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Know Before You Go! A Field Survey of the Preparedness of Wilderness Day Hikers and Trail Runners in Rocky Mountain National Park

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Abstract

Introduction: Actively recreating in natural environments enhances physical and mental health but also carries risk. We aimed to characterize wilderness day hikers and trail runners and examine factors that predict preparedness.

Methods: We conducted a cross-sectional survey in 4 distinct areas of Rocky Mountain National Park in Colorado during June to August of 2024. English-speaking adults returning from a day hike or trail run were invited to participate. We classified visitors as prepared based on the gear they reported carrying.

Results: Of 801 potential participants approached, 586 day hikers (82.3%) and 68 trail runners (76.4%) agreed to participate. The overall average age was 40.7 y (range 18–82 y), 50.1% were female, and the most common state of residence was Colorado (47.3%). Day hikers tended to be older, travel in larger groups, and spend fewer days in the wilderness per year, whereas trail runners reported higher levels of experience and wilderness preparedness and were more likely to experience "close calls." A minority of participants met our definition of wilderness prepared, about half were altitude prepared, and approximately a quarter did not tell anyone where they were going or when they expected to return. Several measures of experience were associated with preparedness.

Conclusion: Both equipment and knowledge are important for safely when enjoying and leaving wilderness settings. Yet, many wilderness users in Rocky Mountain National Park did not meet our definition of adequate preparation, especially those with less experience. Additional efforts to increase the proportion of wilderness day users who are prepared may help further improve visitor safety.

Keywords

rescue work, Colorado, accident prevention, public health, wilderness medicine, running, hiking, cross-sectional studies, medical kit, education, travel, surveys and questionnaires, parks, recreational

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Introduction

The popularity of outdoor activities, such as hiking and off-road running, has increased dramatically in recent years, and participating in outdoor recreation increased during the COVID-19 pandemic.[1–3] Rocky Mountain National Park (RMNP), a large wilderness park in Colorado, is one of the most visited national parks in the United States.[4,5] RMNP encompasses 415 square miles (1075.8 square km), 94.8% of which is designated as wilderness. The elevation in RMNP ranges from 7600 to 14,259 ft (2316–4346 m) and includes 355 mi (571 km) of established trails.[6] Although the vast majority of visitors recreate without incident, between 2009 and 2011, the

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park averaged 229 rescue operations per year.[7] Day hikers make up the overwhelming majority of Search and Rescue (SAR) operations in RMNP.[8]

Many common mishaps in wilderness settings are easily preventable. For example, acute mountain sickness (AMS), dehydration, and respiratory distress can be prevented with acclimatization, access to proper hydration, and prophylaxis with medications such as acetazolamide and dexamethasone.[9,10] When injury or illness occurs in wilderness settings, preparedness may help mitigate morbidity and mortality. Preparedness requires both knowledge and gear. Previous studies have used the "10 essentials" list of key items to carry in case of problems as a proxy for whether hikers are prepared.[11] Many visitors to RMNP, especially those visiting Longs Peak, are unaccustomed to the extreme altitude.[12] Previous research also has documented that most people on the highest mountain peaks in Colorado have low preparedness, often lacking medical knowledge and/or safety gear.[13] Taken together, it would be beneficial to have additional information on wilderness users and how preparedness in gear or knowledge can prevent dangerous situations.

While the epidemiology of preparedness in some outdoor populations, such as backpackers and climbers, has been studied in both RMNP and in general, there is a dearth of peer-reviewed studies on US off-road runners.[13–15] Off-road running includes trail runners, mountain running, skyrunning, fell running, orienteering, cross-country running, and ultramarathon running (collectively referred to as *trail runners*).[16] While trail running has many benefits, it also carries a high risk of injuries.[17,18] Trail running is semi- to fully self-sufficient, whereby runners must carry their own gear, navigation, hydration, and food.[16] Compared with hikers, trail runners often travel further distances while carrying lighter packs with minimal hydration due to weight or comfort concerns, a combination that may put them both at higher risk of injury and at higher risk of adverse outcomes if an incident occurs.[15,19,20] Previous research has focused primarily on trail running in race environments.[21,22] We were unable to find any previous studies specifically examining recreational trail runner preparedness and habits. Additionally, no study has examined preparedness among visitors to RMNP following the COVID-19 pandemic (after 2020), a period when park usage first dropped significantly and subsequently surged.[4] During the COVID-19 pandemic, after initial stay-at-home orders ended, many people turned to outdoor recreation as a safe, healthy, and beneficial activity—a substantial portion of whom were new or inexperienced.[3,23]

To address these knowledge gaps, we conducted a cross-sectional survey in RMNP in 2024 during the 3 busiest months of the year. Our goals were to 1) characterize the demographics, experience, and preparedness of post-pandemic wilderness day users and 2) examine the association between experience and preparedness among both trail runners and day hikers.

