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Impact of COVID-19 on neighbourhood physical activity in older adults

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ABSTRACT

Physical activity is critical for older adults' health and was particularly important during the coronavirus (COVID-19) pandemic. To slow the spread of COVID-19, built environment modifications were introduced in public spaces including one-way walking systems, social distancing, and the restricted use of public toilets and seating. These modifications intended to encourage safe exercise but may have reduced walkability and inadvertently hindered older adults' physical activity. We aimed to investigate whether Covid-related built environment modifications reduced older adults' physical activity. We surveyed 282 older adults in the UK using a mixed methods Concurrent Triangulation Design. Physical activity decreased during COVID-19. Older adults believed many Covid-related built environment modifications negatively affected physical activity because of safety or accessibility issues. These negative modifications were more prominent in areas of higher walkability and associated with reduced physical activity. However Covid-related Traffic Reduction and some elements of One-Way Walking Systems were largely considered positive modifications that helped facilitate physical activity. We concluded common Covid-related built environment modifications hindered exercise, reduced walkability, and possibly contributed to reduced physical activity in older adults. If similar modifications are required in the future, older adults' needs must be accommodated to avoid discouraging physical activity and compromising long-term health.

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Healthy ageing; older adults; built environment; COVID-19; physical activity

Introduction

Throughout 2020/21, the coronavirus pandemic (COVID-19) had a devastating impact on day-to-day life worldwide. To reduce the spread of COVID-19, many countries including the United Kingdom urged the public to minimise contact with others and remain at home where possible. At the same time physical activity was being encouraged as a way of supporting wellbeing and healthy lifestyles. Outdoor exercise such as walking or cycling was particularly important at this time because many gyms, social clubs, and other exercise facilities were closed (European Health & Fitness Report 2021). However, outdoor physical activity also became more challenging due to modifications made to the built environment which aimed to promote social distancing as a protection against Covid infection (CDC Guidance for Administrators in Parks and Recreational Facilities 2020). Specifically, these Covid-related built environment modifications included one-way walking systems within retail and local services, space rationing, and restricted access to public sidewalks, toilets, and seating.

The built environment, encompassing all man-made structures like buildings, streets, and green spaces, is widely thought to influence physical activity (Sallis *et al.* 2006, Owen *et al.* 2007, van Dyck *et al.* 2010, Chudyk *et al.* 2017), therefore any modifications, such as those that enforce social distancing, may also have impacts on physical activity. Older adults' activity levels are particularly susceptible to built environment influences because most exercise takes place within their own neighbourhood (Chaudhury *et al.* 2016). For older adults, physical activity is especially important to maintain health, wellbeing, and independence (Bean *et al.* 2004). They are advised to engage in 150 minutes of moderate-intensity activity per week, such as walking or cycling, or 75 minutes of vigorous activity, such as hiking or jogging (Sparling *et al.* 2015). Achieving these goals can lead to well-established health benefits including reduced risk of cardiovascular disease, diabetes, depression, and stress (Musich *et al.* 2017), and may reduce fall risk by preserving muscle strength and gait capabilities (Trudelle-Jackson & Jackson, 2018). Despite this, even prior to the COVID-19 pandemic 85-90% of older adults in the United Kingdom did not attain the recommended physical activity guidelines (Jefferis *et al.* 2014), and they commonly cite built environment barriers as a reason for reduced physical activity (Nagel *et al.* 2008, Carlson *et al.* 2012). In the time of COVID-19, the built environment likely posed additional barriers to physical activity for older adults, firstly through modifications such as one-way walking systems that reduced sidewalk availability or obstacles

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(Lockett & Edwards, 2005, Brownson *et al.* 2009), and secondly because this age group was more vulnerable to severe illness from Covid, and likely faced additional safety concerns.

One way to minimise these barriers and encourage physical activity in older adults is to make the built environment highly walkable. Walkability is a term used to describe how conducive a built environment is to walking and can be evaluated using both subjective and objective built environment characteristics (Rosso *et al.* 2011, Todd *et al.* 2016). Highly walkable areas typically have high residential density, good connectivity, high land use diversity, accessible amenities, and design features that support safe and comfortable walking, including sidewalks segregated from traffic, quality surfaces, greenery, and appropriate street furniture. For older adults in particular, pedestrian-friendly streets must be safe and accessible, with wide, even sidewalks which are free of obstacles, readily available benches so they can rest where necessary, frequent transit stops, and a high intersection density, allowing efficient access to their destination (Rosenberg *et al.* 2013, van Holle *et al.* 2014, Chen *et al.* 2019). If these features are present, the area will be likely to be supportive for physical activity in older adults (Christian *et al.* 2011, van Holle *et al.* 2014, van Cauwenberg *et al.* 2016, Cleland *et al.* 2019). Conversely, areas of lower walkability, or even the perception of low walkability, may discourage physical activity (Lee & Dean 2018) because associated features such as narrow, crowded sidewalks with obstacles, and lack of sidewalk accessibility, are often considered challenging, with potential fall hazards and safety risks (Ottoni *et al.* 2016).

