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Green Exercise, Blue Spaces and Active Leisure Events: The Performance of New Participants is Associated With Their Response to Event Characteristics

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ABSTRACT

Active leisure events (ALEs) promoting activity among non-traditional sporting participants are an increasingly important part of health interventions and social prescribing. Identifying characteristics of ALEs that encourage engagement are key for enhancing their efficacy. Models revealed first-time participants returned to parkrun more quickly if they were male, older, performed poorly, attended a larger event with more new adult participants, a hard surface type and with woodland and freshwater on its route. Interaction terms between performance and event characteristics revealed poor performing new participants were particularly influenced by event size and less influenced by woodland and freshwater suggesting that they might find it easier to hide at large events and feel less out of place. This highlights the importance not just of identifying characteristics of ALEs that influence return rates but also identifying interaction terms with performance so the behavior of target demographics can be better understood. Organisers of ALEs might want to consider prioritizing the use of routes that maximize exposure to woodland and freshwater and consider introducing additional strategies designed to make less fit participants feel that they belong.

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1. Introduction

The socio-ecological model of physical activity posits that activity levels are determined by both the individual characteristics and the societal, physical and political characteristics of the environments within which individuals exist (Lee & Park, 2021; McLeroy et al., 1988). Despite the recent surge in interest in green exercise surprisingly little is known about what physical environmental characteristics encourage running (Deelen et al., 2019). Existing studies have typically used simple measures

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of the greenness of an environment such as the Normalized Difference Vegetation Index or the Green View Index to positively relate frequency of running to the amount of green space (Huang et al., 2023; Liu et al., 2023). Proximity to blue spaces has also been found to be associated with improved mental health (McDougall et al., 2021) suggesting that blue spaces could act in a similar way to green spaces in encouraging physical activity. Classification of land-cover types would provide a more detailed assessment of specific characteristics of environments that runners find attractive and allow the separation of effects from green and blue spaces. It would also allow for testing whether all green types of space are equally valuable, for example do grassland and forest provide equivalent stimuli as green environments. A parallel question can be applied to blue space, for example are saltwater and freshwater equally attractive to those running adjacent to them. Developing a more detailed understanding of green exercise and the specific aspects of natural environments that promote exercise and mental wellbeing and how these interact with characteristics of individuals would be invaluable to development of spaces that maximize engagement with physical activity.

2. Active Leisure Events

Mass participation sporting events designed to promote levels of physical activity among non-traditional sporting participants have recently been framed under the banner of active leisure events (Hillman et al., 2021). The largest organizer of such events are parkrun who have a mission to create a healthier and happier planet through encouraging outdoor exercise (Reece et al., 2019). Understanding the factors influencing engagement with active leisure events (ALEs) such as parkrun are crucial for the development of management strategies that enhance the efficacy of such events .Many studies have focused on the behavior of participants in ALEs, particularly in terms of their continued engagement in physical activity post-event (McVinnie et al., 2023), however key knowledge gaps remain. In particular, how the environmental characteristics of an event influence engagement and how these interact with participant characteristics to shape behavior is largely unexplored. Key knowledge gaps surrounding ALEs include how event setting and physical environment and the social structure within an event shape participant behavior and also what characteristics of events acts as constraints to participation and how participants respond to these constraints (Hillman et al., 2021). Filling these knowledge gaps could have profound impacts upon the long-term success of ALEs as health interventions. Furthermore, very few studies have investigated how to encourage non-traditional sporting participants to engage with physical activity on a large scale (Reis et al., 2016),

3. Parkrun as a Model System

One source of potentially important information to help fill these knowledge gaps is parkrun (Hindley, 2022). Unlike other ALEs which typically occur annually, parkrun occurs weekly. This means there are much greater opportunities to return

(McVinnie et al., 2023) and consequently, develop social connections that enhance engagement further (Hindley, 2022). The weekly nature of parkrun provides a unique opportunity to studies factors associated with continued engagement due to the volume of data generated (Gilburn, 2023b). Parkrun was originally established in 2004 and in its early years was a series of weekly time trial events for traditional runners. In 2008 the name was changed from time trial to parkrun to encourage more attendance from the non-traditional running community. Encouraging previous non-runners to take up and then continue to participate in parkrun has become the key focus of their activity. It now provides free weekly community 5 km events at nearly 2000 worldwide locations across 22 countries.

The results of parkrun events are published online resulting in a huge database containing information on participation levels of more than 5 million parkrun participants across the globe. Although parkrun events are timed, there is no time limit and people are actively encouraged to participate at walking pace if they wish to do so ((Hindley, 2022; Reece et al., 2022). Their free nature and lack of pressure to run makes parkrun more inclusive to many who are excluded from taking part in other mass participants sporting events (Cleland et al., 2019; Gilburn, 2023a; Hindley, 2022). Furthermore, participants are allowed to use wheelchairs, walking frames and run with dogs increasing their inclusivity further (Hindley, 2022). The age limit for registering is just four and those with younger children can push them in a buggy meaning that parkrun is much more inclusive for those with childcare responsibilities than more traditional running events (Grunseit et al., 2020; Hindley, 2022). As part of achieving their aim of a making the planet healthier and happier, parkrun has been actively involved in social prescribing by creating partnerships between medical practitioners and individual parkrun events (Fleming et al., 2020, 2022; Wiltshire et al., 2017). As a consequence, parkrun has been described as a social intervention masquerading as a running event (Hindley, 2022)