Methods

We administered a cross-sectional survey to a convenience sample of day hikers and trail runners on backcountry trails in RMNP in June, July, and August of 2024. RMNP was chosen because of its popularity, varied elevation, and generalizability to other large mountainous wilderness parks. More than 4 million visitors enter RMNP each year, and more than half of the total visits each year occur during these 3 months.[4] We approached day hikers and trail runners in 4 areas of the park (Bear Lake, Longs Peak, Wild Basin, and the Colorado River District; Figure 1). Each area of the park was sampled on a rotating basis on both weekends and weekdays throughout the 3 months, for a total of 38 sampling days. These areas were selected to provide a sample of users across trails that varied in characteristics, popularity, and difficulty level. Longs Peak was of particular interest because it has high use and high altitude; most of the trail is above tree line and therefore very exposed, with frequent extreme weather.[24] The Bear Lake area is one of the most visited locations in the park and is often recommended for its network of trails, accessibility, and lakes.[25,26] The other trailheads offer hikes of varying difficulty, popularity, terrain, elevation, and other attributes. National Park Service (NPS) signage at the beginning of all trailheads surveyed listed essential items to carry, the hazards of high altitude (including the symptoms of AMS), a reminder to let someone know where you're going and when to expect you back, regulations (including "Stay on trail"), a map, hazard information, and more (see Supplemental Figure 1).

We approached potential participants as they were returning from their hike/run to minimize recall bias about their experience. Potential participants were informed of the study purpose and asked if they would be interested in participating. We approached every third group of day hikers and every trail running group. Those who met the inclusion criteria (≥18 years of age, literate in English, and returning from a hike or run that was <24 hours in duration and >2 miles) and were willing to participate were invited to complete the anonymous survey on a tablet. The first section of the survey included information required for informed consent. Given the wilderness context of the study, the use of tablets to administer the survey digitally, and verbal consent procedures, participants did not receive a copy of the consent form. All participants hiked or ran in wilderness designated areas. If hikers/runners were in a group, only 1 person per group was eligible to take the survey. For groups with more than 1 person, the person with the next birthday was asked to take the survey to eliminate volunteer bias. The survey was developed and

Figure 1. Study trailheads. A map of the park showing the trailhead locations that were surveyed within Rocky Mountain National Park. Base map data: Copyright OpenStreetMap; data: National Park Service.

implemented in REDCap, and administered via tablets in offline mode. Survey responses were uploaded to REDCap once internet access was available. The study was approved with an exempt determination by the Boston University Medical Campus Institutional Review Board.

Most of the survey questions were multiple choice or spectrum based; some were optional and open response.[12,27] Hikers and trail runners self-selected their level of wilderness experience (one, little, some, experienced), days/years of wilderness experience, self-designated preparedness, equipment carried, health status, demographics, residence, hike completion status, altitude experience, and health problems or safety concerns encountered during the hike. Most survey questions were intended for the individual answering the survey, but some required considering everyone in the group.

We are not aware of any standardized convention for determining day hiker/trail runner preparedness or altitude preparedness. Consequently, we developed our own scale

to assess each of these, using previously published literature,[12,13,27] wilderness educational information, and feedback from experienced outdoor enthusiasts. Participants were categorized as "wilderness prepared" if they had at least 1 L of water *and* 7 of 13 of the "10 essentials" *and* a map or equivalent *and either* 2 rescue devices *or* 8 of 15 recommended first aid items. The rationale for this scale is that prepared visitors should have adequate hydration, carry the "essentials," be able to orient themselves, and be able to signal for help or be equipped for basic first aid in the event of an injury or illness.[28] We included 13 items on our list of "10 essentials" because different sources include different essentials, and although most overlap, some participants may reasonably opt to carry different items depending on their source of information.[29–32]

Similarly, we used a scale to determine whether participants were prepared for high altitude. Participants who scored 3 or more points were categorized as "altitude prepared." One point was awarded for each of the following: having an altimeter or equivalent (topographic map + compass or a GPS device), taking or considering pharmacologic prophylaxis for altitude illness, self-reporting a safe ascent plan, and knowing at least 2 of the major symptoms of AMS (headache, emesis, fatigue, difficulty sleeping, tachycardia, irritability, dyspnea, and dizziness).[10] Synonyms for certain AMS symptoms were accepted as correct. This scale is identical to that used in a previous survey study conducted in RMNP in 2018.[12]

Data were stored and analyzed in REDCap, Microsoft Excel 2016 (Microsoft Corp, Redmond, WA) and R (version 4.2.3).[33] Data cleaning included removing extreme values likely to be typos (e.g. age −35 was removed). We performed descriptive statistics and multivariate logistic regression analysis to quantify the association between experience and preparedness, adjusting for activity, trip time, sex, age, and group size. Continuous variables were tested for statistical significance using an independent 2-sample t test, and categorical variables were tested with Pearson's χ^2 test for independence. $P \leq 0.05$ was used to determine statistical significance. Based on *a priori* power calculation, we planned to enroll at least 515 participants because this number was estimated to provide sufficient sample size to find a 15% absolute difference in the proportions of groups that are prepared using χ^2 single-variable analysis, with extra statistical power for multivariate logistic analysis. We express our findings of the regression analysis as odds ratio (OR) with 95% confidence intervals (CI).

