Master's thesis

NTNU
Norwegian University of Science and Technology
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Department of Circulation and Medical Imaging

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The impact of Covid 19 lockdowns on the physical activity level in older adults

Insights from the Generation 100 study

Master's thesis in Exercise Physiology
Supervisor: Dorthe Stensvold
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Infographic

The Impact of the Covid 19 lockdowns on the physical activity level in older adults

Insights from the Generation 100 Study

Analyzing physical activity from 2018 til 2021 in older adults previously randomized to supervised high intensity interval training (HIIT), moderate intensity continuous training (MICT) or to a control groups asked to follow physical activity recommendations. Did the Covid 19 lockdowns have an impact on physical activity level?

Participants

Physical Activity assessed through annual questionnaire

Results

	2018	2019	2020	2021
Control	3,97	4,01	3,55	3,77
MICT	4,21	3,98	3,67	3,74
HIIT	4,42	4,35	3,64	3,85

Conclusion

All groups had a significant decrease in physical activity between 2019 and 2020. This study suggests that Covid 19 lockdowns had a negative impact on physical activity in all three groups, with no differences between the groups.

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First and foremost, I would like to thank Professor Dorthe Stensvold for giving me the opportunity to write this thesis and sharing advise and expertise whenever needed. I couldn't have finished this project without her help.
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Abbreviations

BMI	Body Mass Index
HRmax	Maximal Heart Rate
HIIT	High Intensity Interval Training
LTPA	Leisure Time Physical Activity
MICT	Moderate Intensity Continuous Training
PA	Physical Activity
PA-Index	Physical Activity Index
SD	Standard Deviation

Abstract

Background: The Covid 19 pandemic is to date one of the largest global health crises, causing millions of deaths worldwide. Older adults were especially vulnerable to the infection. Physical activity (PA) has been highlighted as an important strategy to maintain physical and mental health as people age. Knowledge on how the pandemic and lockdowns affected PA in older adults is scarce. The present study aims to investigate the impact of Covid 19 lockdowns on PA level in older adults.

Methods: This is a sub-study of the longitudinal randomized controlled trial in older adults, the Generation 100 project. In total, 1110 older adults (72.3 ± 2.0 years at baseline) participating in Generation 100 were included in the present study. Total physical activity was measured using a physical activity index, calculated from questionnaire answers obtained at year 5, 6, 7, and 8. A linear mixed model was utilized to analyze the changes over time between the groups, while the Wilcoxon test was used to investigate changes within each group.

Results: All groups had a significant reduction in total PA of 11.86% on average, from 2019 to 2020, coinciding with the implementation of Covid 19 lockdowns. Despite changes within all groups, there were no significant reductions in PA level between groups. Only MICT showed a significant decrease in PA frequency from year 6 to 7, while HIIT and Control had a significant reduction in duration of PA during the same period. Control and HIIT also showed a significant decrease in training intensity from 2019 to 2020, while only Control significantly decreased intensity according to the BORG scale during that time.

Conclusion: The present study suggests that Covid 19 lockdowns had a notable impact on the total PA in older adults, regardless of intervention group. These findings underscore the importance of considering PA patterns among the senior population when implementing preventative strategies during public health emergencies.

Keywords: Covid 19, physical activity, older adults, lockdowns

Introduction

Due to the rising age of the population and declining birthrates, society is witnessing a shift in the demographic, by which the proportion of the elderly within civilization is rising (1). This demographic shift represents progress within the field of medicine, however, it poses both challenges and opportunities for public health (2,3). Due to more incidences of age-related diseases, the economic burden on society will increase, but investing in successful ageing is important for society and the world economy (3). The elderly are an active part within the economy. Science and medicine must therefore shift their focus not only to more and better geriatric healthcare, but also to find ways for the aging population to lead a more active and healthy life (2).

Physical activity and exercise have emerged as an important factor determining the health and life quality of the aging population (4). According to the World Health Organization (4) older adults should engage in 150-300 minutes of moderate intensity aerobic physical activity, or 75-150 minutes of high intensity aerobic activity per week. However, little is known about older adults' compliance with current guidelines (5). The long term Generation100 study (6) has produced numerous sub-studies exploring the effect of exercise on all-cause mortality and cardiovascular health of the senior population (7,8). Exercise interventions have been shown to increase physical activity in the elderly (6), however, evidence suggests that the increase in physical activity level does not lead to long term behavior changes (9). Previous studies have also shown physical activity to have a positive effect on the immune system (4,10). This applies to the elder population as well (6).

In 2020 the world experienced one of the worst pandemics in history. A wide array of administrative failures, a lack of international communication, and the late acceptance of the severity of the Covid 19 infection (11) led the world to shut down. Studies have reported that both mental and physical health diminished during resulting lockdowns (12). The worst effect, however, was death. Nearly 8 million deaths related to Covid 19 have been reported to date (13). A significant percentage (80% between 2020 and 2021) were people older than 60 years old (14). Thus, older adults are especially vulnerable to such health emergencies (15). The increased risk

of infection for the older population led to a multitude of studies analyzing the impact of the pandemic on older adults (12,16).

