Health Promotion International, 2024, **39**, daae098
https://doi.org/10.1093/heapro/daae098
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Coming back for more: individual participation patterns in the physical activity initiative *parkrun* in Australia

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Abstract

Most physical activity (PA) maintenance research has concerned adherence to small-scale interventions or infrequent observation in cohort studies. We analysed individual attendance trajectories and their drivers in a large-scale 'real-world' community-based weekly PA event (*parkrun*) cohort in Australia. Data were weekly attendance (walking/running) of 223 224 unique *parkrun* participants over their first 3 years of participation. An unweighted moving average of participation in the preceding 12 weeks from the 12th week since the first participation to the 156th week was calculated and submitted to a cluster analysis of attendance patterns. Association of individual- (demographic, personal *parkrun* performance) and site-level (aggregated site-level participant characteristics and area-level measures) covariates with cluster membership was estimated with multinomial logistic regression models. We identified four groups: Few-Timers (76.4%), Decliners (12.4%), Low Maintainers (6.9%) and High Maintainers (4.3%). In the first 12 weeks, attendances averaged 2, 6, 5 and 7.5 times for each cluster, respectively, and by 52 weeks, they were 0.17, 1.9, 3.4 and 7.6 times, respectively. Continuing participation (vs Few-Timers) was strongly associated with faster personal finish times, but slower performance at the site level. Higher running club/group membership at a participant's *parkrun* predicted higher odds of being a High Maintainer. Our identification of a Low Maintainer group shows a community-based initiative may sustain interest, despite not requiring continuous or near-continuous attendance. Where someone is placed 'in the pack' locally and degree of identification with others in the group may be bidirectionally associated with attendance, underscoring the importance of considering social environment of PA maintenance.

Keywords: physical activity, exercise maintenance, adherence, social identification, mass participation

Contribution to Health Promotion

- This article provides new understandings of how we can characterize maintenance of physical activity in the real world.
- The social environment in which physical activity takes place is important to participation patterns.
- People can maintain physical activity participation at low intensity over long periods even when little or no commitment is required.

INTRODUCTION

The beneficial effect of physical activity (PA) on mortality and chronic disease prevention is well established (Mok *et al.*, 2019; Yang *et al.*, 2022). Most health gains are found achieving low-to-moderate levels of activity compared with none (Sattelmair *et al.*, 2011; Gebel *et al.*, 2015; Aune *et al.*, 2021) although such positive effects may dissipate when current PA decreases, underlining the importance of maintenance (Mok *et al.*, 2019; Saint-Maurice *et al.*, 2019; Lee *et al.*, 2022). For many people, maintaining PA is challenging. For example, a recent review of structured PA interventions targeting inactive adults found adherence rates between 53% and 80% with follow-up assessments mostly in the range of 6–18 months (Willinger *et al.*, 2021). Observational cohort studies in population-based samples show lower estimates over longer periods of up to 15 years, with between 48% and 56% of adults maintaining a moderate or stable level of PA (Saint-Maurice *et al.*, 2019; Sanchez-Sanchez *et al.*, 2020; Jasiukaitiene *et al.*, 2021; Hassan *et al.*, 2023). Given that improvements in population health from PA can only be derived from sustained activity amongst those already active as well as initiation by the inactive, these estimates underscore the importance of maintenance in large-scale preventive health interventions.

Examining PA maintenance has not been straightforward in terms of translatability to real-world contexts to inform

promotion of sustainable well-being. Most research has focused on adherence to a specific, small-scale intervention or through periodic observation in cohort studies where there has been inconsistent definition of the outcome of adherence or maintenance. Many studies refer to around 6 months following the intervention as the time frame in which maintenance occurs and habits develop (Marcus *et al*., 2000; van Stralen *et al*., 2009; Amireault *et al*., 2013; Murray *et al*., 2017; Willinger *et al*., 2021), while others define 3 months post-intervention (Madigan *et al*., 2021). Observational studies may simply use concordance of PA at the measurement time points to assess maintenance, irrespective of the time elapsed between (Bauman *et al*., 2017). Other researchers argue that there is no evidence to support specific time criteria (van Stralen *et al*., 2009; Rhodes and Sui, 2021) which may vary with type of PA and may have limited utility if the goal is to promote maintenance, given the complex interaction between time and drivers of maintenance. Hence a threshold-based approach may not be the most informative if the goal is to maintenance-conducive conditions.

One alternative taken by Fuchs *et al*. (Fuchs *et al*., 2005) was to investigate different patterns of maintenance. The authors documented weekly sports participation or use of a weight room (gym) over a period of 13 weeks and identified four different trajectories: maintainers, fluctuaters, early dropouts and late dropouts (Fuchs *et al*., 2005). The analysis allowed for identification of key moments of change in attendance pattern and also profiled the individuals following different trajectories. With more frequent data collection and data-driven characterization of participation, such an analysis may be more useful for developing support for sustaining PA than those selecting fixed time-points to define adherance or maintenance. However, the study duration was only 13 weeks, so how well these classifications apply in the longer term remains unknown.

Hence, examination of prevalence and correlates of persistence in PA (whether as adherence or maintenance of PA or change in PA) has been hampered by limited follow-up of the more granular data of specific intervention studies, and longer term but infrequent measurement in observational studies. The current large community-based study draws on the strengths of these two bodies of evidence to report on national participation patterns and their correlates in a 'real-world' community-based weekly PA event (*parkrun*) in Australia. Frequent data collection, large sample size and long study period of a naturally occurring event extends previous research and could identify intervention points to increase regular and sustained participation.

parkrun

parkrun is a free, weekly timed 5 km walk/run conducted in open public spaces such as parks originally established in the UK in 2004 and commencing in Australia in 2011. The parkrun phenomenon has achieved notable population reach, based on wide geographic and community participation. Events are run largely by volunteers in over 480 sites across Australia with an average of 16 total participation occasions per participant since inception in 2011 (www.parkrun.com.au, accessed 20 February 2024). Participants in *parkrun* demonstrate improvements in fitness, total PA, vigorous PA, body mass index (BMI) and mood with participation (Grunseit *et al*., 2020). Outcomes show a positive dose–response effect with participation and the strongest improvements occur among risk groups such as the previously inactive and those who are overweight or obese (Stevinson and Hickson, 2019). With wide spread [22 countries and 250 000 weekly participants globally (parkrun, 2023)] weekly format with participation recorded and a low threshold for participation (no minimum fitness requirements, cost-free, one-time registration), *parkrun* presents a unique opportunity to examine PA maintenance under real-world conditions.