Results

We invited 801 groups or individuals (712 day hikers and 89 trail runners) to participate in the study. Of these, 82.3% (n=586) of day hikers and 76.4% (n=68) of trail runners consented to participate (median age 38 y, range 18–82 y, interquartile range 28–52 y). Approximately half the respondents were female (50.1%), and the most common state of residence was Colorado (47.3%). Respondents represented a total of 1714 individuals from 44 US states and 15 countries.

Differences Between Groups

Compared to day hikers, trail runners were more likely to be male, younger, and travel in smaller groups (Table 1). Group sizes ranged from 1 to 20 for day hikers (median 2) and from 1 to 5 (median 1) for trail runners. Day hikers reported significantly fewer days of wilderness experience per year (30.1±37.3 vs 92.7±86.1, mean ± SD) compared with trail runners. Trail runners also tended to have more days of wilderness experience per year, self-reported higher wilderness experience levels, and were more likely to have previously experienced a wilderness injury/illness. Trail runners reported going "significantly off trail" at much higher rates than day hikers (26.9% vs 3.3%). Trail runners were more frequently only recreating in the wilderness for 1 day, whereas day hikers reported recreating in the wilderness for more consecutive days. Trail runners self-reported higher levels of physical fitness than day hikers; few (n=34) participants in either group self-reported low fitness. More than 90% of participants reported completing their planned hike or run.

The overall proportion of those who experienced injuries or illness on the day of the survey was low: 2.9% of hikers and 4.5% of runners. The most common injuries were ankle injuries, and the most common illness was AMS. Significantly more trail runners reported experiencing safety concerns or "close calls" on the day they participated compared to day hikers (13.4% of runners, 6% hikers, P=0.023). The most common of these close calls were weather related (e.g. being above the tree line in a thunderstorm), followed by falls and near falls.

Nearly all day hikers (87.7%) and trail runners (88.2%) categorized themselves as "adequately prepared" or higher; however, only a minority of day hikers (15.7%) and trail runners (25.0%) were classified as wilderness prepared using our measure. Less than half were categorized as altitude prepared. Overall, those who reported living at altitude were less likely to consider altitude prophylaxis (1.2% vs 5.4%, P=0.012) compared with others. Those who lived at altitude were more likely to be altitude prepared (46.8% vs 38.1%, P=0.039). Fewer day hikers informed a third party of their plan for the day or when to expect them back compared with trail runners (72.9% of hikers, 83.6% of runners). On average, day hiker groups reported carrying more first aid items than trail runners. Individuals from both groups reported carrying about the same number of essential items.

Extra food and extra clothing were the most commonly carried essential items among respondents (Figure 2). Day

Table 1. Characteristics of Day Hikers and Trail Runners in Rocky Mountain National Park (RMNP) in Summer 2024.

	Overall, N=654	Day hiker, N=586	Trail runner, N=68	*P*-value[a]
Age (y), median (p25, p75)	38 (28, 52)	39 (28, 53)	32 (28, 45)	0.019
Age category (y), n (%)				0.108
18–29	201 (31%)	176 (30%)	25 (37%)	
30–39	142 (22%)	122 (21%)	20 (30%)	
40–49	117 (18%)	106 (18%)	11 (16%)	
50–59	97 (15%)	91 (16%)	6 (9.0%)	
60+	94 (14%)	89 (15%)	5 (7.5%)	
Group size, median (p25, p75)	2.0 (2.0, 3.0)	2.0 (2.0, 3.0)	1.0 (1.0, 2.0)	<0.001
Sex, n (%)				0.034
Male	316 (48%)	273 (47%)	43 (63%)	
Female	324 (50%)	300 (51%)	24 (35%)	
Other/unknown[b]	14 (2.1%)	13 (2.2%)	1 (1.5%)	
Wilderness experience level, n (%)				<0.001
None/little	115 (18%)	113 (20%)	2 (3.1%)	
Some/experienced	522 (82%)	459 (80%)	63 (97%)	
Experienced safety concerns or "close calls" today, n (%)	44 (6.8%)	35 (6.0%)	9 (13%)	0.023
Informed third party of plans and when to expect them back, n (%)	479 (74%)	423 (73%)	56 (84%)	0.060
Wilderness prepared, n (%)[c]	109 (17%)	92 (16%)	17 (25%)	0.052
Altitude prepared, n (%)[d]	260 (41%)	228 (40%)	32 (49%)	0.166
Consecutive days planning to be in the wilderness, n (%)				<0.001
1 d (today only)	291 (46%)	247 (43%)	44 (68%)	
2–3 d	144 (23%)	137 (24%)	7 (11%)	
4–6 d	111 (17%)	107 (19%)	4 (6.2%)	
7+ d	89 (14%)	79 (14%)	10 (15%)	
Number of essential items carried, median (p25, p75)	6.0 (3.0, 8.0)	6.0 (3.0, 8.0)	6.0 (3.0, 8.0)	0.806
Number of first aid items carried by group, median (p25, p75)	2.0 (1.0, 4.0)	2.0 (1.0, 4.0)	1.0 (0.0, 3.0)	0.002

[a]Pearson's χ^2: Rao and Scott adjustment, design-based Kruskal-Wallis test.
[b]6 (1%) hikers selected 'prefer not to answer' for sex, 1 hiker was non-binary
[c]Participants were categorized as 'wilderness prepared' if they had at least 1L water, and 7/13 of the '10 essentials', and a map or equivalent, and either two rescue devices or 8/15 recommended first aid items
[d]Participants were categorized as 'altitude prepared' if they reported at least 3 of: having an altimeter or equivalent, taking or considering pharmacologic altitude illness prophylaxis, self-reporting a safe ascent plan, knew at least two of the major symptoms of AMS.

