitswesens MIT Personen (einschließlich Beschäftigten in Gesundheitsberufen), die MIT COVID-19- Infizierten in Der EU in Kontakt standen – zweite Aktualisierung 8, 2020. Available: [https://www.ecdc.europa.eu/sites/default/files/documents/Public%20health%20management%20people%20in%20contact%20with%20COVID19%20cases\\_DE.pdf](https://www.ecdc.europa.eu/sites/default/files/documents/Public%20health%20management%20people%20in%20contact%20with%20COVID19%20cases_DE.pdf) [Accessed 11 Jan 2022].
  - 18 Lange C, Jentsch F, Allen J, *et al.* Data resource profile: German Health Update (GEDA)--the health interview survey for adults in Germany. *Int J Epidemiol* 2015;44:442–50.
  - 19 Betsch C, Wieler LH, Bošnjak M. Germany COVID-19 snapshot monitoring (COSMO Germany): monitoring knowledge, risk perceptions, preventive behaviours, and public trust in the current coronavirus outbreak in Germany. *PsychArchives* 2020.
  - 20 Amenta EM, Spallone A, Rodriguez-Barradas MC, *et al.* Postacute COVID-19: an overview and approach to classification. *Open Forum Infect Dis* 2020;7:ofaa509.
  - 21 Ainsworth BE, Haskell WL, Herrmann SD, *et al.* 2011 compendium of physical activities: a second update of codes and Met values. *Med Sci Sports Exerc* 2011;43:1575–81.
  - 22 Chaabene H, Prieske O, Herz M, *et al.* Home-based exercise programmes improve physical fitness of healthy older adults: a PRISMA-compliant systematic review and meta-analysis with relevance for COVID-19. *Ageing Res Rev* 2021;67:101265.
  - 23 Ghram A, Bragazzi NL, Briki W, *et al.* COVID-19 pandemic and physical exercise: lessons learnt for confined communities. *Front Psychol* 2021;12:618585.
  - 24 Ghram A, Briki W, Mansoor H, *et al.* Home-based exercise can be beneficial for counteracting sedentary behavior and physical inactivity during the COVID-19 pandemic in older adults. *Postgrad Med* 2021;133:469–80. –.
  - 25 Augustin M, Schommers P, Stecher M, *et al.* Post-COVID syndrome in non-hospitalised patients with COVID-19: a longitudinal prospective cohort study. *Lancet Reg Health Eur* 2021;6:100122.
  - 26 Salman D, Vishnubala D, Le Feuvre P, *et al.* Returning to physical activity after covid-19. *BMJ* 2021;372:m4721.
  - 27 Wolf S, Seiffer B, Zeibig J-M, *et al.* Is physical activity associated with less depression and anxiety during the COVID-19 pandemic? a rapid systematic review. *Sports Med* 2021;51:1771–83.