The scale of parkrun provides a unique opportunity to investigate factors affecting patterns of engagement with a sporting event primarily focused on increasing levels of physical activity in the community. It involves large numbers of participants from many different socio-economic backgrounds and across different environments and geographical locations (Gilburn, 2023a, 2023b; Reece et al., 2022). Approximately one third of new participants to parkrun never return (Gilburn, 2023b; Reece et al., 2022). Identifying predictors associated with the likelihood and time to return could help us identify and remove barriers to participation and identify and enhance factors that promote participation (Fullagar et al., 2020; Gilburn, 2023b; Peterson et al., 2022; Reece et al., 2022). Previous studies have identified a range of factors associated with participation at parkrun (Cleland et al., 2019; Gilburn, 2023a, 2023b; Peterson et al., 2022; Reece et al., 2022; Stevinson et al., 2015; Stevinson & Hickson, 2014). These studies have focused primarily on the characteristics of participants and these have shown that there is some significant engagement with parkrun among key target demographics such as women, older adults, the relatively unfit and those from more deprived backgrounds. However, they have also found barriers to participation are often greater within these groups.

As well as characteristics of participants, the characteristics of the events they attend could also influence the experience and their likelihood of engaging with

parkrun in the future, yet few studies have investigated the event characteristics even though these are the factors where management strategies have the greatest potential to have impact (Gilburn, 2023a, 2023b). Another largely ignored factor is the environmental characteristics of the areas that parkrun routes travel through (Gilburn, 2023b). Furthermore, interactions between the demographics of participants and the characteristics of events and routes could also be important. Identifying event and environmental characteristics favored by key target demographics would be particularly valuable for achieving parkrun's mission. Furthermore, such studies would likely be applicable to other ALEs with a similar target demographic.

The parkrun database provides a number of mechanisms of testing hypotheses related to participation level. A recent study in Scotland investigated predictors of whether or not new parkrunners returned to parkrun (Gilburn, 2023b). This revealed higher return rates for new participants that were older, male and those with a faster finishing time. Various characteristics of the event they attended were also found to be associated with return rates. Higher return rates were found at events with a higher proportion of other new participants, smaller attendances; those closer to other events; and those with a higher proportion of woodland and freshwater along their routes.

Using parkrun as a model, where large numbers of people utilize the same routes on a weekly basis, also provides a unique opportunity to explore the specific characteristics of green and blue environments that runners find attractive through detailed assessments of the land-cover types surrounding the routes. To date only two studies have investigated the impact of the environment on the outcomes of participation at parkrun and one of those only looked at four events and failed to find a significant impact (Rogerson et al., 2016). The other looked at all events across Scotland and identified apparent green and blue space benefits to attending events with a higher proportion of woodland and freshwater as evidenced by a higher return rate of new participants after attending such events (Gilburn, 2023b). The parkrun database has the potential to provide huge amounts of information on green exercise, particularly in terms of identifying features of routes that provide the greatest benefit to participants. If green exercise does encourage continued engagement with physical activity then it is predicted that new participants attending parkrun events with the most natural environments would not only be more likely to return but be likely to return more quickly and return to the same event, as levels of satisfaction with mass participation events have been found to be positively correlated with future participation at future iterations of the same event (Funk et al., 2011).

One proposed solution is to develop a systems approach to, not only identify the factors impacting the effectiveness of interventions such as ALEs but also, understand how these factors interact and change over time (Rutter et al., 2019). This requires studies to identify interactions between event and participant characteristics and determine how these shape engagement with ALEs. It is of particular importance with this approach to use suitably large datasets to have the statistical power to detect and quantify interaction terms and also allow the consideration of the impacts of environmental and geographical factors (Aaltonen et al., 2020). This is particularly important as the environment within which someone exercises can substantially

affect their mental health as well as their physical health (Fraser et al., 2019) and influence their level and pattern of engagement with physical activity (Flowers et al., 2018; Fraser et al., 2019; Li et al., 2022). Consequently, understanding how green exercise influences engagement with ALEs is likely to be key for the development of events which encourage participation to return.

The aim of the current study is to generate the first model to identify predictors of the time take to return and location of return of first-time parkrun participants. This provides a test of the socio-ecological model of physical activity as it includes characteristics of individuals, a societal component of the environment in terms of numbers of runners and proportion of new participants as well as physical environmental characteristics of events based upon land cover data. The socio-ecological model also posits that synergies occur between the individual and societal factors determining physical activity (Lee & Park, 2021), so the model developed will also include interaction terms between these characteristics. The study is on a large-scale and uses generalized linear mixed models (GLMM) to test for interactions between performance and event characteristics. The model is only the second to include most of the key types of predictors likely to be operating within the parkrun system, namely characteristics of individual participants, characteristics of the event such as field size and proportion of new participants and the environmental characteristics of routes. Identifying the characteristics of parkrun routes that encourage faster return rates and return visits to the same location will fill knowledge gaps that could be invaluable for those designing ALEs aimed at increasing inclusivity and those designing and managing the public spaces that ALEs, causal runners and walkers alike utilize.