These features became accentuated throughout the COVID-19 pandemic. Public streets were modified to facilitate emergency health and safety measures aiming to control the spread of the virus, which included restricting access to public spaces such as sidewalks, benches and rest facilities, and the implementation of one-way walking systems, to promote safe walking (HM Government 2021). While the public were encouraged to remain active during this time, these Covid-related modifications had many features that had been associated with lower walkability and therefore may have inadvertently created additional barriers to physical activity, particularly for older adults. For example, one-way walking systems often restricted available walking space and required the use of barriers or instructional signs, which could serve as obstacles. Road closures and reduced public transport stopped pedestrians from accessing preferred routes or destinations, which can present safety risks and discourage physical activity in older adults (van Holle *et al.* 2014, van Cauwenberg *et al.* 2018). In addition, use of rest facilities were limited and, in some cases, prohibited. Access to public toilets and outdoor seating helps to facilitate physical activity in older adults (Newton *et al.* 2010, Ottoni *et al.* 2016, Brookfield *et al.* 2017), however their use was restricted due to concerns that these facilities increased the spread of COVID-19 through proximity to others (*CDC Guidance for Administrators in Parks and Recreational Facilities* 2020). Although the extent of these restrictions differed greatly between countries and even counties in the UK, in general most public toilets and all attended toilets were closed temporarily and some permanently, and access to benches was also restricted, without clear instructions for their use (Government of the United Kingdom 2020), which created a lack of clarity surrounding the law and outdoor seating rules among the general public. Existing research on the built environment influences on walking would suggest that these COVID-19 modifications could be associated with a reduction in walkability, and a decrease in physical activity, particularly for older adults who are more sensitive to built environment changes (Chaudhury *et al.* 2016).

Overall, the similarities between the Covid-modified built environment and areas of lower walkability suggest that these modifications could decrease physical activity. This decrease may be greater in older adults because of their dependence on built environment features (e.g. benches, public toilets), and because COVID-19 modifications did not accommodate their specific needs. Due to the rapid onset of COVID-19, and severe related health risks, these modifications were necessary to slow the spread of COVID-19 and help keep the public safe, many of these modifications were still present more than a year after they were implemented, and they may have created additional barriers to physical activity for older adults, which over time could become detrimental to long-term health and wellbeing. COVID-19 movement restrictions have previously been associated with a decrease in physical activity for working-age adults and those with chronic illness (Duncan *et al.* 2020, López-Sánchez *et al.* 2021), however the potential influence of built environment changes for older adults has not yet been fully explored.

The aim of this study was to investigate how COVID-19-related built environment modifications, such as one-way walking systems, impacted older adults' physical activity. We used both quantitative and qualitative methods in a Concurrent Triangulation Design. Given that the Covid-modified built environment exhibits features associated with lower walkability, we predicted that these modifications would lead to decreased physical activity levels in older adults. Furthermore, based on the documented increase in susceptibility to built environment influences with age (Berke *et al.* 2007, Carlson *et al.* 2012) we expected that a reduction in physical activity and increase in negative COVID-19 modifications will be reported as a function of age.

Method

Participants

We surveyed 282 UK residents (126 male and 156 female), aged between 65 and 88, who were able to walk for at least five minutes unaided. The nature of the survey required participants to have been able to freely move around outside the home, therefore we excluded those who had been self-isolating, 'shielding', or bound by a government 'Stay-at-home' order, for over 7 days in the previous month.

Materials

This survey was built on Qualtrics and consisted of multiple-choice questions, free-text questions, and standardised scales. To determine the prevalence of built environment modifications, participants selected any of the following items that they had noticed in their neighbourhood: One-Way Walking Systems, Narrow Sidewalks, Restricted Sidewalk Access, Limited Toilet Access, Limited Seating Access, Road Closures, Reduced Public Transport, and Reduced Traffic. These items were chosen as they appeared commonly throughout the COVID-19 pandemic. In addition to these items we included 'Use of Masks/Hand Sanitiser' on our list of changes. Although this is more of a societal change than a direct change to the built environment, the use of masks and hand sanitiser was enforced in many public spaces in the UK and undoubtably influenced older adults' experience within the built environment. We established the effect of these modifications by asking participants whether they considered them to have a positive or negative impact on physical activity, and to describe why.

