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1 **Physical Activity Changes From Before to During the First Wave of the COVID-19 Pandemic**
2 **Among Community-Dwelling Older Adults in Finland**

3

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1 **ABSTRACT**

2

3 This study aimed to compare community-dwelling older adults' physical activity (PA) during the
4 COVID-19 restrictions in 2020 to their PA levels two years before and investigate associations
5 between earlier physical performance and PA levels over the follow-up. Participants' (n=809, initial
6 age 75-85 years) self-reported PA was assessed at baseline in 2017-2018 and May/June 2020 as total
7 weekly minutes of walking and vigorous PA. Physical performance was assessed at baseline using
8 the maximal handgrip strength and Short Physical Performance Battery (SPPB) tests. During the first
9 wave of the COVID-19 pandemic, a median change in total weekly minutes of walking and vigorous
10 PA among all participants was + 20.0 (IQR: -60.0 - 120.0, $p < 0.001$) min/week compared to two
11 years earlier. Higher baseline SPPB total scores were associated with higher total weekly minutes of
12 walking and vigorous PA over the follow-up in men and women, and better handgrip strength in
13 women.

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15 **Keywords:** aging, lockdown, physical exercise, physical performance

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1 INTRODUCTION

2 Physical activity (PA) is essential for daily functioning, and it also slows the progression of
3 disease and disability (Cunningham et al., 2020). Physical activity guidelines for older adults
4 recommend at least 150-300 min of moderate-intensity aerobic PA or at least 75-150 min of vigorous-
5 intensity aerobic PA weekly (Bull et al., 2020; Piercy et al., 2018). Prior to the pandemic and despite
6 its recognized health benefits, substantial numbers of older adults worldwide were not meeting the
7 recommended level of PA (Sun et al., 2013). Moreover, as a significant proportion of older adults'
8 PA is performed by running daily errands (Davis et al., 2011; Tsai et al., 2016), concerns about
9 whether older adults were engaging in a sufficient amount of PA grew during the social distancing
10 recommendations issued in response to the global COVID-19 pandemic (Schrack et al., 2020).

11 At an early stage during the COVID-19 pandemic, older age was associated with disease
12 severity (Fang et al., 2020) and higher mortality risk (Bonanad et al., 2020). In spring 2020, many
13 governments implemented non-pharmacological policies, such as social distancing and lockdowns,
14 to restrict the spread of the SARS-CoV-2 virus. To protect the health of at-risk groups, such as older
15 adults, sheltering at home was recommended in many countries, while in others, curfews were
16 introduced (WHO/Europe, 2020). In Finland, the Emergency Powers Act was in force from 16 March
17 2020 until 16 June 2020, suspending all social, cultural, and community activities. During that time,
18 all cultural and social institutions, leisure centers, swimming pools, other indoor sport facilities, along
19 with cafés and restaurants, etc. were closed to minimize contacts. Moreover, public gatherings were
20 limited to no more than ten persons. Day center services for the older adults were suspended, and
21 visits to the hospitals, health care units, and housing services for risk groups like older adults were
22 prohibited. Curfews were not imposed; instead, people over age 70 years were advised to avoid
23 crowded places and close contact with people outside their immediate household. Outdoor activities
24 like walking and hiking were allowed all this time, but a sufficient physical distance from others was
25 still recommended (Prime Minister's Office Finland, 2020a, 2020b). Consequently, concerns were
26 raised that due to the COVID-19 restrictions, older adults' PA could fall well below the recommended

1 level, triggering a cascade of adverse events leading to accelerated health decline, especially among
2 the more vulnerable, i.e., the oldest old, those living alone, and those with physical and cognitive
3 limitations.

4 A recent systematic review on older adults concluded that PA levels worldwide decreased
5 and sedentary behavior increased during the first wave of the COVID-19 pandemic (Oliveira et al.,
6 2022). However, most previous studies on changes in PA have been based on convenience samples
7 of older adults or used mainly retrospective methods, which are known to be prone to bias. Moreover,
8 only a few prospective studies have assessed longitudinal changes in older adults' PA since the
9 COVID-19 outbreak (Oliveira et al., 2022). A Spanish study utilized four cohorts of older adults and
10 found a temporary decrease in PA levels and increase in sedentary time during the lockdown in the
11 first wave of the COVID-19 pandemic (García-Esquinas et al., 2021). In the UK, an increased
12 proportion of older adults were doing only minimal PA (household chores) during the lockdown
13 between late spring and early summer 2020 (Okely et al., 2020). A Swedish study found that about
14 20 to 30 % of people both under 70 years and over 80 years reported a reduction in light or higher-
15 intensity PA in the beginning of the summer season 2020 compared to their pre-pandemic levels
16 (Sjöberg et al., 2022).

