Social Reward and Support Effects on Exercise Experiences and Performance: Evidence from Parkrun

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Research article

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Abstract

Background: There is growing academic, civic and policy interest in the public health benefits of community-based exercise events. Shifting the emphasis from competitive sport to communal activity, these events have wide appeal, including among those new to sport or exercise. In addition to health benefits of physical activity, regular participation can reduce social isolation and loneliness through opportunities for social connection. Taking a broad evolutionary and social psychological perspective, we suggest that social factors warrant more attention in current approaches to physical (in)activity and exercise behaviour. We develop and test the hypothesis that social reward and support in exercise are associated with positive exercise experiences and greater performance outputs.

Methods: Using a repeated-measures survey design, we examine the influence of social behaviour (e.g., attending with others, pre-event socialising) and perceptions of social support and belonging on subjective enjoyment, energy, fatigue, effort, and objective performance (run times) among a UK sample of parkrun participants.

Results: Social factors were associated with greater subjective enjoyment and energy. Higher subjective energy, in turn, was associated with faster run times, without any corresponding increase in perceived effort. No significant main effects of social factors on fatigue, performance or effort were detected.

Conclusions: The role of social structural factors has long been recognised in public health approaches to physical activity. Our results motivate greater research attention on how positive and rewarding social behaviours and experiences – particularly subjective enjoyment and energy, and perceptions of community social support and belonging - influence exercise-related behaviour, psychology and physiology, and promote health through collective physical activity. Approaching community exercise as a powerful context for social collaboration, reward and belonging also supplements the traditional focus on social facilitation and team sport that has dominated social psychological approaches within the sport and exercise sciences, and offers new avenues for understanding the deep connections among psychological, social and physical function in everyday health.

1. Background

Physical activity and social relationships are critical “flashpoints” for health policy [1, 2]. Low levels of physical activity and high levels of loneliness have been independently associated with poorer mental and physical health outcomes and mortality [3]. Despite the established benefits of sufficient physical activity and secure social ties for mental and physical health, levels of physical inactivity are extremely high globally [e.g., 4, 5]. Although evidence on the prevalence of loneliness is less well established, loneliness as the perception of social isolation (even when among other people), is also widely recognized as a “real mental health challenge for the nations” [6] and a growing problem worldwide [7, 8]. In the world’s first government loneliness strategy [9] and in its first Loneliness Annual Report [10], the UK
government committed to improving the evidence base on loneliness through the use of standard measures [7, 8].

Medicalist perspectives predominate in assessments of the negative effects of physical inactivity and loneliness (e.g., morbidity-mortality risks, “pandemic” terminology). Nevertheless, these are widely considered to be complex social issues that require collaborative, integrated and holistic public health approaches [11]. Indeed, evidence suggests that one problem compounds the other, with loneliness having been identified as a risk factor for physical inactivity [12, 13] and physical inactivity as a risk factor for psychiatric and psychosocial health problems that are directly or indirectly associated with depression and loneliness [14, 15]. Physical inactivity and loneliness can therefore be approached as interlinked problems that require integrated solutions. Toward this general aim, this paper contributes new theoretical and empirical perspectives on the behavioural and psychological synergies between physical exercise and social relationships.

Although considerable research attention has been directed at understanding how social-environmental factors influence physical activity behaviour [e.g., 16], connections between the affective dimensions of physical activity, particularly exercise, and sociality remain underappreciated. Previous research offers some promising clues. For example, positive affect in exercise – i.e., liking or enjoyment – is a key determinant of adherence [17] and, in general, intense emotional experiences happen more often in the context of interdependent social connection and belonging than in independent situations [18]. This suggests a possibility for social enhancement of positive affect in physical exercise [19–22], with corresponding increases in motivation and adherence. In addition, there are links between collective physical activity in diverse forms, such as play, sport, dance, and exercise, and feelings of social bonding and belonging [e.g., 20, 23], which in turn are associated with positive motivation and adherence [24]. Taken together, these links trace a virtuous circle between affectively rich, meaningful and positive social connections and intrinsically motivated engagement and enjoyment in collective physical activity.

Besides links to social-motivational psychology, a large and growing literature spanning the behavioural and psychological sciences, physiology and neuroscience has also elucidated the effects of perceived social support on the homeostatic regulation of stress, fatigue and pain [e.g., 25, 26, 27]. Applying these insights to the physical activity domain, it can be hypothesised that perceptions of social support buffer, or reduce, unpleasant exercise-induced affect, such as fatigue and pain [19], thereby potentially increasing performance outputs, sense of achievement, and engagement in exercise.

Despite the apparent connections among affective and behavioural dimensions of exercise and sociality, surprisingly little research has directly investigated the effects of either the rewarding or buffering aspects of social bonding and support on exercise experiences. Identifying how social experiences modulate positive affect, feelings of energy and fatigue, and performance in exercise contexts can begin to provide much-needed insight into the public health value of exercise in social settings, including community-based physical activity events and interventions [28]. It can also inspire new research directions on the
psychobiological pathways via which human sociality, psychology and biology co-regulate one another in exertive physical activity more generally.

We examine these questions in the context of parkrun, a community-based organisation that convenes free, weekly, timed 5 km runs in public parks and spaces. Since its inception in 2004, parkrun has seen rapid and sustained international growth; at the time of writing, parkrun events occur in over 2,000 locations in 22 countries worldwide. The research adds to a growing literature on the role of community-led collective exercise initiatives in facilitating and promoting positive social and exercise experiences [e.g., 29, 30, 31].

1.1. Exercise in social context

Despite wide recognition and understanding of the impact of social-demographic factors on physical activity uptake and maintenance [28], relatively little research has investigated the psychological and biological pathways by which fundamental elements of cooperative sociality (e.g., social bonding, belonging and support) influence exercise experiences and performance [32]. Traditional social psychological approaches in sports and exercise science, which originate as far back as the early observations of Norman Triplett in the late 19th century, have focused on competitive and evaluative aspects of social presence and their facilitating effects on motivation, effort and performance across different types of task [for a review, see 33]. Early studies on “social facilitation” [34] demonstrated that social presence enhanced simple task performance but impaired complex task performance [35, 36]. Subsequently, following Cottrell’s [37] social evaluation account of facilitation effects (beyond “mere presence”) the bulk of research focused on anxiety-related reactions to potentially evaluative and threatening social presence on performance in technically complex vs. simple tasks (see [38]). In this paradigm, mechanistic explanations have emphasised arousal, evaluation apprehension, and distraction caused by the presence of others. More recent research has shown that personality traits (e.g., neuroticism, extraversion, self-esteem) can moderate orientations toward social presence also via positive appraisals, and that personality effects contribute more to predicting performance than the level of task complexity [e.g., 39]. This hints at the many blind spots that remain in our understanding of how, when, why and on what outcomes social facilitation operates, particularly via positively valanced social perceptions.