The remainder of the survey consisted of standardised scales. We assessed physical activity using the Community Health Activities Model Program for Seniors (CHAMPS) questionnaire (Stewart *et al.* 2001), where participants reported how often they engaged in a range of activities specifically tailored to older adults. This scale was chosen due to its in-depth assessment of activities, the relevance for older adults, and because CHAMPS is frequently used during exercise programs or interventions to assess differences in physical activity. In this instance we used CHAMPS to assess physical activity at two timepoints: a 'pre-test' where participants estimated physical activity from before COVID-19 (around January 2020); and 'post-test' where participants reported current physical activity (May 2021).

Finally, we recorded experiences with COVID-19 using the Coronavirus Perceived Threat Questionnaire – Short Form (Conway 2020) which assessed fear of COVID-19; and the Coronavirus Experiences Questionnaire – Short Form (Conway 2020) which detailed participants' personal experiences with COVID-19. These scales consisted of three and seven items respectively.

Procedure

Participants completed a single-session online survey, which was built on Qualtrics. The survey was made available to UK residents aged 65+ on Prolific, an online participant pool, during May 2021. Average completion time for the survey was 22 minutes and those who provided complete responses received £5 compensation for their time. Within the survey, we first asked basic demographics questions to confirm inclusion criteria, followed by questions about the built environment. Subsequently, in the following order, participants completed the CHAMPS (Stewart *et al.* 2001) pre-test (describing typical physical activity from before the COVID-19 pandemic, around January 2020); and post-test (describing activity during the COVID-19 pandemic, May 2021). Finally, participants were given the option to answer the Coronavirus Impact Questionnaire – SF, and the Coronavirus Experiences Questionnaire – SF (Conway 2020).

Data analysis

We used a mixed methods Concurrent Triangulation Design to investigate the impact of Covid-related built environment modifications on physical activity in older adults. This design was chosen to combine quantitative and qualitative methods, allowing us a more comprehensive view of older adults' behaviour and motivations, and to help clarify elements of the complex relationship between physical activity and COVID-19 and highlight the effects of the built environment over general safety issues.

Physical activity was considered from two points, pre-test (January 2020 before COVID-19 - with no modifications in place), and post-test (May 2021 during COVID-19 - with restrictions and built environment modifications in place). CHAMPS outcome measures were 'Frequency (sessions)' and 'Duration (hours)' per week, of both Total Physical Activity (TPA), and Moderate-to-Vigorous Physical Activity (MVPA). The following CHAMPS items were classified as MVPA: dancing, playing golf or tennis, skating, heavy housework or gardening, working with machinery, jogging or running, hiking or walking for exercise, cycling, aerobics or aerobic gym work, swimming and water exercise, strength training, and playing ball games. TPA items included all MVPA items, plus woodwork and crafts, light housework or gardening, walking for leisure, and yoga or tai chi. Sedentary activities were not included in either classification.

The frequency and duration of TPA and MVPA were compared at pre- and post-test timepoints using paired samples *t*-tests.

Built environment modifications were totalled, and further categorised as 'Positive' or 'Negative'. Free-text answers, where participants described how these modifications affected physical activity, were analysed using Theoretical Thematic Analysis with open coding, to find the most common benefits and challenges these changes posed to older adults.

Using walkscore.com we converted participant postcodes to a walkability score between 0 (low) and 100 (high). Coronavirus Experiences, and Perceived Threat questionnaires were scored according to standard instructions (Yardley *et al.* 2005, Conway 2020). Respectively, a high score denoted prior experience with COVID-19, or significant fear of COVID-19. Outcomes from each of these scales were correlated with post-test CHAMPS scores, built environment modifications, and demographic factors.

Results

Age

Participants in this study were aged between 65 and 88, (Mean age = 71 years, SD = 4.81). For physical activity, age only correlated negatively with post-test TPA duration $r(281) = -.13$, $p = .031$, suggesting the length of older adults' physical activity sessions decreased with age. No other associations were found between age and Covid-10 modifications, or Covid experiences.

Physical activity

TPA frequency decreased throughout the coronavirus pandemic, from pre-test ($M = 19.04$ sessions per week, $SD = 10.07$) to post-test ($M = 17.36$ sessions per week, $SD = 9.32$), showing that older adults engaged in fewer exercise sessions during the coronavirus pandemic $t(276) = 3.53$, $p < .001$ (Figure 1(a)). Frequency of MVPA also decreased from pre-test ($M = 5.16$ sessions per week, $SD = 4.57$) to post-test ($M = 4.5$ sessions per week, $SD = 4.46$), $t(264) = 3.77$, $p < .001$ (Figure 1(b)). Physical activity sessions were also shorter during COVID-19, as TPA duration decreased from pre-test ($M = 15.07$ sessions per week, $SD = 8.2$) to post-test ($M = 12.79$ sessions per week, $SD = 7.47$, $t(269) = 5.45$, $p < .001$ (Figure 1(c)), as did MVPA duration (pre: $M = 5.47$ sessions per week, $SD = 4.91$; post: $M = 4.19$, $SD = 4.36$), $t(273) = 6.63$, $p < .001$ (Figure 1(d)).