A small number of studies have reported on attendance rates among *parkrunners* in the UK. Stevinson and Hickson reported a median attendance of 42% since first participation occasion (median duration of follow-up 51 weeks) among 7308 survey participants (Stevinson and Hickson, 2014). More recently, Quirk *et al*. (Quirk *et al*., 2021) reported that from its inception on 2nd October 2004 to 3rd December 2018, UK *parkrunners* attend a mean of 3.7 times (mean 3.5 years since registration) (Quirk *et al*., 2021). However, these studies describe only a small number of unadjusted correlates and yearly attendance rate which are likely to obscure significant variation in attendance trajectories among the *parkrun* cohort. More could be learned regarding potential intervention points to foster adherence and sustainment with this community intervention.

The overall aim for the current study is to use *parkrun* data to examine participants' attendance over their first 3 years of *parkrun* participation (walking/running) in Australia. The specific objectives are to: (i) characterize any patterns in *parkrun* walking/running participation and (ii) examine the individual- and site-level correlates of the patterns identified in the first objective.

METHODS

This study was approved by the University of Sydney Human Research Ethics Committee and the University of Technology Human Research Ethics Committee with the approval numbers 2018/586 and ETH22-6989, respectively.

We recognize that the analysis examines behavioural performance of PA and cannot distinguish whether the behaviour constitutes maintenance or initiation; the duration of follow-up makes it likely that we are observing at least the behavioural sequelae of maintenance (Rhodes and Sui, 2021).

Study design

The study design was a secondary analysis of a cohort of *parkrun* participants over their first 3 years of participation.

Data collection

The *parkrun* administrative database holds participation and participant demographic data since inception (2nd April 2011). Participants register once and receive a unique *parkrunner* ID which is linked to their recorded finish time and/or volunteering role each time they participate. Registration information comprises gender, date of birth and postcode of residence, and participants are required to select one *parkrun* site as their 'home' *parkrun*. Following registration, registrants can also optionally select a 'running group/club' (parkrun Global Limited, 2023b). Participation data include finish place, finish time, age category, and gender- and age-graded score or rank (a percentage which compares a participant's finish time against the world record time for their gender and age—higher scores indicate faster relative time) (parkrun Support, 2023).

Data extraction

In June 2022, we retrieved 8 393 948 running and 974 823 volunteering observations from inception date (2nd April 2011). Informed consent was not separately obtained as use of anonymized data for research purposes is covered by the *parkrun* privacy policy (parkrun Global Limited, 2023a). We included participation data from adult participants only (aged 18 or over) with at least 3 years elapsed since their first *parkrun* participation as a walker or runner. Only those who attended before 28 January 2017, 3 years prior to the first confirmed COVID case in Australia (25th January 2020), were included to avoid the period where there were COVID19 restrictions on movement. The analytic sample comprised 223 224 unique participants for the analysis (Supplementary Figure S1).

Measures

The main participation outcome was weekly walking/running (i.e. whether a person had walked or run a *parkrun* that week). We derived an unweighted moving average of participation in the previous 12 weeks from the 12th week since the first run/walk participation to the 156th week (i.e. 3 years) which formed the basis of the cluster analysis. If a person volunteered with a walk/run time recorded (e.g. as a tailwalker), this was counted as a walk/run participation occasion, but was not counted as such if they only volunteered. Once clusters were generated, group membership became the outcome variable regressed on the covariates.

Covariates were generated from individual-level and *parkrun*-level data and merged with the group classification for each participant as described below.

Individual-level data

Weekly walk/run results and volunteering information were merged with participants' demographic data using the unique *parkrunner* ID. Individual-level data were gender, year and age at first walk/run, average personal finish time, average personal age-graded score and total volunteer occasions (including where they combined walking/running and volunteering).

parkrun site-level course covariates

Data at the *parkrun* level were for the most frequented *parkrun* attended by a participant in the study period (or the first site attended if two sites were frequented equally).

We collected site-level information on *parkrun* routes from the *parkrun* official course description (https://www.parkrun.com.au/events/) and *Strava* (https://www.strava.com/), an open-source exercise GPS data repository to generate five categorical descriptors to capture the potential influence of social and physical preferences on participation (Reichhart and Arnberger, 2010).

1. Route: route format is (i) out-and-back (mostly bidirectional along the same route), (ii) mostly unidirectional loop/s or (iii) loop(s) with cross-over (unidirectional and bidirectional movement on the same route) (Supplementary Figure S2).
2. Repetition: repeated if ≥1 km course in the same direction.
3. Terrain: set of dichotomized variables indicating whether the route contains (i) trail, (ii) grass, (iii) sand or (iv) concrete/bitumen.
4. Route difficulty: indicated by total elevation and maximum gradient (based on GPS data from *Strava* via an open-source calculator (https://www.doogal.co.uk/js/ElevationCalculator.js?v=1).
5. Blue space: whether river/lake or sea was visible or route was surrounded by land only as determined by the official *parkrun* course map as this has been found previously to be associated with well-being (Pasanen *et al.*, 2019).