In a largely separate line of research, team cohesion has been studied as a predictor of effort and performance in sport. For example, group cohesion in sport settings – defined as “a group dynamic process that is reflected in the tendency of a group to stick together and remain united in the pursuit of instrumental objectives and/or for the satisfaction of member affective states” [40; p. 213] – positively predicts performance success [40], adherence to group exercise programmes [41] and physical exertion in team sports [42]. Related research drawing inspiration from social identity theory has begun to identify the importance of social-group identities for promoting physical activity engagement, adherence, enjoyment and effort. For example, in a recent parkrun study, Stevens et. al [31] found that stronger identification with the parkrun running group positively predicted participation, life satisfaction, exercise-
specific satisfaction, and group cohesion. Similarly, Graupensperger et al. [43] identified links between subjective evaluations of groupness (i.e., the perception of a group as an interdependent unit in which members adopt roles and group norms) and exertion, enjoyment and affective valence in a fitness class context. In a preliminary study with recreational runners ($n=17$), Carnes and Mahoney [44] also found that higher perceived task cohesion (defined as individual involvement in and group unity around common goals) and social support and were associated with lower perceived exertion during group running, and higher enjoyment in both interval and group running. These studies offer support for the idea that individuals’ perceptions of the social group as cohesive and supportive, and with which they can strongly identify as group members, can promote positive affective exercise experiences, increase participation in physical activity, and facilitate performance via socially-mediated mechanisms other than arousal, evaluation apprehension and distraction.

Overall, a large and well-developed literature has elucidated the types, causes and consequences of group cohesion in sports. However, the psychological, physiological, and performance effects of bonded sociality outside of team or group-based sport (e.g., in transient collectives, virtual settings, and exercise groups without clearly defined boundaries, interdependent roles and shared goals) remain relatively unexplored, both theoretically and empirically. Research across a wider range of activities, social contexts and outcome measures is needed in order to determine how social behaviours and perceptions of social support, integration and belonging influence exercise-related affect, physiology and performance, and to better understand the public health significance and value of community exercise schemes and events.

In the present study, we examine how social behaviours as well as perceptions and cues of social connectedness and support affect the experiences and performance of exercisers in a naturalistic setting (parkrun). We hypothesised that social engagement and perceptions of social support would increase positive affect (e.g., feelings of enjoyment and energy), decrease negative affect (e.g., feelings of fatigue), and enhance performance outputs (i.e., decrease run times). These hypotheses are theoretically situated in a broad evolutionary approach to humans as thoroughly social creatures, for whom surviving and thriving depends on social connections [45–47]. In this view, the social environment directly influences the brain-body signalling that undergirds adaptive homeostatic maintenance in everyday life, including in physical exercise, via affective states experienced as pleasure-displeasure [48–51]. Moreover, the intrinsic pleasure of social connection that is experienced in the context of close bonds is thought to arise in part via activation of endogenous neurobiological systems, such as the opioidergic and endocannabinoid systems [47, 52, 53], that are also involved in modulating responses to nociceptive stimuli and in sustaining endurance exercise [54–57]. Social bonding in the context of exercise can therefore potentially boost feelings of enjoyment and pleasure in exercise while also buffering pain and fatigue.

Our hypotheses are corroborated by an extensive clinical and neuroscientific literature on the positive effects of social support in stress, pain, immunity and healing responses [26, 58]. Across this literature, perceived social support (i.e., the belief or expectation of available help when needed) has proven to be a more consistent predictor of positive health outcomes than received social support (i.e., help given). There is also preliminary evidence for buffering effects of perceived social connection and support in
exercise. For example, experimental studies have found that exercising with others versus alone leads to significantly greater pain thresholds, and cues to social bonding prior to an individual sprint challenge improve performance outputs, without corresponding increases in subjective ratings of fatigue [19, 21, 59].

Altogether, existing research suggests that rewarding and supportive social environments can influence pleasure or enjoyment during physical activity, that social support can improve performance via reduced fatigue and increased energy, and that these socially-derived experiences and effects can increase motivation and engagement in exercise activities. Distinct from social facilitation, group cohesion and social identification, perceived social support refers specifically to the individual’s belief that they are valued and cared about by others who will offer help when needed [60]. As a consistent predictor of physical and mental health, and an effective buffer of stress, it seems unlikely that the hypothesised positive effects of social reward and support on exercise experiences and performance can be wholly or primarily attributed to social facilitation factors, such as evaluation pressure and self-monitoring. Perceptions of social support are anchored in our cooperative sociality, and are thought to be associated – evolutionarily, ontogenetically and cognitively - with perceived safety and resource availability [50, 61]. As such, perceived social support aligns more closely with existing constructs of team cohesion and social identification. Importantly, however, the effects of social reward and support on homeostatic regulation and affective states in exercise can occur outside or alongside team cohesion or group identification processes, and can be sourced not only in co-actors, but also family, friends, fans and even rivals.

1.2. The current study

In the current study, we investigate how perceived social support and behaviours associated with social reward influence feelings of enjoyment, fatigue, and energy as well as objective performance among parkrunners. The aim of parkrun is to “promote physical activity and community spirit, by providing supportive opportunities to exercise” [30], p. 171). Organised by local volunteers and describing itself as a ‘run and not a race’ with no ability or attendance requirements, parkrun offers a welcoming, community-based setting for participants to attend as often as they please. This inclusive ethos allows parkrun to attract participants who do not identify with traditional views on competitive running, thus creating a participating population that includes a wide range of demographic categories and skill levels [29, 30]. Researchers have described parkrun as a “mass community event” and a “home away from home” that offers participants “psychological comfort, warmth, and mutual support” [29], p. 10). While parkrun strives to create an inclusive ethos – it has a relatively even gender split (reported as a binary variable), and all age groups are well-represented across sites – it should be noted that individuals from ethnic minorities and low-socio-economic status (SES) groups are underrepresented at parkrun, including in areas that are ethnically diverse [62].