Built environment modifications

The total number of built environment modifications, and how participants classified them, are summarised in Table 1. Changes which helped to make physical activity easier were classified as Positive, those which made physical activity more challenging were classified as Negative. Limited Toilet Access was the most prevalent negative change, and less traffic was the most prevalent positive change.

No correlations were found for positive modifications, however negative modifications were negatively correlated with post-test TPA frequency $r(80) = -.27$, $p = .018$ (Figure 2(a)), and MVPA frequency, $r(80) = -.24$, $p = .032$ (Figure 2(b)),

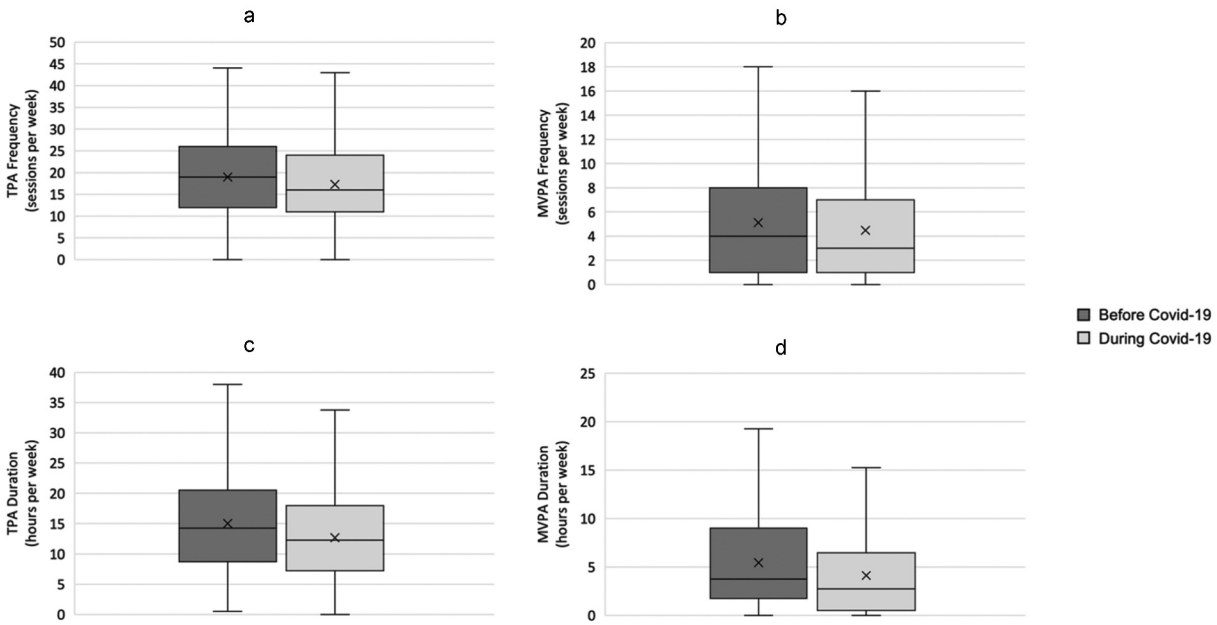

Figure 1. Physical activity before and during the coronavirus pandemic: TPA frequency (a), MVPA frequency (b), TPA duration (c), and MVPA duration (d).

Table 1. Prevalence of built environment modifications reported by participants.

	Positive Change	Negative Change
Masks/Sanitiser Required	15	8
Traffic Reduction	65	1
Limited Toilet Access	2	47
One-Way Walking Systems	22	15
Limited Seating	3	25
Reduced Public Transport	4	7
Narrow Sidewalks	0	26
Restricted Sidewalk Access	0	23
Road Closures	4	7

showing participants in areas with more negative modifications engaged in less frequent physical activity.

Also, negative modifications positively correlated with walkability, $r(80) = .28$, $p = .03$, perhaps suggesting participants living in highly walkable areas found built environment modifications more disruptive to physical activity, compared to those in less walkable areas (Figure 3).

Built environment modifications: older adults' views

So far, our results show that physical activity decreased for older adults throughout the COVID-19 pandemic, particularly for those who report a higher number of negative built environment modifications. While there may be multiple factors contributing to falling physical activity levels during COVID-19, such as lack of opportunity, social commitments, or COVID-19 fears, these modifications may have made exercise more challenging. In this study participants were given the opportunity to describe if, and how, these modifications made physical activity easier or more challenging. To gain a more comprehensive understanding of these effects we used Thematic Analysis with open coding to determine commonalities. Two raters independently reviewed the data, and our Thematic Framework is presented below (Figure 4).

