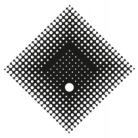
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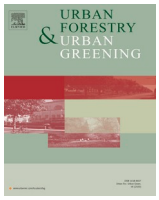

Something for the young and old: A natural experiment to evaluate the impact of park improvements

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ABSTRACT

Given the significant time and financial investment required to improve parks, evaluations of the effectiveness of park improvements are crucial to inform future investment and design to benefit people of all ages. This natural experiment study examined the impact of park improvements on park visitation and park-based physical activity (PA) in two suburban parks (Park A and Park B) compared to a control park with no improvements. Park A underwent substantial improvements with wide range of facilities, including an all-abilities large adventure-style playground, outdoor fitness area designed for older adults, walking paths and other amenities. Park B received relatively minor improvements that included a playground for young children, outdoor fitness equipment for older adults, and a picnic area. Direct observations were conducted using the System for Observing Play and Recreation in Communities at three timepoints; before (T1–2020) and after (T2–2021, and T3–2022) the improvements. At Park A, there was a significant increase in the total number of park visitors at both timepoints, and those engaged in moderate-to-vigorous physical activity (MVPA) from T1 to T3, relative to the control park. There were also significant increases in active park visits among children, adults, and older adults. At Park B, there were no significant changes in the total number of park visitors or those engaged in MVPA at either timepoint relative to the control park. These findings suggest the extent of improvements and the diversity of facilities included can influence the success of the intervention. The study highlights that including challenging and diverse play equipment suitable for various age groups and abilities, as well as other recreational features such as walking paths and outdoor fitness equipment can increase park visitation and physical activity across different age groups. The findings can inform future park management and planning decisions.

1. Background

Physical inactivity is a significant contributor to many non-communicable diseases and is the fourth leading global risk factor for mortality, responsible for around 6 % of deaths worldwide (World Health Organization, 2009). To meet the target of 15 % reduction in physical inactivity by 2030 outlined in the World Health Organization's (WHO) Global Action Plan on Physical Activity 2018–30, coordinated efforts implemented at multiple levels are needed (World Health Organization, 2018). The provision of high quality public open spaces such as parks plays a crucial role in facilitating physical activity for all age groups (Sallis et al., 2016). In addition, exposure or access to parks can positively impact health via several pathways, such as the provision of opportunities for social interaction and social cohesion, reduction in stress and mental fatigue and improvements in environmental quality, such as quality of air, and reduction in noise and heat (Hartig et al., 2014; James et al., 2015). It is therefore important to understand how to ensure parks are appealing for encouraging park visitation and physical activity.

Previous research has shown that park quality, and specific features are associated with park-based physical activity across different age groups (Kaczynski et al., 2008; Schipperijn et al., 2013; Sugiyama et al., 2010). Additionally, past studies indicate that different age groups have different needs and preferences for park features. For example, the

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presence of large flying foxes and adventurous playgrounds were found to be the most important features for encouraging children to be physically active (Veitch et al., 2021), while sports courts were the most important driver of park-based physical activity among teens (Rivera et al., 2021). Walking paths were mostly valued by adults and older adults (Veitch et al., 2022; Veitch et al., 2022).

Natural experiment studies have been highlighted as a priority for understanding causal associations between physical activity and the built environment (Craig et al., 2012; Mayne et al., 2015; Sallis et al., 2009). A 2015 systematic review of natural experiment studies examining the influence of interventions in urban green spaces on usage and physical activity levels has shown inconsistent findings (Hunter et al., 2015). Since then, more recent studies using varying methodologies have also shown mixed outcomes in park use and active park visits across different age groups (Cohen et al., 2019; Cranney et al., 2018; Duncan et al., 2021; Poppe et al., 2023; Veitch et al., 2021; Veitch et al., 2018). For example, an Australian study that evaluated the impact of installing outdoor fitness equipment and a multi-sports court in a park did not find any significant differences across any age group in the number of park visitors and those engaging in Moderate-to-Vigorous Physical Activity (MVPA) following park improvements compared to the control park (Veitch et al., 2021). In contrast, other studies conducted in Australia and US showed a significant overall increase in the total number of visitors and those engaging in MVPA at the intervention park compared to the control park, although, most increases were seen among children and adults with no significant effect of the intervention on teens and older adults (Veitch et al., 2018; Cohen et al., 2019). These discrepancies in impact across different age groups may be due to the absence of targeted improvements for specific age groups. This can be further supported by the study conducted in Belgium which found an increase in the number of people visiting and number of those engaging in physical activity across all age groups compared to control park following park improvements that were targeted to different age groups, including installation of a playground for all age groups (toddler, children and teen), outdoor fitness equipment, accessible walking and cycling path, and a picnic area and seating (Poppe et al., 2023). An Australian study also aligned with these findings reporting increase in the number of visitors across all age groups and increase in activity levels due to targeted park improvements, including, children play equipment, outdoor fitness equipment for older adults, sports court and other amenities (Duncan et al., 2021). However, no control park was used in this study. Similarly, another Australian study that lacked a control park reported significant increases in proportion of people engaging in MVPA in the outdoor fitness area, especially among older adults, after installation of equipment suitable for this age group (Cranney et al., 2016). Including a control park in studies assessing the impact of park improvements is crucial as it provides a baseline against which the effects of the improvements can be compared, which makes it possible to determine whether any observed changes are truly due to the park improvements (Craig et al., 2012).