Researchers looked into the effect of Covid 19 on exercise and vice versa with mixed results (17). National lockdowns and other regulations might have caused a reduction in exercise for many, which could have led to worse health outcomes for the older population in particular (18). Nygård et al. observed not only a decrease in physical activity in older adults, but also that those who decreased their PA level had worse health than those who continued their regular PA (19). Furthermore, researchers have found an increase in sedentary time and resulting decline in mental health (20). Some studies have come to the conclusion that a regular exercise regimen can lead to a better immune response, which might help lessen the effect of the Covid 19 virus (21,22).
Long term studies such as the Generation 100 (23) allow researchers to further understand not only the interplay between aging and exercise, but also between exercise and potential positive health outcomes during a global health crisis (22), such as Covid 19.

Although previous studies have shown that PA decreased during the pandemic, data on older adults is scarce. Thus the aim of this study was to examine the effects of Covid 19 lockdowns on the activity level in older adults (23).

Methods

Study design

This is a sub-study of the long-term randomized controlled trial, the Generation 100 study (6), that examined long term effects of different training modalities on all-cause mortality and cardiovascular health in older adults. The complete study protocol has been described previously (23) and will not be portrayed in detail at this point.
Briefly, 1567 participants were included in the study, with females accounting for 790 of the participants and males 777. All participants were between 70-77 years of age and were randomly assigned to one of two intervention groups, or to a control group. The high intensity interval training (HIIT) group trained two times per week, consisting of 4x4 minute intervals at 85-95% of maximum heartrate (HR_{max}), with 3 minute breaks between the intervals (24). Prior to the intervals, 10 minutes of warm-up were performed. Participants in the moderate intensity continuous group (MICT) trained for 50 minutes two times per week at ~70% of their HR_{max}. Both MICT and HIIT were supervised during training. They also attended a mandatory spinning session every 6^{th} week.
The remaining participants were assigned to the control group and instructed to follow guidelines for physical activity outlined by the Norwegian Health Department (25). These guidelines advise daily activity for 30 minutes of moderate intensity.
The intervention period lasted from 2012 to 2018, whereafter the participants were encouraged to continue to exercise on their own. All remaining participants were sent an annual detailed questionnaire to assess their health status and PA level after 6, 7, and 8 years follow-up.
Results of the Generation 100 show that supervised aerobic exercise was not superior to a control group on 5 years survival in older adults. However, there was a strong tendency that HIIT was better than MICT.

Subjects

In this study the existing list of participants within the Generation 100 study is utilized to analyze the physical activity of participants during the pandemic. A total of 1110

participants, that had previously been randomized 2:1:1 to control, MICT, and HIIT, were included in this study. All participants that have replied to at least one questionnaire after the intervention (2018) until 2021 were included in the analysis. The number of participants in each group at 5,6, 7, and 8 years follow-up are presented in Figure 1. A complete study protocol and exclusion criteria can be found in Stensvold et al. 2015 (23).