Two researchers (A.C.G. and B.-H.H.) independently evaluated categorization of route types, repetitiveness and blue space in a random selection of 10% of *parkrun*s ($n = 46$) with 100% inter-rater agreement before the remainder were coded by B.-H.H.

parkrun site-level participant characteristics

parkrun-level aggregate site-level variables were mean finish time, mean age-graded rank of participants and proportion of participants who belong to a club/group. We also calculated an index of volunteer heterogeneity (or diversity), a ratio of the number of different volunteers (people) occupying the volunteer roles in a month to the number of available volunteer roles. Diversity indices closer to 1 denote higher heterogeneity (Simpson, 1949) and, in this case, reflect how much volunteering is shared amongst participants as a possible incentive or disincentive.

parkrun site-level areal covariates

We matched socioeconomic index [rank decile of Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD) (Australian Bureau of Statistics, 2018)] and remoteness [Accessibility/Remoteness Index of Australia (ARIA+) from Australian Bureau of Statistics (ABS) (Australian Bureau of Statistics, 2016)] to each *parkrun* site by postcode. ARIA+ was categorized into three groups: major cities, inner regional and outer regional/remote/very remote combined. We operationalized IRSAD as tertiles (deciles 1–3, 4–7 and 8–10); higher IRSAD scores indicate more advantage and less disadvantage. PA norm (proportion of the population with at least 150 minutes of exercise per week) and greenspace accessibility (proportion of the population within 400 m of greenspace) from the National Health Survey data (Australian Bureau of Statistics, 2015) were matched to *parkruns* by postcode (Supplementary Figure S3) to capture the influence of local propensity, and opportunities, for PA (Sugiyama *et al.*, 2013).

Supplementary Material details procedures (Supplementary Appendix 1), definitions and granularity of the covariates (Supplementary Tables S1 and S2).

Data treatment

Personal finish time (in minutes) and personal age-graded rank (as a percentage) were operationalized as averages and volunteer count was summed (used in walk/run analysis only) over each person's first 3 years of participation. Year and age at first walk/run and gender were treated as constants.

The *parkrun* site-level age-graded score, percent running club membership, volunteer heterogeneity, surrounding socioeconomic index, remoteness and PA norm were calculated as weighted averages over each person's first 3 years of participation. Route type, repetition, terrain textures, route difficulty (total elevation and maximum gradient), blue space

presence and greenspace accessibility were fixed values and these were time invariant.

Statistical analysis

Statistical analyses were conducted with *SAS* Enterprise Guide Version 8.3 (SAS Institute, Cary, NC, USA) and the *kml* package (Genolini and Falissard, 2011) in *R* software (RStudio, PBC, Boston, MA, USA).

Cluster analysis

To identify different patterns of the moving average of walking/running across the first 3 years since the first participation, we utilized *K*-means cluster analysis with five iterations each searching for partitions from two to six clusters. We selected the optimal number of clusters (groups) based on the validity metrics (Caliński and Harabasz, 1974; Davies and Bouldin, 1979; Ray and Turi, 1999).

Descriptive statistics and multinomial logistic regression of cluster membership

Means and standard deviations for continuous variables and percentages for categorical variables were calculated for all personal demographic and site-level characteristics over group membership along with omnibus tests of association (bivariate linear regression for continuous variables and chi-squared for categorical variables).

We used the groups generated by the cluster analysis in multinomial logistic regressions to examine the association of individual demographics, personal *parkrun* performance data, *parkrun* site-level participant characteristics and performance, and surrounding area characteristics (covariates) with group membership (outcome) with 'few-timers' as the reference category. The linearity assumptions were checked by plotting components plus the residuals against the observed covariates values and were found not to be violated. Results are expressed as odds ratios (with 95% confidence intervals) of belonging to a group vs 'few-timers' per one-unit change in the predictor variable.

RESULTS

Cluster analysis

The validity metrics showed the highest agreement across iterations on three or four clusters. We chose four groups since it provided better differentiation between the groups while maintaining an adequate proportion of the sample in the smallest groups (Supplementary Figure S4). The trajectories over the first 3 years of participation of the four groups generated from the cluster analysis are shown in Figure 1.

The majority (76.4%) participated an average of four times in total over the 3 years (Few-Timers) (Table 1; Figure 1); on average, twice in the first 12 weeks compared with approximately 6 times for Decliners, 5 times for Low Maintainers and 7.5 times for High Maintainers (Supplementary Table S3). At around week 32, the Decliners and Low Maintainers were both attending on average 3 times in 12 weeks, with the former on a downward trajectory and the latter on an upward trajectory (Figure 1). By 52 weeks, the estimated frequencies were 0.17, 1.9, 3.4 and 7.6 times in 12 weeks for Few-Timers, Decliners, Low Maintainers and