3. Methods

3.1. Data Sources

This was an analytical study using aggregated secondary data, no new data were collected and there were no active participants. The primary data sources were the publicly available parkrun event results pages at parkrun.org.uk. The results for all parkrun events that took place in Scotland between January 2019 and January 2020 were harvested using an Excel macro (Hoffman, 2021). This was used to extract the following information about each participant: age category, gender, parkrun ID number and their age graded performance score (AGPS). AGPS is calculated as a percentage of the expected world record performance for someone of that age and gender (Gilburn, 2023a). The number of participants, date of the event and the event venue were then added to the participant information. Gender is parkrun's definition of gender which is selected by participants rather than based upon genetically assigned sex. Individuals who selected "preferred not to say" or "another gender identity" were excluded from the study as they are not assigned an age graded performance score by parkrun.

Any adult participants taking part in their first parkrun were identified. For these participants their age group was converted into a number corresponding to the midpoint of the age range they were assigned. Parkrun uses 5-year age groups apart

from for adult teenagers where a 2-year range is used. The parkrun history of all first-time participants was accessed between November 2022 and January 2023 to identify those that returned. Consequently, all participants had a period of at least 33 months in which to return to parkrun. However, it should be noted that as all Scottish parkrun events were suspended between March 2020 and July 2021, because of the COVID-19 pandemic, as a result the possible return time was around 17 months shorter that the date gap for any participants that returned after the suspension. The return time was adjusted for all participants who returned after the restart by disregarding the period where parkrun was suspended due to the pandemic. This adjustment also took into account the fact that two parkruns in Scotland, Bressay and Kirkwall, returned slightly earlier. Any participants that did not return in the study period were disregarded. Return time was measured in weeks as parkrun usually only occurs on a Saturday, however two additional days also held parkruns at some event locations so a small proportion of time to return in week scores were not integers so these were rounded to the neatest integer to allow count data models to be used in the analysis. Additional characteristics were collected for the event each of the participants that returned first attended. These were the number of new adult participants, the elevation gained on the route, the type of surface and the travelling time in minutes to the next nearest parkrun (Gilburn, 2023a). The study also included measures of the surrounding habitat types along routes (Gilburn, 2023b). The land-cover type was characterized for 30 m surrounding each parkrun route included in the study. Land cover was separated into proportions of woodland, grassland, freshwater, shoreline, saltwater and urban space with full details given in Gilburn, (2023b). Finally, the Scottish Index of Multiple Deprivation (SIMD) was used to assess the level of deprivation in the area that each parkrun was located (*SIMD*, n.d.). This separates Scotland into nearly 7000 areas each of which are ranked on a range of indicators of deprivation level. It should be noted that not all variables were included for testing specific hypotheses, registration number and date were not included as they would both inevitably be associated with return time. The study was approved by the Ethics Committee of The University of Stirling (EC 2021 0524 1382, 4/2/21).

3.2. Data Analysis

The data were analyzed using R x64 4.1.1 (R Core Team, 2022). Time to return displayed a distribution typical for positively skewed count data. With very few zeros in the dataset (as these could only occur on a single day when it was possible to complete two parkruns) the two most appropriate errors distributions would be a Poisson model or a negative binomial model (Green, 2021). The lme4 function was used to generate generalized linear mixed modes (GLMM) with both a negative binomial and a Poisson error distribution of time taken to return to parkrun (Bates et al., 2015). The r squared GLMM function in the MuMIn package was used to assess the pseudo-R-squared value for both types of models and identified that using a Poisson error distribution produced a better fit. It should also be noted that the data were not overdispersed which would favor the use of a negative binomial error

distribution (Green, 2021). A GLMM with a binomial error distribution was used to model whether or not first-time participants returned to the same event venue on their second visit to parkrun. GLMMs were used because there could be non-independence in the behavior of individuals at the same event, so event was included as a random effect to account for this. All continuous explanatory variables were scaled to have a mean of 0 and a standard deviation of 1. The list of explanatory variables in both models is provided in Table 1. Minimum Akaike Information Criterion (AIC) was used to select the final model (Bates et al., 2015). Variation

Table 1. The random and fixed effects used in the GLMMs and where appropriate their mean and standard deviation.

Predictor	Type	Effect	Description	Mean (s.d.)
Event	Factor	Random	Name of the event	–
Participant Ccharacteristics				
AGPS	Numeric	Fixed	Age graded performance score (%)	0.48 (0.09)
Age	Numeric	Fixed	Mid-point of age category range	39.92 (12.06)
Registration No.	Numeric	Fixed	Numbers are allocated in chronological order or registration so higher numbers are more recent	5536353 (1156128)
Gender	Factor	Fixed	Gender as selected by participant at registration	–
Event characteristics				
Date	Numeric	Fixed	Days from start date of study	–
Proportion of new adult participants	Numeric	Fixed	Proportion of field made up of new adult first time participants (%)	0.07 (0.06)
Travelling time to next nearest parkrun	Numeric	Fixed	In minutes calculated using Google maps on a Saturday morning	28.79 (54.98)
Number of participants	Numeric	Fixed	Size of the field	260.96 (165.2)
Elevation gain	Numeric	Fixed	Metres of elevation gained on route as determined using the Strava routes mapping function	35.71 (32.27)
Surface type	Factor	Fixed	Hard, mixed or soft	–
SIMD	Numeric	Fixed	Scottish Indicator of Multiple Deprivation Index of area in which parkrun is located	3877.69 (1973.51)
Woodland	Numeric	Fixed	% of route surrounded by woodland	40.05 (28.72)
Grassland	Numeric	Fixed	% of route surrounded by grassland	36.36 (22.68)
Freshwater	Numeric	Fixed	% of route surrounded by freshwater	4.65 (7.28)
Saltwater	Numeric	Fixed	% of route surrounded by saltwater	1.01 (5.03)
Shoreline	Numeric	Fixed	% of route surrounded by shoreline	4.12 (9.61)
Urban	Numeric	Fixed	% of route surrounded by urban features	11.37 (11.26)

inflation factors were assessed using the vif function in the car package with no variable combinations included that created a vif score for any independent variable of >3. Interaction terms were also included in the model between AGPS and each of the significant event characteristics. These were included as they provide the most relevant information for testing whether specific event characteristics are particularly associated with the return rates of those with the lower performance scores as these are the primary target audience for ALEs.

