Original article

Patterns and correlates of participation in a weekly mass participation physical activity event, *parkrun*, in Australia, 2011 to 2020

Running title: Participation in *parkrun* Australia

Abstract word count: 249 words

Manuscript word count: 4693 (including references)

Submission date: 19th September 2023

(Corresponding author): Anne C Grunseit[1,2] anne.grunseit@uts.edu.au ORCID: 0000-0003-1250-3265

Bo-Huei Huang[1] bo-huei.huang@uts.edu.au 0000-0001-8543-3152

Dafna Merom[3] D.Merom@westernsydney.edu.au 0000-0001-6459-8628

Adrian Bauman Adrian.bauman@sydney.edu.au 0000-0002-0369-4621

Leonie Cranney[1] leonie.cranney@uts.edu.au 0000-0002-9441-5703

Kris Rogers[1] kris.rogers@uts.edu.au 0000-0001-5497-4298

Affiliations:

1 School of Public Health, Faculty of Health, University of Technology Sydney

2 Sydney School of Public Health, University of Sydney

3 School of Health Sciences, Western Sydney University

Keywords: population health; prevention; health promotion; running; walking

ABSTRACT

Background: Studying effective interventions already operating at scale is critical to improving physical activity (PA) intervention research translation. The free, weekly, timed 5km run or walk *parkrun* represents a unique opportunity to examine successful organic dissemination. We conducted an ecological analysis to identify patterns of growth in Australian *parkrun* participation and their correlates from 2011 to 2020.

Method: Outcome variables were 1) weekly counts of walkers/runners and 2) monthly number of new *parkrun* registrants. We used latent class analysis to characterise growth trajectories followed by logistic regression on class membership. Covariates included *parkrun* course characteristics (e.g., surface type, route), site-level aggregate participant profile (e.g., proportion women, mean age) and surrounding area characteristics (e.g., population density, PA norm).

Results: 363 *parkruns* were included (n=8,388,695 participation instances). Sixty-nine percent followed a low growth and 31% a high growth participation pattern. High growth was associated with greater participation by women, concrete/bitumen surface type, lower area socioeconomic status, and greater volunteer heterogeneity. Odds of being in the slow growth class were higher if the course contained >1km of repetition, higher average age of participants, better average *parkrun* performance, and higher running group membership. Two patterns of new registration were identified: high start followed by steep decline, and low start, slow decline with similar correlates to participation.

Conclusion: *parkruns* with a less competitive social milieu may have more rapid dissemination. As a free and regular event, *parkruns* in low socioeconomic areas have the potential to improve the activity levels of those with fewer resources.

INTRODUCTION

Physical activity (PA) decreases risk of adverse health conditions such as cardiovascular diseases, type 2 diabetes, breast and colon cancers, increases life expectancy and acutely improves blood pressure, glucose-level control, cognitive function and stress, and subjective mood.[1] Despite the compelling need for effective PA interventions delivered at a population level, a review of sustainable public health programs found that only 7% were PA programs, and only half of these had been implemented in 100 sites or more.[2] Studying effective interventions already operating at scale has been identified as vital to improving PA intervention research translation.[3]

The global grassroots PA phenomenon, *parkrun* (www.*parkrun*.com) is rare among PA interventions in its spread, accessibility and sustainment despite being almost exclusively driven by community initiation.[4] *parkrun* comprises a free, weekly, timed run or walk in public open spaces (e.g., park or trail) on a pre-defined 5km route. There is no minimum age or skill level and implementation is largely through volunteers with a small number of paid staff globally. Participants demonstrate sustained improvements in fitness, total PA, vigorous PA, BMI, and mood[5,6] with a positive dose-response effect of participation on health outcomes.[7] It has been successfully implemented in 23 countries across five continents with vastly different geographic, cultural and socio-political contexts (for example, South Africa, Poland and Australia) with over 7 million registrants worldwide. New *parkrun* sites do not graft onto existing organisational networks such as schools, government authorities or sporting associations (with the exception of those conducted in correctional centres) otherwise regarded as key to scaling up.[3] As such, it represents a unique opportunity to study successful organic dissemination.

Previous research on *parkrun* participation shows at the individual level, higher attendance has been associated with being married/partnered, having lower levels of education,[8] and being a non-runner at registration.[9,10] Among system-level analyses, a study of 56 Scottish *parkruns* found that the average participant age and proportion of women participants increased over time.[11] Other studies have shown lower participation rates in areas with higher ethnic density[12] and lower socioeconomic status.[13] These two studies, however, modelled participation rates at the geographic area rather than the *parkrun* level. One study of *parkruns* in Canada and the US descriptively analysed their settings (distance to a park, walkability, population density for example) but did not correlate these factors with participation.[14] Therefore, despite the remarkable dissemination success of *parkrun*, the participation growth trajectories and their site-specific correlates remain unexplored.