17 The differences in implementing the COVID-19 restrictions between countries (Wang &
18 Mao, 2021) may have resulted in varying possibilities for PA participation. Compared to Finland the
19 COVID-19 restrictions in spring 2020 seemed stricter in the UK and Spain, where national stay-at-
20 home orders were in force and leaving homes was allowed only for a few reasons. By contrast,
21 Sweden relied more on people's voluntary adherence to the recommendations (García-Esquinas et
22 al., 2021; Sjöberg et al., 2022; Wang & Mao, 2021). Therefore, the current study aims to
23 prospectively investigate changes in community-dwelling older adults' PA with a population-based
24 sample in a context where no curfews were imposed, but still many activities were suspended and
25 staying at home was recommended.

1 Physical performance that refers to mobility-related objectively measured whole body
2 function (Beudart et al., 2019) can be either a prerequisite for PA or a consequence of engaging in
3 regular PA (Cooper et al., 2015; Moreno-Agostino et al., 2020; Paterson & Warburton, 2010).
4 Handgrip strength and the Short Physical Performance Battery (SPPB) are frequently used to assess
5 physical performance due to their ease of use and their predictive value for health and functioning in
6 old age (Guralnik et al., 1994, 2000; Rijk et al., 2016). Handgrip strength and SPPB can be used to
7 measure muscle strength and lower extremity performance, respectively, which forms part of the
8 theoretical pathway in the disablement process. For example, dysfunctions in specific body systems
9 (e.g., weak muscle strength) can lead to restrictions in basic physical actions (e.g., decreased lower
10 extremity performance) that further restrict performance of the desired activity (Verbrugge & Jette,
11 1994), in the present instance being generally physically active. Some preliminary results indicate
12 that limited physical function and pre-existing mobility difficulties were associated with a negative
13 impact of the COVID-19 pandemic on the PA levels of older adults (Sjöberg et al., 2022; Visser et
14 al., 2020). However, there is still limited evidence of the effect of earlier physical performance on
15 PA of older adults during the COVID-19 pandemic. This study aimed to examine the association
16 between physical performance and PA levels in community-dwelling older adults over the follow-up
17 before and during the COVID-19 pandemic.

18

19 **MATERIALS AND METHODS**

20 **Study design and participants**

21 This study forms part of the ‘Active aging – resilience and external support as modifiers of
22 the disablement outcome’ (AGNES) study. Follow-up data (AGNES-COVID-19 survey) were
23 collected via a postal questionnaire in May and June 2020, when the Emergency Powers Act
24 recommending social distancing was in force in Finland. These data were compared to the baseline
25 data collected from the same participants in 2017-2018. The AGNES study protocol (Rantanen et al.,

1 2018) and non-respondent analyses of both datasets have been reported in more detail elsewhere
2 (Portegijs et al., 2019; Rantanen et al., 2021).

3 Briefly, at baseline, the participants were three age cohorts (75, 80, and 85 years) of
4 individuals who were living independently in the region of Jyväskylä, Finland, and whose contact
5 information had been drawn from the Finnish Digital and Population Data Services Agency. The
6 inclusion criteria were living independently in the Jyväskylä region and able to communicate and
7 provide an informed consent. The initial baseline sample consisted of 1 021 participants. At follow-
8 up, a postal questionnaire was sent to the 985 surviving baseline participants who had not withdrawn
9 their consent and were still living independently in their homes. In total, 809 respondents returned a
10 completed follow-up questionnaire (Rantanen et al., 2021).

11

12 **Ethics**

13 The AGNES study was approved by the Ethics Committee of the Central Finland Health
14 Care District on 23 August 2017, and the same ethical committee gave an additional positive ethical
15 statement for the AGNES-COVID-19 survey on 13 May 2020. The AGNES study follows the
16 principles of the Declaration of Helsinki, and all participants signed an informed consent form prior
17 to participating in the study.