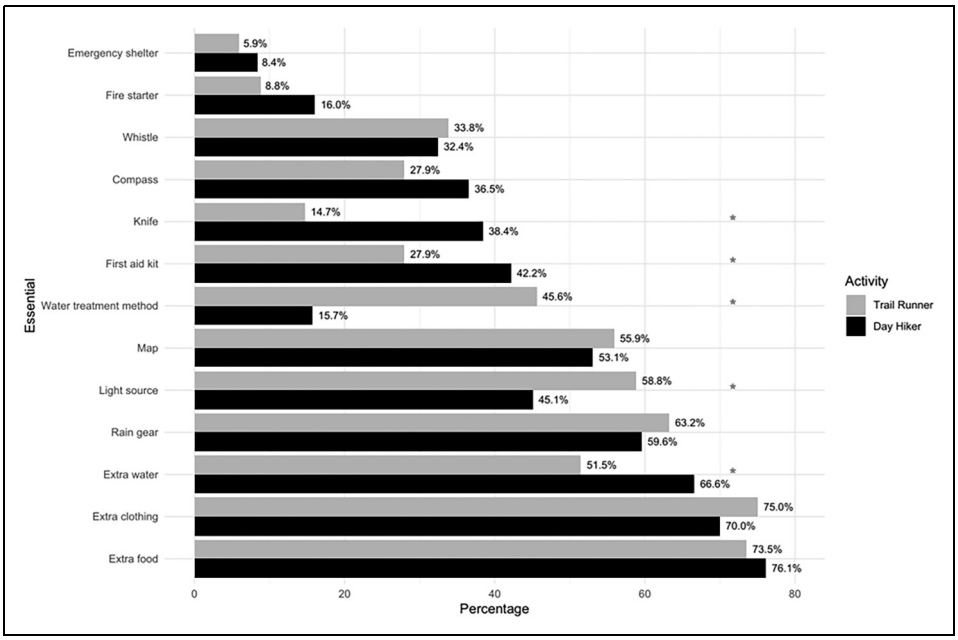

Figure 2. Percentage of individuals carrying each essential item by activity. Statistical significance marker: **P*<0.05.

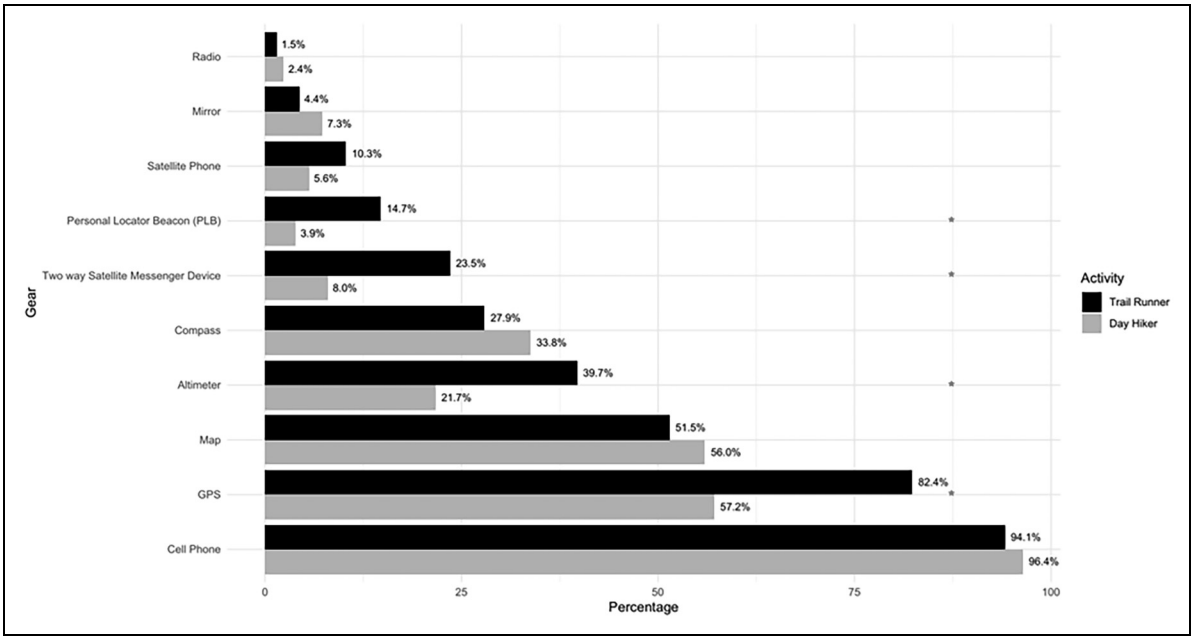

Figure 3. Percentage of people/groups carrying navigation and communication gear by activity. Statistical significance marker: *$P<0.05$.

hikers were significantly more likely to carry extra water, a first aid kit, and a knife compared with trail runners. Trail runners were significantly more likely to carry a light source and water treatment method compared with day hikers.