Understanding the influence of *parkrun* site-level and surrounding population characteristics on *parkrun* dissemination can inform the scale-up of other PA interventions, as well as *parkrun* operational decision-making when establishing new sites. We conducted an ecological analysis to identify patterns of growth in *parkrun* participation and its correlates over nine years in Australia.

METHODS

We analysed growth patterns of two different measures: 1) recorded number of 'finishers' (those who run or walk a *parkrun*) each week and 2) number of new registrants at a *parkrun* site each week, to reflect engagement of new participants. The study was approved by the University of Sydney Human Research Ethics Committee, approval number 2018/586 and the University of Technology Human Research Ethics committee, approval number ETH22-6989

parkrun

parkrun came to Australia in 2011 and currently organises weekly events in 465 locations in every state and territory (https://www.*parkrun*.com.au/). Participants register once and receive a unique barcode and parkrunner ID which is linked to their recorded finish time each time they participate. Registration information comprises: gender, date of birth, 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".[15] Participants are emailed their position, time, and age-graded score (a percentage which compares a participant's finish time against the world record time for their sex and age – higher score indicate faster relative time).[16] Tabulated weekly results are also posted to the public webpage for each *parkrun*.

Data extraction

Anonymised registration and weekly participation data since inception (2nd of April, 2011) were provided by *parkrun* from the Australian database. We right-censored the 25th of January 2020 (when the first COVID case in Australia was reported) because of travel restrictions and the eventual suspension of *parkrun* events. The non-public data on new registrations for each *parkrun* were collapsed to monthly counts (to prevent cross-referencing to publicly available identifiable weekly run results). Informed consent was not separately obtained as research use of anonymised data is covered by the *parkrun* privacy policy.[17]

parkrun sites that were a) private (i.e., custodial or military), b) junior (only allowing *parkrun*ners between 4 and 14 years on a 2-km course), c) the relocated sites of an already included parkrun, d) established after 25th of January 2020, or e) lacking essential information about site characteristics were excluded from the study sample (see flow diagram Figure S1, Supplementary Materials).

Study Variables

<u>Main study outcomes</u>

The key outcomes were a) the *parkrun* site-specific weekly counts of participants who run or walk and b) monthly newly registrations.

<u>*parkrun* site-level course covariates</u>

To examine site-level correlates of participation and registration, we collected information on *parkrun* routes and their surrounding area from the *parkrun* official course description (https://www.parkrun.com.au/events/) and *Strava* (https://www.strava.com/), a free-access running GPS data repository. Site characteristics include a characterisation of the route types: a) out-and-back (mostly bidirectional along the same route), b) mostly unidirectional loop/s or c) loop(s) with cross-over (unidirectional and bidirectional movement on the same route) (Figure S2 Supplementary Materials). We also indicated route repetition where ≥1 km of the route was repeated in the same direction.

We characterized terrain as individual dichotimised variables, classifying the route surface having 1) trail, b) grass, c) sand, and/or d) concrete/bitumen from official *parkrun* course description (Table S2, Supplementary Materials).[11] Sites were classified for the presence of 'blue space', i.e., whether there was a visible body of water or watercourse from *Strava* information and the official *parkrun* course map. We operationalised route difficulty as the total elevation change and maximum gradient (derived from the GPS data on Strava with an open-source calculator https://www.doogal.co.uk/js/ElevationCalculator.js?v=1).

For validation, a subsample of routes was independently coded by AG and BH for route type, repetitiveness, and blue space with 100% inter-rater agreement (further details in Supplementary Materials). The route type, repetitiveness, surface, difficulty and blue space variables captured the potential influence of social and physical preferences on participation.[18]

parkrun site-level participant covariates

Contextual *parkrun*ner participant variables that may affect participation growth were time-varying (week or month, as appropriate for outcome) and derived at the site level. We included proportion who were women, mean age, proportion of participants reporting belonging to a running group/club, and mean age-graded score of participants. We used the Simpson/Herfindahl approach to calculate a diversity index of volunteer heterogeneity using the weekly volunteer information from the *parkrun* database to capture the potential effect of perceived volunteering attractiveness/obligation on participation.[19] For each site, we generated 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 one denote greater diversity.[20]

parkrun site-level areal covariates

We included population density (the proportions of persons in the area who reside in a sub-area with more than 2,000 people per square kilometer),[21] PA norm (proportion of the population with at least 150 minutes of exercise per week,[22] greenspace accessibility (proportion of the population within 400 meters of green space)[23] of the nearest Medicare Local(s) matched to each *parkrun* site by postcode (Figure 3, Supplementary materials). Socio-economic status (rank decile of Index of Relative Socio-economic Advantage and Disadvantage (IRSAD)[24] and remoteness (Accessibility/Remoteness Index of Australia (ARIA+) were derived from Australian Bureau of Statistics data matched to the *parkrun* by postcode.[21] We operationalised IRSAD as tertiles (deciles 1-3, 4-7, and 8-10); higher IRSAD scores indicate more advantage and less disadvantage. The ARIA+ is based on relative access to services, which we then classified into three groups: major cities, inner regional, outer regional and remote. Supplementary Materials detail procedures, definitions, and granularity of the covariates.