As park modifications and improvements require significant time and investment to design and build, it is crucial to determine their effectiveness to inform future investments and design considerations for people of all ages. Previous research have highlighted the need for more studies to analyse the effects of park improvement in different parks (Hunter et al., 2015; Joseph and Maddock, 2016; Veitch et al., 2014) that focus on including age specific park features that appeal to different age groups (Cohen, Han, Isacoff, et al., 2019; Cohen et al., 2015).

An opportunity for a natural experiment in Melbourne, Australia served as the basis of the current study, which aimed to examine the impact of installing a new children's playground, outdoor fitness equipment specially designed for and targeted to older adults and other amenities in two different parks on park use and physical activity among park visitors. The authors were informed about the upcoming park improvement projects by local council representatives who identified suitable parks for the study based on alignment with the authors' research focus.

2. Methods

This study examined the impact of park improvements in two suburban parks compared with a control park where no improvements were made, on park visitation and active park use among children, teens, adults and older adults via direct observations of park visitors. The baseline assessments (T1) were undertaken in October 2020. After the improvements were completed, both parks were fully opened to public in June-2021. First follow-up (T2) assessments were completed in November 2021 and the second follow-up (T3) was conducted in October 2022 to assess the longer-term effects of the park improvements. The mean daily maximum temperature at T1 was 15.8°C (range: 14.9°C-16.9°C), at T2 was 18.7°C (range: 17.3°C-20.2°C), and at T3 was 19.3°C (range: 16.1°C-21.5°C) (data obtained from the Bureau of Meteorology: www.bom.gov.au). Ethical approval for this study was provided by the Deakin University Human Ethics Advisory Group (HEAG-H 117_2020).

2.1. Study setting

This study included two intervention parks and a control park within Bayside City Council in Melbourne, Australia. Fig. 1 presents the location map showing intervention and control parks. Table 1 shows population density and age groups in the suburbs where the parks are located are located. The first intervention park (Park A) is approximately 3.7 ha and is located about 15.5 km southeast of Melbourne CBD with a decile score of 9/10 for the Index of Relative Socio-economic Disadvantage (IRSD) at the suburb level with a higher score indicating a lower level of disadvantage. The second intervention park (Park B) is approximately 4.8 ha and situated about 11 km southeast of Melbourne's CBD with a decile score of 10/10 for the IRSD at suburb level. The control park is approximately 4.0 ha and located about 4 km from Park A and 7 km from Park B. It is located around 18 km southeast of Melbourne CBD, with an IRSD decile score of 8/10, and was the most comparable to the intervention parks in terms of size and outdoor facilities of all parks in the same local government area. During the study period, no changes were made to the control park and no new parks were added within the City Council area where the intervention or control park were located.

2.2. The park improvements

Table 2 shows the park features present in the three parks before park improvements were made and the new park features added to the intervention parks. The local council conducted community consultations to understand community needs, which informed the park designs. The authors had no input into the design of the parks. Fig. 2 shows pictures of the control park, and Figs. 3 and 4 show pictures of Park A and Park B, respectively, before and after park improvements.

2.3. Measures

A modified version of the System for Observing Play and Recreation in Communities (SOPARC) was used to collect information on park users and their activity in the park (McKenzie et al., 2006). This observation method uses systematic scans through momentary time sampling. Designated target areas were scanned from left to right and participants present in each target area were recorded based on estimated age group (categorised as child: 1–12 years); teen: 13–20 years; adult: 21–59 years; or older adult: 60 years and above), their sex (male or female), and their activity (e.g. sedentary behaviour such as sitting or lying down; light activity such as standing; moderate activity such as walking, or using playground equipment; or vigorous activity such as jogging, cycling, or playing sport). The SOPARC has previously demonstrated acceptable