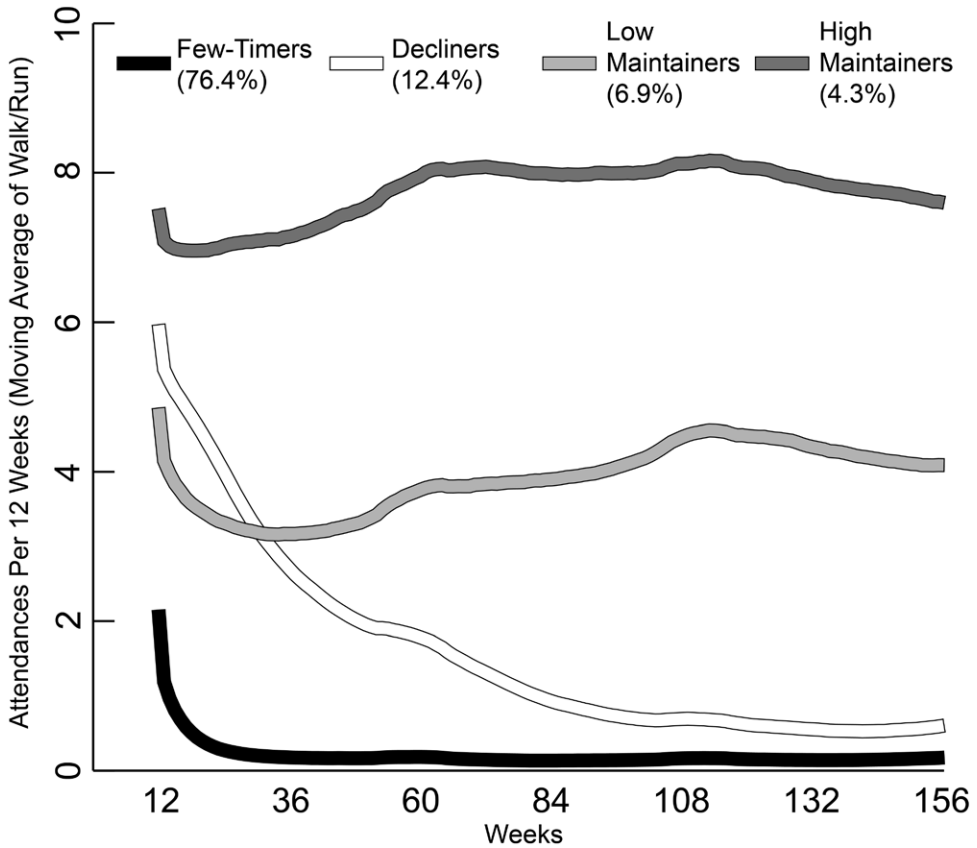

Fig. 1: Attendance proportion for four groups (Few-Timers, Decliners, Low Maintainers and High Maintainers).

Table 1: Personal demographic and site-level characteristics for four-cluster solution for walk/run participation with omnibus tests for association between groups and characteristics (n = 223 224)

Characteristic[a]	All	Few-Timers	Decliners	Low Maintainers	High Maintainers	
Total *N* (%)	223 224	170 544 (76.4)	27 581 (12.4)	15 461 (6.9)	9638 (4.3)	
Mean (SD) attendance over 3 years	13.9 (12.5)	4.2 (4.3)	22.5 (9.3)	51.7 (13.4)	100.5 (17.3)	
Individual-level covariates						*p*-value
Gender (%)						
Female	129 337 (57.9)	100 993 (59.2)	15 667 (56.8)	8042 (52.0)	4635 (48.1)	<0.001
Male	93 887 (42.1)	69 551 (40.8)	11 914 (43.2)	7419 (48.0)	5003 (51.9)	
Year of registration (%)						
2011	1022 (0.5)	727 (0.4)	128 (0.5)	95 (0.6)	72 (0.7)	
2012	9395 (4.2)	6950 (4.1)	1214 (4.4)	771 (5.0)	460 (4.8)	
2013	30 688 (13.7)	22 824 (13.4)	4163 (15.1)	2264 (14.6)	1437 (14.9)	
2014	48 426 (21.7)	36 948 (21.7)	6061 (22.0)	3313 (21.4)	2104 (21.8)	
2015	54 725 (24.5)	42 065 (24.7)	6611 (24.0)	3746 (24.2)	2303 (23.9)	
2016	70 046 (31.4)	54 265 (31.8)	8233 (29.9)	4691 (30.3)	2857 (29.6)	
2017	8922 (4.0)	6765 (4.0)	1171 (4.2)	581 (3.8)	405 (4.2)	
Age at first walk/run participation (years), mean (SD)	38.1 (11.4)	37.3 (11.3)	39.1 (11.1)	41.2 (11.2)	44.9 (11.5)	<0.001
Average personal finish time (min), mean (SD)	33.0 (9.1)	33.4 (9.5)	31.9 (7.9)	30.9 (7.4)	31.1 (7.1)	<0.001
Average personal age-graded score (percentile rank), mean (SD)	48.4 (11.0)	47.6 (11.2)	49.8 (9.8)	52.0 (9.8)	52.9 (9.3)	<0.001
Volunteer counts, mean (SD)	1.2 (5.0)	0.2 (2.0)	1.5 (4.6)	5.3 (9.4)	11.8 (12.5)	<0.001
parkrun site-level course covariates						
Route type (%)						
Out and back	128 253 (57.5)	97 401 (57.1)	16 043 (58.2)	9196 (59.5)	5613 (58.2)	<0.001
Unidirectional loop(s)	44 705 (20.0)	34 536 (20.3)	5397 (19.6)	2852 (18.4)	1920 (19.9)	
Loop(s) with cross-over	50 266 (22.5)	38 607 (22.6)	6141 (22.3)	3413 (22.1)	2105 (21.8)	
Terrain: trail (%)						
No	138 020 (61.8)	105 523 (61.9)	17 064 (61.9)	9590 (62.0)	5843 (60.6)	0.096
Yes	85 204 (38.2)	65 021 (38.1)	10 517 (38.1)	5871 (38.0)	3795 (39.4)	
Terrain: grass (%)						
No	178 454 (79.9)	136 739 (80.2)	22 067 (80.0)	12 038 (77.9)	7610 (79.0)	<0.001
Yes	44 770 (20.1)	33 805 (19.8)	5514 (20.0)	3423 (22.1)	2028 (21.0)	
Terrain: sand (%)						
No	214 008 (95.9)	162 758 (95.4)	26 775 (97.1)	15 050 (97.3)	9425 (97.8)	<0.001
Yes	9216 (4.1)	7786 (4.6)	806 (2.9)	411 (2.7)	213 (2.2)	
Terrain: concrete (%)						
No	26 685 (12.0)	20 193 (11.8)	3240 (11.7)	1988 (12.9)	1264 (13.1)	<0.001
Yes	196 539 (88.0)	150 351 (88.2)	24 341 (88.3)	13 473 (87.1)	8374 (86.9)	
Blue space (%)						
River	174 089 (78.0)	132 866 (77.9)	21 637 (78.4)	12 034 (77.8)	7552 (78.4)	<0.001
Sea	40 785 (18.3)	31 453 (18.4)	4859 (17.6)	2817 (18.2)	1656 (17.2)	
Land	8350 (3.7)	6225 (3.7)	1085 (3.9)	610 (3.9)	430 (4.5)	
Repetition (%)						
No	166 735 (74.7)	128 141 (75.1)	20 572 (74.6)	11 291 (73.0)	6731 (69.8)	<0.001
Yes	56 489 (25.3)	42 403 (24.9)	7009 (25.4)	4170 (27.0)	2907 (30.2)	
Total elevation (m), mean (SD)	53.7 (23.9)	53.8 (23.9)	53.2 (23.8)	53.5 (23.5)	53.5 (23.8)	<0.001
Maximum gradient (degrees), mean (SD)	4.9 (2.5)	4.8 (2.6)	4.87 (2.6)	4.84 (2.5)	4.85 (2.5)	0.787
parkrun site-level participant covariates						
Average site finish time (min), mean (SD)	31.5 (2.4)	31.5 (2.4)	31.7 (2.4)	31.8 (2.4)	32.0 (2.4)	<0.001
Average site age-graded score (percentile rank), mean (SD)	48.4 (2.8)	48.5 (2.8)	48.3 (2.8)	48.2 (2.8)	48.0 (2.9)	<0.001