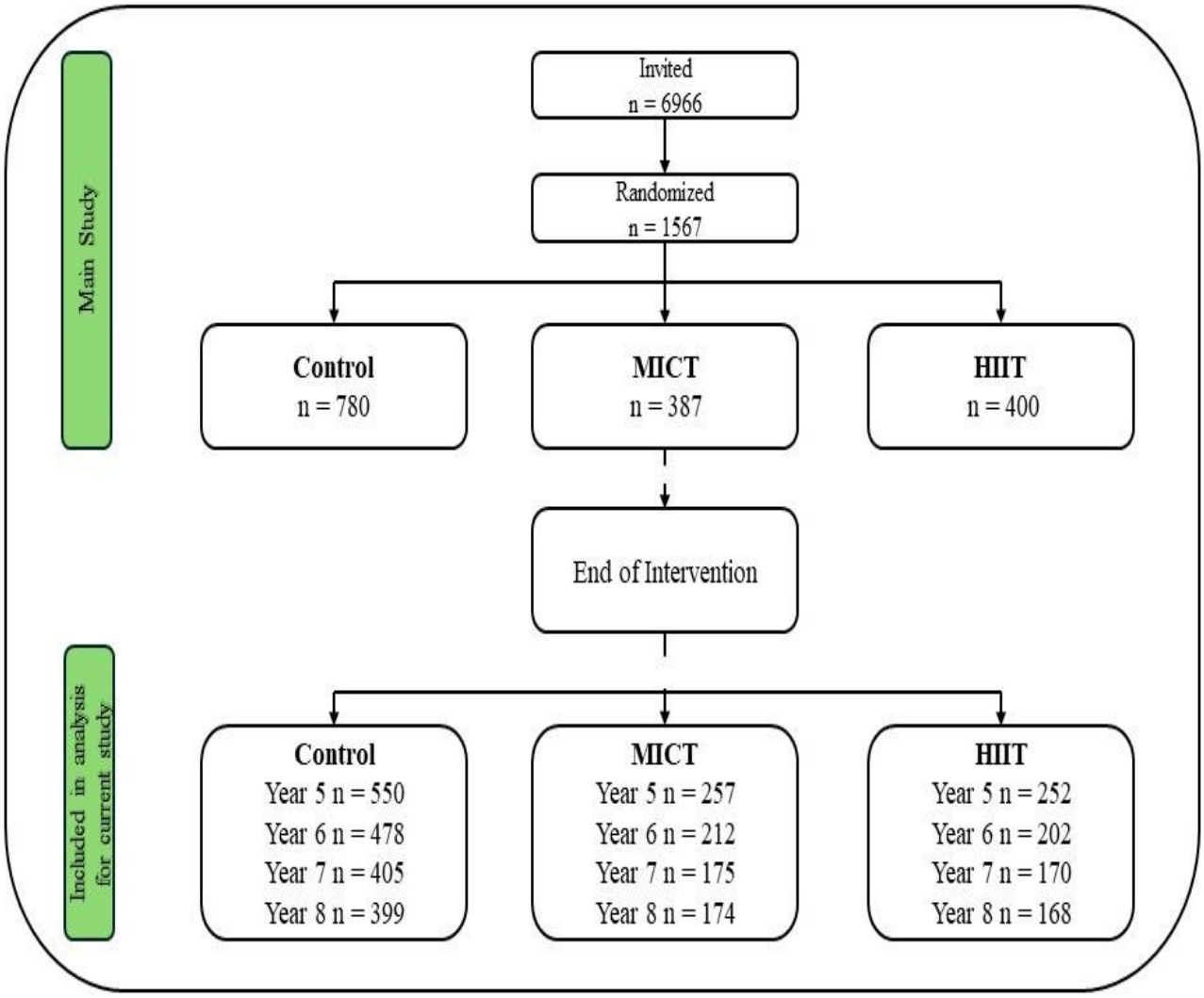

Figure 1: Flow chart of study population from the beginning of the Generation 100 study (2012) until year 8 (2021)

Physical Activity Index

To analyze the physical activity of participants, the annual questionnaire included multiple questions concerning physical activity, which were used to calculate the physical activity index (PA-Index) by multiplying the answers of the questions

presented in Table 1. PA-Index was used to quantify total PA of participants. Total PA therefore is the product of training frequency, duration, and intensity (19,26). The use of the questionnaire and the reliability of the PA-Index have been validated by Kurtze et al. (26). And used in several studies (27) . Total PA was thus measured at years 5, 6, 7, and 8.

The questions are weighted to yield a PA-Index between 0 – 15. Each participant was grouped into one of three activity levels (28):

1) 0.05 – 1.50 = low activity level
2) 1.51 – 3.75 = medium activity level
3) 3.76 – 15.0 = high activity level

In addition to total PA, changes in the individual components of the index (frequency, duration, intensity) and a subjective measurement of intensity, BORG-Scale (29), were assessed in the present study. The BORG-Scale (Appendix 2: Table 4) is a measure of perceived exertion (29).

Table 1: Questions used to calculate the PA-Index. The weight for each answer is marked in parentheses. Table and associated values are adapted from Kurtze et al. (26)

How often do you exercise?	How hard do you exercise?	What is the average duration in each session?
Never (0)	Easy, not getting out of breath or sweaty (1)	Less than 15 minutes (0.10)
Less than once a week (0.5)	Hard, so I am out of breath and sweaty (2)	15-29 minutes (0.38)
Once a week (1.0)	To exhaustion (3)	30-60 minutes (0.75)
2-3 times per week (2.5)		More than 60 minutes (1.0)
Almost every day (5.0)		

Anthropometric measures

At baseline (year 5) participants were invited to have clinical datapoints measured. Researchers recorded data of participant's height and waist circumference in cm. A stadiometer (Seca 222, Hamburg, Germany) was utilized to measure participants height to the nearest millimeter. To measure the waist circumference, a measuring tape was used at the upper iliac crest around the waist. Body weight in kg and BMI in kg/m² were measured using bioelectrical impedance (Inbody 720, BIOSPACE, Seoul, Korea). For participants with pacemakers, the BMI was calculated by hand. National registries were used to identify age and sex of the participants.

Statistical analysis and data presentation

Descriptive variables are presented stratified by group as mean ± standard deviation, while categorical variables are presented as number and percentage.
Q-Q plots were utilized to assess normality of the data. These plots showed a non-normal distribution, therefore a Wilcoxon Signed Rank Test was used to analyze changes within the groups. Confidence intervals of 95% were used for statistical tests, with significance level set at $\alpha=0.05$.

To calculate the changes in total PA and its components from year to year, a linear mixed model (LMM) was used, in which participants were run as random effects, while all outcome variables were tested individually as dependent variables. All groups and years were included in the LMM to compare groups with each other from year to year (group*time). No other covariates were included in the calculations.
The Wilcoxon Signed Rank Test was applied to analyze changes within each group throughout the study period.
Changes from year 6 to year 7 are of primary importance. Year 6 of the study corresponds to calendar year 2020, in which the Covid 19 pandemic hit.

All statistical analysis was conducted using the IBM SPSS Statistics 28.0.0.0 (SPSS Inc, Chicago, USA). Tables were designed within Microsoft 365 Word (Redmond, Washington, USA), while graphs were built using Microsoft 365 Excel (Redmond, Washington, USA). The flow chart in Figure 1 was constructed in Microsoft 356

Power Point (Redmond, Washington, USA). The Infographic was illustrated utilizing Canva 1.42.0 (App, Perth, Australia).

Results

Baseline characteristics

As the current study analyzes years 5 to 8 of the Generation 100 study, the baseline characteristics refer to values from year 5 (2018). Table 2 shows the baseline characteristics exclusively of participants who have attended testing at year five in addition to answering the annual questionnaire of the same year.