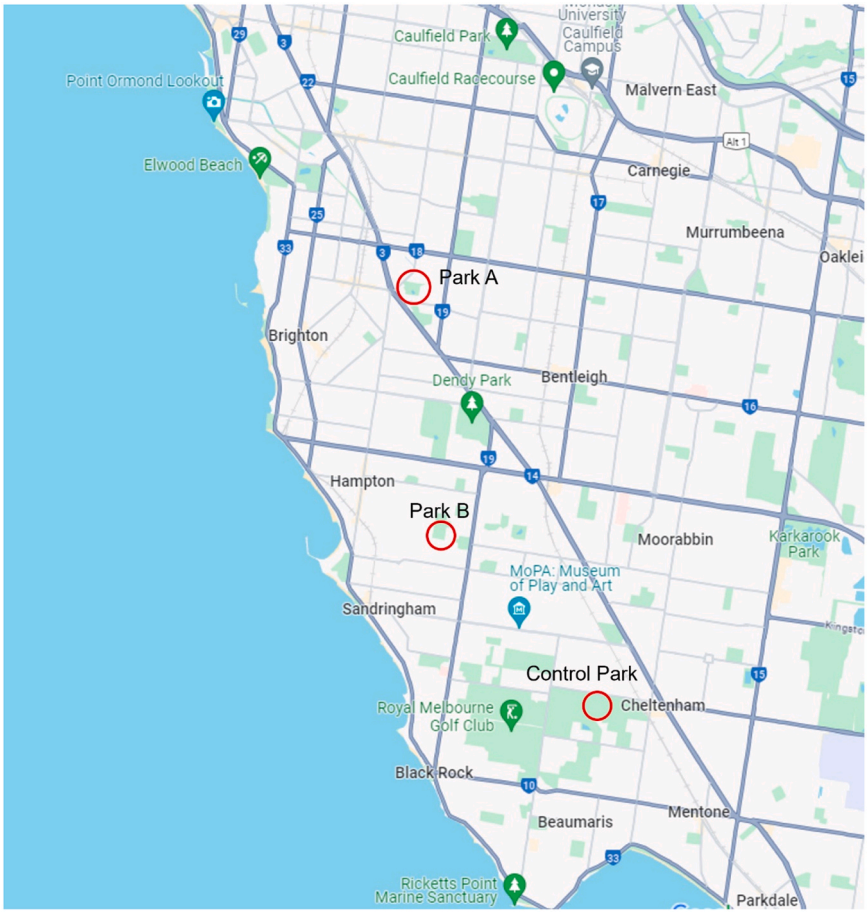

Fig. 1. Location map showing three parks.

Table 1
Population density and age groups in the suburbs where the parks are located.

	Park A	Park B	Control Park
Population density (inhabitants per km^2)	3306	3001	2302
Population (%)			
Children (0–9)	9.8	10.7	12.1
Teens (10–19)	14.9	15.4	11.2
Adult (20–59)	49.7	46.0	53.0
Older Adult (60+)	25.6	27.9	23.7

Source: (Australian Bureau of Statistics, 2021)

reliability and validity for measuring park users, park characteristics, and the activity level of park users (Evenson et al., 2016; Joseph and Maddock, 2016; McKenzie et al., 2006). Research staff were trained to use SOPARC during on-site park visits before each data collection timepoint.

Data were collected on the same days and times for all three parks at each timepoint (T1, T2, T3). T1 data collection was initially scheduled for two weekdays and two weekend days, however due to rain on one of the weekend days, data collection was extended to include two weekdays and three weekend days. At T1, data collection was conducted every hour from 8:30 am to 5:30 pm (10 observation points/day) for the two weekdays and one weekend day. On the other two weekend days, data collection occurred every hour from 8:30 am to 11:30 am (4 observation points) on one day and from 12:30 pm to 5:30 pm (6 observation points) on the other day for a total of 40 observation points across all five days. Both follow up (T2 and T3) data collection timepoints were conducted over two weekdays and two weekend days (40 observation points each) with observations conducted every hour from 8:30 am to 5:30 pm (10 observation points/day).

At all timepoints, the control park had eight target areas which included the playground, pathways, seating areas, cricket oval, and the dog park. At T1, Park A and Park B had 8 and 7 target areas respectively, which included the playground, grassy open areas, seating areas and pathways. At T2 and T3 in Park A, the newly installed playground was divided into 10 target areas to enable more accurate observations of playground users, and the outdoor fitness area was a separate target area resulting in a total of 18 target areas. AT T2 and T3, in Park B, the new playground was divided into two target areas, and the outdoor fitness area was a separate target area resulting in a total of 9 target areas. For the control park, a total of 320 scans (8 target areas X 40 observation points) were completed at each timepoint. For Park A, a total of 320 scans (8 target areas X 40 observation points) were completed at T1 and 720 scans (18 target areas X 40 observation points) were completed at both T2 and T3. For Park B, a total of 280 scans (7 target areas X 40 observation points) were competed at T1 and 360 scans (9 target areas X 40 observation points) were completed at both T2 and T3. This resulted in a total of 3720 scans across all three parks.

During T1 and T2, several restrictions were in place in Melbourne to reduce the spread of COVID-19. These measures encompassed various actions, including but not limited to, restrictions in indoor gatherings at home or other indoor venues such as cafes and gyms, maintaining physical distancing, and limits on the size of outdoor groups (Premier of Victoria, 2021; Victoria State Government, 2020).

2.4. Statistical analysis

Descriptive statistics were computed for visitor counts, both overall and stratified by age group, sex, day of the week, and activity levels, in

Table 2
Description of park features.

Features before park improvements	Features included in the park improvements
Park A	
• Adventure style children's playground • Open grassy areas • Seating and BBQ areas • Informal unpaved walking paths • Toilets	• Extensive new all abilities large adventure-style playground that included trampolines, flying foxes, slides, a range of swings, a parkour course, climbing area, sand pit, water play area, a large and small timber castle, music area (DJ spinning deck) and a mouse wheel (replaced existing playground) • Outdoor fitness equipment designed for older adults to target balance, flexibility, mobility, functional movement and range of motion, such as steps, pull-up/push-up bars, walking balance beams, finger stairs and calf raise, hand roll, shoulder arches, walking ramp and net, balance stool, and core twister. The equipment was installed on a rubber surface with instructional signage and QR codes, shade sails, and an accessible water fountain and built shelter with table and seats nearby. Additional seating was also placed around the equipment. • A 500-metre asphalt walking circuit around the perimeter of the park and other walking paths throughout the park. • Picnic and BBQ shelters throughout park. • Toilets and changing rooms (replaced existing toilet).
Park B	
• Children's playground • Open grassy areas • Seating areas • Unpaved walking paths • Toilets • Pond • Attractive gardens and landscaping	• New playground primarily targeted for younger children (<5 years), which included new swing sets, two new sandpits with waterplay elements, new wooden play structure with a range of soft play elements and a spinning rope climb (replaced existing playground). • Outdoor fitness equipment designed for older adults similar equipment to Park A but with no shade and instructional signages. Placed on a cushioned rubber/PVC surface. A picnic shelter with BBQ was installed near the equipment at T3. • Additional seating areas throughout the park
Control Park	
• Children's playground • Cricket oval • Toilets • Seating and BBQ area • Designated dog park	No changes