Table 1. Continued

Characteristic[a]	All	Few-Timers	Decliners	Low Maintainers	High Maintainers	
Average site club membership (percentage), mean (SD)	26.1 (7.3)	26.0 (7.2)	26.2 (7.4)	26.2 (7.8)	27.0 (8.1)	<0.001
Average site volunteer heterogeneity (range 0–1), mean (SD)	0.89 (0.02)	0.89 (0.03)	0.89 (0.03)	0.89 (0.03)	0.89 (0.02)	<0.001
parkrun site-level areal covariates						
Average site SES (%)						
Low (IRSAD ≤ 3)	28 394 (12.7)	21 226 (12.4)	3668 (13.3)	2051 (13.3)	1449 (15.0)	<0.001
Medium (3 < IRSAD ≤ 7)	89 491 (40.1)	67 178 (39.4)	11 668 (42.3)	6520 (42.2)	4125 (42.8)	
High (IRSAD > 7)	105 339 (47.2)	82 140 (48.2)	12 245 (44.4)	6890 (44.6)	4064 (42.2)	
Remoteness (%)						
Major cities	170 544 (76.4)	130 820 (76.7)	20 878 (75.7)	11 586 (74.9)	7260 (75.3)	<0.001
Inner regional	39 957 (17.9)	29 902 (17.5)	5129 (18.6)	3030 (19.6)	1896 (19.7)	
Outer regional/remote/very remote	12 723 (5.7)	9822 (5.8)	1574 (5.7)	845 (5.5)	482 (5.0)	
Average site percentage greenspace, mean (SD)	75.1 (16.5)	75.3 (16.4)	74.6 (16.7)	74.7 (16.6)	74.0 (17.0)	<0.001
Average site percentage meeting PA guidelines, mean (SD)	45.7 (8.3)	45.8 (8.3)	45.2 (8.1)	45.1 (8.0)	44.7 (7.8)	<0.001

IRSAD = Index of Relative Socioeconomic Advantage and Disadvantage; PA = physical activity; SD = standard deviation; SES = socioeconomic status.
[a]Averages in the group are calculated over the values allocated to participants for their study period.

High Maintainers, respectively. The Low and High Maintainers increased their attendance rates up until week 106 where they levelled out to between 3 and 4 attendances per 12 weeks and 8 attendances per 12 weeks, respectively (Supplementary Table S3).

Correlates of group membership—descriptive and univariate statistics

Group membership showed significant associations with virtually all demographic, personal and site characteristics (Table 1) likely due to the large sample size. A small number of differences are worth noting due to the size of differences. The Few-Timers were majority women (59.3%) as were the Decliners (56.6%), whereas High Maintainers were majority men (51.8%). High Maintainers were the oldest group by over 3 years and the Few-Timers had the slowest personal finish time and lowest age-graded rank. The High Maintainer group had a higher proportion from sites with repetition (30.1%) compared with the other three groups (24.9–27.0%). Volunteer counts were higher among the Low (5.3) and High (12.5) Maintainers than Decliners (1.5) and Few-Timers (0.2), although volunteer heterogeneity was consistent at 0.89 (despite the statistically significant *p*-value). Finally, a lower percentage of High Maintainers were from *parkruns* in high-socioeconomic status (SES) areas (42.2%), compared with Few-Timers (48.2%).

Correlates of group membership—multiple logistic regression analysis

Table 2 shows the results for multiple logistic regression analysis for walking/running group membership. The results are the odds ratio for each predictor variable compared with its reference category of belonging to one of the three other groups compared with the Few-Timers. As with the univariate analyses, many of the results were statistically significant due to the large sample size.

Consistently higher odds of some form of continuing attendance were associated with a participant being older at first participation, volunteering more, attending a *parkrun* in a major city or inner regional area (vs outer regional/remote/very remote), and having more local greenspace in the local area around the site. Higher odds of being in the Few-Timers group were associated with more recent initiation, slower personal finish times, the course containing sand sections, a higher average age-graded score at the *parkrun* site and a higher percentage of the local population meeting PA guidelines.

Other results showed associations with membership of one or two groups compared to the Few-Timers group. For example, in the adjusted analysis, men had lower odds of belonging to the Decliner group than women (vs Few-Timers), but the results for Low and High Maintainers were not significant. Participants with higher personal age-graded scores had lower odds of being in the Decliners group and High (but not Low) Maintainer group (vs Few-Timers). If a participant's modal *parkrun* site contained trail, grass and higher maximum gradients (but not total elevation), they had lower odds of being a High Maintainer, but if a course contained concrete, the odds of being in the Decliner group increased. Participants at courses with a sea or river view (vs a land view) had lower odds of being in the Decliners and Low Maintainer groups. Odds of being a Decliner or High Maintainer increased with volunteer diversity.