Statistical Analysis

For transparency and validity, we outlined our data analysis plan prior to conducting formal analyses and registered this on the Open Science Framework (OSF) (https://osf.io/apmrv/?view_only=33646c8bba264d22bf1d0df53a416c78). In the first stage, the analysis estimated distinct groups of trajectories of the two key outcomes (weekly runners/walkers and monthly registrations) and in the second, factors associated with membership to each group.

We applied latent process mixed modeling to predict the growth trajectories of our key outcomes of interest.[25] We entered a linear function of time at the population level as a fixed effect and time at the *parkrun* sites level with two correlated random effects on the intercept and time. This approach separates individual *parkrun* site growth patterns from time effects that affect all *parkrun* sites, e.g., seasonal changes. The extended Marquardt algorithm was used to obtain the maximum likelihood estimators. We applied the initial values from the asymptotic distribution of a single-class model to the models with more-than-one classes. Two to six classes were considered and the best fit of classes were determined using posterior membership probabilities above selected thresholds (0.7, 0.8, 0.9) based on Bayesian Information Criteria (BIC). Supplementary Materials provide detailed methods of choosing the potential transformation of dependent variables and model specifications. Data cleaning and variable derivation were conducted in *Excel* and *SAS* software, while statistical analyses were performed with the *lcmm* package in the *R* software.[25]

In the second phase, class membership regressed on the covariates using a logistic model comparing the probability of a *parkrun* being in one class with the probability of being in the referent class.

RESULTS

Selection and description of sites

From 453, we excluded 90 *parkruns* which: started after the census date (n=63), were private *parkruns* (n=7), junior *parkruns* (n=7), relocations of another included *parkruns* (n=5), or had missing/unusable information (n=8); leaving data from 363 *parkruns* available for analysis.

Descriptive information about the *parkrun* sites appears in Table 1.

INSERT TABLE 1 ABOUT HERE

Most *parkrun* sites were established from 2014 onwards and used an out-and-back course. The surface was most commonly concrete/bitumen but grass and trail were also relatively common, and most *parkruns* were near blue space of river or ocean. *Parkrun* sites had a majority of female participants, a mean participant age of almost 40 years and a mean age-graded score of 46%. Just 28% of *parkrun* sites were in population dense areas but most commonly in middle IRSAD, major city areas. On average, the included *parkruns* were in areas where less than half of the population were meeting PA recommendations.

Latent class analysis

<u>Weekly run/walk participation</u>

Two classes were selected for weekly count of people who ran or walked based on BIC (Supplementary Table S3). The proportion of allocated probability of memberships was high (95% >90% allocated probability) indicating good discrimination between the classes.

The growth trajectories derived from the analysis are shown in Figure 1.

INSERT FIGURE 1 ABOUT HERE

Both classes showed growth in the number of weekly walkers/runners and had similar starting points (Figure 1). *parkruns* in Class 2 (n=111) had higher growth ('high growth') than those in Class 1 (n=252) ('slow growth'). By the end of the follow-up period, the marginal number of walkers/runners was over two times higher (predicted number of finishers= 273) in high-growth compared to slow-growth *parkruns* (predicted number of finishers=131).

Odds ratios for the probability of belonging to a high growth *parkrun* for each of the study factors are shown in Table 2 for weekly walk/run participation. Odds ratios >1 indicate a higher chance of belonging to the high growth class; OR <1 is more chance of belonging to the slow growth class.

There was good evidence that site and aggregate participation profile characteristics were associated with the type of growth trajectory of participation.

INSERT TABLE 2 ABOUT HERE

The odds of a *parkrun* belonging to the fast growth category (vs slow growth) increased if the course terrain contained bitumen or concrete surfaces by 87%. The probability of being a high growth *parkrun* also increased with the proportion of female participants and where there was more heterogeneity in people taking volunteer roles. Factors associated with belonging to the 'slow growth' *parkruns* (i.e., OR<1) were a repetition of at least 1 km, containing trail terrain, *parkruns* with a higher average age of participants and higher group/club membership, and where the proportion of people in the surrounding area meeting PA guidelines was higher. For example, the odds of being in the slow growth trajectory increased over two and a half fold (OR=2.78) if there was repetition of 1km in the same direction in the course, and 16% per year increase in the average age of participants. Among the surrounding area factors, *parkruns* in medium and high SES areas were more likely to experience slow growth compared to *parkruns* in areas in the lowest three deciles. Inner or outer regional/remote areas had odds of 4.8 and 16.8 respectively to be slow growth *parkruns* compared with those in major urban areas.

<u>Monthly new registrations</u>

Two classes were also selected for monthly registrations based on BIC (Table S3, Supplementary materials) with fair discrimination between the classes (83.8% >70% allocated probability). The trajectories both indicated decline in the rate of new registrations over time but had very different starting points, 480 vs 96 (Figure 2).