4. Results

The dataset consisted of 14,453 adult parkrun participants made up of 8219 females and 6634 males across 56 different event venues. The mean age of females (39.5, SD = 11.9) was a year lower than the mean age of males (40.5, SD = 12.2). Descriptive statistics for all predictor variables are provided in Table 1.

4.1. Factors Associated with Return Time to Parkrun for First-Time Participants

A generalized linear mixed model of return time for first-time participants revealed that individuals who achieved a lower age graded performance score returned much more quickly (Table 2). Older participants returned to complete their second parkrun more quickly (Figure 1). Date was inevitably associated with return time as those with a longer time within which to return would be expected to have a longer mean duration. Male participants (61.9 days, s.e. = 1.50) returned more quickly than female participants (63.2 days, s.e. = 1.36). First-time participants who attended an event with a higher proportion of other first-time participants returned more quickly. New participants returned more quickly after attending a larger event.

Table 2. A Poisson generalized linear mixed model of time in weeks to return to parkrun. Event venue was included as a random effect. Model specification: Maximum Likelihood Laplace Approximation Poisson GLMM using glmer function in lme4 package.

Parameter	Estimate	SE	*Z*	*P*
Intercept	2.180	0.026	83.70	<.001
Age graded performance score	0.218	0.003	76.39	<.001
Age	−0.159	0.003	55.54	<.001
Date	−0.115	0.003	35.06	<.001
Registration No.	−0.071	0.003	27.09	<.001
Gender(Male)	−0.946	0.006	16.65	<.001
Proportion of new participants	−0.066	0.005	12.81	<.001
Number of participants	−0.018	0.007	2.49	.013
Freshwater	−0.037	0.030	1.26	.206
Woodland	−0.018	0.026	0.69	.491
Performance * Number of participants	−0.021	0.003	7.88	<.001
Performance * Woodland	−0.020	0.003	6.92	<.001
Performance * Freshwater	−0.014	0.003	5.16	<.001

Model formula: glmer (Weeks to return ~ Performance + Age + Date + Registration No + Gender + Prop New Participants + No of participants + Prop freshwater + Woodland + Performance * No of participants + Performance * Woodland + Performance * Freshwater + Intercept + (1 | Event Name), family = poisson). A negative estimate shows that as a predictor increases so the time to return to parkrun reduces so a predictor is having a positive impact on return times. Interaction terms measure a greater than additive combined effect of two predictors again with a negative estimate showing a positive effect of the predictors in combination.

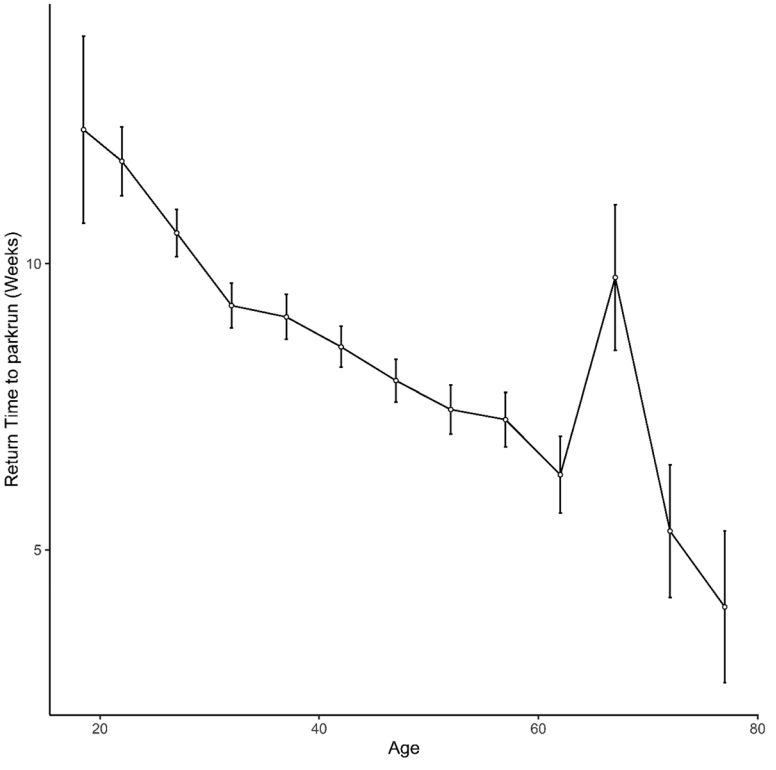

Figure 1. The mean time to return to parkrun in weeks for new participants of different ages. The error bars display standard errors.

A significant interaction term was maintained in the model between AGPS and the number of participants with low performing new participants particularly more likely to return when attending a larger event (Figure 2).

There was an interaction term between AGPS and both the proportion of woodland and the proportion of freshwater along the route with higher performing new participants disproportionately returning quicker on more wooded routes (Figure 3) and routes with more freshwater (Figure 4).