Parkrun’s community-based ethos makes it an ideal naturalistic setting in which to study how social connectedness and support influence exercise experiences. According to a study conducted at one UK parkrun site, ‘social togetherness’ was the second most important aspect of parkrun among surveyed
participants, following “getting exercise”[29]. Current literature on parkrun and our own ethnographic observations in the context of this research suggest that social relationships are built and solidified through interactions among parkrunners before and after runs [29, 30, 63]. Individuals report chatting while running alongside other parkrunners, and often begin casual conversations as they wait in line (ordered by finishing rank) to scan their parkrun ID barcodes (used to record run times). Although participants at a given parkrun location can vary from week to week, there is a continuity of core runners and volunteers that work to create a sense of community, which offers runners an informal network of emotional support where “even loose ties with relative strangers can be highly valued” [29, p. 10; see also Morris & Scott, 2018].

Using survey and publicly available performance data, we assessed the influence of social factors on exercise experiences and performance. Specifically, we were interested in how participating with others, and particularly close others, as well as feelings of being integrated within the parkrun community influenced perceptions of fatigue, feelings of energy, enjoyment, and objective performance (run times). Although parkrun has an overall ethos that is supportive and not generally competitive, participants do care about their run performance, with many citing a desire to improve upon previous run times [30, 63].

Three social predictor variables were included: 1) whether participants attended with friends or family vs. attended alone; 2) whether or not participants interacted with others socially before the event; 3) the degree to which participants felt a) supported by, and b) integrated into the parkrun community. Previous research suggests that social reward and support effects vary according to relationship quality and are strongest when individuals are socially integrated [58, 65]. We hypothesised that higher ratings on these social predictor variables would be associated with lower perceptions of fatigue (H1), higher levels of felt energy (H2) and higher levels of enjoyment (H3). We also hypothesised that higher ratings on social variables would be associated with faster run times (H4). Finally, we hypothesised that subjective feelings of fatigue (H5) and energy (H6) would mediate associations between social variables and run times, with higher energy and lower fatigue predicted by higher ratings on social variables, and these, in turn, predicting faster run times (see Table 1). To assess general social facilitation effects, we also analysed associations between social variables and ratings of perceived effort. If social behaviour and perceived support and integration are associated with higher enjoyment, increases in feelings of energy, decreases in perceptions of fatigue, and increases in performance outputs, this suggests an important but underappreciated role for social reward and support in exercise experiences, motivation and adherence, and in exercise-related health benefits.
### Table 1
#### Hypotheses

**H1. Main effects of social predictors on subjective fatigue**

| 1.1–1.3 | Higher subjective ratings of community support and integration will predict lower fatigue (1.1); coming or meeting up with friends/family will predict lower fatigue (1.2); being social (vs. not being social) before the run will predict lower fatigue (1.3). |

**H2. Main effects of social predictors on subjective energy**

| 2.1–2.3 | Higher subjective ratings of community support and integration will predict higher energy (2.1); coming or meeting up with friends/family will predict higher energy (2.2); being social (vs. not being social) before the run will predict higher energy (2.3). |

**H3. Main effects of social predictors on subjective enjoyment**

| 3.1–3.3 | Higher subjective ratings of community support and integration will predict higher enjoyment (3.1); coming or meeting up with friends/family will predict higher enjoyment (3.2); being social (vs. not being social) before the run will predict higher enjoyment (3.3). |

**H4. Main effects of social predictors on 5 km run times**

| 4.1–4.3 | Higher subjective ratings of community support and integration will predict faster 5 km run times (4.1); coming or meeting up with friends/family will predict faster 5 km run times (4.2); being social (vs. not being social) before the run will predict faster 5 km run times (4.3). |

**H5 & H6. Mediators of main effects of social predictors on 5 km run times**

| 5.1–5.3 | Higher scores on the social predictor variables (5.1: community support and integration | 5.2: coming or meeting up with friends/family | 5.3: pre-run sociality) will predict higher perceived energy levels, and higher perceived energy levels will predict faster 5 km run times. |

| 6.1–6.3 | Higher scores on the social predictor variables (6.1: community support and integration | 6.2: coming or meeting up with friends/family | 6.3: pre-run sociality) will predict lower fatigue, and lower fatigue will predict faster 5 km run times. |

## 2. Methods

### 2.1. Participants

Participants (aged 18 and over) were recruited in person and through parkrun event webpages from six parkrun sites in southern England, UK: Oxford, Abingdon, Didcot, Reading, Harcourt Hill, and Fulham Park. Recruitment was on a rolling basis over approximately two months (see SOM 1). Following consent, a weekly survey link was sent to each participant over a maximum of 18 weeks (the total duration of the study), beginning on the first Saturday after which they had given their consent. Participants were encouraged to attend parkrun as usual during the study period and to respond to the survey when they did so, although it was made clear that they were not required to respond to the survey each time they attended a parkrun (this met the request of the parkrun Research Board that the study be minimally intrusive). In total, 188 parkrunners consented to take part; 144 participants completed the survey at least once and there were 734 usable surveys in total (see Sect. 3.1). This study was approved by both the
parkrun Research Board (UK) and the Central University Research Ethics Committee, University of Oxford (reference number: SSH_SAME_C1A_15_084). Data collection did not continue after data analysis.

2.2. Survey procedure

Participants were given the option of receiving the link to the online survey by email, text, or post (no participants chose post). All parkruns are held weekly, on Saturdays at 9:00am. Survey links were sent at 9:45 a.m. and participants were requested to complete the survey as soon as possible after their run. The survey consisted of 14 questions and was administered via Qualtrics’ desktop and mobile platforms. After entering their name and parkrunner ID (used to link responses and run time data from the parkrun database), participants were asked: “Besides other motivations you might have had for attending parkrun today, which of the following options best applies to you? I was motivated to... (a) improve my ranking; (b) improve my time; (c) run together with other people.” Only one response option was permitted.

The remaining eleven questions were asked in a randomised order. On seven-point Likert Scales (1 – not at all, 7 – very much), participants responded to the questions: “How much did you feel supported by the parkrun community today?”, “How much did you feel you were a part of the parkrun community today?” These two questions were later combined using principal components analysis (PCA) in a single ‘parkrun community component’ (see Sect. 3.2 and SOM 2).