Table 2: Baseline characteristics

	Control (472)	MICT (232)	HIIT (218)
Females, n (%)	234 (49.6)	111 (47.8)	103 (47.2)
Age (years)	72.18 ± 2.00	72.27 ± 2.04	72.44 ± 2.07
Height (cm)	169.54 ± 8.84	170.13 ± 9.09	169.37 ± 9.03
Waist circumference (cm)	94.73 ± 10.79	94.72 ± 11.39	93.81 ± 10.76
Weight (kg)	74.20 ± 12.88	74.58 ± 12.46	73.47 ± 13.50
BMI (kg/m²)	25.70 ± 3.46	25.68 ± 3.54	25.45 ± 3.27
PA-Index	3.99 ± 2.79	4.22 ± 2.49	4.35 ± 2.53

Data is presented as mean ± SD. Abbreviations: SD: standard deviation, MICT: moderate intensity continuous training, HIIT: high intensity interval training, BMI: body mass index

Changes in total PA

There were no significant differences observed in the changes of total PA between the groups throughout the years in this study (Figure 2).
A significant decrease in total PA was observed within all three groups from year 6 to 7 with an average of 11.86%. Separated by the groups the decrease in total PA was 11.47% (p=<0.001) in control, 7.79% (p=0.041) in MICT, and 16.32% (p=<0.001) in HIIT.

Only MICT showed a significant decrease in total PA from year 5 to 6 of 5.46% (p=0.048)

No significant changes were recorded from year 7 to 8 in either group.

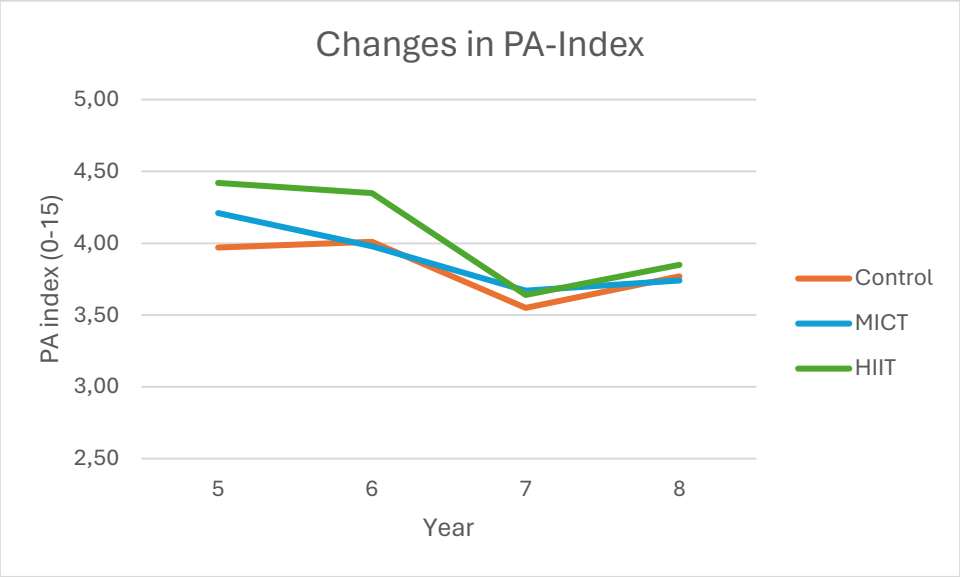

Figure 2: Mean changes in PA-Index from year to year shown separated by groups.
Abbreviations: MICT: moderate intensity continuous training, HIIT: high intensity interval training

Frequency

There were no significant differences between the groups in exercise frequency throughout the study (Table 3). No significant reductions in training frequency were observed from year 5 to 6 in either group. However, MICT showed s significant decrease from year 6 to 7 of 5.68% (p=0.017) and HIIT significantly increased frequency by 3.72% (p=0.030) from year 7 to year 8.

No significant changes in training frequency were observed in the control group at any timepoint.

Duration

There were significant differences in exercise duration observed between HIIT and MICT (p=0.004) at 7 year follow-up, as well as HIIT and control (p=0.023) at 8 year follow-up (Table 3). No other differences between the groups were observed.

However, MICT and HIIT significantly decreased training duration from year 5 to 6 by 2.5% (p=0.036) and 5% (p=0.015) respectively. From year 6 to 7 control significantly decreased duration by 4% (p=0.003), while HIIT decreased duration by 6.58% (0.004). No other changes were observed in control after year 7, while HIIT significantly increased training duration by 9.86% (p=<0.001) from year 7 to 8.

Intensity

A significant difference was observed between HIIT and MICT (p=0.011) at 6 years follow up. No other differences between the groups were observed throughout the study (Table 3). In MICT training intensity was decreased by 4.76% (p=0.002) from year 5 to 6. Training intensity was significantly decreased from year 6 to 7 in control and HIIT by 8.02% (p=<0.001) and 8.43% (p=<0.001) respectively. In MICT no significant intensity changes were observed during that time.
No group showed significant changes from year 7 to 8.

BORG Scale

There was a significant difference in BORG between MICT and control (p=0.006), and between HIIT and MICT (p=0.043) at 7 years follow up. Only control significantly decreased intensity according to the BORG Scale from year 6 to 7 by 3.03% (p=<0.001). No other significant changes were observed within or between the groups during the period of this study (Table 3).

Table 3: Mean frequency, duration, intensity (3-scale), and BORG (6-20 scale) from years 5 through 8.