We felt it was important to consider the data within the context provided by participants, therefore themes are categorised as either Advantages or Disadvantages. From the 160 free-text responses we received, 54% related to advantages, and 46% disadvantages, and four prominent themes emerged, as summarised in Table 2.

Safety

Safety was the most frequently discussed issue, spanning both advantages and disadvantages, with contrasting views between participants. The reduction in traffic was widely considered a safety benefit, however most other modifications were considered negative, or opinion was divided. For example, some believed that 'One-Way Walking Systems' and enforced use of masks helped facilitate physical activity, enabling safe walking at the recommended two-metre 'social distance', and encouraging others to follow safety guidance.

- *"(One-way walking systems mean) it's possible to maintain social distancing and people are more aware and therefore more considerate towards others".*
- *"Although not everyone follows the one-way system, there are fewer occasions when I need to step aside to make space for others and I feel more covid-secure"*

For others, one-way walking systems reduced available walking space by narrowing sidewalks, particularly where they were already narrow, restricting sidewalk use, and adding signs and barriers. This left some older adults feeling more vulnerable to COVID-19, contrary to the primary purpose of these modifications. Narrow sidewalks, and other changes such as sidewalk or road closures and reduced public transport, reduced available space for exercise, causing safety concerns as the areas that were available became more crowded. Rather than facilitating safety and social distancing, in some cases

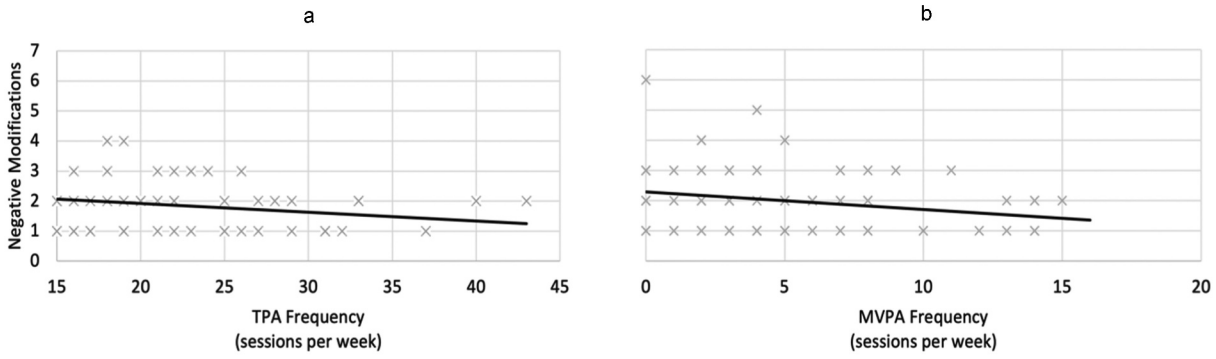

Figure 2. Correlation between negative modifications and post-test TPA (a) and MVPA (b).

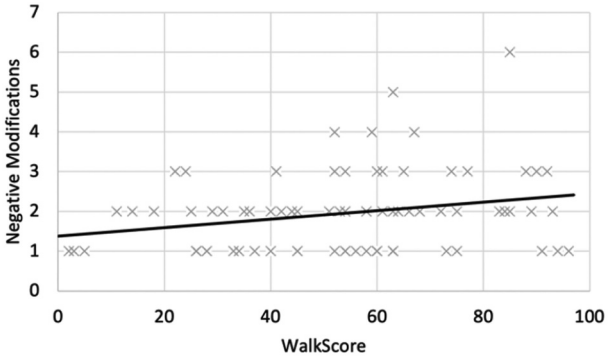

Figure 3. Correlation between negative modifications and walkability.

Table 2. Frequency of themes derived from thematic analysis.

	Theme	Theme Frequency (%)
Advantages	Safety Benefits	35
	Clean Environment	19
Disadvantages	Accessibility Issues	27
	Safety Concerns	19

these modifications effectively forced pedestrians to walk closer together, particularly those who were passing in the opposite direction.

- *"I do not like being faced with someone and having to squeeze past them in an enclosed space, outdoor OR indoors".*
- *"It makes it more difficult to walk and also to socially distance"*
- *"I like to keep distance when walking, but when roads are closed, combined with a one-way system it can get congested and make walking at a pace I like very difficult"*

Similarly, one-way walking systems and narrow pathways sometimes made it more difficult to avoid others who did not follow COVID-19 safety rules. Participants described scenarios where they were forced to choose between maintaining social distancing or walking in the road, risking injury from traffic.