the control and intervention parks. Inferential analyses were used to examine differences in changes over time between intervention parks and the control park for the following outcomes: number of park visitors observed; the number of people observed in MVPA; and the mean physical activity intensity levels, with hourly count as the unit of analysis. The mean physical activity intensity level was calculated by multiplying weighted Metabolic Equivalent (MET) (i.e. 1.5 METs for sitting and standing, 3 METs for moderate and 6 METs for vigorous activity) (Cohen et al., 2015; McKenzie et al., 2006) by the number of people observed in each activity category each hour and dividing by the total number of people observed each hour. To evaluate the impact of park improvements, the models were fitted using generalised estimating equations with exchangeable correlation structure and measurement day as the clustering variable. The models included robust standard errors to provide robustness to potential misspecification of the correlation structure. The total counts for MVPA were calculated by adding the counts for moderate and vigorous activities (see Table 3). Models for total visitor counts and counts of people observed in MVPA were fitted with a negative binomial family and log link function while the model for mean physical activity intensity had Gausian family and identity link function. The model included the main effects of time (T1/T2/T3) and park (intervention/control), as well as a time by park interaction. The baseline observation data (T1) was set as the reference value for time, and the control park was set as the reference value for the park. The models generated two interaction coefficients for each model, representing the differences in outcomes at the intervention parks between T1 and T2 and between T1 and T3, relative to the control park. For number of people visiting parks and number of those engaging in MVPA, the outcome variables were counts, so the interaction effects were reported as Incidence Rate Ratios (IRR). For mean physical activity intensity levels, the interaction effects were reported as coefficients representing mean differences. The models were adjusted for whether observations occurred on a weekday or weekend day, and whether it was sunny or not sunny. Statistical significance levels were set at ≤ 0.05. All analyses were conducted using STATA/BE 17 (StataCorp, TX).

3. Results

3.1. Descriptive statistics

Park visitor counts and counts of visitors categorised by sex, age group, activity levels, and weekdays/weekend days for each park at the three timepoints are presented in Table 3.

3.2. Intervention effects on park visitation (park visitor counts)

Table 4 presents the interaction between time and park relative to the control park regarding park visitation for the overall sample and stratified by age group. The interaction between park and time showed significant increases in total park visitors in Park A with an estimated 229 % increase from T1 to T2, and 225 % increase from T1 to T3, relative to the control park. In Park A, there were also significant increases in the total number of children, adults, and older adults across both timepoints and significant increases in the total number of teens from T1 to T3 relative to the control park. No significant interaction between park and time was observed for the total number of park visitors in Park B relative to the control park for both timepoints. Also, in Park B there were only significant increases in the total number of children and a significant decrease in the number of adults from T1 to T3, relative to the control park.

3.3. Intervention effects on MVPA

There was a significant interaction between time and park regarding park visitors observed engaging in MVPA at Park A, with an estimated 152 % increase from T1 to T2 relative to the control park (see Table 4). However, there was no significant increase in the counts of visitors engaging in MVPA in Park A relative to the control park from T1 to T3. When these analyses were conducted separately for different age groups there were significant increases in the number of children engaging in MVPA across both timepoints; significant increases in the number of adults engaging in MVPA from T1 to T2; and significant increases in the number of older adults engaging in MVPA from T1 to T3, in Park A relative to the control park. In Park B, there was no evidence of an intervention effect on counts of visitors engaging in MVPA relative to the control park from both T1 to T2 and T1 to T3. Furthermore, no significant changes in the number of children and older adults engaging in MVPA were observed for both timepoints, while there was a significant decrease in the number of teens engaging in MVPA from T1 to T2 and significant decrease in the number of adults engaging in MVPA from T1 to T3, in Park B relative to the control park.

3.4. Intervention effects on mean physical activity intensity levels

Table 5 presents the interaction between time and park relative to the control park in relation to mean physical activity intensity levels. In Park A, no statistically significant difference in the mean physical activity intensity levels was observed from T1 and T2, while a significant decrease in the mean physical activity intensity levels was found from

Fig. 2. Pictures of control park a) aerial map ; b) children's playground.

T1 to T3, relative to the control park. In Park B, a significant decrease in the mean physical activity intensity levels was observed from T1 to T2, however no significant differences in the mean physical activity intensity levels were observed from T1 to T3, relative to the control park.

4. Discussion

This natural experiment study observed the behaviour of over 23,000 individuals visiting three parks across three timepoints in Melbourne, Australia, of which two of the parks underwent improvements (installation of new children's playgrounds, outdoor fitness equipment designed specifically for older adults and other amenities). This study aimed to examine the impact of these park improvements on the park visitation and park-based physical activity among park visitors compared to the control park. Overall findings suggest that the improvements at Park A increased the number of people visiting the park and engaging in MVPA relative to the control park, particularly among age groups for whom the improvements were targeted. However, the other intervention park, Park B did not show such effects.