INSERT FIGURE 2 ABOUT HERE

Almost 94% (n=340) had relatively low rates of new monthly registrations which then declined steadily over time. The remainder (6.3%, n=23) had much higher initial new monthly registrations for the first approximately 6 months which only steeply declined over the study follow-up period, remaining lower than the steady decline class at study end.

The results for correlates of a steady decline trajectory (vs steep declining trajectory) are shown in Table 3.

INSERT TABLE 3 ABOUT HERE

If the course was all or in part concrete/bitumen, had a sea view, and higher proportion female, volunteer diversity, population density, and proportion meeting PA guidelines in the surrounding area the *parkrun* had higher odds of demonstrating a slow decline new registration growth pattern. For example, the odds of being in the slow (vs. steep) decline category were over three-fold for *parkruns* with a sea view, and 64% higher for a *parkrun* course containing concrete or bitumen.

However, if more than 1km of the course repeated in the same direction, had higher average age, group/club membership, or was in an outer regional/remote area vs major urban area it was more likely to belong to the initially high then steep decline trajectory. As with the walk/run participation analysis, the course type and elevation were not significantly associated with trajectory, and although socioeconomic status was associated with participation, it was not associated with new registrations.

DISCUSSION

Our unique ecological analysis of Australia's *parkrun* participation over nine years answers the call of the WHO Global Action Plan on PA guiding principles for practice-based evidence for PA.[22] We identified two ascending patterns of growth in participation (high vs. slow), and two patterns of decline in registration over time (steep vs. steady declines), the latter demonstrating new registration reaches saturation irrespective of a high or low starting point. In terms of correlates, many of the factors associated with participation were also associated with new registration patterns, and were dominated by aggregate participant profile, rather than *parkrun* course characteristics. Our findings confirm and extend what is known about what influences people to be active and have implications for both the operation of *parkrun* as well as the fields of PA intervention and public health more widely, as discussed below.

A number of our findings would be informative for *parkrun* operational decision making and planning. For example, in terms of course attributes, somewhat surprisingly growth trajectory was unrelated to format, difficulty (total elevation and maximum gradient) and presence of blue space, but repetition of at least a kilometre (or 20% of the route) and the surface type were. Preferences for hard surface types for recreational trails have been noted by others[3,26] and are a feature which facilitates *parkrun* performance.[11] Further, more rapid dissemination (despite lower starting numbers) and more stable decline in registration was associated with more urbanised areas. Our findings therefore can inform decisions around route selection for new *parkruns* (or other walk/run-based events) or relocations and can assist in preparing new event teams for the most likely growth scenarios, given their location. The positive association of higher volunteer diversity and higher rapid growth in participation and slow rather than steep decline in registration may be more reflective of reverse causality (i.e., the high growth and steady inflow of new registrants leads to greater heterogeneity and perhaps size of the volunteer workforce required). Nonetheless, it suggests that the volunteer pool grows in conjunction with a *parkrun* which may be on the one hand reassuring for organisers, but on the other, may show that the volunteering can fall to a smaller, overused group in slower growing *parkruns* as noted in previous qualitative work on volunteering in *parkrun*.[19]

Informative for *parkrun* but also PA interventions more generally, was the finding that a cluster of variables which could broadly be described as PA performance milieu were associated with participation. *parkruns* with lower average age-graded score, population levels of PA and proportion of club membership were more likely to belong to the high growth class. These inverse relationships could signal that *parkruns* where the average participant is slower, less fit or experienced at running may feel more inclusive and less threatening, especially for the previously inactive or insufficiently active groups which are attracted to parkrun.[8,9] Qualitative research has shown that both initial and sustained *parkrun* participation is in part motivated by feeling accepted irrespective of ability level.[27,28] Together these findings suggest that growth in participation in a PA initiative may be steeper where the milieu might offer a greater chance of a sense of achievement.

The lower growth rate of *parkruns* with higher 'group' or club membership and surrounding area PA norm could also reflect participants at those *parkruns'* greater range of physical activities and hence they may be less regular in their *parkrun* participation.[29] Two studies of UK parkrunners have shown that those inactive at registration have higher *parkrun* attendance rates than occasional or regular runners, consistent with our finding.[9,10] Therefore we may see greater potential for uptake in areas where the population is on average otherwise less active. Future research could further examine *parkrun* participation rates in the context of all PA to yield insights into the interaction between total and range of PA and *parkrun* attendance.

Significantly for PA interventions more broadly is the association between lower SES and the high growth participation pattern. Although *parkruns* are more likely to be in more advantaged areas,[30] one-third of our sample were in the lowest three deciles. Research from the UK has shown that parkrunners from areas of greater disadvantage who are inactive at registration report greater improvements in fitness, physical health, happiness and mental health when compared to the whole sample.[10] As a free and regular event and cost being a major barrier for those with lower resources,[31] a *parkrun* placed in a low socioeconomic area has the potential to improve the activity levels of those living in the surrounding area.