Figure 3 shows the proportion of specific types of navigation and communication gear carried by a respondent or someone in their group. Nearly all participants/groups carried a cell phone. Trail runners were significantly more likely to carry a GPS device, altimeter, 2-way satellite messenger device, and personal locator beacon compared with day hikers. Just over half of all groups carried a map during their wilderness day hike or trail run.

Sunscreen was the most common first aid item carried by both groups. Day hikers were significantly more likely to carry sunscreen and bandage/tape compared with trail runners (Figure 4). Overall, most groups did not carry most of the 15 first aid items asked about in the survey.

Trail Runner Characteristics

We encountered relatively few trail runners while surveying, 142 individuals (compared with 5604 individual day hikers and 270 individuals doing other activities). Among trail runners, those who reported scrambling during their run were significantly more likely to report having gone "significantly off trail" (8.7% vs 36.4%). Male trail runners were significantly more likely to report going "significantly off trail" during their run compared with female participants (see Supplemental Table 1). Those who reported scrambling also rated their run as more difficult, went on longer runs, carried more first aid and essential items, and were more likely to live in Colorado (see Table 2 and Supplemental Table 2).

Wilderness Preparedness and Experience

Our survey asked several questions related to experience. We then fit a model to examine overall experience-related predictors of wilderness preparedness and found key predictors related to experience: trip length, days spent in the wilderness settings per year, higher self-reported experience level, and prior wilderness injury history all significantly increase the odds that someone was wilderness prepared (Table 3). Self-reporting being "some/experienced" vs "none/little" was associated with more than double the odds of preparedness; each additional day spent in the wilderness per year was associated with slightly higher odds (~0.5% per day) of preparedness; each additional hour of trip time was associated with higher odds of preparedness by ~21% per hour; and having experienced a prior wilderness injury/illness was associated with higher odds of preparedness by ~80%, possibly reflecting increased caution or experience following injury. The number of years of wilderness experience reported did not significantly change the odds of being wilderness prepared, nor did the number of times a person had been on that trail before.

Those who were wilderness prepared were significantly more likely to have told a third party of their plans, to have been at high altitude before, to be altitude prepared, to be on trail for more hours, and live in Colorado. There was no

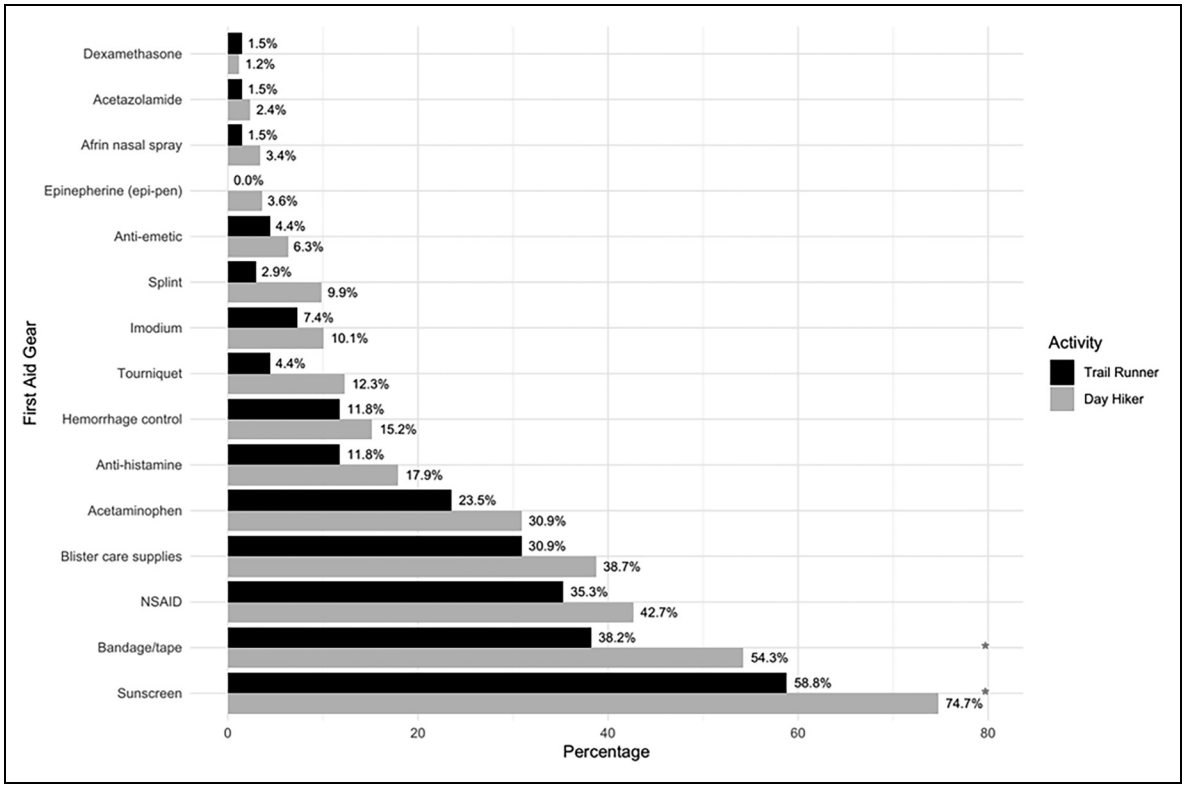

Figure 4. Percentage of people/groups carrying each first aid item by activity. Statistical significance marker: *$P<0.05$. NSAID, nonsteroidal anti-inflammatory drug.

significant association between wilderness preparedness and age, sex, group size, talking to the NPS staff or reading NPS materials, amount of water carried, trip completion status, or injury/illness on the day of the survey.