- *"If you meet people when on a narrow sidewalk, someone has to walk in the road, and some don't seem to want to".*
- *"Sometimes if the pathway is narrow you have to stand to the side to let others go by. Often this behaviour isn't reciprocated as a lot of people feel the pandemic is over and are acting as they would have done before – i.e. no social distancing".*
- *"Some people did not give enough space to keep distanced so had to go into the road".*

However, despite multiple safety concerns from these modifications, 'Traffic Reduction' was considered overwhelmingly positive. Although this was not a directly implemented change, instead arising from home-working or government travel guidance, less traffic had significant consequences for the wider built environment. Many older adults felt this resulted in a safer environment with less traffic risk, encouraging participants to walk, run, or cycle alongside the road without worry. Others felt less anxiety when crossing the roads. Traffic reduction also helped mitigate some of the previously mentioned safety risks, as pedestrians felt safer using road space to maintain social distancing or avoid obstacles.

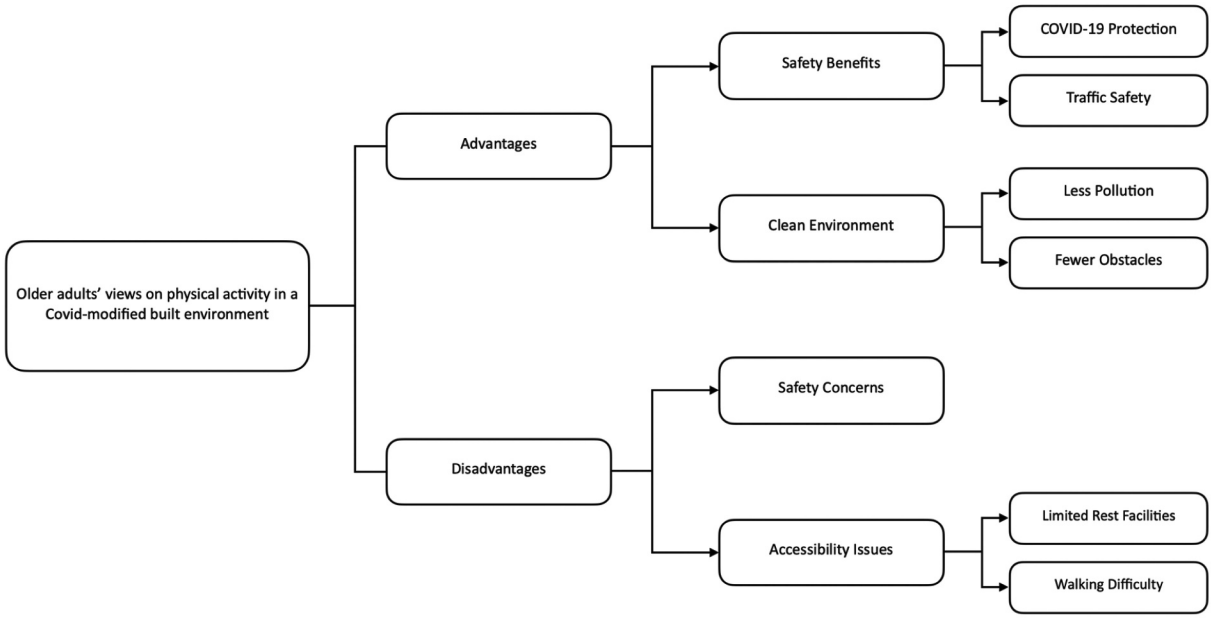

Figure 4. Thematic framework.

- *"I can go out on my bike without worrying about the traffic having to overtake me and I feel safer if I'm out walking with the grandchildren that I don't worry if they are close to a road"*
- "Keeping the 2 m distance means coming off the footpath and on to the road sometimes so that you can keep your distance, less traffic means it is safer to do so".
- "Less cars on the street make it easier to walk on the road within my neighbourhood"

Poor accessibility

Many older adults cited accessibility difficulties due to built environment modifications and restrictions. The inability to access exercise areas and reduced space for walking were frequently discussed, but by far the most prominent issue was limited access to public toilets and seating.

- *"I need ready access to toilet facilities, sometimes with very short notice. Restrictions in pubs, shops and public toilets have made walking around my local area very difficult of late"*
- *"Taped-off benches mean that if I get tired, there is nowhere to sit for a short rest. Sometimes I lean against a lamppost, but this does not give me the rest I need. As a consequence, I have made my walks shorter, or not gone for a walk if I did not feel on top form"*
- *"These closures make walking more difficult, because as you become more elderly, you need places to rest. You also need comfort breaks".*

These quotes highlight how the availability of rest facilities can impact on physical activity for older adults. Many participants felt it was necessary to avoid or limit activities outside their home for fear of not being able to rest or access toilets. This sentiment was echoed by many, and some stated that age exacerbated their difficulties, because as older adults they required more frequent rest breaks or toilet access. One participant noted that even where toilets were available, there were additional difficulties accessing them, such as the need to remember a mask and money.