Although the surrounding green space was not associated with participation growth trajectories or new registration in our analysis, because *parkrun* routes cannot cross roads our finding on repetition lowering the odds of being high growth trajectory and steady (rather than steep) decline in new registrations becomes pertinent. Finding contiguous space which allows for non-repetitive routes is more difficult in areas which have limited or fragmented green space. From a systems point of view, our analysis suggests it is not necessarily the total amount of greenspace available but its configuration which can determine whether a *parkrun* attracts increasing participation, a notion documented by previous cross-sectional research.[32] Numerous reviews demonstrate the importance of greenspace to physical health and mental wellbeing (e.g., Lee & Maheswaran, 2011)[33] and, given our findings, there should be greater consideration in town planning of having green space which can accommodate events such as *parkrun*. Further, the attraction for initial registration with *parkrun* of having blue space as a course feature underscores the importance of retaining beach, river and harbour fronts as publicly accessible rather than under private ownership to support public health amenity.

Our research raises many areas for future exploration. For example, the importance of aspects of *parkrun* courses such as repetition or surface type would benefit from confirmation and expansion through qualitative work to test whether our suppositions are supported by participant experience and to elucidate the mechanisms at play. Examining the factors associated with continuing participation in *parkrun* at the individual level and how it relates to factors such as aggregate PA levels at *parkrun* and in the community would enhance our understanding of milieu on engagement and maintenance. Whether the existence of contiguous space is linked to the establishment of *parkruns* could also be a fruitful area to formally test to further support advocacy for retaining public accessibility to green space. *parkrun* decision-making on course location and format, participation promotion campaigns as well as principles to inform other PA interventions could benefit from such investigations.

Limitations

We only included Australian *parkruns* and therefore the associations found may not be generalisable to other jurisdictions. We could not assess the effect of prior level of PA in our models due to the relatively recent introduction of this variable into the registration process. However, the inclusion of age-graded score and PA norm of the surrounding area allowed us to account for PA levels among the contemporaneous participant group and the community. Our measure of surface type was not independently checked but relied on the accuracy and detail of the course description provided on the *parkrun* website. Therefore, there may be some misclassification in this variable particularly in the definition of 'trail' which is very broad. However, it is likely that such errors would be randomly spread amongst the population of *parkruns* and therefore not unduly impact on the conclusions. We could not assess the impact of proximity to *parkrun* as we could not obtain postcode data with sufficient time granularity due to privacy concerns.

CONCLUSION

The strong showing of site profiles as factors associated with both initiation of *parkrun* engagement (registration) and participation trajectories demonstrates that the provision of inclusive and achievable PA opportunities are likely to be more widely disseminated than those which do not have these features. Social mechanisms for awareness of *parkrun* through friend and family networks[34] may mean that events sited in low socioeconomic and among low active groups could seed dissemination through 'at-risk' target populations for PA interventions.[35] System level factors such as town planning can affect the appeal of PA events to potential and actual participants to the extent that such factors shape the features of *parkrun* courses. Large, attractive, publicly accessible space which can be shared through events such as *parkrun* can promote the popularity of such health-enhancing opportunities.

ACKNOWLEDGEMENTS

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

FUNDING SOURCE

This research was supported by a National Health and Medical Research Council Ideas Grant 2021/GNT2012418.

<u>REFERENCES</u>

1. Physical Activity Guidelines Advisory Committee. *2018 physical activity guidelines advisory committee scientific report*. 2018. https://health.gov/sites/default/files/2019-09/PAG_Advisory_Committee_Report.pdf

2. Schell SF, Luke DA, Schooley MW, et al. Public health program capacity for sustainability: a new framework. *Implement Sci*. 2013;8(1)doi:10.1186/1748-5908-8-15

3. Reis RS, Salvo D, Ogilvie D, Lambert EV, Goenka S, Brownson RC. Scaling up physical activity interventions worldwide: stepping up to larger and smarter approaches to get people moving. *Lancet*. 2016;388(10051):1337-1348. doi:10.1016/S0140-6736(16)30728-0

4. *parkrun* UK. How do you start a parkrun? 11th September, 2019. https://blog.parkrun.com/uk/2019/04/10/how-do-you-start-a-parkrun/

5. Peterson B, Withers B, Hawke F, Spink M, Callister R, Chuter V. Outcomes of participation in parkrun, and factors influencing why and how often individuals participate: A systematic review of quantitative studies. *J Sports Sci*. 2022:1-14.

6. Grunseit AC, Richards J, Reece L, Bauman A, Merom D. Evidence on the reach and impact of the social physical activity phenomenon parkrun: a scoping review. *Prev Med Rep*. 2020;20:101231.

7. Stevinson C, Hickson M. Changes in physical activity, weight and wellbeing outcomes among attendees of a weekly mass participation event: a prospective 12-month study. *Journal of Public Health*. 2019;41(4):807. doi:10.1093/pubmed/fdy178

8. Cleland V, Nash M, Sharman MJ, Claflin S. Exploring the health-promoting potential of the “parkrun” phenomenon: What factors are associated with higher levels of participation? *Am J Health Promot*. 2019;33(1):13-23.