Discussion

Differences Between Groups

In this survey of 654 recreational wilderness day hikers and trail runners in RMNP, we found significant differences between day hikers and trail runners—runners tended to be younger, were more often male, experienced more safety concerns on trail, and tended to be more experienced overall. More frequently, trail runners traveled alone and reported going "significantly off trail," likely increasing their risk if injured. Although most day hikers and trail runners informed a third party of their plans and when to expect them back, a substantial minority did not. Additionally, both day-use visitor groups overestimated their level of wilderness and altitude preparedness.

Our findings differ from prior literature in several important ways. We found that about half of day hikers were female and a majority (63%) of trail runners were male, whereas previous studies of similar hiking populations in other outdoor areas and times generally found that ~60% were male.[11,17,35] This finding may indicate that the gender distribution of day hikers may have changed after the pandemic. Our study found no difference in or association with sex on wilderness preparedness, differing from the findings of Yue et al.[12] The number of essentials carried in our study generally was lower than that found in other studies in New Hampshire and Colorado, although this is likely explained by the exclusion of overnight backpackers from our study and inclusion in others.[13,27] The number of essential items carried in our study (mean=5.6±3.05, median 6) was slightly higher than that found in 2016 by Daniel et al (mean=5 ±2, median 5) in New Hampshire day hikers.[36] Daniel et al reported that the most commonly needed "10 essentials" were the same top 4 (extra food, clothing, water, and rain gear) carried in our sample, although our study found a low proportion carrying a first aid kit—a key piece of gear to prepare for common adverse events. In our study, 11% of all participants reported carrying between 10 and 13 of the "10 essentials" items, whereas 27.2% of participants reported carrying >7 of the essentials. This is lower than what Mason et al found, in which 40.6% carried >7 and 17.8% all 10 essentials in New Hampshire.[27] This may be due to small sample size (n=199) and very different areas (New Hampshire) and years (2011).

Table 2. Characteristics of Trail Runners by Level of Wilderness Preparedness.

	Overall, N=68	Not wilderness prepared, N=51	Wilderness prepared, N=17	*P*-value[a]
Sex, n (%)				0.690
Male	43 (63%)	31 (61%)	12 (71%)	
Female	24 (35%)	19 (37%)	5 (29%)	
Other/unknown	1 (1.5%)	1 (2.0%)	0 (0%)	
Age category, n (%)				0.195
18–29	25 (37%)	15 (30%)	10 (59%)	
30–39	20 (30%)	17 (34%)	3 (18%)	
40–49	11 (16%)	8 (16%)	3 (18%)	
50–59	6 (9.0%)	6 (12%)	0 (0%)	
60+	5 (7.5%)	4 (8.0%)	1 (5.9%)	
Group size, n (%)				0.163
1	39 (57%)	32 (63%)	7 (41%)	
2	17 (25%)	13 (25%)	4 (24%)	
3	6 (8.8%)	3 (5.9%)	3 (18%)	
4	5 (7.4%)	2 (3.9%)	3 (18%)	
5	1 (1.5%)	1 (2.0%)	0 (0%)	
Trip time (h), median (p25, p75)	4.5 (3.0, 6.5)	4.0 (3.0, 6.0)	6.0 (4.5, 7.0)	0.045
Number of times on this trail before today, median (p25, p75)	1 (0, 6)	1 (0, 10)	1 (0, 4)	0.592
Days of wilderness experience per year, median (p25, p75)	70 (30, 104)	50 (30, 100)	100 (30, 150)	0.277
Years of wilderness experience, median (p25, p75)	14 (6, 25)	15 (7, 25)	8 (6, 20)	0.320
Altitude prepared, n (%)	32 (49%)	18 (38%)	14 (82%)	0.002
Went significantly off trail today, n (%)	18 (27%)	13 (26%)	5 (29%)	0.786
Water carried (L), median (p25, p75)	1.0 (0.8, 1.5)	1.00 (0.6, 1.5)	1.50 (1.0, 2.0)	0.021

Note. Data stratified by sex are available in Supplemental Table 2.
[a]Pearson's χ^2: Rao and Scott adjustment, design-based Kruskal-Wallis test.

Table 3. Predictors of Wilderness Preparedness.