- *"I would (pre-Covid) have been more comfortable knowing that the pub on my regular walk has toilets freely available. These are now strictly customers only, and I would need to spend money and remember a mask each time".*

In addition, walking difficulty itself was another prominent issue. Participants found walking taxing on narrow sidewalks or one-way walking systems, particularly where there were crowds or congestion, which often led them to step aside or walk in the road. As well as causing Covid-related safety concerns, this interrupted foot flow and pace, making walking more challenging and less comfortable.

- *"Narrow space to walk and constantly watching for other participants"*
- *"(Narrow sidewalks and one-way walking systems') make an obstacle like course"*
- *"Some sidewalks are very narrow to begin with, then many people do not observe the arrow system for parallel use of paths, the red sign about COVID-19 and socially distancing is placed at a ridiculously high level so that it is easy to miss and, worst of all, illegal sidewalk cycling continues even in these circumstances – e-scooters now too".*

Clean environment

Contrary to the difficulties experienced by some participants, others felt physical activity in their neighbourhood became easier and more pleasant throughout the coronavirus pandemic. Some noticed that street obstructions decreased considerably, as one-way walking systems provided designated walking areas, with everyone walking in the same direction. Others noticed that reduced public transport prevented crowds from congregating at bus stops in the middle of the sidewalk and taped-off benches allowed for clearer sidewalks. Again, less traffic was discussed, as fewer cars led to cleaner streets with lower levels of air and noise pollution, where it was easier to connect to nature. Older adults found this environment more pleasant and were more motivated to walk.

- *"There have been less people and cars around so it has been more enjoyable and less crowded on the streets"*
- *"Less dodging around people and things"*
- *"Less traffic noise makes walking much more appealing"*
- *"The air is clearly better quality, and it's quieter, one can hear the birds making what sounds like happy noises!"*

From these themes we can conclude that safety and accessibility factors, whether advantageous or challenging, influenced how older adults perceived physical activity in the built environment. Consequently, modifications which impact safety or accessibility may be the most likely to influence physical activity levels.

Discussion

This study aimed to investigate the impact of COVID-19 related built environment modifications on older adults' physical activity. Frequency and duration of TPA and MVPA, decreased during the COVID-19

pandemic, particularly in neighbourhoods with negative built environment modifications. In line with our predictions, these results suggest that built environment modifications did not accommodate the basic needs of older adults and have led to decreased physical activity over and above that which would be expected as a result of the COVID-19 pandemic.

Our prediction that built environment modifications would have a detrimental impact on older adults' physical activity was confirmed. Negative modifications were associated with reduced frequency and duration of physical activity, and those who lived in areas of higher walkability were more likely to report them. Furthermore, using Thematic Analysis we ascertained that safety concerns and accessibility issues were the most impactful consequences of negative modifications, and therefore most likely to influence physical activity. This is consistent with previous studies, which claim older adults often feel more confident and motivated to exercise when in a safe environment (Jongeneel-Grimen *et al.* 2013, Kramer *et al.* 2013). Considering the Thematic Analysis results in more depth, we can see that older adults preferred to exercise in a clean, quiet environment, with minimal safety risks, few obstacles, and the ready availability of toilets and benches so they can rest when necessary. These preferences have been well documented in previous research (e.g. Rosenberg *et al.* 2013, Ottoni *et al.* 2016). However, the Covid-modified built environment does not appear to meet these standards. Our findings suggest that Covid modifications did share characteristics with areas of lower walkability such as obstacles, narrow sidewalks, limited access to rest facilities or amenities, and safety issues (Lo 2009, van Cauwenberg *et al.* 2012, Yu *et al.* 2020), and therefore it is possible that streets with many COVID-19 modifications may have experienced a temporary reduction in walkability. If so, this may help to explain the reduction in physical activity during COVID-19, as well as the association between walkability and negative built environment modifications, as those living in more walkable areas found these modifications more disruptive. Given this, built environment modifications related to COVID-19 are likely to influence older adults' physical activity alongside other factors present in the time of COVID-19, such as official movement restrictions, social obligations, and Covid-fears.