9. Stevinson C, Hickson M. Exploring the public health potential of a mass community participation event. *J Public Health (Oxf)*. 2014;36(2):268-274.

10. Quirk H, Bullas A, Haake S, et al. Exploring the benefits of participation in community-based running and walking events: a cross-sectional survey of *parkrun* participants. *BMC Public Health*. 2021;21:1-15.

11. Gilburn AS. New Parkrunners Are Slower and the Attendance Gender Gap Narrowing Making *Parkrun* More Inclusive. *Int J Environ Res Public Health*. 2023;20(4):3602.

12. Smith R, Schneider P, Bullas A, et al. Does ethnic density influence community participation in mass participation physical activity events? The case of *parkrun* in England. *Wellcome Open Res*. 2020;5

13. Smith RA, Schneider PP, Cosulich R, et al. Socioeconomic inequalities in distance to and participation in a community-based running and walking activity: A longitudinal ecological study of *parkrun* 2010 to 2019. *Health Place*. 2021;71:102626.

14. Robertson-Wilson J, Rodden-Aubut S, Tracey J, Miller M, Lapid H. *Parkrun* across the pond: examining location and event characteristics in Canada and the United States of America. *Leisure/Loisir*. 2023:1-22.

15. *parkrun* Global Limited. Biggest clubs. Accessed 11th September, 2023. https://www.parkrun.com.au/results/largestclubs/#featureClub=29137

16. *parkrun* Support. What is age grading? Accessed 11th September, 2023. https://support.parkrun.com/hc/en-us/articles/200565263-What-is-age-grading-

17. *parkrun* Global Limited. *parkrun* privacy policy. *parkrun* Global Limited. Accessed 11 September, 2023. https://www.parkrun.com/privacy/

18. Reichhart T, Arnberger A. Exploring the influence of speed, social, managerial and physical factors on shared trail preferences using a 3D computer animated choice experiment. *Landsc Urban Plan*. 2010;96(1):1-11.

19. Hallett R, Gombert K, Hurley M. "Everyone should muck In": A qualitative study of *Parkrun* volunteering and conflicting motivations. *J Nonprofit Public Sect Mark*. 2021;33(5):493-515.

20. Simpson EH. Measurement of diversity. *Nature*. 1949;163(4148):688-688.

21. Australian Bureau of Statistics. Regional population. Australian Bureau of Statistics. Accessed 9 May 2023, 2023. https://www.abs.gov.au/statistics/people/population/regional-population/latest-release#cite-window1

22. World Health Organization. *Global action plan on physical activity 2018–2030: more active people for a healthier world*. 2018.

23. Australian Bureau of Statistics. *National Health Survey: Users' Guide, 2017-18* Vol. 4363.0. 2019. https://www.abs.gov.au/ausstats/abs@.nsf/PrimaryMainFeatures/4363.0?OpenDocument

24. Australian Bureau of Statistics. *Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia, 2016*. 2018 2033.0.55.001.

25. Proust-Lima C, Philipps V, Liquet B. Estimation of extended mixed models using latent classes and latent processes: the R package lcmm. *arXiv preprint arXiv:150300890*. 2015;

26. Davies NJ, Lumsdon LM, Weston R. Developing recreational trails: Motivations for recreational walking. *Tour Plan Dev*. 2012;9(1):77-88.

27. Morris P, Scott H. Not just a run in the park: a qualitative exploration of *parkrun* and mental health. *Adv Ment Health*. 2019;17(2):110-123.

28. Stevinson C, Wiltshire G, Hickson M. Facilitating participation in health-enhancing physical activity: a qualitative study of parkrun. *Int J Behav Med*. 2015;22:170-177.

29. Bowles HR, Merom D, Chey T, Smith BJ, Bauman A. Associations of type, organization, and number of recreational activities with total activity. *J Phys Act Health*. 2007;4(4):470-481.

30. Smith JL, Reece LJ, Rose CL, Owen KB. Improving access to public physical activity events for disadvantaged communities in Australia. *BMC Public Health*. 2022;22(1):1-8.

31. Sequeira S, Cruz C, Pinto D, Santos L, Marques A. Prevalence of barriers for physical activity in adults according to gender and socioeconomic status. *Br J Sports Med*. 2011;45(15):A18-A19.

32. Schipperijn J, Bentsen P, Troelsen J, Toftager M, Stigsdotter UK. Associations between physical activity and characteristics of urban green space. *Urban For Urban Green*. 2013;12(1):109-116.

33. Lee AC, Maheswaran R. The health benefits of urban green spaces: a review of the evidence. *J Public Health (Oxf)*. 2011;33(2):212-222.

34. Sharman MJ, Nash M, Cleland V. Health and broader community benefit of parkrun—an exploratory qualitative study. *Health Promot J Austr*. 2019;30(2):163-171.