Variable	Year	Control	MICT	HIIT
Frequency (days/weeks)	5	3.04 ± 1.49	3.09 ± 1.29	3.04 ± 1.35
	6	2.97 ± 1.44	2.99 ± 1.41	2.99 ± 1.40
	7	3.02 ± 1.49	2.82 ± 1.41	2.96 ± 1.40
	8	3.09 ± 1.50	2.99 ± 1.35	3.07 ± 1.48
Duration (hours/session)	5	0.75 ± 0.21	0.80 ± 0.19	0.80 ± 0.19
	6	0.75 ± 0.22	0.78 ± 0.21	0.76 ± 0.21
	7	0.72 ± 0.24	0.77 ± 0.21	0.71 ± 0.24
	8	0.72 ± 0.24	0.76 ± .020	0.78 ± 0.20
Intensity (1-3)	5	1.61 ± 0.54	1.68 ± 0.49	1.80 ± 0.54
	6	1.62 ± 0.54	1.60 ± 0.52	1.78 ± 0.55
	7	1.49 ± 0.52	1.59 ± 0.55	1.63 ± 0.52
	8	1.56 ± 0.52	1.53 ± 0.52	1.56 ± 0.55
BORG Scale (6-20)	5	13.24 ± 2.03	13.16 ± 1.83	14.30 ± 1.94
	6	13.20 ± 2.19	13.18 ± 1.83	14.05 ± 2.04
	7	12.80 ± 2.16	13.12 ± 1.80	13.56 ± 2.27
	8	13.04 ± 2.12	13.21 ± 1.88	13.60 ± 2.23
PA-Index (0-15)	5	3.97 ± 2.70	4.21 ± 2.43	4.42 ± 2.53
	6	4.01 ± 2.80	3.98 ± 2.64	4.35 ± 2.68
	7	3.55 ± 2.52	3.67 ± 2.57	3.64 ± 2.36
	8	3.77 ± 2.64	3.74 ± 2.54	3.85 ± 2.57

Data is presented as mean ± SD. Abbreviations: SD: standard deviation, year 5: baseline, MICT: moderate continuous training, HIIT: high intensity interval training.

Discussion

The present study investigated the effects of Covid 19 lockdown measures on PA levels of older adults in Trondheim. This is the first study to evaluate the long-term effect of 5 years of supervised exercise, with different intensities, on physical activity levels in older adults 3 years after the intervention, during a global pandemic. Our data shows that the change in total PA was similar in all three intervention groups throughout this study, thus being randomized to supervised exercise for five years did result in higher PA post-intervention and pre-pandemic. These findings contradict the hypothesis that the HIIT group would show the least reduction in total PA compared to the other groups. Interestingly, a significant decrease in total PA was observed within all three groups from year 6 (2018/2019) to 7 (2020/2021) – 11.86% decrease on average – the year the Covid 19 pandemic started, and lockdowns were implemented.
Furthermore, Control and HIIT showed significant decreases in training intensity and training duration from year 6 to year 7, while MICT showed no significant changes in these categories during the same period. However, MICT was the only group showing a significant decrease in training frequency from year 6 to year 7. These results seem to concede our hypothesis, that the Covid 19 lockdowns had a negative effect on total PA in older adults.

Changes in physical activity

The observed decrease in physical activity during lockdowns in the present study, is in line with the results found in previous studies (30,31). Füzéki et al. 2021 reported a 30% decline on LTPA during the lockdown in middle-aged men and women (30), which is much higher than the results in the present study, even though the participants from Italy are younger yet had not previously been following supervised training interventions. On the other hand, Castañeda-Babarro et al. 2020 reported a decrease in vigorous PA of only 16.8% (31), though their study cohort was similar in age to Füzéki's and had also not participated in supervised training interventions priviously. In general, most studies that analyzed changes in PA during Covid 19 lockdowns, found a significant decrease in PA throughout most age groups and

across the world (32,33). However, the magnitude of change varies among populations and their respective activity level prior to the pandemic.

Even without the Covid 19 pandemic, the activity levels of older adults tend to show a downward trend over time due to biological, psychological, and environmental factors (34). Older individuals often show a decline in muscle mass and strength (35), due to age, as well as reduced PA. Reduced bone density and cardiovascular function are also often observed in older adults (7). The age related changes can affect their ability to engage in physical activity (5,36), while a lack of PA can exacerbate these age related changes. Higher age also increases risks for conditions such as osteoporosis and arthritis, which in turn can limit mobility in the elderly and hence prevent them from engaging in PA (37), even though exercise has been shown to mitigate effects of osteoporosis.

With advanced age, people also tend to change their lifestyle as they retire and withdraw from social life, which can further contribute to the reduction in PA (5). Environmental factors such as access to recreational facilities and the walkability of someone's neighborhood can add yet another barrier for the elderly to engage in PA (38). The disruption of regular life due to the Covid 19 pandemic only exacerbated the decline in PA in older adults as the current study and other studies have shown. Restrictions on outdoor activities, closure of gyms, and social distancing guidelines made it neigh on impossible for many people to continue their regular exercise routine. Participants of the Generation 100 study had a tight-knit peer group that used to train together. The Covid 19 restrictions might have prevented these individuals from training together as usual, which may have led to the decline in total PA.