In contrast to our first prediction, our second prediction for less physical activity and more negative COVID-19 modifications as a function of age was not confirmed. Our study included participants from 65 to 89 years old and based on the documented increase in susceptibility to built environment influences with age (Berke *et al.* 2007, Carlson *et al.* 2012) we expected our oldest participants to report considerably less physical activity and more negative COVID-19 modifications compared with our younger participants. However, this was not the case. Duration of physical activity did decrease with age at post-test, however there was a sixteen-month gap between pre-test and post-test activity estimations, therefore this was possibly due to natural age-related decline. From our results alone, we can only conclude that among older adults, age did not mitigate the effect of COVID-19 modifications on physical activity. Furthermore, also contrary to our predictions, the categorisation of built environment modifications was not as straightforward as anticipated. It would have been reasonable to assume that, except for traffic reduction, all other modifications would be detrimental to physical activity and therefore categorised as negative. In some ways the results aligned with our expectations, as older adults categorised the many of the built environment modifications as negative. However, other modifications, for example Traffic Reduction was categorised as overwhelmingly positive, and many older adults found this facilitated their physical activity through enjoyment, motivation, and safety. Furthermore, some participants categorised. One-Way Walking Systems and the use of masks as positive changes which made them feel safer and actively protected from COVID-19, whereas others believed one-way walking systems actually brought them closer to others. Drawing on results from our Thematic Analysis, it is reasonable to attribute these differences to personal preference or environmental variation. For example, the implementation of 'One-Way Walking Systems' on pathways that were particularly narrow to begin with may be more likely to cause safety concerns or accessibility issues, compared to initially wide sidewalks with surplus walking space where these modifications were more likely to be described as positive.

Built environment modifications can partially explain the decrease in physical activity seen during the COVID-19 pandemic, through both a reduction in walkability and the creation of safety fears or accessibility issues. However, it is likely that there are additional contributing factors. Throughout most of 2020-2021, COVID-19 fears and government restrictions discouraged many activities that involved leaving the house, including exercise. Older adults were likely to be the most affected as they risked severe illness from COVID-19. Despite this, we hope that the timing of our study, in May 2021, helped partially mitigated these problems as the risk from COVID-19 remained, but many older adults were fully vaccinated by this time, and we found no association between physical activity levels and Covid fears. Additionally, many government restrictions on social clubs and gym openings had largely been lifted,

allowing more opportunities for exercise. Therefore, while these factors will inevitably have affected physical activity levels to some degree, we hope the impact was lessened by May 2021, and that older adults felt relatively free to move around.

There are several limitations to this study, primarily concerning the accuracy of CHAMPS physical activity scores. Firstly, we rely on recall of activities from January 2020. As many physical activities are habitual, we hope participants had sufficient recall for their general activity, and that any over- or under-estimation would be negated across the group. However, the inability to measure pre-test activities at the time adds uncertainty to the change from pre- to post-test CHAMPS scores. Another limitation is the self-report format of this study, as previous studies have shown participants are likely to over-report their own physical activity compared to readings from an accelerometer (Downs *et al.* 2014). Again, this calls into question the accuracy of self-reported CHAMPS scores, although we are particularly focused on the change from pre- to post-test, and participants who over-report activity would be likely to do so at both timepoints, minimising this issue. Finally, although at the time of this study (May 2021) many older adults had been fully vaccinated against COVID-19, the threat was still very much present. As previously discussed, safety has a considerable impact on older adults' motivation to walk or exercise, and consequently safety fears will undoubtably be responsible for some of the observed decrease in physical activity from pre- to post-test. Going forward, more research is needed to determine the extent to which these built environment modifications influence physical activity without such heightened safety fears.

Best practice recommendations

Our findings can also be useful in the context of identifying good practice for built environment modifications to be considered for dealing with future pandemics. Our results suggest that older adults' needs were not effectively accommodated during the coronavirus pandemic, with some health and safety measures appearing to directly prevent or discourage physical activity, and this could lead to long-term health or wellbeing issues. In this instance, due to the rapid onset of COVID-19 and the danger it posed, these measures were necessary and had to be implemented quickly to preserve the safety of the public. However prolonged use of these measures may lead to poor health outcomes for older adults. Therefore if similar measures are required in the future more consideration should be given to the needs of older adults during walking or exercise. For example, in a similar situation where one-way walking systems may be necessary, sections of the road could be adapted and used for pedestrians, which would increase space for safe walking with minimal disruption, particularly with widespread traffic reduction. Access to public toilets and outdoor seating should be made a priority, and rules around the use of these facilities clearly outlined to avoid confusion. Generally, guidance could be drawn from walkability guidelines and older adults' preferences, which highlight safety and accessibility as primary factors to consider.

Conclusion

In conclusion, this study adds to growing evidence that the built environment can influence physical activity in older adults. Specifically in the time of COVID-19, emergency built environment modifications may have discouraged exercise by neglecting the basic needs of older adults, such as the need for frequent access to rest stops and toilets, and fears over personal safety. Negative built environment modifications were directly related to decreased physical activity, potentially because they increased barriers to physical activity and caused a temporary reduction in walkability, or because they failed to make older adults feel adequately protected from COVID-19. Therefore, if similar modifications are required in the future, more thought should be given to the needs of older adults that may sometimes be overlooked, as regular exercise is very important and prolonged reduction of physical activity could have serious consequences for long-term health and wellbeing. Finally, looking beyond the COVID-19 pandemic, these results point to some general built environment changes that could benefit older adults, such as 'traffic-free' zones to encourage safe walking and cycling, and more accessible outdoor seating and public toilets.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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