35. Sawka KJ, McCormack GR, Nettel-Aguirre A, Hawe P, Doyle-Baker PK. Friendship networks and physical activity and sedentary behavior among youth: a systematized review. *IJBNPA*. 2013;10:1-9.

Table 1. Characteristics of *parkrun* sites (n=363) included in the study.

Variable	**Level/definition**	**% (N) or mean (SD)**
***parkrun* site-level course characteristics**[1]		
Year site established	2010-2013	14.9% (54)
	2014-2016	38.0% (138)
	2017-2019	47.1% (171)
Route type	Out and Back	62.3% (226)
	Loop(s) with crossover	20.9% (76)
	Unidirectional loop(s)	16.8% (61)
Repetitiveness	>1km same-direction repetition	39.1% (142)
Terrain Texture (partial or full)	Bitumen/concrete	71.3% (259)
	Trail	53.2% (193)
	Grass	32.2% (117)
	Sand	4.7% (17)
Blue space	Land only	9.9% (36)
	River	70.0% (254)
	Ocean	20.1% (73)
Total elevation	Mean metres gained	54.5 (27.7)
Maximum gradient (%)		5.0 (3.2)
***parkrun* site-level participant charateristics**[2]		
Gender	Mean proportion women	53.4 (5.6)
Age	Mean in years	39.7 (2.3)
Running club membership	Mean proportion members	23.0 (9.5)
Age graded score	Mean score	46.3 (3.2)

Volunteer heterogeneity[3]	Mean ratio	0.88 (0.02)
***parkrun* site-level areal characteristics[4]:**		
Population density	Proportion >2,000/km^2	28.3 (26.2)
Physical activity	Proportion meeting guidelines	44.2 (8.7)
Greenspace accessibility[5]	Proportion <400m from greenspace	69.8 (18.7)
Socioeconomic Index[6]	IRSAD decile 1, 2, 3 (more disadvantage)	24.8% (90)
	IRSAD decile 4, 5, 6, 7	42.2% (153)
	IRSAD decile 8, 9, 10 (less disadvantage)	33.1% (10)
Remoteness	Major city areas	52.6% (191)
	Inner Regional areas	28.9% (105)
	Outer Regional and Remote areas	18.5% (67)

[1] Fixed characteristic of site

[2] Time-varying by week, based on average over the study period for each *parkrun*.

[3] Heterogeneity score closer to one denoting a higher diversity

[4] Time-varying by census/national health survey date, based on census/national health survey closest to first week of a *parkrun's* operation

[5] These data was only recorded during the 2014 National Health Survey

[6] Data based on year closest to first week of a *parkrun's* operation

Table 2: Associations with odds of membership of high growth in weekly walkers/runners trajectory (Class 2), compared to stable growth participation.

Characteristic (reference category)	**High growth weekly runners/walkers OR (95%cCI)[1]**
***parkrun* site-level course covariates**	
Route type: (Unidirectional loop)	
Loop(s) with Cross-Over	0.88 (0.43, 1.80)
Out and back	0.60 (0.31, 1.14)
Repeats ≥1km	**0.36 (0.22, 0.58)**
Terrain: Trail (none)	**0.56 (0.34, 0.91)**
Terrain: Grass (none)	0.71 (0.44, 1.15)
Terrain: Sand (none)	0.57 (0.20, 1.60)
Terrain: Concrete/bitumen (none)	**1.87 (1.06, 3.29)**
Blue space (Land)	
River	1.55 (0.74, 3.27)
Sea	2.05 (0.86, 4.90)
Total elevation (per 10 metre increment)	0.97 (0.86, 1.09)
Maximum gradient (per 1 degree increment)	1.02 (0.91, 1.13)
***parkrun* participant site-level covariates**	
% female (per 5% increment)	**1.13 (1.13, 1.14)**
Average age (per 1 year increment)	**0.86 (0.86, 0.87)**
Volunteer diversity (per 10% increment)	**1.33 (1.28, 1.38)**
% with club membership (per 10% increment)	**0.95 (0.94, 0.96)**
Average age-graded score (per 5 percentile rank increment)	**0.78 (0.77, 0.80)**

***parkrun* site-level areal covariates**	
Population density (per 10% increment)	0.99 (0.96, 1.02)
Proportion population meeting PA guidelines (per 10% increment)	**0.69 (0.66, 0.73)**
Local green space accessibility (per 10% increment)	1.06 (0.92, 1.22)
Socioeconomic status (IRSAD decile 1, 2, 3 - less advantaged)	
IRSAD decile 4, 5, 6, 7	**0.75 (0.66, 0.85)**
IRSAD decile 8, 9, 10 (more advantaged)	**0.65 (0.55, 0.77)**
Remoteness (Major city area)	
Inner Regional area	**0.21 (0.12, 0.37)**
Outer Regional and Remote area	**0.06 (0.04, 0.11)**

[1] Results bolded where statistically significant at $p<0.05$

Table 3: Associations with odds of membership of the slow decline trajectory class, compared to sharp decline for monthly registration.