DISCUSSION

Our study on participation patterns as a walker or a runner in *parkrun*, one of the largest and longest-running PA interventions, is unique in both its longitudinal 3-year duration and its use of real-world observational data with detailed and comprehensive insights. We were able to characterize four different weekly attendance patterns in *parkrun* and identify the idiosyncratic personal and contextual variables correlates of

Table 2: ORs of belonging to Decliners, Low Maintainer and High Maintainer groups compared with Few-Timers for walking/running participation

Characteristic (reference category/increment)	OR (95% CI) vs Few-Timers		
	Decliners	Low Maintainers	High Maintainers
Individual-level covariates			
Men (women)	0.85 (0.83, 0.88)***	1.04 (0.99, 1.09)	1.02 (0.95, 1.09)
Year of first walk/run (2011)			
2012	0.87 (0.71, 1.08)	0.80 (0.60, 1.06)	0.72 (0.50, 1.03)
2013	0.87 (0.70, 1.07)	0.70 (0.53, 0.92)*	0.68 (0.47, 0.97)*
2014	0.77 (0.63, 0.96)*	0.63 (0.48, 0.83)**	0.60 (0.42, 0.86)**
2015	0.75 (0.61, 0.93)**	0.67 (0.51, 0.89)**	0.64 (0.45, 0.92)*
2016	0.76 (0.62, 0.94)*	0.73 (0.56, 0.97)*	0.74 (0.52, 1.05)
2017	0.92 (0.74, 1.14)	0.79 (0.59, 1.05)	0.91 (0.63, 1.33)
Age at first attendance (10-year increments)	1.23 (1.20, 1.25)***	1.29 (1.26, 1.32)***	1.79 (1.72, 1.85)***
Average personal finish time (1-minute increments)	0.94 (0.93, 0.94)***	0.93 (0.93, 0.94)***	0.89 (0.88, 0.90)***
Average personal age-graded score (10% increments)	0.79 (0.76, 0.82)***	1.01 (0.95, 1.06)	0.85 (0.79, 0.91)***
Number of volunteer occasions	1.81 (1.79, 1.83)***	2.15 (2.13, 2.17)***	2.26 (2.24, 2.29)***
parkrun site-level course covariates			
Route type (out and back)			
Loop(s)	1.04 (1.00, 1.08)	0.97 (0.92, 1.03)	1.11 (1.03, 1.20)**
Loop(s) with cross-over	1.00 (0.97, 1.04)	0.95 (0.90, 1.00)	1.04 (0.97, 1.12)
Terrain: trail (no trail)	0.99 (0.96, 1.03)	0.96 (0.91, 1.01)	0.93 (0.87, 0.99)*
Terrain: grass (no grass)	0.96 (0.92, 0.99)*	0.97 (0.92, 1.02)	0.80 (0.75, 0.85)***
Terrain: sand (no sand)	0.66 (0.60, 0.72)***	0.55 (0.48, 0.63)***	0.38 (0.31, 0.45)***
Terrain: concrete (no concrete/tar)	1.07 (1.02, 1.13)*	0.96 (0.89, 1.03)	1.05 (0.96, 1.15)
Blue space (land)			
River	0.91 (0.84, 0.98)*	0.88 (0.79, 0.98)*	0.98 (0.86, 1.13)
Sea	0.85 (0.78, 0.92)***	0.85 (0.75, 0.95)**	0.91 (0.78, 1.06)
Repetition > 1 km (no repetition)	0.94 (0.91, 0.98)**	0.96 (0.91, 1.01)	0.98 (0.92, 1.05)
Total elevation (25-m increments)	0.96 (0.94, 0.99)**	0.95 (0.91, 0.98)**	1.02 (0.97, 1.07)
Maximum gradient (2.5°C increments)	1.00 (0.98, 1.03)	0.98 (0.95, 1.01)	0.89 (0.85, 0.93)***
parkrun site-level participant covariates			
Site average finish time (1-minute increments)	1.02 (1.00, 1.05)	0.95 (0.92, 0.99)**	0.99 (0.95, 1.04)
Site average age-graded score (10% increments)	0.70 (0.57, 0.86)***	0.30 (0.23, 0.40)***	0.30 (0.21, 0.44)***
Average site club membership (10% increments)	0.99 (0.97, 1.01)	0.98 (0.96, 1.01)	1.07 (1.03, 1.11)***
Volunteer diversity (0.1 increments, range 0–1)	1.08 (1.02, 1.14)**	1.01 (0.93, 1.09)	1.25 (1.12, 1.39)***
parkrun site-level areal covariates			
Average site IRSAD (lowest tertile)			
Medium	0.95 (0.90, 1.00)	1.05 (0.98, 1.14)	1.07 (0.97, 1.18)
Highest	1.01 (0.97, 1.06)	1.05 (0.98, 1.12)	1.01 (0.93, 1.09)
Remoteness (outer regional, remote, very remote)			
Inner regional	1.18 (1.10, 1.26)***	1.57 (1.41, 1.73)***	2.07 (1.80, 2.38)***
Major cities	1.25 (1.17, 1.33)***	1.68 (1.52, 1.85)**	2.66 (2.32, 3.04)***
Proportion greenspace (10% increments)	1.02 (1.01, 1.03)***	1.07 (1.05, 1.09)***	1.08 (1.06, 1.10)***
Proportion meeting PA recommendations (10% increments)	0.94 (0.92, 0.96)***	0.87 (0.84, 0.90)***	0.83 (0.79, 0.86)***

CI = confidence interval; IRSAD = Index of Relative Socioeconomic Advantage and Disadvantage; OR = odds ratio; PA = physical activity.
Significance of comparison with reference category (Few-Timers):
*$p < 0.05$;
**$p < 0.01$;
***$p < 0.001$.

each group. Our analysis has implications not only for the operation of *parkrun* and similar initiatives, but also the field of PA maintenance and adherence.