All of that said, our data also show a slight increase in total PA, as well as most of the components of total PA, from year 7 to year 8 (2020-2021). Though none of these upward changes are significant, they do indicate a return to pre-lockdown activity habits. Nygård et al. however reported that it is unlikely for many to return to pre-pandemic activity levels, or it may take a long time for people to do so (19), yet the participants in the present study show a clear upward trend immediately after reduction in lockdown measures. This may be due to the participants having previously followed supervised training interventions.

While this study specifically examined the impact of Covid 19 lockdowns on total PA in older adults, all age groups were impacted by the global pandemic (20,39). However, younger people may have been more adaptable to other forms of exercise, such as home-based workouts. The younger generations are more involved with technology that could allow them to continue their lifestyle (40), than older adults tend to be, which could have exacerbated the decline in PA in the elderly. Nonetheless, this does not mean the elderly were uniquely impacted by Covid 19. All age groups had their challenges during the pandemic, and differences in PA may exist within and between the different age groups. It is therefore imperative to implement physical activity as mitigation strategy and general health strategy for everyone (41).

Changes in physical activity components

Since total PA is a product of training frequency, duration, and intensity, the decline in total PA could be due to changes in either of these three components. Interestingly, the control group was the only group showing decreases in two of three components, plus the BORG Scale, from 2019 to 2020. MICT only decreased training frequency during the same period, while HIIT decreased training duration and intensity, but showed otherwise no changes during that time. In a recent study Brand et al. aimed to analyze the changes in frequency of PA, during Covid 19 lockdowns, and using a statistical model to predict changes in exercise frequency for future pandemics (42). Interestingly, the results from the latter study revealed that people who were not active pre-pandemic tended to increase their training frequency during the lockdown. Importantly, that study also showed that people who were active pre-pandemic tended to maintain their level of training frequency (42), which is in line with the findings of this study.

As our analysis revealed, training duration was also significantly reduced in both the control group and the HIIT group from year 6 to year 7 of the Generation 100 study. An intriguing study analyzing PA of athletes at different levels during the lockdown period found that “higher level” athletes were more inclined to maintain their training (43). Though the participants of the current study cannot be classified as athletes, one could have suspected the HIIT group to maintain their training duration while lockdowns were implemented, since they are the group with the highest total PA.

However, the data show that HIIT decreased training duration to the lowest level of all three groups during that time. Unfortunately, research is currently lacking in this specific area.

Similar to training duration, control and HIIT also showed a significant decrease in training intensity from year 6 to year 7. Most studies looking at exercise intensity during the pandemic were conducted on athletes (44). However, a study by Washif et al. showed a negative impact of the Covid 19 lockdowns on training frequency, duration, and intensity, especially in amateurs athletes (44). Though the participants of the current study were highly active compared to non-participants, they could not reasonably be thought of as amateur athletes, yet one could argue the findings of the current study underline the findings of the two studies by Washif et al. (43,44), considering all groups decreased their training intensity when pandemic lockdowns were implemented.

Though perceived training intensity according to the BORG Scale (29) is not part of the total PA discussed in this thesis, it was nevertheless analyzed like the other training components. As mentioned, intensity according to the BORG Scale was not part of the calculations for total PA, but it might yield interesting results, as there is a great similarity between the answer alternatives 2 and 3 in the question about training intensity, which was used in the PA-Index. One could plausibly argue that the BORG Scale might give a better picture of the change in training intensity. Curiously, only the control group showed a significant decrease in their perceived training intensity, though all groups show a reduction in their BORG Scale scores in our data. Altogether data on intensity strongly indicates that all three groups tend to reduce the intensity of activity during the pandemic. However, since all groups trained at a relatively high intensity prior to pandemic lockdowns, it seems easier for participants to continue activity of moderate intensity while everything is closed down.

Physical activity as mitigation strategy

Multiple studies have shown PA to have positive health effects not only on the general life quality of the elderly, but also as a mitigation strategy for Covid 19 and possibly similar infections (18,45,46). Interestingly, some studies have shown moderate intensity training to be superior to high intensity training, when it comes to

mitigating infection (21,41,47). To further understand the impact of the changes in total PA on health outcomes during Covid 19, it would be interesting to investigate whether or not elderly people with a higher total PA have indeed a lower prevalence of severe cases and death due to the infection. As all groups showed decreases in one or more of the components of total PA, but were still very active, a comparison of the death percentage between participants and non-participants could enlighten researchers as to whether or not physical activity should be implemented as a prevention strategy during the next pandemic. And even during lockdowns, systems must be put into place to allow people to continue their exercise.

Strength and limitations

Since the current study is a sub-study of the large Generation 100 study, one of its strengths is the longitudinal design. This allows researchers to clearly visualize changes within behavior over time.
Another strength is the trial design. Randomized control trials are a gold standard when it comes to eliminating bias and creating intervention groups of equal distribution (48). That together with the large sample size of the largest study of its kind worldwide, allows us to clearly detect differences between the various intervention groups. Additionally, a large proportion of females have been participating in the main study, while women have historically been underrepresented in research.