The findings showed a significant increase in the total number of park visitors in Park A at both timepoints, indicating sustained impact of the park improvements, with an estimated magnitude of increase at each time point greater than 200 % relative to the control park. Park A also experienced a significant increase in the number of park visitors engaged in MVPA at one timepoint. Conversely, Park B did not experience significant changes in the number of total visitors or those engaged in MVPA relative to the control park. This may be attributed to the extent of improvements in Park B, which were much smaller compared to the major overhaul at Park A. This suggests that the features included in the park improvements are critical and more natural experiments are required to examine the impact of different types/levels of park improvements. Additionally, Park B was already a popular destination at baseline with the highest number of visitors compared to the other two parks, so the relatively minor modifications made to the park may not have been sufficient to attract new visitors. Given that both the quality and number of park facilities are critical determinants of park visitation and physical activity (Cohen et al., 2019; Flowers et al., 2020; Kaczynski et al., 2008), the extensive improvements made to Park A may have been more alluring to new visitors. As previous research suggests, parks need to offer unique and engaging facilities/amenities to attract visitors of all age groups and maintain their interest (Cohen et al., 2015).

Findings from the present study also showed a significant decrease or no significant changes in relation to the shift in mean physical activity intensity level following improvements in both the intervention parks relative to the control park. As Park A observed an increase in the number of people engaging in MVPA, this finding for mean physical activity intensity level suggests a simultaneous increase in the number of visitors engaging in sedentary pursuits. This could be attributed to various factors such as the availability of new seating and picnic areas, and increased opportunities for socialising following the improvements. Furthermore, it is worth noting that the increase in sedentary behaviour need not be interpreted negatively. Parks are important for offering

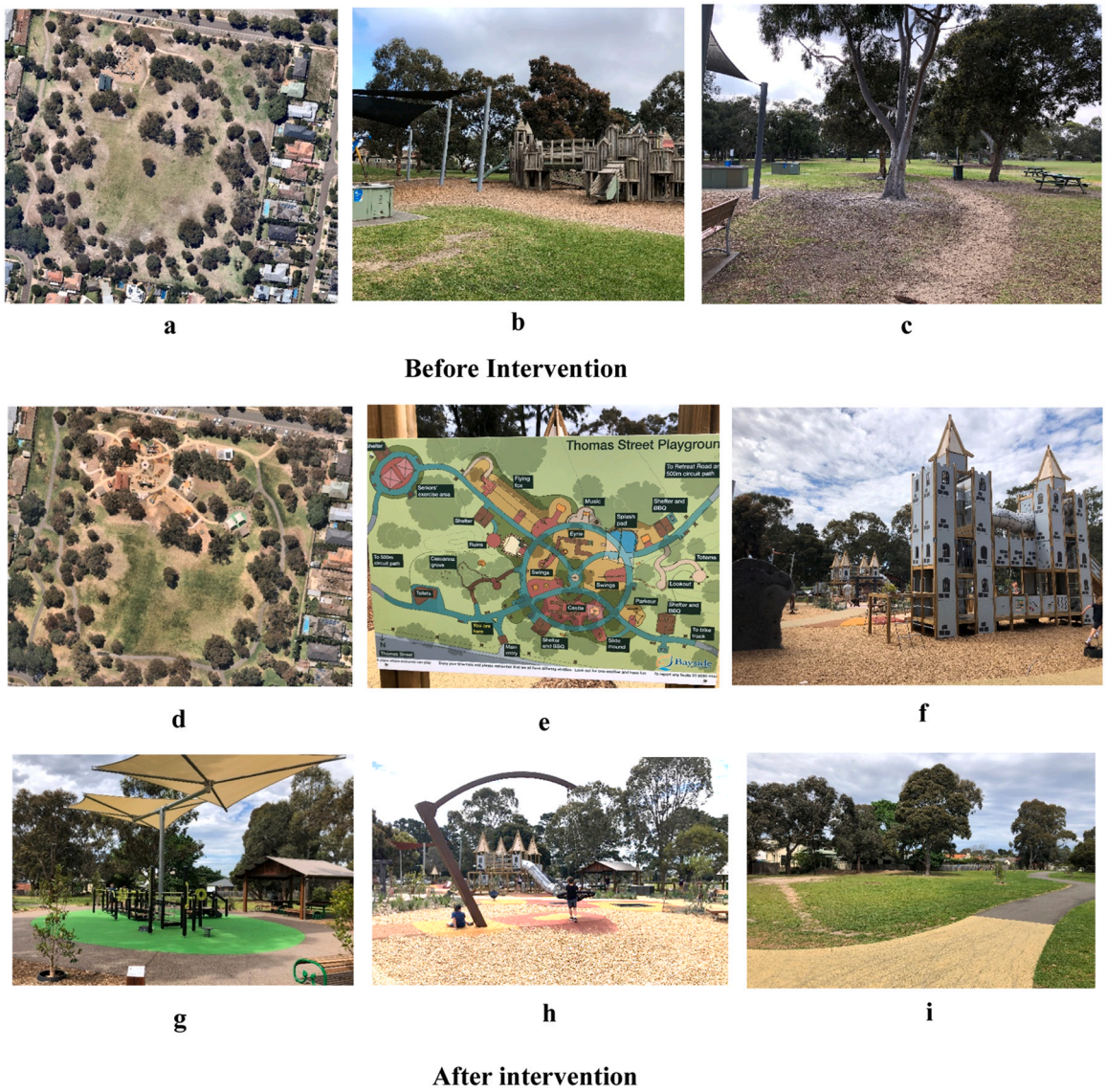

Fig. 3. Pictures of Park A before and after intervention; a) aerial map before intervention; b) playground before intervention; c) informal walking paths before intervention; d) aerial map after intervention; e) Signage displaying illustrated map of playground; f) adventure playground after intervention g) outdoor fitness area for older adults after intervention; h) playground after intervention; i) sealed walking circuit after intervention.

