

# Defining Off-road Running: A Position Statement from the Ultra Sports Science Foundation

## Authors

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## ABSTRACT

Off-road running continues to grow in popularity, with differing event categories existing, and terminologies are often used interchangeably and without precision. Trail running, mountain running, skyrunning, fell running, orienteering, obstacle course racing and cross-country running all take place predominantly in off-road terrain. Ultramarathon running refers to any running event over marathon distance conducted in any terrain and surface. Although some overlap may exist between these running events, mainly through the common denominator of off-road terrain, distinct features need to be recognised. As scientific interest in these activities grows, it becomes important to clarify these terms and develop a universal language for discussing these events. Similarly, off-road running athletes are generally not properly defined within the scientific literature, which makes intra- and inter-study comparisons difficult. The current position statement of the Ultra Sports Science Foundation highlights the different off-road running events and recommends clear reference to distance, surface, elevation change and altitude, type of event (continuous vs. staged), type of support, name and year of the event, governing body, and guidance on terminology. We further recommend to describe off-road running athletes by basic data, physiological determinants, training and competition characteristics in the scientific literature in order to facilitate and guide further research and practice.

## Introduction

Off-road (e. g. unsealed surface and natural environment) running events have become increasingly popular and participation has grown substantially in recent years with many new races appearing around the world [1–4]. Trail running, for example, as the most popular off-road running sport, has grown considerably from approximately 4.8 million participants in 2009 to 9.1 million in 2017 in the US alone [5]. Popular worldwide endurance races include the

Ultra Trail du Mont Blanc, Marathon de Sables, Comrades Marathon, and Western States Endurance Run [4, 6, 7]. Within this broad context of athletic activities, several distinct categories of running events exist, including trail running, mountain running, skyrunning, fell running, orienteering, obstacle course racing, cross country running, and ultramarathon running. The descriptive terms for these events are often used interchangeably and without precision. Running event categories are generally differentiated by distance,

terrain, elevation change, race time, and competition rules as defined by the respective governing bodies [8–11]. Some overlap exists, with the broad category inclusive to all disciplines being the off-road terrain and environment. However, it is vital to include other distinct features when defining those running events to appropriately and accurately describe them. For example, ultramarathons, which are defined by a distance longer than the standard marathon distance of 42.195 km, can either take place on tarmac roads (e. g. paved, etc.), an athletic track, or off-road [2]. An ultramarathon held off-road can be considered trail running, fell running, or skyrunning, depending on the specifics of distance, terrain, and elevation change. Indeed, most ultramarathons take place off-road and fall within the defined area of trail running. Thus, they should be considered an ultra trail race according to the specific definitions by the governing body [10, 11]. Similarly, trail running, mountain running, skyrunning, and fell running all take place in natural environments, and they are generally surmised to be within the broad category of trail running. However, this is not correct because each discipline has quite distinct characteristics in terms of distance, elevation change, terrain, environmental conditions, and “event culture” (e. g. individual race characteristics, competitiveness, and community involvement). There is also an abundance of different nomenclature and spelling used in scientific publications, such as: ultramarathon, ultra marathon, mountain ultra marathon, mountain ultramarathon, ultra-trail-marathon, ultra trail running, long distance trail running, and trail running ultramarathon [12–17]. As scientific interest in these activities grows, it becomes imperative to clarify the terms and develop a universal language for discussing these events to avoid research misinterpretation and miscommunication and apply it appropriately to the relevant running population.

Furthermore, a variety of qualitative terms have been used in the literature to classify and define off-road running athletes. These classifications encompass terms such as physically active, recreational, endurance-trained, amateur, well-trained, and highly trained [17–20]. However, a misclassification from these qualitative categorisations is a problem from a scientific perspective. This is because comparing research data from one study group to another may be challenging and even confusing. Hence, providing clear direction for the characteristics recommended in defining off-road and endurance runners will enable a more precise and meaningful interpretation of existing studies and data.