A perceived limitation lies within the methodology of the current study, even though using linear mixed models to analyze longitudinal changes is a gold standard. Since all participants who had at least one data point pertaining to physical activity were included, the results only show an aggregate of the groups, not however of the participants. For future research it might be interesting to do a case study using similar analysis of only participants that have all necessary datapoints throughout the study period and compare their data by person and group affiliation. However, since randomized control trials are the gold standard, this analysis might be more accurate when not analyzed on a case-by-case basis, but still with only those participants that have all datapoints throughout the study period. The sample size would likely be significantly reduced, but the results might give a clearer understanding of the

changes within and between the intervention groups.
Another limitation is that the control group was highly active during the intervention period and have even used high intensity interval training, thus potentially blurring the lines between the control and the HIIT group.
Furthermore, as reported by Stensvold et al. (23), participants in the current study are on average of higher education and general health, as severe disease and mobility issues were an exclusion criteria for the Generation 100 study. This could lead to overestimations of the PA in older people, when generalizing the results of the current study. The findings described here should therefore be used with caution when trying to implement the results in health policies.
The biggest limitation in the methodology is that total PA was measured using a questionnaire. The gold standard for measuring total PA is the accelerometer. However, since there is not a well-established threshold to map different levels of activity with an accelerometer in older adults, the questionnaire is a valid method to assess PA in this age group (6).
Additionally using two measurements of training intensity might be confusing. The difference in perception between training intensity and BORG Scale might be due to the fact, that self-reported perceived exertion is very subjective to each person. Furthermore, subjective measurements follow a relative longitudinal development as well, as indicated by the high standard deviation seen in Table 3. However, multiple studies have attested to the reliability of self-reported exertion with the help of questionnaires (26,49).

This thesis seeks to add to the knowledge, and therefore help the older population and society at large to adjust their lifestyle accordingly in order to enhance their health and successful ageing. The Covid 19 pandemic serves as a stark reminder that society is likely to encounter similar global health crises in the future (50). This thesis therefore tries to add valuable insights, which in turn might be implemented in real life to stem the next global pandemic.

Conclusion

This study provides insights into the impact of lockdown measures during the covid 19 pandemic on the total PA of older adults.

Our data shows a decrease in total PA -albeit not statistically significant- from year 7 to year 8 (2020-2021) in HIIT, MICT, and control, with no differences between the groups. As studies have shown physical activity to have had positive health effects, our data highlight the need to facilitate PA during potential future lockdowns in order to prevent negative health outcomes for all people and specifically among older adults, though much more research is needed to further understand the intricacies of viral outbreaks and physical activity as prevention and mitigation strategy.