spaces for relaxation, social interaction, and connection with nature, contributing to improved mental and social well-being (Hartig et al., 2014). The upsurge in sedentary activities may reflect visitors taking advantage of these opportunities. It is also possible that even if people are sedentary at the park, they may have walked or cycled to get there, which can still contribute to their overall physical activity levels. Future research should explore the effects of park improvements on social interaction and psychological health among park visitors.

Findings from this study showed an increase in the number of children visiting and observed being active in Park A, at both timepoints after park improvements relative to the control park. This result is not surprising given the park improvement at Park A included the installation of new play areas with a diverse range of equipment and activities for children of all ages and abilities (see Table 2). It is important to emphasise that these play areas were designed to offer a varied, dynamic, and challenging play experience, offering an inviting environment that encouraged active participation. These findings support a recent ACBC study conducted in Australia among children (8–12 years) that found children preferred challenging and adventurous play equipment to encourage them to be physically active (Veitch et al., 2021). Notably, the top features preferred by children in that study, included long flying foxes, large adventurous playgrounds, climbing structures, large round swings and obstacles /parkour areas (Veitch et al., 2021) were included in the park improvements in Park A along with other features that were suited for younger children. Furthermore, the playground at Park A was designed to cater for children of all abilities, which supports previous studies that have underscored the importance of creating inclusive play environments (Gately et al., 2023; Moore and Lynch, 2015). Significant increases were also seen among adult visitors for both timepoints at Park A, which may be attributed to adults bringing their children to the park. These findings align with previous natural experiment studies, which also observed an increase in children and adult visitors and an increase in the number of children and adults being active following park improvements that included the installation of diverse range of play equipment (Cohen et al., 2019; Poppe et al., 2023; Veitch et al., 2018). The addition of a sealed walking circuit along with fitness equipment in Park A may have also encouraged park- based physical activity among adults. In a recent qualitative study conducted among adults in Australia, participants frequently mentioned walking paths and outdoor fitness equipment as park features that would

Fig. 4. Pictures of Park B before and after intervention; a) aerial map before intervention; b) playground before intervention; c) aerial map showing improved area; d) playground after intervention; e) Outdoor fitness area for older adults after intervention; f) Picnic shelter and BBQ area after intervention.

encourage physical activity in parks (Veitch et al., 2022). In contrast, at Park B a significant increase in the number of children was only observed for one timepoint, and no significant increases in MVPA were observed. The new playground installation in Park B was similar in scale and type of equipment to the playground at baseline and lacked challenging play opportunities for older children. This lack of diversity in play equipment and activities may have contributed to its limited appeal for older children to engage in physical activity. Consistent with previous studies (Bohn-Goldbaum et al., 2013; El-Kholy et al., 2022; Flowers et al., 2020; Veitch et al., 2006; Veitch et al., 2007), these findings highlight that including diverse play equipment that is suitable for various age groups and offers varied, dynamic, and challenging play experiences, may be important when considering (re)designing of playgrounds in public parks.

New outdoor fitness equipment, which was specially designed for older adults, was included in the park improvements at both parks. However, only Park A experienced an increase in the number of older visitors and those engaging in MVPA, compared to the control park. In addition to the fitness equipment, the improvements at Park A included a 500 m paved walking circuit and additional walking paths throughout the park. Walking is a popular activity among older adults and previous studies have consistently emphasised the significance of walking paths as a park feature that promotes physical activity and park visitation (Veitch et al., 2022; Veitch et al., 2020; Zhai et al., 2021; Zhang et al., 2019). Therefore, it is possible that the addition of the walking paths in Park A also played a role in attracting older adults to the park and encouraging physical activity. Furthermore, Park A had diverse play equipment, which may have encouraged older adults to accompany

Table 3
Counts of park visitors observed at the intervention and control parks at the three timepoints.