4.2. Factors Associated With Whether First-Time Participants Return to the Same Event When Participating in Their Second Parkrun

A generalized linear mixed model of return rate to the same parkrun for first-time participants (Table 3) revealed individuals that achieved a lower age graded performance score were more likely to return to the same parkrun. Older participants were also more likely to return to the same parkrun.

New participants who attended an event with a higher proportion of other new participants were more likely to return to the same event. First-time participants were more likely to return to the same event if it had a smaller field size. Return rates to the same parkrun were higher for event venues with lower elevation gains. First-time participants who registered with parkrun more recently were also more

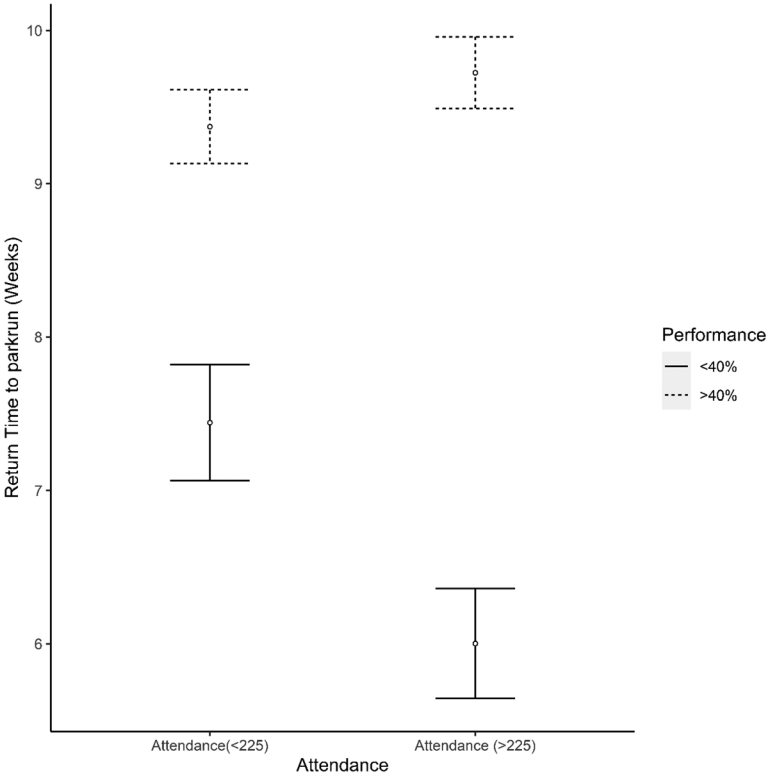

Figure 2. The mean time to return to parkrun in weeks from large (>225 attendees) and small events (<225 attendees) for very low performance (AGPS < 40%) and higher performance (AGPS > 40%) new participants. The error bars display standard errors.

likely to return to the same event. Male participants were more likely to return to the same parkrun than females. Return rates to the same event were also higher for events on tarmac compared to trail. Return rates were higher to events with a higher proportion of woodland on the route. There were no significant interaction terms maintained in the model. The one non-significant interaction term maintained in the model hinted that lower performing new participants might be the most deterred by higher elevation gain routes.

5. Discussion

5.1. Predictors of Time to Return of New Parkrun Participants

This study was the first to identify predictors of the time to return to parkrun for new participants to parkrun. It identified a range of characteristics of both the participant and the event are associated with return time and that interactions between these characteristics can be particularly important for informing those designing ALEs by identifying how the target demographic of ALEs responds to characteristics of events.

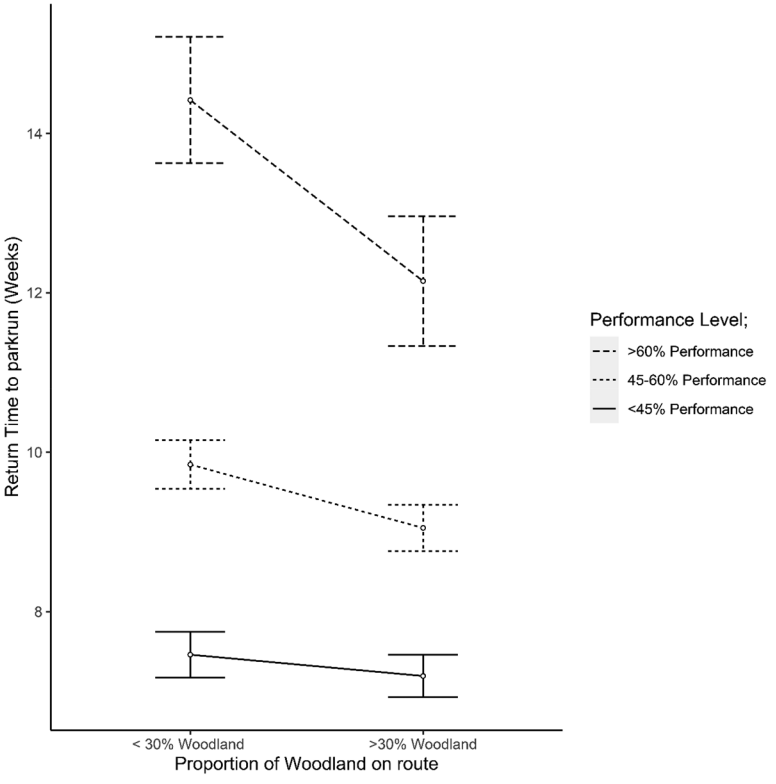

Figure 3. The mean time to return to parkrun in weeks from highly wooded (>30% woodland) and less wooded (<30 woodland) events for low performance (AGPS < 45%), mid (AGPS 45-60%) and high performance (AGPS > 60%) new participants. The error bars display standard errors.