We identified four broad patterns of adherence over the first 3 years since a participant's first walk or run. The majority (75%) attended on an average of four occasions over the first 3 years. A recent study examining those who attend *parkrun* only once found an inconvenient start time (24%), a lack of time (21%), injury/illness (15%) and childcare obligations (14%) as the most common reasons for people to report not continuing. The authors found the first two reasons (i.e. inconvenient time of the run and lack of time) and

childcare were less important for older age groups, aligning with our observation that as ages increases, the likelihood of being a Few-Timer decreases. On the one hand, this is encouraging as sports participation declines with age after age 20 (Eime *et al.*, 2016). On the other, given the size of the Few-Timer group, there may be scope to promote the flexible nature of *parkrun* to younger age groups, where coming intermittently is acceptable (Stevinson *et al.*, 2015) and can yield acute, if not long-term, health benefits (Rogerson *et al.*, 2016).

Our four groups find resonance with those of Fuchs *et al.* (Fuchs *et al.*, 2005), who studied patterns of attendance at a university sports program among university students and employees. Their 'early dropouts', similar to our Few-Timers, attended for only 1 or 2 weeks. Their 'maintainers' who came 90% of the time over the 13-week study period are similar to our High Maintainers; and 'late dropouts' (who slowly declined in attendance rate over time) akin to our Decliners. The fourth group had a trajectory reminiscent of our Low Maintainers but were characterized by Fuchs *et al.* (Fuchs *et al.*, 2005) as 'fluctuaters'. The more irregular characterization may reflect the short study duration which with our longer time period appears as low intensity but continuing attenders.

The similarities between analyses lend some external validity to our findings and raise implications for research on PA maintenance in community programs. People who continue to attend regularly but at a lower rate demonstrate that it is possible for an intervention to sustain interest, even though it does not require continuous or near-continuous attendance. Stevinson *et al.*'s early qualitative study with *parkrunners* showed that one of the reasons people continue to come to *parkrun* was the lack of pressure to attend (Stevinson *et al.*, 2015). Paying a fee or team membership may exert pressure on participants to attend at least while they are prepared to pay. However, studies of dropout from gyms showed that permanent dropout is significantly higher once attendance goes below 7–8 times a month (Oliveira *et al.*, 2021). As *parkrun* is ongoing and free, low or fluctuating maintenance is a viable option for many who may have seasonal sport, family or work commitments, concerns about cost or preferences for other activities. The easy ingress and egress of participation can be seen as a strength of the *parkrun* model as it may be easier to engage over the longer term where there is no commitment required (Stevinson *et al.*, 2015; Hindley, 2022).

More technically, attendance in previous studies may conceptualize adherence as frequency of participation rather than regularity. Over the short term, some patterns could appear as 'disengagement' but over a longer-term view, look more like continuation but at a lower intensity. Therefore, our use of a 12-week moving average over 3 years shows a more nuanced categorization of behavioural maintenance in real-world interventions in the longer term.

There are also several health promotion implications for *parkrun* and other PA initiatives arising from our analysis. First, less challenging environments may be conducive to attending *parkrun* beyond a few visits. The site age-graded performance most strongly differentiated groups with reductions in the odds of being a High Maintainer and of being a Low Maintainer with each 10% increment in the average age-graded score of the *parkrun* for walking/running. The effects held after accounting for participants' personal age-graded score (which showed that comparatively fitter runners had lower likelihood to be High Maintainers or Decliners). Strong inverse effects of belonging to a higher attendance group were also seen where the PA norm was higher (up to 17% lower odds) and the course surface contained sand (34–62% lower odds), a much more difficult surface to run on (Pinnington and Dawson, 2001) along with significant but weaker effects for increasing total elevation and increasing maximum gradient. Together these results suggest that challenging sites, whether through increased local competition (despite personal ability) or running conditions, are associated with less sustained attendance. While the mixing of more with less experienced participants in *parkrun* can have benefits for building social capital (Wiltshire and Stevinson, 2018), there may still remain some disincentives for slower participants to regularly attend if the environment is more competitive. The finding may also reflect the concept of 'sport habitus' (the propensity and choice of sports habits developed through social interaction) which was explored in relation to *parkrun* by Haake *et al.* (Haake *et al.*, 2022). Although, unlike Haake *et al.* (Haake *et al.*, 2022), we did not find an effect of SES, the notion of the cumulative effect of context might be seen in the associations in our study with group membership of PA norm as well as availability of local greenspace and geographic location. Further qualitative exploration would assist understanding how peer performance interacts with individual commitment in *parkrun* which already makes considerable efforts to promote participation rather than competition (Stevinson *et al.*, 2015) and the broader and lifetime PA context.

Second, personal finish time was strongly related (6–11% higher odds per minute faster) to being in any of the continuing groups compared with Few-Timers. It is likely that such an effect is bidirectional—regular attendance not only improves performance (Stevinson and Hickson, 2019; Gilburn, 2023) but improved performance is an incentive for continued participation (Stevinson *et al.*, 2015; Bowness *et al.*, 2021). Results emails report when a participant achieves their personal best, and previous qualitative research has demonstrated that some *parkrunners* are motivated by the opportunity for personal achievement (Stevinson *et al.*, 2015; Morris and Scott, 2019) such as improved finish times. More generally, feedback on performance has been shown to promote PA increase maintenance (Howlett *et al.*, 2019). For first-time participants, however, the prospect of an improved time may feel unlikely; Reece *et al.* (Reece *et al.*, 2022) found 'feeling too unfit' was a reason given by 13% of those who register for *parkrun* but never attend. A range of other incentives, such as milestone shirts for attendance and volunteering, are also offered, and *parkrun* emphasizes participation more than performance (Stevinson *et al.*, 2015). Therefore, further highlighting performance may be inconsistent with the *parkrun* ethos, but strategies to normalize walking *parkrun* such as the 'parkwalker' role (instituted in 2022) may assist in retaining those with slower times (parkrun Group, 2022).