Participants also used seven-point Likert Scales (1 – not at all, 7 – very much) to respond to the questions: “How much did you enjoy your run today?”, “How energising did it feel to be with the other parkrunners today?”, and “How physically fatigued did you feel during your run today?” (if participants answered with a 5 or greater on the seven-point Likert Scale for this question, they were asked, using the same scale, “How physically painful did this fatigue feel?”). Questions about energy and fatigue levels were adapted from the Profile of Mood States items measuring ‘Vigour-Activity’ and ‘Fatigue-Inertia’ [66, 67]. As a measure of their effort, participants were also asked: “Please rate your feeling of exertion (how much physical effort you felt you were giving) during your run today”, with response options following the Borg Rating of Perceived Exertion scale [68] (see SOM Figure S2).

Participants were also asked about social aspects of their run: “Please choose the answer that best describes your run today. Today I ran... (a) on my own; (b) alongside one or more acquaintances; (c) alongside one or more friends/family members; (d) alongside a mix of acquaintances and friends/family members”. Two questions asked participants about their sociality before the run: “Please choose the option that best describes what you were doing just before you went to the start line today; (a) Getting ready or hanging out on my own; (b) Getting ready or hanging out with others; (c) Something else (e.g., rushing to get the start line, chatting on my phone, etc.)”, and “Did you come along with, or meet up with, anyone else at parkrun today? Please choose the answer that best applies to you. Today I came/met up with... (a) nobody else; (b) one or more acquaintances; (c) one or more friends/family members or a mix of acquaintances and friends/family members.”
To assess the extent to which parkrunners altered their running behaviour when running with others, they were further asked: “Which of the following best applies to you? (a) Today I slowed down for my running partner(s); (b) Today I sped up for my running partner(s); (c) Today my natural pace was pretty much the same as the pace of my running partner(s); (d) Not applicable – I ran on my own.”

2.3. Additional data acquisition

Participants’ 5 km run times were collected for every run for which a survey response was recorded. Each parkrun location has a publicly available webpage with event-specific finish lists containing the 5 km run times for all registered runners who participated on a given date. We acquired 5 km run time data for participants who had returned a completed survey, as well as information on participant age and sex (see SOM 3). Age data are grouped according to age categories pre-determined by the parkrun organisation (18–19 year olds, 20–24, 25–29, etc., up to 75–79).

2.4. Inferential statistical models

Statistical analyses were performed in R version 3.5.3. The R packages lme4 [69] and lmer [70] were used to perform the primary analyses. Marginal $R^2$ ($R^2_m$ and $R^2_c$) was calculated using functions from the piecewiseSEM package in R [71]. The R packages mediation [72] and lme4 [69] were used to perform the multilevel mediation analyses, which employed bias-corrected and accelerated (BCa) bootstrap-based confidence intervals.

All multilevel models included parkrunner identification numbers as the level-two grouping variable. When possible, maximal random effects structures were used (see SOM 4).

For models testing effects of social predictor variables on subjective fatigue, energy and enjoyment (Hypotheses 1.1–3.3), there were no covariates. Models on 5 km run times (Hypotheses 4.1–4.3) included a ‘pace influence’ covariate, based on the survey item on whether participants actively slowed down to run with a running partner, ran at a natural pace (either with a partner or on their own), or sped up to run with a running partner. These models also used logged 5 km run times to improve model fits.

Mediation analyses, which tested whether subjective energy or fatigue mediated the relationship between the social predictor variables and 5 km run times (Hypotheses 5.1–6.3), were based on two multilevel models: one using the social predictor variable to predict the potential mediator, and another using the social predictor variable to predict 5 km run times, while controlling for the mediator [72]. Both models included the ‘pace influence’ covariate, and 5 km run times were logged to improve model fits. All direct, indirect, and total effects were calculated following the procedures of Tingely et. al [72].

Multilevel models were also used to assess whether survey response times (time elapsed from receiving the survey link to submission) affected responses to affect-related questions. In these models, logged (to improve model fits) response times were the predictor, and subjective fatigue, energy, enjoyment, and the parkrun community component were the outcomes. No covariates were included in these models. Response times are unlikely to have influenced descriptive responses (e.g., who participants reported
coming to parkrun with), but they may have influenced responses to the affect-related questions. To test whether the social predictor variables predicted increased effort, multilevel models were used to test the effects of the social predictor variable on subjective effort (RPE). No covariates were included in these models.

Assumption checks were carried out in accordance with the methods suggested by [73] and [74]. Full model selection criteria and assumption checks and are reported in SOM 4 and SOM 5, respectively.

2.5. Family-wise error rates

When testing families of comparisons (hypotheses) it is necessary to control for the increased probability of Type I error due to conducting multiple hypothesis tests [75–77]. The analyses reported below used the procedures of Benjamini and Hochberg [75] in determining more conservative critical values for each of the three related tests in the five families of hypotheses in Table 1.

For the mediation analyses, each type of effect (indirect, direct, and total) was treated as a sub-family of tests when accounting for multiple comparisons for Hypothesis 5.1 – Hypothesis 5.3 and Hypothesis 6.1 – Hypothesis 6.3.

The full procedure used for controlling for multiple comparisons can be found in SOM 6.

3. Results

3.1. Survey responses

In total, there were 765 survey responses. Some survey responses could not be matched to a particular parkrun ID and were thus dropped from analyses. If a participant responded more than once on a given day, their first response was retained for analysis, and all subsequent responses from that day were removed (see SOM 3 for full data cleaning procedures). After removal of unidentified and duplicate returns, there were 734 survey responses from 143 participants (see SOM Figure S3); 49% of participants were female ($n = 70$), and females represented 46% of all surveys returns analysed ($n = 341$). Respondents were drawn from all adult age categories (18–19–75–79). The mean age of survey respondents (taking the midpoint of the age category as the respondent's age) was 48.21 years (median = 47 years, $SD = 11.92$ years). Participants responded to the survey an average of 5.09 times (median = 4, $SD = 4.02$, range = 1–17).

The median survey response time (from when the link was sent) was 4 hr 32 min. The distribution was highly positively skewed (skewness = 2.98), with a range of 4 minutes 17 seconds to 6 days 22 hrs and 31 minutes, and a mean of 15 hr 32 min ($SD = 26$ hr 38 min). Of the 734 survey responses, 195 (27%) were returned within 2 hrs, 585 (80%) within one day, 664 (90%) within two days, and 717 (97%) within four days (see SOM Figure S4a). The median survey completion time (time elapsed from when a participant started the survey to when they returned the completed survey) was 2 minutes 39 seconds ($M = 14$ min 41 s, $SD = 150$ min 40 s, range = 56 s – 43 hr 10 min); 87% of surveys were completed in under
5 min, and 96% were completed in under 10 min (see SOM Figure S4b). There were no a priori exclusions based on time taken to return or complete surveys.