18

19 **Measurements**

20 **Self-reported PA** was assessed at both baseline and follow-up using the Yale Physical
21 Activity Survey (YPAS) for older adults (Dipietro et al., 1993). The YPAS was administered at
22 baseline during the home interview and at follow-up as part of the postal questionnaire. On both
23 occasions, four items of the YPAS questionnaire were used to assess participants' PA: two for
24 vigorous PA and two for walking. The participants were asked how many times, and for how long
25 per typical session they had engaged in vigorous physical activity and walking for longer than 10
26 minutes during the past four weeks. Weekly minutes of vigorous PA and walking were calculated

1 based on the self-reported frequency (0 = 'Not at all', 1 = '1-3 times per month', 2 = '1-2 times per
2 week', 4 = '3-4 times per week', and 6 = '5+ times per week'), and duration (20 = '10-30 minutes',
3 40 = '31-60 minutes', 60 = 'over 60 minutes') of both activity using the formula
4 '*frequency*duration*'. After that, weekly minutes of both activities were summed to express the total
5 weekly minutes of walking and vigorous PA (Portegijs et al., 2019).

6 **Physical performance** was assessed at baseline using the maximal handgrip strength test
7 and the Short Physical Performance Battery (SPPB). In the disablement process (Verbrugge & Jette,
8 1994), handgrip strength can be considered a more distal measure than the SPPB, and therefore both
9 were chosen. Maximal handgrip strength was measured in the dominant hand in participants' homes
10 using a hand-held adjustable dynamometer (Jamar Plus digital hand dynamometer, Patterson
11 Medical, Cedarburg, WI, USA) with the results expressed in kilograms (kg). The SPPB comprises
12 balance, walking speed, and chair rise speed tests with established cut-off points (Guralnik et al.,
13 1994) and was conducted in strict accordance with the test protocol in the participants' homes. The
14 total score was calculated (range 0-12, higher scores indicating better lower extremity performance)
15 when at least two tests were completed. Participants who were unable to perform a test were assigned
16 a score of zero for that test.

17 **Descriptive variables** were obtained from the baseline measurements: age and gender were
18 obtained from the Digital and Population Data Services Agency when the sample was drawn. Age
19 cohorts at the baseline were formed based on participants' birth years. Age cohorts consist of people
20 born in 1942-1943 (75-years cohort), 1938-1939 (80-years cohort), and 1933-1934 (85-years cohort).
21 Educational level was used as an indicator of socioeconomic status. Highest educational attainment
22 was self-reported and subsequently categorized as low (primary school or less), intermediate (middle
23 school, folk high school, vocational school, or secondary school) or high (high school diploma or
24 university) (Eronen et al., 2019). Housing type was self-reported and categorized into two types, an
25 apartment block and a row/semi-detached/detached house, as a rough indicator of neighborhood
26 population density and possibilities to go outside without encountering other people. Total number

1 of chronic conditions was calculated at baseline from a list of self-reported physician-diagnosed
2 chronic conditions. A list included the following conditions: respiratory conditions, cardiac
3 conditions, vascular conditions, cerebrovascular condition or brain injury, musculoskeletal
4 conditions, visual or auditory impairment, neurological conditions, diabetes mellitus, malignant
5 cancer, and depression. Also, an open-ended question about any other physician-diagnosed chronic
6 conditions was provided. Cognitive function was assessed with the Mini-Mental State Examinations
7 (MMSE), with higher scores indicating better cognitive function (range 0-30) (Folstein et al., 1975).
8 Depressive symptoms were assessed with the 20-item Centre for Epidemiologic studies Depression
9 Scale (CES-D), with higher scores indicating more depressive symptoms (range 0-60) (Radloff,
10 1977).

11

12 **Statistical analyses**

13 The analysis included all the participants who participated in the AGNES study and for
14 whom key baseline and follow-up data were available. Fourteen participants lacked PA data at
15 baseline. Missing baseline total weekly minutes of walking and vigorous PA was imputed for
16 participants with only one missing item in the YPAS questionnaire (n=4) using the multiple
17 imputation. Ten participants lacked more than one item in the YPAS at baseline and were thus
18 excluded. Sixteen participants lacked follow-up PA data. In these cases, follow-up PA data were
19 imputed by utilizing multiple imputation based on baseline values. Thus, the final analysis comprised
20 799 participants. Sensitivity analyses showed that inclusion of the participants with imputed values
21 did not change the results.