	Park A			Park B			Control Park		
	T1 n (%)	T2 n (%)	T3 n (%)	T1 n (%)	T2 n (%)	T3 n (%)	T1 n (%)	T2 n (%)	T3 n (%)
Total visitor counts	2878	4694	4025	3956	1764	1395	2416	1036	937
Average hourly counts (Mean ± Std Err)	72.0 ± 9.8	117.4 ± 11.0	100.6 ± 11.5	98.9±12.3	44.1±4.0	34.9±3.3	60.4±8.3	25.9±2.9	23.4±2.9
Counts by day of week									
Weekday	728 (25)	1470 (31)	1128 (28)	1269(32)	688 (39)	519 (37)	638 (26)	393 (38)	259 (28)
Weekend	2150 (75)	3224 (69)	2897 (72)	2687(68)	1076 (61)	876 (63)	1778 (74)	643 (62)	678 (72)
Counts by sex									
Female	1597 (55)	2635 (56)	2218 (55)	2316(59)	1054 (60)	806 (58)	1363 (56)	585 (56)	516 (55)
Male	1281 (45)	2059 (44)	1807 (45)	1640 (41)	710 (40)	589 (42)	1053 (44)	451 (44)	421 (45)
Counts by age group									
Child (1−12)	1130 (39)	2045 (44)	1747 (43)	930 (24)	456 (26)	415 (30)	779 (32)	299 (29)	233 (25)
Teen (13−20)	107 (4)	242 (5)	135 (3)	129 (3)	32 (2)	53 (4)	98 (4)	65 (6)	14 (1)
Adult (21−59)	1438 (50)	2124 (45)	1781 (44)	2113 (53)	906 (51)	635 (46)	1244 (51)	550 (53)	596 (64)
Older adult (60+)	203 (7)	283 (6)	362 (9)	784 (20)	370 (21)	292 (21)	295 (12)	122 (12)	94 (10)
Counts by activity levels									
Sedentary	869 (30)	1043 (22)	981 (24)	1709 (43)	616 (35)	380 (27)	795 (33)	254 (25)	173 (18)
Light	796 (28)	1432 (31)	1737 (43)	1143 (29)	516 (29)	424 (30)	923 (38)	294 (28)	307 (33)
Moderate	812 (28)	1604 (34)	1176 (29)	948 (24)	571 (32)	538 (39)	657 (27)	444 (43)	443 (47)
Vigorous	401 (14)	615 (13)	131 (3)	156 (4)	61 (3)	53 (4)	41 (2)	44 (4)	14 (1)
MVPA	1213 (42)	2219 (47)	1307 (32)	1104 (28)	632 (36)	591 (42)	698 (29)	488 (47)	457 (49)

their grandchildren to the playground. Older adults are usually under-represented in parks (Joseph and Maddock, 2016) and several past natural experiment studies have reported park interventions to be less effective among older adults compared with other age groups (Cohen et al., 2019; Veitch et al., 2021; Veitch et al., 2018). Therefore, the increase in both the number of older adult visitors and those engaging in MVPA in at least one of the intervention parks is encouraging.

There was a large increase in the number of teens visiting Park A from T1 to T3 compared to the control park; however, no changes were observed in number of teens engaging in MVPA. It is possible that organised sports events that were taking place during T3 following COVID-related restrictions at the sports oval and netball courts in front of Park A (but not part of Park A) could account for the rise in park visitation, as individuals may have used the park for socialising after participating in sport. There was no notable variation in teenage visitation at Park B; however, a significant reduction in the number of teens engaging in MVPA was observed at T2 in comparison to the control park. Previous research with adolescents has shown that sports facilities are among the most important park features influencing their choice of park for engaging in park-based physical activity (Rivera et al., 2021). Although both the intervention parks did not include any sports facilities as part of the park improvements, the presence of a cricket oval at the control park and nearby sports facilities at Park A may have drawn teenagers to these parks, whereas Park B lacked any features that could particularly appeal to this age group. It is likely that incorporating features that are suitable for teens may be important for encouraging them to visit the park and be active once there; however, a recent evaluation showed no significant increase in teens visitation after multi-purpose sports courts and outdoor fitness equipment were installed (Veitch et al., 2021). More natural experiments studies that incorporate features preferred by teens are required to understand the extent of improvements required for increases in active park visits by teens.

4.1. Strengths and limitations

The study design had several strengths. The natural experiment design included two intervention parks with varying levels of improvements targeting younger and older age groups, a control park and three timepoints to determine if the intervention had a sustained impact. The extensive collection of observational data occurred every hour across four/five days (40 observations in total), surpassing the recommended four observations per day on four days and ensuring robust measures of park visitation (Cohen et al., 2011). In addition, observations were conducted on the same days and times and around same time of year in all three parks and all three timepoints to minimise any confounding factors that could affect the results. However, it is worth noting that direct observations provide only a broad indication of park visitation during specific days and times, and the outcomes may have been different if the observations had been carried out on different days.

Despite our efforts to select a control park that was closely matched to the intervention parks, there were variations in the amenities offered at all three parks. It should be acknowledged, however, that identifying an identical control park is often a challenging task (Veitch et al., 2017). During baseline and the first follow-up, multiple COVID restrictions were in place, however we were unable to delay the baseline measurements until all restrictions were lifted due to the impending park improvements. As a result, it is possible that more individuals visited parks during these periods as there were restrictions on gatherings at home and other indoor venues (Victoria State Government, 2020). Globally, it was reported that demand for public spaces and local parks increased during pandemic (Geng et al., 2021). However, this issue was minimised by the inclusion of a control park. A limitation of SOPARC is the potential for duplicate records or undercounting due to users moving around different areas of the park during the observation scans, however, this is minimised by conducting frequent observations at predetermined intervals (Evenson et al., 2016). Although data collection occurred around the same months each year (T1 in October, T2 in November, and T3 in October), the mean maximum daily temperature at T1 was 2.9 degrees lower than at T2 and 3.54 degrees lower than at T3. Although, it should be noted that the weather conditions were the same for the control and intervention parks at each timepoint.

5. Conclusion

This natural experiment found a significant increase in the total number of park visitors and those engaging in physical activity in the intervention park that received extensive improvements whereas the intervention park that received relatively minor improvements did not observe similar effects. Furthermore, in the park with extensive improvements, significant increases in the total number of children, adults and older adults visiting and engaging in physical activity were observed. These findings suggest the extent of improvements and the

Table 4
Interaction between time and park relative to the control park regarding park visitation and park visitors observed engaging in MVPA for the overall sample and by age group.