Predictor	Odds ratio	95% CI	*P* value
Sex			
Male	—	—	
Female	1.01	0.64, 1.61	>0.9
Other/unknown	0.49	0.05, 4.55	0.5
Age (y)	1.01	0.99, 1.03	0.3
Group size	0.99	0.87, 1.12	0.9
Self-reported wilderness experience level			
None/little	—	—	
Some/experienced	2.32	1.04, 5.16	0.040
Activity			
Day hiker	—	—	
Trail runner	1.03	0.48, 2.22	>0.9
Trip time (h)	1.21	1.09, 1.33	<0.001
Number of times on this trail before today	1.00	1.00, 1.00	>0.9
Days of wilderness experience per year	1.01	1.00, 1.01	0.015
Years of wilderness experience	0.98	0.96, 1.00	0.10
Experienced prior wilderness injury/illness	1.80	1.09, 2.98	0.022

Trail Runner Characteristics

To our knowledge, this study is the first of its kind to evaluate wilderness preparedness among trail runners compared with general wilderness preparedness. Trail runners were found to have distinct characteristics and patterns. Trail runners reported experiencing safety concerns or "close calls" on the day of the survey in higher proportions than day hikers. This may be due to their higher speed and resulting reaction-time differences or may be due to other factors. Notably, a high percentage of trail runners went "significantly off trail" (26.9%), especially those who reported scrambling. These trail runners are typically more difficult to find if a search is initiated. In recent years, multiple trail runners have gone missing or died while off trail or scrambling, and SAR teams have had difficulty finding or reaching them.[20,34,37] These findings, taken together, illustrate the importance of trail runners prioritizing measures to ensure their safety, even more so than for day hikers. Our results confirm findings from a recent study of Brazilian trail runners that reported high rates of injuries (36%) in the past 12 months.[17] The lower participation rate and smaller sample size of trail runners suggest the need for further inquiry into this group. Just over 40% of runners in our study reported previously

experiencing a wilderness injury or illness. Although "only" 4.5% of runners reported experiencing an injury or illness on the day of surveying, when extrapolated to the entire population, this represents a large number of people experiencing injuries and illnesses while trail running.

Wilderness Preparedness and Experience

We identified multiple measures of experience that were associated with wilderness preparedness. Our findings suggest that visitors who spend fewer days in the wilderness per year, who are on shorter trips, and who identify as less experienced were less wilderness prepared. Consequently, Preventative Search and Rescue (PSAR) efforts for preparedness may be most effective when targeting these groups. Those who have previously experienced a wilderness injury or illness seem to have learned from this experience and were significantly more likely to be prepared in our sample. Neither years of wilderness experience nor familiarity with that trail significantly changed the odds of being wilderness prepared. This may indicate a sense of overconfidence or complacence. Our findings further suggest that PSAR should not assume that visitors with more years of wilderness experience, age, or familiarity with the trail are more wilderness prepared. Previous research has shown mixed evidence on the impact of age on wilderness preparedness but generally agrees with our finding that experience increases preparedness.[11–13]

Overall

Wilderness day hikers and trail runners generally must be in good physical shape because hiking or running in the wilderness of RMNP is physically taxing due to both the altitude and the mountainous terrain. It is unsurprising that most of the participants met this requirement. Visitors to the park may experience shortness of breath, fatigue, or other symptoms during periods of exertion activities at altitude. Higher levels of fitness and altitude acclimatation can reduce the risk of experiencing these symptoms, and visitors are advised to prepare for a wilderness adventure by increasing fitness and acclimatation beforehand. Nearly half the study participants reported living in Colorado and therefore may have been at least partly acclimated to the altitudes experienced in the park. However, most of the respondents did not live at altitude, and their youth or general fitness may have been an inadequate substitute for intentional preparedness.

RMNP, like most wilderness areas, generally has poor cellular coverage. For this reason, it's important for wilderness users to carry an alternative method to signal for help in case something goes wrong. Although nearly every group/individual carried a cell phone, it should not currently be relied on as a way to signal for help. A higher number of hikers and runners than expected carried alternative methods such as 2-way satellite messaging devices, satellite phones, and personal locator beacons. However, these numbers still were relatively small; fewer than a quarter of hiking groups and fewer than half of running groups had an alternative way to call for help beyond a cell phone. This may change in the coming years because phone manufacturers are increasingly adding satellite SOS and 2-way satellite messaging to new cell phones. In 10 years, carrying an extra battery/cord to charge a satellite-capable cell phone may be just as effective as carrying one of these dedicated devices today. Currently, only a few cell phones are able to connect to satellites, but this market is expected to expand rapidly and may increase both dependence on smartphones and wilderness connectivity.[38] This has not yet been studied in a systematic way but may have major implications in the near future. Future studies should examine the impact of these phones, once they are commonplace.

As other groups have identified, just carrying 10 items from a list does not solely determine whether one is ready to safely recreate in the wilderness.[36] We categorized participants as prepared mainly based on the equipment they carried, but physical preparation and mental preparation are also likely just as important as the gear carried. Another consideration is that for a short hike on a high-traffic trail, certain items will be more useful or have a higher likelihood of use than others. Future studies should consider taking into account the distance traveled, popularity, and difficulty of the trail when categorizing preparedness. Each wilderness user should be aware of the physical, mental, and equipment recommendations and prepare for each excursion accordingly. Wilderness users should ensure that they know how to use all the items they decide to carry.