22 Participants' background information for continuous and discrete variables are reported as
23 medians (Mdn) and interquartile ranges (IQR), and for nominal variables as percentages (%) and
24 frequencies (f). The Shapiro-Wilk normality test indicated that some of the variables were not
25 normally distributed, and therefore non-parametric tests were used. In the non-respondent analyses,
26 the baseline data were compared between respondents (n = 809) and non-respondents (n = 212) with

1 the Mann-Whitney U-test. To test differences in background variables between age cohorts the
2 Kruskal-Wallis test was used, and to test differences between sexes the Mann-Whitney U-test was
3 used. The Chi-square test was used for nominal variables.

4 Correlations between baseline and follow-up total weekly minutes of walking and vigorous
5 PA were analyzed with the Spearman's Rank Order correlation. The Wilcoxon Signed-Rank test was
6 used to test the difference in total weekly minutes of walking and vigorous PA between baseline and
7 the COVID-19 pandemic in each participant by sex and age cohort groups. The Mann-Whitney U-
8 test was used to test the differences in PA levels between sexes at baseline and during the COVID-
9 19 pandemic and to test the difference in the absolute change of total weekly minutes of walking and
10 vigorous PA between sexes. Differences between age cohorts were tested with the Kruskal-Wallis
11 test. As ancillary analyses the Wilcoxon Signed-Rank test was used to test the difference in total
12 weekly minutes of walking and vigorous PA between baseline and the COVID-19 survey within
13 participants by each season and the Kruskal-Wallis test to test the difference in absolute change
14 between different seasons.

15 Generalized Estimating Equations (GEE) takes into account the intra-individual correlations
16 between repeated measurements (Liang & Zeger, 1986). Therefore, associations between baseline
17 physical performance and total weekly minutes of walking and vigorous PA over two time points
18 were assessed with GEE modeling with linear link function and an unstructured working correlation
19 matrix, where total weekly minutes of walking and vigorous PA over the follow-up was a dependent
20 variable. For the analyses, time was coded as categorical with measurement points 1 (baseline) and 2
21 (follow-up). The results are presented as regression coefficients (B) and standard errors (SE). Model
22 1 represents an unadjusted model including time, SPPB result, and handgrip strength. In Model 2,
23 age, sex, and educational level were added. In Model 3, a number of chronic diseases, MMSE, CES-
24 D, and housing type were added. In these models, B represents the covariate-adjusted association
25 between main predictors of interest and PA, and corresponding p-values refer to the statistical

1 significance of the covariate-adjusted association. The significance level was set at 0.05, and all
2 analyses were conducted using IBM SPSS version 28 for Windows (IBM Corp., Armonk, NY).

3

4 **RESULTS**

5 The final analysis was conducted for 799 participants (58 % women) with a median follow-
6 up duration of 2.1 years (IQR 1.7 - 2.3). The non-respondent analyses have been reported elsewhere
7 (Rantanen et al., 2021). Briefly, those who responded to the follow-up survey were younger, had
8 better baseline cognitive function and physical performance than non-respondents. Those who
9 participated in the follow-up survey were also more physically active (*YPAS [min/week]*; Mdn 240.0,
10 IQR 120.0 - 320.0 vs. Mdn 200.0, IQR 120.0 - 320.0, $p < 0.05$) at baseline than non-respondents.
11 However, the sample of participants can nevertheless be considered heterogeneous since many people
12 older in age and with worse health participated in the follow-up study. The background characteristics
13 of the respondents are presented in more detail in Table 1.

14 A median change in total weekly minutes of walking and vigorous PA among all participants
15 was + 20.0 (IQR -60.0 - 120.0, $p < 0.001$) min/week. No statistically significant differences between
16 either the age cohorts ($p = 0.232$) or between the sexes ($p = 0.182$) were observed in the absolute
17 change of total weekly minutes of walking and vigorous PA (Table 2). Baseline and follow-up total
18 weekly minutes of walking and vigorous PA correlated moderately ($r_s = 0.524$, $p < 0.001$). To confirm
19 the results concerning how baseline PA affected the change of PA during the follow-up, the absolute
20 change in total weekly minutes of walking and vigorous PA was compared between quintiles of
21 baseline total weekly minutes of walking and vigorous PA. Over the follow-up, PA increased between
22 the first to fourth quintiles (the median range of baseline PA across quintiles 80.0 – 320.0 min/week).
23 But among those in the highest quintile of the YPAS scale distribution (the median baseline PA 480.0
24 min/week) the ceiling effect of the scale prevented observing an increase.