With these previous points in mind, the main purpose of this position statement is to describe the different off-road running events and demonstrate the differences in these categories. We then offer our recommendations on proper descriptions of these running disciplines for future research related to these events. A further purpose is to describe and recommend athletes' characteristics that should be included in further research studies to enable a more precise and meaningful interpretation of existing studies and data putting the athletes' characteristics, competitiveness, and competition results into perspective.

## Materials and Methods

In 2018, an expert panel was convened under the direction of the first author (VS) with the assistance and support of the Ultra Sports

Science Foundation (USSF) (<http://ultrasportsscience.org>). This foundation is a non-profit body that aims to: enhance the health and safety of athletes participating in ultra-endurance sports; educate athletes, coaches, health professionals, and scientists on aspects of ultra-endurance sports, training, and competition; support international research; and organise educational meetings and raise awareness of scientific outcomes in ultra-endurance sports. Panel members have expertise in sports and exercise science, exercise physiology, biomechanics, sports nutrition and dietetics, environmental physiology, and sports medicine. Members were initially tasked with issuing a description of the different off-road endurance running events and population, highlighting the different disciplines and terminologies currently used to describe the event categories, characteristics, and participation. Pertinent literature was reviewed relating to ultra-endurance running, off-road running, trail running, mountain running, skyrunning, fell running, cross country running, orienteering, obstacle course racing, and ultramarathon running. Rules and definitions from the international governing bodies that oversee the different running disciplines, such as World Athletics (WA; formerly known as the International Association of Athletics Federations (IAAF)), International Trail Running Association (ITRA), World Mountain Running Association (WMRA), International Skyrunning Federation (ISF), Fell Runners Association (FRA), International Association of Ultrarunners (IAU), International Orienteering Federation (IOF), and Fédération Internationale de Sports d'Obstacles (FISO) were also reviewed. We acknowledge the existence of several national bodies or federations across all disciplines (e. g. British Athletics (BA), Trail Running Association (TRA) in the UK or the American or Australian Trail Running Association (ATRA)); however reviewing country-specific governing bodies was outside the review scope. Additionally, literature pertinent to defining athletic populations in these events was also retrieved and reviewed.

Panel members wrote specific sections of the manuscript addressing all components of the proposed article. Recommendations were then offered on standardised definitions and nomenclature for future scientific use. The background drafts were discussed and critically appraised by all members. In 2019, following regular discussions, members completed an initial draft of the position statement. After several rounds of discussions and some face-to-face meetings between some of the panel members, the manuscript and recommendations were finalised, and all panel members agreed. Research was conducted according to ethical standards [21].

## Historical background

Humans have been running for thousands of years and are capable of running long distances in pursuit of live prey with persistence hunting, a technique that relies on tracking and running down prey over long distances and periods of time [4, 22]. Notable groups that engaged in these activities include the San People, the Tarahumara, the Navajo and Paiutes, and Australian Indigenous Aboriginal tribes [23, 24]. In ancient Greek times, long-distance running was used to deliver messages. One of the most well-known messengers was Pheidippides (490 BC), who, during the Greek and Persian war, covered the distance between Athens and Sparta (around 140 miles) and return in 3–4 days to request military aid from neighbouring Spartans

for the impending Persian invasion of Greece [25]. Pheidippides may have been the first recognised ultra-endurance runner. The oldest and largest ultra-endurance running event was first run in 1921, the Comrades Marathon, an event that ‘celebrates mankind’s spirit over adversity’ commemorating South African soldiers killed during World War I. It is held annually and covers a distance of approximately 90 km and is currently capped at around 20 000 participants [4]. The first marathon was held at the Olympic Games of the modern area in Athens in 1896. Women at that time were not allowed to participate officially in running events. However, a Greek woman unofficially covered the same distance the following day after the men’s Olympic marathon. But women have been running since at least around 1000 BC, during the Herean games, an ancient Greek festival where young girls competed in foot races to honour the Greek goddess Hera [26]. But it was not until the Olympic Games in Los Angeles in 1984 that women were allowed to compete in Olympic marathon races [27]. Hill running (a.k.a. fell running) also has a long history with the first race being recorded in Scotland in 1040, with the aim of finding a fast messenger. But the first fell running races did not take place until the 19<sup>th</sup> century. Cross country races have been held since the 19<sup>th</sup> century and were an Olympic discipline between 1912 and 1924. Many off-road running and ultra-endurance running events have subsequently emerged all around the globe (e. g. the Ultra Trail du Mont Blanc, Marathon de Sable, Western States Endurance Run, Leadville 100, London to Brighton Run, and Al Andalus Ultimate Trail). Trail running as a governed sport is the newcomer, with the International Trail Running Association (ITRA) founded as recently as in 2013.