To test whether survey response times were related to affect-related survey questions (see Sect. 2.4), logged survey response times were used to predict subjective fatigue, energy, enjoyment, and the parkrun community component (see Sect. 2.4). Response times did not significantly predict any of these variables (see SOM Table S1 – S4).

### 3.2. Relationship with the parkrun community

Responses to the two questions on the parkrun community were highly correlated (“How much did you feel supported by the parkrun community today?” and “How much did you feel you were a part of the parkrun community today?”; \( r = .72 \)). A PCA was used to test the relationship between these two variables, based on the expectation that the questions on support and inclusion would load onto a component related to social support from the parkrun community (see SOM 2 for a full summary of this analysis).

The one component extracted from the two variables had a Kaiser's criterion of 1.72, explained 86% of the variance in answers to the two questions, and had good reliability (Cronbach's alpha = .840). The component (henceforth, the ‘parkrun community component’) was taken to represent the perceived strength of participants’ relationship with the parkrun community, and is used as a predictor variable in the analyses described below.

### 3.3. Descriptive statistics

The majority of survey responses indicate that participants were more motivated to attend parkrun for social reasons, i.e., “to run together with other people” (\( n = 448, 61\% \)), than to attend for reasons related to training (“to improve my time”; \( n = 268, 37\% \)) or competition (“to improve my ranking” \( n = 18, 2\% \)). In the majority of responses, participants reported running without a partner or companion (\( n = 497, 68\% \)), with the remainder split between running “alongside one or more friends/family members” (\( n = 106, 14\% \)) and running “alongside one or more acquaintances” (\( n = 85, 12\% \)), and “alongside a mix of acquaintances and friends/family members” (\( n = 47, 6\% \)). In the majority of surveys, participants reported coming or meeting up with friends and family, or a mixture of friends, family, and acquaintances (\( n = 394, 54\% \)), versus coming or meeting up with one or more acquaintances (\( n = 202, 28\% \)) or coming on their own (\( n = 138, 19\% \)).

Regarding what participants were doing just before the run (henceforth ‘pre-run sociality’), the response most frequently chosen was ‘getting ready or hanging out with others’ (\( n = 462, 63\% \)), followed by ‘getting ready or hanging out on my own’ (\( n = 189, 26\% \)) or doing something else (\( n = 83, 11\% \)).

For the inferential analyses reported below, we created binary categories for the variables on who participants came/met up with and their pre-run sociality: either coming/meeting up with friends/family (\( n = 394, 54\% \)) or not (\( n = 340, 46\% \)) and either being social before the run (\( n = 462, 63\% \)) or not (\( n = 272, 37\% \)).

Regarding the two questions that made up the parkrun community component, the mean response to the question concerning perceptions of parkrun community support was 5.72 (\( SD = 1.06, range = 2–7 \)), and the mean response to the question on being part of the parkrun community was 5.76 (\( SD = 1.08, range = 1–7 \)).
Participants’ 5 km run times were positively skewed (skewness = 0.87; see SOM Figure S5); the mean 5 km run time was 27 min 52 sec (SD = 5 min 53 s, range = 16 min 36 s – 57 min 20 s). Although attending or meeting up with others appears to be the norm for this sample, the majority of survey responses indicate that participants ran on their own. In 74.25% (n = 545) of surveys participants reported running on their own; in 8.17% (n = 60) of surveys, participants reported slowing down to run with their partner(s), in 6.13% (n = 45) of surveys, participants reported speeding up to run with their partner(s), and in 11.44% (n = 84) of surveys participants reported running at a natural pace with their partner(s).

Regarding subjective effort, the mean response on the RPE scale was 14.61 (SD = 2.25, range = 6–20), between “13 – Somewhat hard” and “15 – Hard (heavy)” on the 20-point scale. Subjective effort was highly correlated with subjective fatigue (r = .706). The mean rating of fatigue was 4.79 (SD = 1.27, range = 1–7). The follow-up to this question, on how physically painful the fatigue was, was only asked when participants’ reported level of fatigue was 5 or greater (64.17% of surveys; n = 471), and was 4.24 (SD = 1.32, range = 1–7). Participants reported enjoying their runs; the mean response was 5.64 (SD = 1.06, range = 1–7). Regarding subjective energy, the mean response was 5.64 (SD = 1.06, range = 1–7).

Although informative of the survey results as a whole, this descriptive picture should be interpreted with caution as it is most heavily influenced by those participants who answered the survey the most times (see SOM Figure S3).

### 3.4. Main effects of social predictor variables on subjective experiences and 5 km run times

#### 3.4.1. Main effects of social predictor variables on subjective fatigue (H1)

Higher scores on the parkrun community component, coming/meeting up with friends/family, and pre-run sociality were all hypothesised to predict lower perceptions of fatigue (H1). The parkrun community component and pre-run sociality did not significantly predict participants’ perceptions of fatigue (see SOM Table S5 and Table S7). There was an association between who participants came/met up and perceptions of fatigue; coming/meeting up with friends/family (vs. coming or meeting up with acquaintances or alone) predicted significantly lower fatigue, $b = -0.250, SE = 0.111, t (df) = -2.245 (92.7), p = .027$ (see SOM Table S6), but this $p$-value was not significant at its Benjamini-Hochberg adjusted critical value.

#### 3.4.2. Main effects of social predictor variables on subjective energy (H2)

The parkrun community component positively predicted perceived energy, $b = 0.559, SE = 0.034, t (df) = 16.51 (659.5), p < .001$, as did coming or meeting up with friends/family, $b = 0.209 SE = 0.081, t (df) = 2.60 (730.2), p = .009$, and pre-run sociality, $b = 0.310, SE = 0.092, t (df) = 3.38 (62.9), p = .001$ (see SOM Table S8 – Table S10). All $p$-values were significant at their Benjamini-Hochberg adjusted critical value.
3.4.3. Main effects of social predictor variables on subjective enjoyment (H3)

The parkrun community component positively predicted enjoyment, $b = 0.439$, $SE = 0.039$, $t (df) = 11.21 (673.6)$, $p < .001$, as did coming or meeting up with friends/family, $b = 0.230$, $SE = 0.086$, $t (df) = 2.67 (714.2)$, $p = .008$, and being social before the run, $b = 0.346$, $SE = 0.010$, $t (df) = 3.47 (80.8)$, $p < .001$ (see SOM Table S11 – Table S13). All $p$-values were significant at their Benjamini-Hochberg adjusted critical value.