A number of characteristics of new participants were found to be associated with returning to parkrun more quickly including age and gender with older participants and males returning more quickly. Male and older new participants have been previously been found to be more likely to return to parkrun (Gilburn, 2023b; Reece et al., 2022). This shows that associations with this new measure of engagement with parkrun are consistent with previously used measures. The consistent finding of better future engagement of older new participants supports the findings of smaller scale studies that have suggested that older adults might be more likely to engage in physical activity because of higher levels of motivation to improve their health and fitness (Cannella et al., 2023; de Maio Nascimento et al., 2023). Many studies have identified an issue with lower engagement with sporting events among females. Although new female participants are less likely to return (Gilburn, 2023b; Reece et al., 2022), there are more new female participants to begin with which helps to compensate for the lower return rates (Gilburn, 2023b). Interestingly, AGPS, was actually found to have the opposite relationship with return time compared to the likelihood of returning. A previous study found that new participants with lower a AGPS were less likely to return (Gilburn, 2023b). The current study found that new participants with lower a AGPS returned more quickly if they did return which is a much more encouraging finding. This suggests that return time to parkrun is a

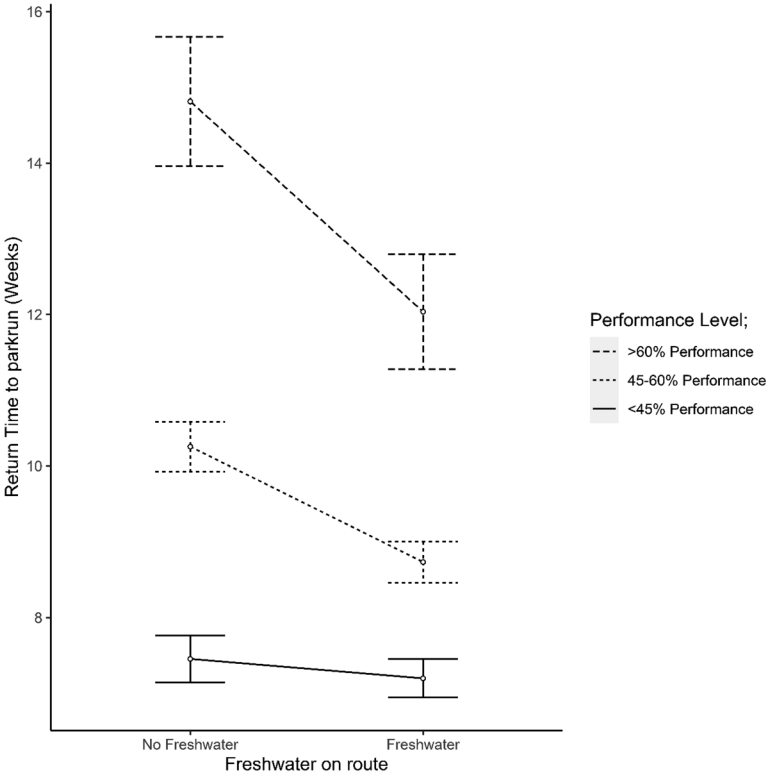

Figure 4. The mean time to return to parkrun in weeks from events with and without freshwater on the route for low performance (AGPS < 45%), mid (AGPS 45% - 60%) and high performance (AGPS > 60%) new participants. The error bars display standard errors.

valuable new measure of future engagement with parkrun and that returning alone does not provide a complete picture of engagement. This also suggests that previous concerns about low performing new participants being less likely to return are at least partly compensated by the fact that if they do return, they do so more quickly. The other characteristic of the participant that was found to be associated with a fast return time was their registration number revealing that more recent registrants returned more quickly. This is consistent with a previous study that found that more recent registrants were more likely to return (Gilburn, 2023b). More recent registrants are known to more likely be non-traditional sporting participants as the AGPS of new registrants to parkrun in Scotland is declining as parkrun becomes increasingly inclusive (Gilburn, 2023a).

Several characteristics of events were also found to be associated with time to return. This is only the second study to look at the impacts of event characteristics on the returning behavior of new parkrun participants. The first two predictors of time to return were related to number of attendees with both total size of the field and the proportion of the field that were new adult participants being associated with faster return times. Faster return times for fields with a higher proportion of new adult participants is consistent with the finding that return rates were also higher from events with a higher proportion of new adult participants (Gilburn, 2023b). By

Table 3. A generalized linear mixed model of whether a first-time participant returned to the same event on their second trip to parkrun. A binomial error distribution was used. Event venue was included as a random effect.