Age group	Outcome	Park[a]	Timepoint[b]	IRR	Estimated change[c]	95 % CI	P-value[d]
Overall	Visitation	Park A	T2	3.39	229 % ↑	2.27, 5.05	**<0.0001**
		Park A	T3	3.25	225 % ↑	2.14, 4.92	**<0.0001**
		Park B	T2	0.98	2 % ↓	0.64, 1.48	0.913
		Park B	T3	0.91	9 % ↓	0.62, 1.34	0.639
	MVPA	Park A	T2	2.52	152 %↑	1.57, 4.04	**<0.0001**
		Park A	T3	1.60	60 %↑	0.97, 2.64	0.063
		Park B	T2	0.80	20 %↓	0.53, 1.23	0.310
		Park B	T3	0.79	21 %↓	0.55, 1.15	0.223
Child	Visitation	Park A	T2	4.84	384 %↑	3.10, 7.56	**<0.0001**
		Park A	T3	4.99	399 %↑	3.30, 7.53	**<0.0001**
		Park B	T2	1.44	44 %↑	0.90, 2.30	0.133
		Park B	T3	1.64	64 %↑	1.08, 2.51	**0.022**
	MVPA	Park A	T2	3.42	242 %↑	2.10, 5.57	**<0.0001**
		Park A	T3	2.55	155 %↑	1.59, 4.09	**<0.0001**
		Park B	T2	1.11	11 %↑	0.68, 1.81	0.688
		Park B	T3	1.08	8 %↑	0.64, 1.82	0.782
Teen	Visitation	Park A	T2	2.36	136 %↑	0.67, 8.28	0.180
		Park A	T3	7.87	687 %↑	2.71, 22.82	**<0.0001**
		Park B	T2	0.26	74 %↓	0.07, 1.01	0.051
		Park B	T3	2.52	152 %↑	0.81, 7.84	0.111
	MVPA	Park A	T2	1.02	2 %↑	0.28, 3.73	0.972
		Park A	T3	2.18	118 %↑	0.63, 7.53	0.216
		Park B	T2	0.07	93 %↓	0.02, 0.29	**<0.0001**
		Park B	T3	1.02	2 %↑	0.30, 3.47	0.978
Adult	Visitation	Park A	T2	2.88	188 %↑	1.89, 4.38	**<0.0001**
		Park A	T3	2.25	125 %↑	1.47, 3.44	**<0.0001**
		Park B	T2	0.90	10 %↓	0.57, 1.42	0.636
		Park B	T3	0.61	39 %↓	0.40, 0.92	**0.020**
	MVPA	Park A	T2	2.40	140 %↑	1.50, 3.86	**<0.0001**
		Park A	T3	0.99	1 %↓	0.56, 1.75	0.984
		Park B	T2	0.81	19 %↓	0.52, 1.26	0.345
		Park B	T3	0.48	52 %↓	0.29, 0.79	**0.004**
Older adult	Visitation	Park A	T2	3.06	206 %↑	1.50, 6.24	**0.002**
		Park A	T3	4.82	382 %↑	2.67, 8.71	**<0.0001**
		Park B	T2	1.11	11 %↑	0.53, 2.30	0.783
		Park B	T3	1.18	18 %↑	0.66, 2.12	0.570
	MVPA	Park A	T2	1.57	57 %↑	0.68, 3.62	0.289
		Park A	T3	2.43	143 %↑	1.25, 4.72	**0.009**
		Park B	T2	0.69	31 %↓	0.33, 1.42	0.309
		Park B	T3	1.43	43 %↑	0.83, 2.47	0.200

Visitation refers to all visitors observed in the park regardless of their physical activity
[a] Control park set as the reference value for the park.
[b] Baseline observation data (T1) set as the reference value for time.
[c] ↑ indicate estimated increase and ↓ indicate estimated decrease from T1 relative to control park
[d] values ≤0.05 indicates significant difference

Table 5
Interaction between time and park relative to the control park in regard to mean physical activity intensity levels for the overall sample.

Park[a]	Timepoint[b]	Coefficient	95 % CI	P-value[c]
Park A	T2	−0.09	−0.38, 0.21	0.576
Park A	T3	−0.58	−0.84, −0.31	**<0.0001**
Park B	T2	−0.24	−0.46, −0.20	**0.032**
Park B	T3	−0.12	−0.32, 0.09	0.276

[a] Control park set as the reference value for the park.
[b] Baseline observation data (T1) set as the reference value for time.
[c] values ≤0.05 indicates significant difference

diversity of facilities included may impact the success of the intervention. This study highlights that including challenging and diverse play equipment suitable for various age groups and abilities, as well as other features such as walking paths and outdoor fitness equipment may encourage park visitation and physical activity engagement across age groups. Future research should explore usage of specific park features included in the park improvements to determine their individual impact on the observed changes. This study contributes to the broader literature on the role of parks and green spaces in promoting physical activity and health, providing evidence to support investment in park for positive public health outcomes. The findings can inform future park management and planning decisions.

Ethics approval and consent to participate

Ethical approval for this study was provided by the Deakin University Human Ethics Advisory Group (HEAG-H 117_2020).

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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