3.4.4. Main effects of social predictor variables on 5 km run times (H4)

We further hypothesised that social predictor variables are associated with 5 km run times, specifically that higher parkrun community component ratings, attending with family or friends, and pre-run socializing predict faster run times. The models included a ‘pace influence‘ covariate, described above. Participants’ 5 km run times were logged to improve model fits. None of the social predictor variables predicted 5 km run times (see SOM Table S14 to Table S16).

3.4.5. Perceived energy as a mediator of main effect of social predictors on 5 km run times (H5)

We also predicted that the association between the social predictor variables and performance would be mediated by perceived fatigue and energy, such that decreases in fatigue and increases in energy would mediate the relationship between the social variables and participants’ run times. The following mediation models included the ‘pace influence‘ covariate, described above, and 5 km run times were logged to facilitate model fits.

All three predictor variables had significant, ergogenic indirect effects on 5 km run times, with perceived energy as the mediating variable (H5.1-5.3; see Fig. 1 and SOM Figure S6).

The first mediation analysis tested whether participants’ perceived energy mediated the relationship between their scores on the parkrun community factor and their (logged) 5 km run times (5.1). Analyses revealed a significant average indirect effect of $-0.008$ (95% CI: $[-0.013, -0.001]$, $p < .001$), a significant average direct effect of $0.015$ (95% CI: $[0.007, 0.020]$, $p < .001$), and a non-significant total effect of $0.007$ (95% CI: $[-0.001 0.020]$, $p = .110$): how energised participants felt mediated the relationship between the parkrun community component and participants’ 5 km run times. The average indirect effect was significant at its Benjamini-Hochberg adjusted critical value (see SOM Table S17 and Table S18 for model summaries and SOM Figure S6a and Figure S6d for predictor, mediator, and outcome variable relationships).
The second mediation analysis tested whether participants’ perceived energy mediated the relationship between who participants came or met up with and their (logged) 5 km run times (H5.2). Results showed a significant average indirect effect of $-0.002$ (95% CI: $[-0.004, -0.001]$, $p = .012$), a non-significant average direct effect of $0.008$ (95% CI: $[-0.009, 0.020]$, $p = .338$), and a non-significant total effect of $-0.006$ (95% CI: $[-0.011, 0.020]$, $p = .468$): the relationship between who participants came or met up with and logged run times was mediated by how energised they felt. The average indirect effect was significant at its Benjamini-Hochberg adjusted critical value (see SOM Table S19 and Table S20 for model summaries and SOM Figure S6b and Figure S6d for predictor, mediator, and outcome variable relationships).

The third mediation analysis tested whether participants’ perceived energy mediated the relationship between their pre-run sociality and their (logged) 5 km run times (H5.3). Results showed a significant average indirect effect of $-0.003$ (95% CI: $[-0.006, -0.001]$, $p = .006$), a non-significant average direct effect of $0.012$ (95% CI: $[-0.005, 0.030]$, $p = .138$), and a non-significant total effect of $0.010$ (95% CI: $[-0.008, 0.030]$, $p = .236$): the relationship between participants’ pre-run sociality and logged 5 km run times was mediated by how energised they felt. The average indirect effect was significant at its Benjamini-Hochberg adjusted critical value (see SOM Table S21 and Table S22 for model summaries and SOM Figure S6c and Figure S6d for predictor, mediator, and outcome variable relationships).

### 3.4.6. Subjective fatigue as a mediator of main effect of social predictors on 5 km run times (H6)

With fatigue as the mediating variable (H6), none of the social predictor variables had significant direct, indirect, or total effects on 5 km run times. Mediation summaries can be found in SOM Figure S7, and model summaries can be found in SOM Table S23 – Table S28.

### 3.4.7. Main effects of social predictor variables on subjective effort

None of the social predictor variables significantly predicted subjective effort levels (RPE; see SOM Table S29 – Table S31). This suggests that social predictor effects on participant experiences and performance are not confounded by social-motivational factors associated with competition or threat of evaluation.

### 4. Discussion

Community-based sports and exercise events, particularly those offered on a continuous and regular basis, have been identified as having significant but untapped public health benefits [62]. Existing evidence suggests that participation in collective exercise events, such as parkrun, can be encouraged not just for the physical and psychological benefits of physical activity and exercise, but also for the simultaneous wellbeing benefits of social connection, integration and support [24, 64]. Although it has been shown that individuals often draw on existing connections to initiate their participation in parkrun...
[e.g., 63], and that stronger identification with the parkrun collective is associated with more frequent participation and higher life satisfaction [31], little is known about the effects of social reward and support on participants’ affective experiences of exercise, and related performance. Addressing this gap can begin to contribute valuable new data relevant to tackling pressing international public health challenges of physical inactivity and loneliness, while at the same time advancing our scientific understanding of the social modulation of homeostatic mechanisms that contribute to feelings of fatigue, energy, enjoyment and performance in exertive physical activity [51].

To investigate the social determinants of affective experiences and performance in exercise in a naturalistic group setting, we analysed associations between a range of social variables and self-reported enjoyment, fatigue and energy, as well as recorded run times, in a sample of UK parkrunners. Via a repeated-measures survey, participants reported their primary motivation for attending parkrun, their social engagement and perceptions of support, and their running experiences. This allowed us to examine direct and mediated effects of social variables on experiences and performance. Results give partial support to our hypotheses and suggest a more nuanced account of how social environments affect experiences and outputs during physical exercise.

Survey responses confirmed previous findings of high levels of sociality at parkrun [29, 30, 62, 78]: in the majority of surveys, participants reported coming or meeting up with friends and family, or a mixture of friends, family, and acquaintances. Running with others, rather than running to improve times or rankings, was the predominant motivation for attending. As participants primarily report running on their own, however, this motivation appears to relate more to the parkrun collective rather than specific running partners or groups. Perceived support from and integration within the parkrun community was high, as were subjective enjoyment, energy, effort and fatigue. Overall, the descriptive picture is of a positive and facilitative social context for invigorating and challenging self-paced exercise.