Parameter	Estimate	SE	*Z*	*P*
Intercept	1.254	0.139	9.05	<.001
Age graded performance score	−0.272	0.023	11.89	<.001
Age	0.206	0.023	9.17	<.001
Proportion of new participants	0.326	0.040	8.19	<.001
Date	−0.110	0.025	4.45	<.001
Number of participants	−0.193	0.049	3.98	<.001
Elevation gain	−0.221	0.066	3.34	<.001
Registration No.	0.051	0.022	2.36	.018
Gender (Male)	0.097	0.045	2.17	.030
Surface (Tarmac)	0.426	0.172	2.48	.013
Surface (Mixed)	0.194	0.168	1.16	.247
Woodland	0.158	0.073	2.15	.032
Age graded performance score * Elevation gain	0.039	0.022	1.78	.075

Model specification: Maximum Likelihood Laplace Approximation Binomial GLMM using glmer function in lme4 package. Model formula: glmer (Returned to same event ~ Performance + Age + Date + No of participants + Elevation gain + Registration No + Gender + Surface + Woodland + Performance * Elevation gain + Intercept + (1 | Event Name), family = binomial). A positive estimate shows that as a predictor increases so the likelihood of a new participant returning to the same parkrun increases to parkrun suggesting it is having a positive impact on return times. Interaction terms measure a greater than additive combined effect of two predictors again with a positive estimate showing a positive effect of the predictors in combination.

contrast, field size is generating the opposite effect to that seen in a previous study where return rates from events with smaller field were higher (Gilburn, 2023b).

The other two characteristics of events that predicted time to return were the proportion of woodland and freshwater along the route. A previous study found higher return rates from events with a higher proportion of woodland and freshwater (Gilburn, 2023b). The current study shows that not only are the return rates higher they are also faster. It does appear that green exercise is better promoted by woodland but not grassland and that there is a blue space component that only relates to freshwater and not saltwater.

Significant interaction terms were maintained in the model between AGPS and three event characteristics. One revealed that slower new participants were more likely to return quickly after visiting a larger event. The other two showed that slower new participants were less influenced by the land cover surrounding an event route. In combination, these findings suggest that slower participants are less concerned with the green and blue characteristics of an event's route and more concerned about its size. A previous study found that the psychological impact of feeling too unfit to participate was a key barrier to participation in parkrun, particularly for women (Reece et al., 2022). Larger events might allow slower new participants to feel less self-conscious about their lack of fitness by being able to hide amongst a larger field. Furthermore, the larger a field the greater the chance of there being other slower participants and walkers. The model has not only identified a new and potentially key finding but shows the importance of including interaction terms with performance as slower new participants, who are the key target demographic of parkrun, might behave differently to other participants, therefore models lacking interaction terms could lead to misleading recommendations based upon parkrun

participants in general rather than the key target demographic of non-traditional runners.

The study findings support the socioecological model of physical activity revealing that individual, societal and physical environment components combined to determine how quickly a new parkrun participant returned to parkrun. Individual characteristics such as performance and age were the most important determinants but societal factors such as the number of participants and proportion of new participants also had significant impacts. The physical environmental impacts were mainly seen in terms of how they interacted with an individual characteristic, performance level.

5.2. Predictors of Location to Return of New Parkrun Participants

Individuals with low performance scores were more likely to return to the same event. This could be related to them feeling more comfortable at that event, having completed it previously. By contrast, traditional runners completing their second parkrun are likely to be more used to running at different event locations. First-time participants who attended an event with more other first-time participants were more likely to return to parkrun more quickly and were also more likely to return to the same event. Therefore, it seems that attending an event with a higher proportion of other first-time participants could make first-time participants feel like part of the parkrun community through a shared sense of camaraderie which has been found to increase engagement with physical activity (Walsh et al., 2022). Several studies have reported how important the social benefits of parkrun and other ALEs are to continued engagement and well-being (Ashdown-Franks et al., 2023; Grunseit et al., 2017; Hindley, 2020, 2022; McVinnie et al., 2023; Piper et al., 2022; Stevens et al., 2018; Wiltshire & Stevinson, 2018).

Older participants were more likely to return to the same parkrun. They were also found to be more likely to return to parkrun generally and to return more quickly, so there is a consistent finding that older new participants have better future engagement after their first participation. This is consistent with other studies that have found older individuals have higher motivation levels to improve their health and wellbeing (Aaltonen et al., 2020; Cannella et al., 2023; de Maio Nascimento et al., 2023).

New participants were more likely to return to the same event if it had a smaller field size. A previous study also found that new participants were more likely to return to parkrun if they attended a smaller event (Gilburn, 2023b). This could suggest that it is easier for new participants to start to form social bonds with other participants and volunteers at smaller events. There was no interaction term between AGPS and event size suggesting that there might be conflicting factors related to event size that affect return behavior with large events enabling those more self-conscious about their fitness to feel more comfortable while smaller events might have other benefits such as making it easier to start to establish new social bonds. My personal experience of having participated at events at 78 different parkrun locations, including all the events included in this study, is that volunteers find it easier to spot and engage in conversation with visitors at smaller events. If they

can spot visitors then the same is likely to apply to new participants, who they will also not recognize as a regular participant at that specific parkrun event.

Return rates to the same parkrun were higher for event venues with lower elevation gains and faster surfaces suggesting that flatter, faster parkrun events are preferred by new participants. There were no significant interaction terms with AGPS so this seems to be the case for both non-traditional and traditional runners. Return rates were higher to events with a higher proportion of woodland on the route adding to the growing body of evidence being accumulated that suggests that trees play a key role in the positive response to green exercise by parkrun participants (Gilburn, 2023b).

5.3. Limitations of the Study

The study was restricted to Scotland and the results might not translate to other areas where parkruns are located. The patterns of participants returning to parkrun could also have been impacted by the COVID-19 pandemic with the effects of field size on return rates possibly increasing if participants felt more at risk of contracting COVID-19 at more crowded events. Consequently, it would be useful for future studies to look at the behavior of returning parkrun participants in other geographical locations and also after parkrun returned from suspension during lockdowns.