Characteristic (reference category)	**Slow decline new registrations OR (95%cCI)[1]**
***parkrun* site-level course covariates**	
Route type: (Unidirectional loop)	
Loop(s) with Cross-Over	0.78 (0.46, 1.34)
Out and back	0.63 (0.39, 1.03)
Repeats ≥1km	**0.58 (0.40, 0.83)**
Terrain: Trail (none)	0.83 (0.57, 1.21)
Terrain: Grass (none)	0.77 (0.54, 1.10)
Terrain: Sand (none)	0.54 (0.24, 1.20)
Terrain: Concrete/bitumen (none)	**1.64 (1.06, 2.54)**
Blue space (Land)	
River	1.71 (0.96, 3.04)
Sea	**3.30 (1.68, 6.50)**
Total elevation (per 10 metre increment)	1.03 (0.94, 1.13)
Maximum gradient (per 1 degree increment)	0.97 (0.90, 1.05)
***parkrun* participant site-level covariates**	
% female (per 5% increment)	**1.20 (1.17, 1.23)**
Average age (per 1 year increment)	**0.83 (0.82, 0.84)**
Volunteer diversity (per 10% increment)	**1.27 (1.18, 1.36)**
% with club membership (per 10% increment)	**0.90 (0.87, 0.94)**
Average age-graded score (per 5 percentile rank increment)	**0.49 (0.47, 0.52)**

***parkrun* site-level areal covariates**	
Population density (per 10% increment)	**1.07 (1.01, 1.12)**
Proportion population meeting PA guidelines (per 10% increment)	**1.34 (1.24, 1.46)**
Local green space (per 10% increment)	1.00 (0.94, 1.05)
Socioeconomic status (IRSAD decile 1, 2, 3 - less advantaged)	
IRSAD decile 4, 5, 6, 7	0.93 (0.75, 1.15)
IRSAD decile 8, 9, 10 (more advantaged)	0.92 (0.69, 1.21)
Remoteness (Major city area)	
Inner Regional area	0.66 (0.43, 1.02)
Outer Regional and Remote area	**0.18 (0.11, 0.30)**

[1] Results bolded where statistically significant at $p<0.05$

<u>Figure 1:</u> Class specific mean trajectory for slow growth (class 1) and high growth (class 2) participation trajectory *parkruns*.

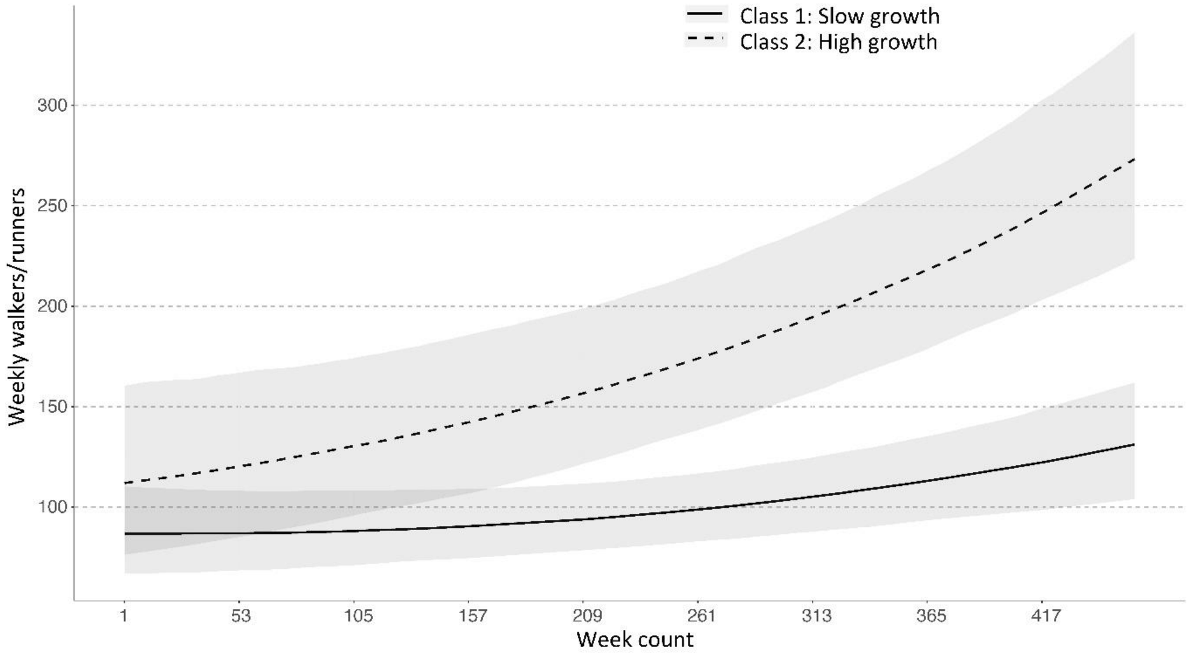

Figure 2: Class specific mean trajectory for steep declining (class 1) and steady decline (class 2) in new registrations trajectory *parkruns*.