Social predictors had positive effects on subjective enjoyment and energy, and performance, in line with our hypotheses. The social predictor variables did not directly predict participants’ perceptions of fatigue, however. Furthermore, it was only through indirect effects that they were associated with lower 5 km run times. Specifically, the social predictor variables were positively associated with subjective energy levels, and these were negatively related to 5 km run times (i.e., relatively higher subjective energy was associated with faster 5 km run times). The mediation analyses revealed that all of the social predictor variables had significant indirect negative effects on 5 km run times, via positive effects on subjective energy. A one unit increase in the social predictor variables led to between 0.17% and 0.74% decreases (depending on the predictor variable) in 5 km run times, such that 5 km runs were between 3.34 s and 11.70 s faster for a participant with 5 km run times equal to that of the overall average of 27 min 52 s [79].

Taken together, these results suggest that, even among those who generally run slower times, it is not social factors per se that lead to reductions in run times. Rather, social factors, on average, are positively associated with greater feelings of energy, and these predict faster 5 km run times. In fact, when
controlling for subjective energy, there was a significant direct effect of the parkrun community factor on run times, but in the opposite direction predicted. This likely reflects the variable performance motivations represented across these participants; those with stronger motivations to improve their run times may be more likely to benefit from the energizing effects of social support and integration relative to those less concerned about their running performance.

Overall, these results point to potential beneficial effects of social reward on positive affect, including enjoyment and subjective energy, with potential regulatory effects on performance. As there is no indication that social predictors were associated with self-reported effort, it seems unlikely that the mediating effect of subjective energy on performance is attributable to motivations traditionally identified in social facilitation research (e.g., evaluation apprehension). Rather, we suggest that the felt energy and enjoyment associated with the social predictor variables can be explained, in part, by the intrinsic psychological reward of positive and supportive social engagement [80, 81]. This interpretation is in line with observational research showing that perceptions of social support and cohesion at parkrun are associated with more positive experiences [82]. Although this study does not examine potential causal mechanisms, our interpretation is also corroborated by extensive neurobiological evidence that endogenous systems involved in sustaining physical exercise, such as the endocannabinoid and opioidergic systems, are also activated by positive social interactions [54, 81, 83–85]. Overall, we suggest that positive social engagement and perceptions of support modulate the balance of pleasure-displeasure that regulates self-selected exercise intensity and performance output, and that this can be instrumental in motivating adherence [17, 51, 86].

Although all of the social predictor variables were associated with participants’ subjective energy, there was no significant relationship detected between the social predictors and fatigue, nor any interaction effect of social predictors and fatigue on run times. As our hypotheses predicted positive effects on energy and negative effects on fatigue, these results suggest a qualification of our account. Fatigue and energy are both conceptualized in the literature as multidimensional states that concern ability to sustain voluntary activity. However, whereas feelings of fatigue relate specifically to the perceived difficulty of maintaining task goals [87], feelings of energy relate to perceived ability to maintain task goals, captured in standard measures as “vigour” or “vitality”. Our results suggest that, in the parkrun context, both reported fatigue and reported energy were relatively high ($M = 4.79$, $SD = 1.27$ and $M = 5.64$, $SD = 1.06$, respectively, on a 7-point scale), but that increased feelings of energy are the affective mechanism through which social cues affect performance outputs (run times). This suggests a distinction between “boosting” (i.e., energy-giving) and “buffering” (fatigue-reducing) mechanisms and effects on affect and related performance. Our results do not indicate substantive differences among the three social predictor variables and their effects on outcome variables. Thus, there is no suggestion of differential effects of, for example, community integration vs. pre-run socializing with friends, on subjective enjoyment and energy vs. subjective fatigue. Future research could systematically manipulate those aspects of social behaviour most directly associated with increasing pleasant affective states (e.g., social laughter, behavioural synchrony, such as in singing or dancing [88] and those most directly associated decreasing
unpleasant affective states (e.g., safety signaling [89], and measure effects on subjective energy and fatigue.

An alternative explanation for the significant mediation effect is that the presence of known social others increased levels of competition and motivation among parkrunners, and these effects were captured by the perceived energy variable. Indeed, motivation and felt energy are likely overlapping constructs, both leading to increased physical outputs [90]. It is possible that the presence of friends or family members increases competition levels at parkrun. However, it is unclear why socialising before the event or feeling more included and supported by the parkrun community would predict higher competition levels. Furthermore, contrary to the competitive-motivation account, we found no association between social predictor variables and subjective effort (RPE). Future studies could investigate relationships among social reward or support, felt energy and fatigue, and performance in a range of social exercise settings. Fatigue-buffering effects of perceived social support may be more likely in high-intensity exercise contexts characterized by both positive sociality, support or camaraderie and high-stakes performance near the limits of exercise tolerance [51, 91, 92].

4.1. Limitations

The results of this study should be considered in light of its limitations. First, the study was observational in nature and causality can only be inferred. Higher feelings of energy could, in principle, be predictive of higher sociability and perceptions of social support generally, though we are not aware of any evidence directly supporting this conjecture. More plausibly, higher performance outputs could prompt reports of higher subjective energy, via positive feedback mechanisms. Although some parkrunners track their times on personal watches, not all participants would have been aware of their objective performance during or immediately after the event. Surveys were sent out 45 min after the beginning of each parkrun. The median time taken to return the survey was approximately 4.5 hrs, and 20% of surveys were returned over 24 hrs after they were received (see SOM Figure S4a). All returned surveys were included in analyses. Parkrun confirms run times via email and on its websites up to one day after a run’s completion, so it is likely that some participants would have accessed their 5 km run times before completing the survey. Post-hoc appraisals of subjective energy could therefore have been informed by knowledge of objective run time data. However, analyses show no effect of response time on variables related to participants’ affective experiences (i.e., their self-reports of fatigue, energy, or enjoyment) or their scores on the parkrun community component, and there is no theoretical reason to assume that this prior knowledge would affect reports of pre-run sociality or who participants reported coming to or meeting up with at parkrun.

Previous qualitative research also offers some support for the causality we hypothesised. Participants’ statements reveal their awareness and appreciation of the social support received from other parkrunners, including the boosting effects on performance [29, 30]. For example: “When people come through the finish line, you know, there’s people there and they’re all cheering you on and, you know, it just gives a real boost really; and like that first experience I had of that woman, you know, supporting me through the last little bit when I was struggling. That happens all the time” (Wiltshire et al., 2018, p. 10).
The link to adherence is also explicit in these reflections: “Running with others is a massive motivation. The self-talk doubts don’t creep in when in a group … I don’t think I would run 5 km every week if I didn’t have a group like this to run with” [29; p. 12].