The demographics of participants and their response to characteristics of events could vary with running distance so the findings might be less applicable to some other ALEs that use different running or walking distances or different sports. Nevertheless, a high volume 5 km event is probably the most useful current model system for studying non-traditional participants due to it being relatively short and the target distance of the increasing number of couch to 5k program designed to get non-runners running (Johnson et al., 2022).

A limitation of the data science methodology adopted in the study is that all associations identified are correlational and derived from a noisy dataset rather than a controlled experimental study. This means caution should be applied with respect to drawing conclusions related to cause and effect. Although the data science approach involved the inclusion of large numbers of variables, many more than adopted in most studies, the secondary nature of the dataset meant that there were no actual participants in the study and therefore no qualitative assessments could be made of the individual motivations for participating in parkrun. Some qualitative assessments of motivations have found them to be associated with some of the participant characteristics used in this study, particularly age and gender. For example, women are more self-conscious about being unfit (Reece et al., 2022) and older individuals have higher motivations to engage with ALEs due to increased concerns about needing to improvement their health and fitness (Aaltonen et al., 2020; Cannella et al., 2023). Consequently, known associations have been discussed where appropriate and caution has been used in interpreting correlation associations. Studies combining a data science and a qualitative approach might be particularly valuable in the future with only two such studies conducted in relation to parkrun (Reece et al., 2022; Stevinson & Hickson, 2014).

5.4. Management Implications

The benefits gained from attending an event with a higher proportion of other first-time participants suggests that parkrun could facilitate this by marketing specific events as new participant events. This would also allow event directors to potentially include additional measures to make first-time participants feel more welcome, for example, by having a first-timer ambassador. This could be supported by educational materials such as a poster that highlights the key benefits of parkrun that is manned by a first-timer ambassador.

The discovery that slower first-time participants prefer larger events could be a sign that they are self-conscious about their low level of fitness and find it easier to hide at larger events. This study was conducted prior to parkrun introducing the parkwalk initiative ("Parkwalker Role Explained," 2022). This involves having volunteers who walk the route in the hope of encouraging others to do the same. This could have two substantial benefits by encouraging new participants to walk without being self-conscious whilst at the same time enabling an opportunity for social bonds to start to form between new participants that walk and the parkwalk volunteers. Consequently, it appears that parkrun have already introduced an appropriate management strategy for dealing with this specific barrier to returning to parkrun identified in this study.

General practitioners who prescribe parkrun might want to review the event and route characteristics of their nearby parkruns and consider these in relation to specific patients before prescribing attendance at a specific event. Patients could also be encouraged to attend a parkrun for the first time together in a group, potentially combining patients from multiple practices.

The faster return times after attending parkruns with routes with more woodland and freshwater shows that the engagement level of new participants could be managed. A previous study found that both woodland and freshwater were associated with higher return rates (Gilburn, 2023b). One key implication of the findings of these two studies is that more new participants return and also return quicker when attending a parkrun with woodland and freshwater along the route. This suggests that parkrun and other ALEs should ideally include both these land cover types when designing routes. This finding also raises the question about the value of parkrun events with routes that are relatively poor at encouraging new participants to return. Their value will to some extent depend upon their proximity to other parkrun events and the nature of those events. An isolated parkrun event on a relatively unenticing route is still likely to be result in more parkrun participants in that local area than not having an event. By contrast, a poor event with a much more attractive neighboring event could have an overall negative impact on the number of parkrun attendees in an area. Studies have shown that around a third of all new participants to parkrun never return (Gilburn, 2023b; Reece et al., 2022). As all parkrun events are not equal in their ability to motivate new participants to return a single attractive event could potentially create more regularly new participants than two events where one is relatively poor at converting new participants to parkrunners. Future studies modelling the impact of variation in the ability of different events to convert new participants with respect to their location relative to other parkrun events could be really valuable.

6. Conclusions

This study set out to fill some key knowledge gaps surrounding ALEs including how the event setting shapes participant behavior, what characteristics of events can act as constraints to participation and how participants with different performance levels respond to event characteristics (Hillman et al., 2021). Flat, fast, events with a high proportion of other new participants, with woodland and freshwater along their route seem to be the ideal for encouraging new participants to return. This means that events lacking in woodland and freshwater are likely to fair less well in converting new participants into part of the parkrun community. Return times from smaller events were longer which suggest that small events could act as a barrier to conversion of a new participant into a parkrunner by making them feel more self-conscious about being relatively unfit. Furthermore, this was particularly the case for slower participants suggesting that small events could be constraining conversion rates of the ley target demographic. The study was conducted prior to the parkwalk initiative. This could have potentially resolved the issue of constraints related to event and increased the positive impacts of woodland and freshwater on the key target demographic. Future studies investigating the impact of parkwalk on conversion rates and timing could be particularly useful.

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Data Availability Statement

This study was an analysis of aggregated secondary datasets and as such no new data were generated. The parkrun results data belong to parkrun Global and were accessed as a permitted act for independent non-commercial research purposes through fair dealing legislation, allowing access to publicly available databases. Only a small proportion of the parkrun results database was accessed (data from just 56 of more than 2000 event venues). The complete dataset are available from the Stirling DataSTORRE.

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