Strengths and Limitations

Our study had several limitations. The items included on "10 essentials" lists vary widely, and our list of 13 items may not have included all the items included on whichever list any individual may have consulted before packing.[32] Additionally, some items on our list may vary by person (e.g. what they consider to constitute extra clothing). Trail runners declined to participate at a higher rate than day hikers, and fewer were recruited than planned. The most common reasons given for declining to participate in this study were a lack of time and an unwillingness to stop. A handful of potential participants declined to participate due to dehydration/lack of water, hunger, fatigue, or weather. Potential subjects who declined to participate may represent a possible source of selection bias. Additionally, day hikers and trail runners who visit RMNP between September and May may represent a

different population than our study cohort. Preparedness is difficult to assess with a written survey, and the instruments used here have not been validated. However, our results are generally consistent with related literature. Individuals who live at altitude may not need to prepare for altitude because they are already partly or fully acclimated, but we did not account for this in our assessment. As with all surveys, there is variability in individual effort, however we believe that most participants put ample effort into answering. Due to low participant volume, no data collection occurred after dark, but this may have caused us to unintentionally exclude some of the least or best prepared hikers or runners. Lastly, our survey population only included individuals who were 18 years of age or older, so Scouts and Junior Rangers, who may be more well prepared, were excluded.

Notable strengths of this study include that this was the first of its kind to characterize wilderness trail runners and their preparedness. Data collection occurred in the field as participants were returning, so recall bias was minimized and data are high quality. Nearly all other wilderness survey studies have a limitation in which they may have missed participants who required SAR. In our study, no participants reported injuries severe enough that they planned to go to a clinic or hospital for treatment, but 1 SAR incident occurred on the same trail during the survey. The incident required assistance from the field researcher (JTL), and data collection was halted for the day. The individual requiring assistance was not asked to participate in the study; they were a day hiker requiring hospital-level treatment for an injury resulting from a fall. Other SAR incidents occurred in other parts of the park or at different times from data collection but did not impact participation, data collection, or findings.

Notwithstanding this study's limitations, our findings have implications for improving visitor preparedness and safety by providing insight into wilderness day users. Although most of both hikers and trail runners informed someone of where they were going and when to expect them back, increasing PSAR efforts to get those percentages (72.9% and 83.6%) closer to 100% would have a low cost/effort and high reward. When SAR is required, time is critical. A timely alert to an overdue person and accurate information about their planned whereabouts is likely to save lives.[39] Our finding that users who had previously experienced a wilderness injury/illness are more likely to be prepared illustrates that past experience is more predictive of preparedness than many other attributes. This finding reinforces the importance of lived experience as a driver of preparedness in these populations and warrants further attention. With only 15.7% of hikers and 25% of trail runners categorized as wilderness prepared, it is clear that ample opportunity for PSAR exists. PSAR seeks to educate wilderness visitors and reduce the number of visitors requiring SAR assistance. Visitors who are more prepared may be better able to quickly and accurately request help, self-rescue, or not need SAR at all. While RMNP already has PSAR efforts in place, this study illustrates where current strategies may require refinement or additional resources. However, RMNP is just one of many national parks, and itself is surrounded by national and state forests. Millions of wilderness hours are spent in similar environments, and it's important that day hikers and trail runners develop and use skills and equipment whenever they are in wilderness settings. RMNP and other parks may be ideal locations for teaching and equipping people to be safe no matter where or when they recreate in nature. The results from this study may help to inform better direct messaging during PSAR efforts to those who are least prepared or at elevated risk.

Conclusion

Wilderness day hiking and trail running are demanding activities, especially at the high altitude and rapidly changing weather of RMNP. The results of this study strengthen our understanding of wilderness trail runners and day hikers. Wilderness travel has certain inherent risk, both this study and prior work illustrate that injuries and illnesses can happen to anyone in the wilderness.[35,40,41] Overall wilderness preparedness was highly variable but generally low—possibly due to limited experience and the high cost of equipment. There are a number of factors that lead to SARs, but increased education and preparedness have been shown to decrease SAR missions. Aiming educational interventions at those at highest risk or lowest preparedness may help increase preparedness and reduce SAR events in the future. Should an incident occur on the trail, the success of safely leaving the wilderness depends in large part on the equipment and knowledge of those involved.

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Ethical Considerations

The study was approved under exempt determination by the Boston University Medical Campus Institutional Review Board (IRB No. H-44879) on May 5, 2024. We obtained the necessary permit to conduct research in Rocky Mountain National Park (Permit No. ROMO-2024-SCI-0012) on May 15, 2024.

Consent to Participate

Participants verbally consented to participate in this study. Written consent was waived by the Boston University Medical Campus Institutional Review Board. No personally identifiable data were collected.

Author Contribution(s)

John T. Lambert: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Writing – original draft; Writing – review & editing.

Davidson H. Hamer: Methodology; Resources; Supervision; Writing – review & editing.

Taylor N. Weckstein: Conceptualization; Methodology; Writing – review & editing.

Gregory A. Wellenius: Formal analysis; Methodology; Resources; Supervision; Writing – review & editing.

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Declarations of Conflicting Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data Availability

The datasets generated during and/or analyzed during this study are available from the corresponding author on reasonable request.

Supplemental Material

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1177/10806032261430331.

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