The rationale for running has shifted over the centuries from a necessity to survive, providing food for the tribes and families, to delivering messages and information during ancient Greek times, to the current day popularity of recreational running activities with the positive effects of exercise on health. With this popularity, many new running events and disciplines have emerged or increased their participation, including trail running, mountain running, skyrunning, fell running, cross country running, and ultramarathon running.

## Participation

Running is a popular sport and recreational races up to marathon distance showed that approximately 7.9 million participated in running events in 2018, down from approximately 9.1 million in 2016 [28]. These numbers do not include off-road running events and endurance runs, walks for charity events, or obstacle course races and other non-traditional running events [28]. The exact extent of participation in off-road running events is difficult to establish because there is currently no published or documented data available. In general, it is a growing sport, with trail running being the largest off-road running discipline, with approximately 9.1 million participants in the US alone, across all distances in 2017, which is up from 4.8 million in 2009 [5]. Estimates from ITRA suggest that around 13 million runners participate currently worldwide. More precise data is available for ultramarathon running [4]. However, events are held on road, athletic or routed tracks, or off-road, with the majority of events held on the latter surface. Participation numbers are much smaller than shorter distance endurance running events. In 2018, over 357 000 runners completed ultramarathon events, with 22% of runners being female finishers [4, 29]. Ultramarathon participation has increased

over the last 20 years, and so has the numbers of female and master participants [1, 4, 30]. The most popular ultramarathon running distances are that of 50 km, followed by 100 km, 50 miles and 100 miles [4, 29]. Even children and adolescents are participating in ultramarathon running events, but numbers are much lower compared with adult participation [31].

Reliable numbers for mountain running and cross country running, orienteering or obstacle course racing are not readily available. Estimates for orienteering are thought to be in the region of 2 million, whereas obstacle course racing may include several million participants [32, 33]. In skyrunning, over 50 000 athletes from 65 countries currently participate in about 200 races worldwide [9]. Fell running is a minority sport, mostly performed in the UK with just over 600 races in 2018, with the Ben Nevis Race in Scotland being one of their most well-known events [8, 34].