25 The season of baseline participation and the season of the COVID-19 survey was different
26 for most participants. At baseline, 11.6 % of the participants were measured in summer (June-

1 August), 46.3 % in autumn (September-November), 15.3 % in winter (December-February), and 26.8
2 % in spring (March-May). The COVID-19 survey was conducted at the beginning of the summer
3 season (late May and June). The ancillary analyses showed a statistically significant increase in total
4 weekly minutes of walking and vigorous PA despite the baseline measurement season ($p < 0.05$ for
5 all), and the absolute change of total weekly minutes of walking and vigorous PA did not differ
6 according to the season of baseline participation ($p = 0.319$).

7 The associations between physical performance measurements and total weekly minutes of
8 walking and vigorous PA over the follow-up are presented in Table 3. Because physical performance
9 differed between sexes, also sex-stratified results are presented. In the unadjusted model, both
10 handgrip strength and SPPB were associated with the total weekly minutes of walking and vigorous
11 PA over the follow-up ($p < 0.001$). However, in the final model (adjusted for age, sex, educational
12 level, number of chronic diseases, MMSE, CES-D, and housing type), only higher SPPB total scores
13 (B 18.49, SE 2.50, $p < 0.001$) were associated with a higher amount of total weekly minutes of
14 walking and vigorous PA. In the final model for men, only higher SPPB total scores (B 14.14, SE
15 4.45, $p < 0.001$) were positively associated with total weekly minutes of walking and vigorous PA
16 over the follow-up. In women, both better maximal handgrip strength (B 13.94, SE 4.26 $p = 0.001$)
17 and higher SPPB total scores (B = 20.90, SE 2.75, $p < 0.001$) were positively associated with total
18 weekly minutes of walking and vigorous PA.

19

20 **DISCUSSION**

21 Compared to two years before the COVID-19 pandemic, the total weekly minutes of walking
22 and vigorous PA of community-dwelling older adults in Finland increased with median increase
23 being 20 minutes during the first wave of the COVID-19 pandemic. Over the follow-up, men
24 remained more active than women, and the youngest age cohort was more active than the oldest age
25 cohort. However, no statistically significant differences between sexes or age cohorts were observed
26 in the absolute PA changes over time. Baseline and follow-up PA correlated moderately, indicating

1 that those who were more active at baseline were also likely to be more active during the COVID-19
2 pandemic. Over the follow-up, higher baseline SPPB total scores, i.e., better lower extremity
3 performance in both men and women and better maximal handgrip strength in women, were
4 associated with higher total weekly minutes of walking and vigorous PA.

5 The inconsistency between our results indicating an increase in total weekly minutes of
6 walking and vigorous PA and the results from other countries that have mainly indicated a decrease
7 in PA during the first wave of the COVID-19 pandemic may be explained by the different infection
8 situations and strategies implemented to prevent the global spread of the virus, as Oliveira et al.
9 (2022) point out in their systematic review. Moreover, different study designs and methods for
10 assessing PA complicate the comparison of studies. A pooled analysis of the prevalence of
11 insufficient PA in 168 countries conducted before the pandemic found significant cross-country
12 variation. Interestingly, among the high-income Western countries, the prevalence of insufficient PA
13 was lowest in Finland (Guthold et al., 2018). This indicates that differences in pre-pandemic PA
14 levels in different countries may also affect observed changes in PA during the pandemic.

15 A few factors can be offered as potential explanations for our finding of increased PA. The
16 non-respondent analyses indicated that those who answered the follow-up survey were more
17 physically active at baseline than non-respondents. In addition, if the total weekly minutes of walking
18 and vigorous PA is considered an indicator of at least moderate-intensity PA, most of the participants
19 met at least the moderate-intensity PA recommendations (150-300 min/week) (Bull et al., 2020;
20 Piercy et al., 2018) at both baseline and follow-up. Therefore, our results may overestimate the
21 increase in PA in the older population. However, similar observations by another study conducted
22 among older adults in the same geographical area during the first wave of the COVID-19 pandemic
23 (Savikangas et al., 2021) support our results of the direction of the change in PA among community-
24 dwelling older adults. It should also good be borne in mind that no curfew was imposed in Finland,
25 and people were encouraged to engage in outdoor walking and hiking. A previous study by our
26 research group showed that visits to physical exercise destinations (i.e., sports facilities and outdoor