Second, although our primary statistical analyses accounted for the repeated measures design, multilevel model results are influenced most by those participants with relatively high numbers of survey responses [73]. There was wide variation in the response rate across participants; 32 participants (18%) responded nine or more times, making up 50% (n = 369) of the total responses. Further, 29 participants (20%) responded to the survey once, and the majority (64%) of participants filled out the survey fewer than five times. However, there are few significant differences between participants with high survey response counts (nine or more responses) and those with low survey response counts (fewer than nine responses). Compared to participants with low survey response counts, those with high response counts were older (53 years old v. 47 years old), slower (28 min v. 27 min 5 km run times), and less social before their runs (59% of the surveys from high response count participants reported being social before runs v. 67% of surveys from participants with low response counts). See SOM 7 and SOM Table S32 for full results for comparisons between high and low frequency survey responders. These differences should be considered when extrapolating the results of this study beyond the current sample.

More frequent sampling across different parkrun occasions can potentially help ensure a more representative picture of each individual’s experience in general. Participants were encouraged to attend parkrun as usual during the study period and were reminded that survey participation following any given parkrun event was voluntary. However, future studies could work to create greater incentives for research participation from a wider sample of parkrunners and to ensure higher return rates. The growing popularity of organized exercise in virtual settings (e.g., via social media functions) also offers new opportunities for online data collection that can be better integrated with exercise activities, while at the same time testing hypotheses among remotely connected gatherings and communities.

Third, the study does not investigate factors predicting variation in perceptions of social support, or in the association between social predictors and positive experiences or performance outcomes. It is important to note that the presence of others, even family and friends, does not always serve as a cue of social reward or social support. An important factor in the effects of social reward and support in exercise-related affect and performance is the closeness and quality of the relationship [e.g., 65]. Compared to the parkrun community component, which measures support from and inclusion in the broader parkrun community, and participants’ pre-run sociality (which measures pre-run social interactions with the broader parkrun community), coming or meeting up with friends and/or family at parkrun is likely the most direct indicator of the presence of close, supportive relationships. However, even here, social comparison and feelings of inadequacy or incompetence could interfere with the predicted links between social support and energy, fatigue, pain, and physical performance, depending the on the affective quality of the relationship.
Furthermore, even where support is given, being the recipient of support is not always a positive experience. Previous research has demonstrated that personality and cultural factors can affect people's affective experience of receiving social support. For example, highly neurotic individuals focus on the interpersonal costs of receiving social support while highly independent individuals can react to social support with feelings of compromised independence [93]. These responses have been theorised to reduce (or even abolish) the positive effects of social support on coping with stressors [93, 94]. Future research could examine effects of relationship quality and personality on experiences in exercise, as well as the effects of different exercise contexts (e.g., primarily competitive or primarily cooperative) on the quality of participants’ social connections and relationships. There could be further investigation also into how personality and relationship characteristics relate to subjective energy and self-efficacy levels, and how these variables relate to exercise experiences and adherence [95–97]. This work could inform the design of interventions that better leverage and target the potential of social connection, reward and support to benefit the exercise experiences and health outcomes of individuals across a wider range of personality traits and socio-cultural backgrounds.

5. Conclusion

Affective dimensions of physical exercise and social integration and belonging are fundamental to addressing global public health challenges of physical inactivity and social isolation or loneliness. Traditionally, physical (in)activity research and social psychological research on these issues have proceeded in parallel, occupying distinct academic domains. Despite promising recent examples [31, 62, 63, 98], cross-fertilization between domains is historically limited by parochial emphases on the social factors that influence either health and wellbeing or performance in physical activity and exercise. Whereas social-environmental approaches to physical inactivity have focused primarily on social-ecological conditions that promote or inhibit health-beneficial exercise behaviour, social psychological approaches to exercise adherence and performance have focused overwhelmingly on social facilitation effects engendered via stress (at worst) or distraction (at best), or on the benefits of cohesion for adherence, performance and health in team or group settings with clearly defined boundaries.

Here, we suggest that these issues do not belong in any single discipline, and that approaches need to draw from traditionally disparate areas of science (e.g., sports science, evolutionary anthropology, social psychology) to effectively inform public policy and civic engagement. The research here takes a broad interdisciplinary, evolutionary and psychological approach to human social behaviour, drawing from an extensive literature demonstrating that humans derive intrinsic pleasure from connecting, coordinating and cooperating together, and that our cooperative sociality profoundly influences homeostatic function, wellbeing and health. How do the motivations and rewards of human cooperative sociality, in general, influence exercise experiences? Using survey and performance data, we analysed hypothesised associations between rewarding and supportive social experiences and perceptions, subjective feelings of enjoyment, fatigue, and energy and objective performance in the context of parkrun. Results reveal associations between positive social engagement, integration and support and feelings of energy, which in turn positively impact performance outputs. The findings motivate new orientations on old questions
about the social determinants of engagement and performance in exercise, offer novel directions for research into the public health value of community-led sports and exercise initiatives, and contribute to our nascent understanding of the synergistic interdependencies between social, psychological and biological factors in homeostatic self-regulation in exercise.

**Abbreviations**

RPE – Rating of Perceived Exertion

SOM – Supplementary Online Material

**Declarations**

**Ethics approval and consent to participate:**

This research was approved by the School of Anthropology and Museum Ethnography Departmental Research Ethics Committee, University of Oxford (reference number: SSHSAME_C1A_15_084) and all participants gave prior, written, informed consent.

**Consent for publication:**

not applicable

**Availability of data and materials:**

The dataset generated during the current study and all code are available on GitHub, [https://github.com/arranjdavis/parkrun_survey_analyses_sociality_and_exercise_performance](https://github.com/arranjdavis/parkrun_survey_analyses_sociality_and_exercise_performance)

**Competing interests:**

The authors declare that they have no competing interests.

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**Authors’ contributions:**
AD and EC contributed to study design, analysis, and write-up; PM and AD wrote the scripts needed to acquire data via the parkrun website; AD collected survey data along with a research assistant. All authors approved the final publication.

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Figures

Figure 1

Mediation diagram depicting the direct, indirect, and total effects of the social predictor variables – the parkrun community component (H5.1), whether or not participants came or met up with family and/or friends (H5.2), and their pre-run sociality (H5.3) – on 5 km run times, with participants' perceived energy as a potential mediator. Statistical significance: p < .001 (**), p < .01 (**), p < .05 (*).

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