Third, the walker/runner analysis showed the amount of volunteering was strongly associated with being in all groups vs the Few-Timers, with a positive gradient of effect across the higher attendance rates (from 1.81 to 2.26 increased odds). Although the significant comparisons with Few-Timers are self-evident, the gradient likely reflects that an increasing sense of obligation and/or confidence to take a volunteer role is associated with a higher rate of attendance (Hallett *et al.*, 2021). Higher volunteer diversity at a participant's modal *parkrun* (i.e. greater variation in uptake of available volunteer roles) by contrast was associated with being a Decliner

or High Maintainer. The significance of this result is unclear; at the very least it may suggest that less regular attendance is associated with a concentration of volunteering (i.e. lower diversity), an important finding for *parkrun* which does not impose volunteer obligations on participants (Hallett *et al*., 2021).

Our analysis showed a greater proportion of club/group membership at *parkrun* was associated with greater likelihood of being in the High Maintainer group for walking/running participation. Although not overly strong (7–14% increased odds), the result may reflect the social component of the *parkrun* model. Attendance at *parkrun* as part of running club training or the reverse where joining a group is more likely because of regular attendance may signify the influence of social identification, interaction and connection in *parkrun,* a recurring theme in previous research (Morris and Scott, 2019; Stevens *et al*., 2019; Davis *et al*., 2021; Hindley, 2022). For example, Stevens *et al.* (2019) found stronger identification as a *parkrunner* was associated with increased attendance and Bowness *et al*. found that *parkrun* can facilitate the development of a stronger runner identity (Stevens *et al*., 2019; Bowness *et al*., 2021). More broadly, although there are studies on PA maintenance social support (Lindsay-Smith *et al*., 2017; Scarapicchia *et al*., 2017) and group exercise (Ward *et al*., 2020), the absence of studies examining the role of social connection in mass participation PA perhaps points to a unique aspect of *parkrun*. Future research could examine running groups or clubs in *parkrun* to better understand the mechanics of social connections within *parkrun* and how *parkrun* fits with the broader running system.

Strengths and limitations

Strengths of our analysis include its large sample size over an extended period with weekly granularity. Our data are drawn from inception of *parkrun* in Australia up until disruption by the COVID19 pandemic covering potential changes in participation patterns over the growth of *parkrun* in this country. We included a broad range of personal and contextual variables and allowed the data to drive outcome conceptualizations rather than selecting arbitrary cut-points. Our data are from a real-world scaled-up initiative which includes a wide age range and people with varying levels of fitness. It can be used to inform other PA initiatives designed to have population-wide impact. Limitations are that the analysis could not include prior level of PA nor current total PA. Therefore, we cannot gauge how *parkrun* participation patterns may contribute to achieving recommended PA levels (Bull *et al*., 2020). Our measure of SES was derived from the location of the *parkrun* rather than the individual and therefore precludes estimation of more direct effects of this variable. Data are only from Australia and there may be differences in other countries with different PA levels, *parkrun* 'maturity' and weather contexts. Our analysis only identified main walk/run participation trends and their correlates. Future studies could quantify critical inflexion points in attendance which may guide the development of interventions for maintenance.

CONCLUSION

Understanding population-level program motivation and sustainment is essential to promoting PA. What may motivate and influence maintenance may change over the trajectory of participation; what is important in earlier phases of someone's participation with a new activity may be different to what will motivate them to engage months or years later (Rhodes and Sui, 2021). We have shown that real-world maintenance with a particular type of PA may not involve the same or high frequency of attendance for everyone. While the Few-Timers and Decliners may require some intervention to bring them back or keep bringing them back to *parkrun*, others may find a level of participation that works for them that is sustainable over extended periods of time. Moreover, where someone is placed in 'the pack' locally and the degree of identification with others in the group may bidirectionally interact with attendance pattern, underscoring the importance of considering the social aspects of PA maintenance rather than just psychological factors. It seems *parkrun* can accommodate a range of PA patterning, which may involve absences due to seasonal sport, holidays or fluctuating motivation because of the flexible but reliable model and the lack of 'sanctions' for irregular but continuing attendance.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *Health Promotion International* online.

AUTHOR CONTRIBUTIONS

A.C.G. participated in the study design, reviewed the literature, sourced the data and contributed to the interpretation of the results. B.-H.H. conducted the data extraction, contributed to the analysis design, conducted the analysis and contributed to the interpretation of results. D.M. contributed to the analysis design and interpretation of results. A.B. contributed to the analysis design and interpretation. L.C. contributed to the review of the literature and interpretation of results. K.R. contributed to the study design, analysis design and the interpretation of results. All authors contributed to the manuscript writing. All authors have read and approved the final version of the manuscript and agree with the order of presentation of the authors.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the *parkrun* Global Research Board for approving the research and parkrun, in particular Mike Graney, for providing the *parkrun* participation and registration data.

FUNDING

This work was supported by a National Health and Medical Research Council Ideas Grant 2021/GNT2012418. The funding source played no role in the study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the article for publication except that it must be submitted to a journal with Open Access.

CONFLICT OF INTEREST STATEMENT

A.C.G. is a member of the *parkrun* Global Research Board. A.C.G., B.-H.H., K.R. and L.C. are parkrunners.

DATA AVAILABILITY

The data underlying this article were provided by *parkrun* by permission. Data will be shared on request to the corresponding author with permission of *parkrun*.

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