1 recreational areas) were less impacted by the COVID-19 restrictions than older adults' other activity
2 destinations (e.g., churches, restaurants, clubs) where visits almost entirely ended during the
3 pandemic's first wave. However, the median distance from home to physical exercise destinations
4 declined from 1.3 km to 0.6 km (Portegijs et al., 2021), which may indicate that physical exercise
5 destinations changed from closed indoor sports facilities to outdoor recreational areas closer to
6 homes. Moreover, the fact that spring was early in the Jyväskylä region in 2020 potentially had a
7 positive effect on PA, as indoor activities were suspended and replaced, for example, with outdoor
8 walking and gardening. The time of the year when the follow-up questionnaire was conducted may
9 facilitate outdoor PA for older adults in general. However, the observed increase in PA among those
10 whose baseline measurement was conducted at the same time of the year also indicates the
11 independent effect of the COVID-19 pandemic on PA. Lastly, although the COVID-19 pandemic
12 was a new and worrisome situation for everyone in spring 2020, the rate of infection was steady in
13 the Jyväskylä region. By June 2020, only 102 cases had been confirmed in the Central Finland
14 Hospital District (population 253 000; 21 municipalities) (Rantanen et al., 2021), a factor which may
15 also have affected individuals' sense of security outside the home.

16 Some other studies have also observed stable or increased PA in older adults during the
17 COVID-19 pandemic. Leavy et al., (2021) observed no marked change in PA in older participants
18 with Parkinson's disease during the first wave of the COVID-19 pandemic in Sweden. A study
19 conducted in the UK by Richardson et al., (2021) also noted that a convenience sample of older
20 participants maintained or even increased their PA levels during the six-week lockdown in spring
21 2020. In both studies, the authors also suggested that the observed stability or increase in PA may be
22 explained by their relatively physically active study samples and/or good spring weather.

23 Our results also showed that better baseline SPPB total scores, which indicate better lower
24 extremity performance, were associated with higher total weekly minutes of walking and vigorous
25 PA in both men and women over the follow-up. The association between SPPB and PA remained
26 significant even after adjusting for covariates. However, adding the number of chronic conditions in

1 the models attenuated the associations markedly, most likely because chronic conditions reduce both
2 physical performance and PA. Better baseline maximal handgrip strength was associated with total
3 weekly minutes of walking and vigorous PA only in women. These results may be explained by the
4 fact that the lower average muscle strength observed in women may lie closer to a critical threshold
5 for PA among women than men. Men's muscle strength may be well above the critical threshold for
6 PA, which explains the lack of association. It is worth noting, that lower extremity performance test
7 gives a good picture of a person's ability for PA, while handgrip strength is more distal from the
8 physical activities included in the YPAS.

9 In the previous pre-pandemic studies, better physical performance has been associated with
10 higher PA levels (Cooper et al., 2015; Laddu et al., 2017). Our results suggest that better physical
11 performance, especially better lower extremity performance, was positively associated with the total
12 weekly minutes of walking and vigorous PA over the follow-up before and during the COVID-19
13 pandemic. The present findings are also supported by a previous study from our research group
14 concluding that during the first wave of the COVID-19 pandemic, those older adults reporting no
15 walking difficulties coped better with the COVID-19 restrictions and remained more active than those
16 with walking modifications or difficulties (Leppä et al., 2021).

17 In Finland, many factors, such as season, the possibility of moving freely outdoors, and the
18 low incidence of COVID-19 infections in early summer 2020, potentially facilitated increasing PA,
19 especially because most other activities were suspended. Moreover, our results suggest that better
20 baseline physical performance was associated with higher PA levels in older adults over the follow-
21 up. In the future, older adults should not be treated as a homogenous predominantly vulnerable group.
22 Instead, the differences in health and physical performance should be considered to provide more
23 targeted guidelines and support.

24 This study has its limitations. Owing to the subjective methods used to assess PA, we cannot
25 entirely rule out the possibility of recall bias. Because information was only collected on walking and
26 vigorous PA at follow-up, we cannot estimate changes in total PA or sedentary behavior. Moreover,

1 the way the YPAS was administered at baseline compared to follow-up may have affected the results.
2 As already mentioned, the baseline and follow-up measurements were not conducted at the same
3 season of the year for some participants. However, the ancillary analyses indicated that the season
4 during which the baseline measurements were performed was not associated with the change in PA
5 over the follow-up. Because the two YPAS questions used in this study do not differentiate the indoor
6 and outdoor PA or the effect of the season, further analyses were not conducted. Finally, because the
7 pandemic situation prevented follow-up physical performance measurements, comparing baseline
8 and follow-up physical performance was impossible.