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Appendices

Appendix 1: Supplemental Figures of changes in physical activity components

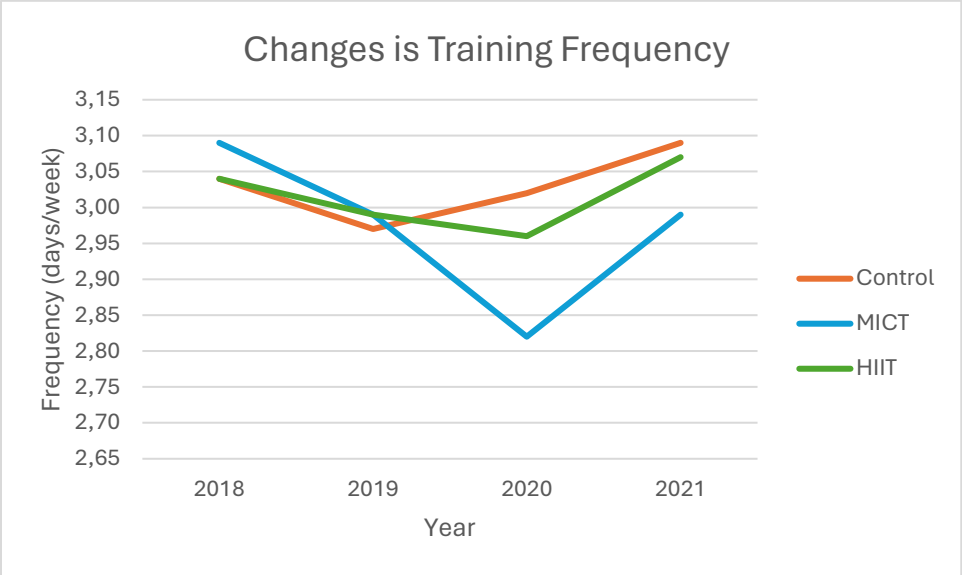

Figure 3: Changes in training frequency from 2018 to 2021

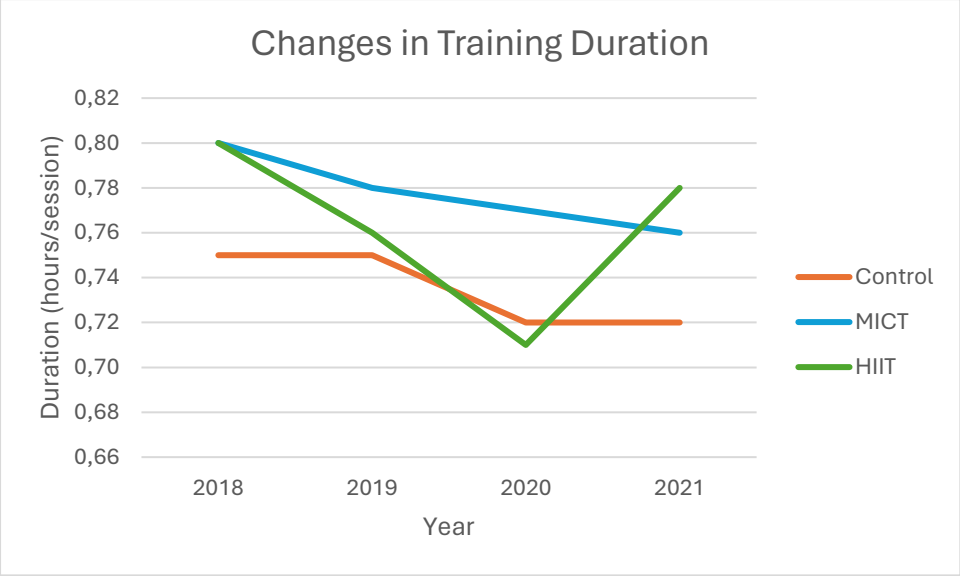

Figure 4: Changes in training duration from 2018 to 2021

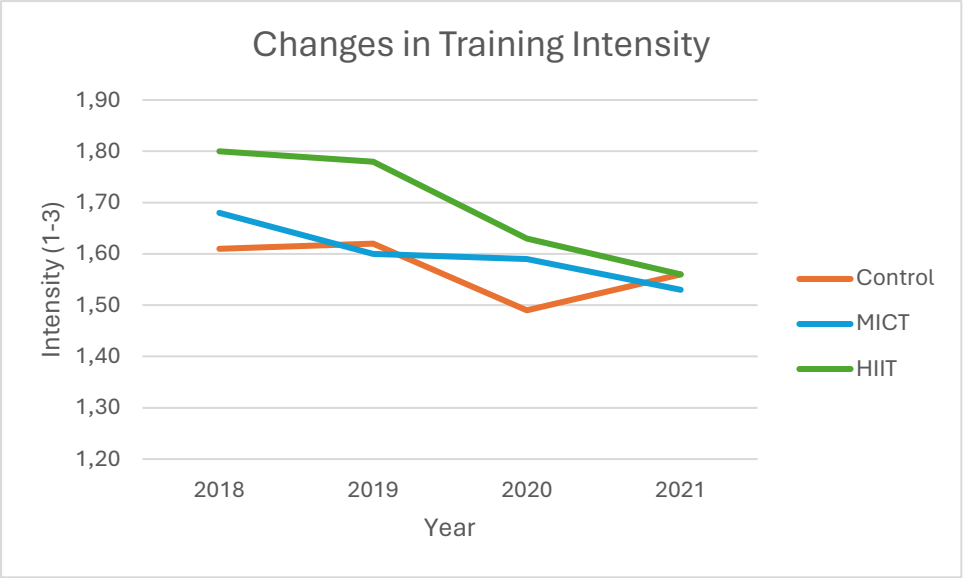

Figure 5: Changes in training intensity from 2018 to 2021

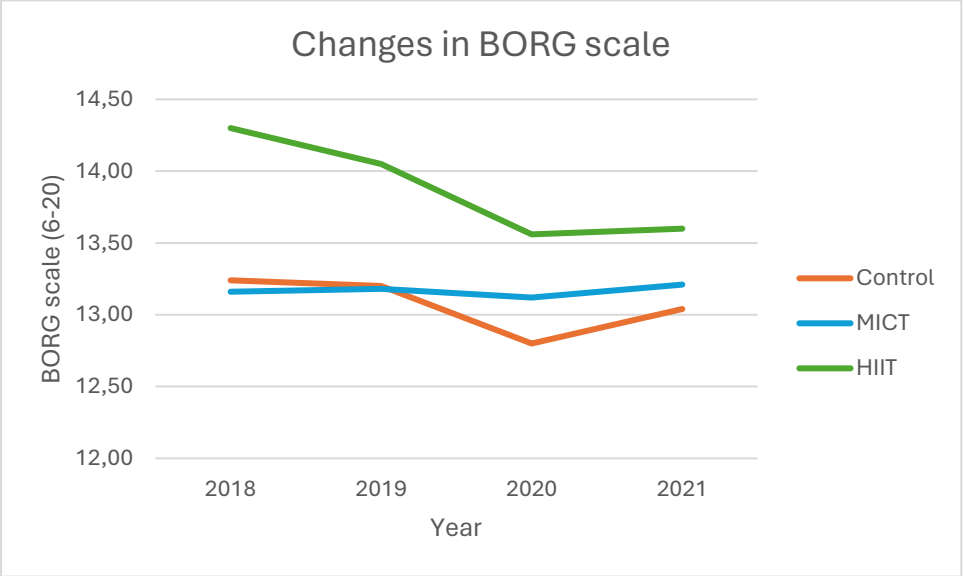

Figure 6: Changes in training intensity according to the BORG Scale of perceived exhaustion from 2018 to 2021

Appendix 2:

Table 4: BORG Scale of perceived exhaustion and its explanation (29)

6	**No exertion at all**	No muscle fatigue, breathlessness or difficulty in breathing.
7	**Extremely light**	Very, very light.
8		
9	**Very light**	Like walking slowly for a short while. Very easy to talk.
10		
11	**Light**	Like a light exercise at your own pace.
12	**Moderate**	
13	**Somewhat hard**	Fairly strenuous and breathless. Not so easy to talk.
14		
15	**Hard**	Heavy and strenuous. An upper limit for fitness training, as when running or walking fast.
16		
17	**Very hard**	Very strenuous. You are very tired and breathless. Very difficult to talk.
18		
19	**Extremely hard**	The most strenuous effort you have ever experienced.
20	**Maximal exertion**	Maximal heaviness.

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