9 A strength of this study is a population-based sample with a reasonable response rate that
10 yielded essential and timely information on the impact of the COVID-19 pandemic for three older
11 community-dwelling age cohorts. Moreover, PA was assessed shortly before the COVID-19 outbreak
12 and during the first wave of the pandemic with a validated physical activity questionnaire designed
13 for older adults. This enabled a more reliable longitudinal analysis of PA change than, for example,
14 a retrospective study. In addition, physical performance was assessed at baseline using objective and
15 widely accepted methods.

16

17 **CONCLUSIONS**

18 Contrary to expectations, we observed that total weekly minutes of walking and vigorous PA
19 increased for most Finnish community-dwelling older adults during the first wave of the COVID-19
20 pandemic. Our results suggested that better baseline physical performance was associated with higher
21 PA levels in older adults over the follow-up before and during the COVID-19 pandemic. More
22 population-based studies in different settings and countries are still needed, and the effects of a
23 prolonged COVID-19 pandemic consisting of several successive waves on older adults' PA, physical
24 performance, and health in the long run also merit investigation.

25

26

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12

13 **Conflict of interest disclosure:**

14 The authors declare no competing interests of relevance to the content of this article.

15

16 **Ethics statement**

17 The AGNES study and the AGNES-COVID-19 survey were approved by the Ethics Committee of
18 the Central Finland Health Care District. The AGNES study and the follow-up study follow the
19 principles of the Declaration of Helsinki, and all participants signed an informed consent form prior
20 to participating in the study.

21

22 **Data availability statement:**

23 The authors confirm that some access restrictions apply to the data. Researchers interested using the
24 data must obtain approval from the director of the AGNES study, Professor Taina Rantanen
25 (taina.rantanen@jyu.fi), and are required to follow the protocol on the protection of privacy and to
26 comply with the relevant Finnish laws.

1 **Author Contributions**

- 2 Conceptualization (KL, TR, LK), acquisition of data (KL, TR, LK, JE, NK, EP), statistical analysis
3 (KL), original draft preparation (KL), review & editing (KL, TR, LK, JE, NK, EP). All the authors
4 have read and agreed to the version of the manuscript submitted for publication.

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Table 1. Background characteristics of the participants by age cohort and sex, n = 799

Variable	75 years (n = 381)		80 years (n = 259)		85 years (n = 159)		Age cohort		Sex p [‡]
	Men	Women	Men	Women	Men	Women	t	p [†]	
	n = 159	n = 222	n = 113	n = 146	n = 61	n = 98	♂	♀	
	Mdn (IQR)	Mdn (IQR)	Mdn (IQR)	Mdn (IQR)	Mdn (IQR)	Mdn (IQR)			
Follow-up [year]	2.3 (1.8-2.5)	2.3 (1.8-2.5)	2.1 (1.7-2.2)	2.1 (1.7-2.2)	1.7 (1.6-2.0)	1.7 (1.6-2.0)	abc	abc	
Handgrip strength	42.9 (38.5-47.3)	26.6 (22.2-30.7)	39.5 (33.0-45.7)	23.9 (20.7-28.0)	33.7 (30.2-38.6)	22.1 (19.2-26.5)	abc	ac	**
SBBP [score]	11.0 (10.0-12.0)	11.0 (10.0-12.0)	11.0 (10.0-12.0)	11.0 (9.0-12.0)	10.0 (8.0-11.0)	10.0 (8.0-11.0)	bc	bc	**
No. of chronic diseases	3.0 (1.0-4.0)	3.0 (2.0-5.0)	3.0 (2.0-5.0)	3.0 (2.0-4.0)	4.0 (2.0-5.0)	4.0 (2.0-6.0)	c	bc	
MMSE [score]	28.0 (27.0-29.0)	28.0 (27.0-29.0)	28.0 (26.0-29.0)	28.0 (27.0-29.0)	27.0 (25.0-28.0)	27.0 (25.0-29.0)	c	c	
CES-D [score]	5.0 (2.0-9.0)	7.0 (3.0-11.3)	5.0 (2.5-12.0)	8.0 (4.0-13.0)	8.0 (5.0-12.5)	7.0 (4.0-14.0)	c		*
Educational level % (f)									
Low	15.7 (25)	16.7 (37)	25.0 (28)	23.4 (34)	30.0 (18)	36.7 (36)			
Intermediate	52.2 (83)	53.4 (118)	44.6 (50)	51.0 (74)	46.7 (28)	43.9 (43)			
High	32.1 (51)	29.9 (66)	30.4 (34)	25.5 (37)	23.3 (14)	19.4 (19)			
Housing type % (f)									
Apartment block	44.0 (70)	61.7 (137)	48.7 (55)	65.1 (95)	54.1 (33)	67.3 (66)			*
Row/detached house	56.0 (89)	38.3 (85)	51.3 (58)	34.9 (51)	45.9 (28)	32.7 (32)			

Mdn median, IQR interquartile range, ♂ men, ♀ women, f frequency, SPPB Short Physical Performance Battery, MMSE Mini-Mental State Examination, CES-D Center for Epidemiologic Studies Depression Scale, † tested with Kruskal-Wallis; p < 0.05: a = 75 vs. 80, b = 80 vs. 85, c = 75 vs. 85, ‡ tested with Mann-Whitney U; * p < 0.05, ** p < 0.001

Table 2. Total weekly minutes of walking and vigorous PA from baseline (2017-2018) to the first wave of the COVID-19 pandemic (May/June 2020) by age cohort and sex, n=799

	Total weekly minutes of walking and vigorous PA						
	Baseline		The COVID-19 pandemic		Absolute change of PA [§]		
	Median	IQR	Median	IQR	Median	IQR	
All participants	240.0	120.0 - 320.0	240.0	120.0 - 400.0	+20.0	-60.0 - 120.0	**
75 years							
Men	240.0	160.0 - 360.0	320.0	160.0 - 480.0	+40.0	-80.0 - 200.0	**
Women	240.0	160.0 - 320.0	260.0	160.0 - 400.0	+20.0	-40.0 - 120.0	*
80 years							
Men	200.0	120.0 - 340.0	280.0	160.0 - 400.0	+40.0	-60.0 - 120.0	*
Women	240.0	120.0 - 320.0	240.0	120.0 - 370.0	+10.0	-80.0 - 85.0	
85 years							
Men	240.0	120.0 - 320.0	240.0	80.0 - 400.0	0.0	-80.0 - 160.0	
Women	160.0	95.0 - 265.0	190.0	80.0 - 320.0	0.0	-45.0 - 120.0	
Age cohort, p-value [†]	<.001^c		<.001^c				.232
Sex, p-value [‡]	.014		.011				.182

PA physical activity, IQR interquartile range, [†] tested with Kruskal-Wallis; *a* = 75 vs. 80, *b* = 80 vs. 85, *c* = 75 vs. 85, [‡] tested with Mann-Whitney U. [§] tested with Wilcoxon signed-rank test; * *p* < 0.05, ** *p* < 0.001

Table 3. Associations between baseline physical performance and total weekly minutes of walking and vigorous PA over the follow-up

	Model 1			Model 2			Model 3		
	B	SE	P	B	SE	P	B	SE	P
All participants (n = 799)									
Handgrip [per 5 kg]	8.29	2.46	<.001	7.74	3.47	.026	5.22	3.44	.129
SPPB [per 1 score]	24.09	2.33	<.001	23.47	2.36	<.001	18.49	2.50	<.001
Men (n = 333)									
Handgrip [per 5 kg]	2.74	4.79	.568	1.65	5.23	.748	-2.06	4.96	.678
SPPB [per 1 score]	21.13	4.14	<.001	20.52	4.07	<.001	14.14	4.45	<.001
Women (n = 466)									
Handgrip [per 5 kg]	16.35	4.33	<.001	15.94	4.30	<.001	13.94	4.26	.001
SPPB [per 1 score]	25.96	2.61	<.001	25.29	2.69	<.001	20.90	2.75	<.001

B regression coefficient, *SE* standard error, *SPPB* Short Physical Performance Battery. Model 1: unadjusted model. Model 2: adjusted for sex (model with all participants), age, and education. Model 3: adjusted for sex (model with all participants), age, education, number of chronic conditions, MMSE, CES-D, and housing type.