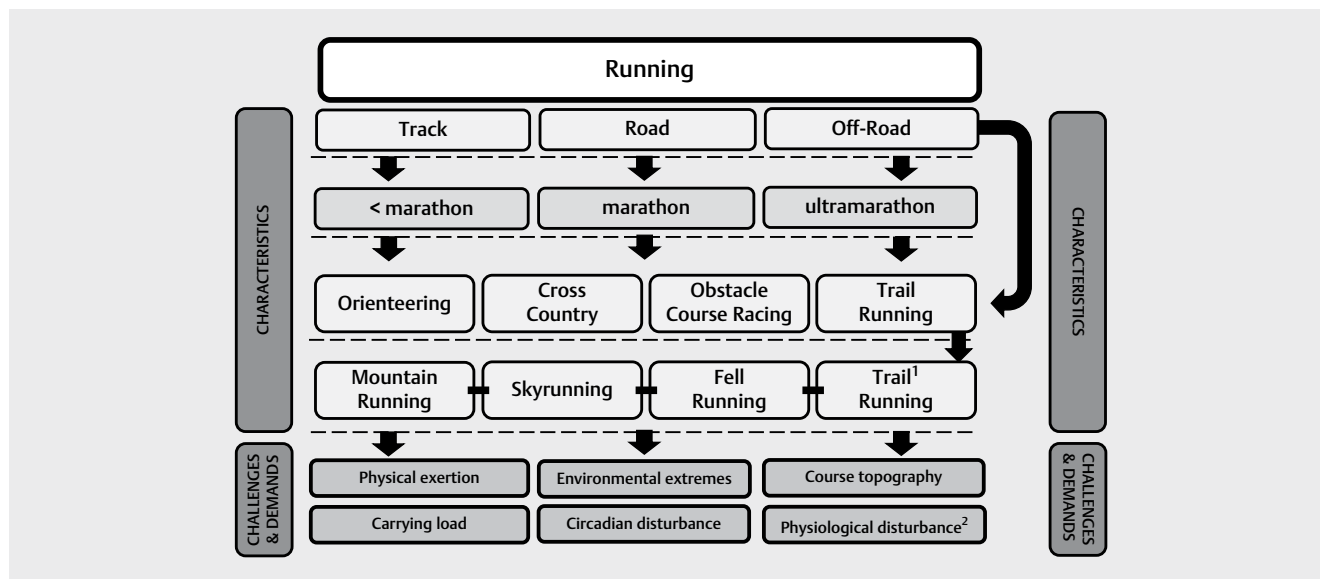
## Definition of events

A general definition of running events and categories can be seen in ► **Fig. 1**. Running events can be broadly classified by terrain (athletic or routed track, road, and off-road) and broad distance categories (<marathon, marathon, and ultramarathon). Trail running, mountain running, skyrunning, and fell running are mostly defined by the environment, terrain, technical difficulties, and distance. Different governing bodies set standards and rules defining the categories of events (► **Fig. 2**). In-depth definitions of each category follow and are further summarized in ► **Table 1**, and ► **Figs. 1** and ► **2**. These also include the less traditional running events, such as orienteering and obstacle course racing.

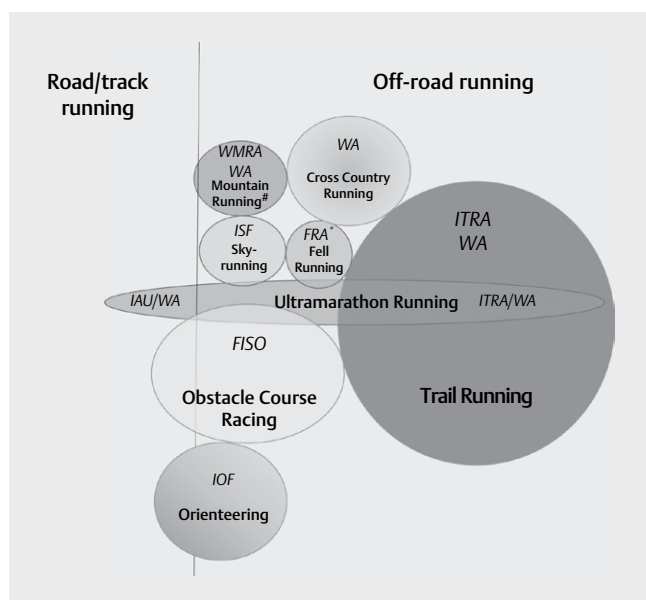
### Trail running

Trail running, the most popular discipline of off-road running, is defined as a foot race in a natural environment including mountains, deserts, forests, coastal areas, jungles/rainforests, grassy or arid plains over a variety of different terrains (e. g. dirt road, forest trail, single track, beach sand, etc.) with minimal paved or asphalt roads, not exceeding 20–25% of the total race course [10, 11]. This category has no restrictions on distance or elevation change. The route must be properly marked, meaning the runners will have enough information to complete the race without getting lost, either by means of physical markings (e. g. flags, tapes, and/or signs), global positioning system (GPS) coordinates, or map indication. The race is commonly self-sufficient, with athletes being autonomous between aid stations, regarding clothing, communications, food, and drink [10, 11]. The race organisers may impose or recommend obligatory security equipment to reduce adverse effects or risks to athletes and ensure safety to athletes and officials, providing race-specific plans for health, safety, and rescue. ITRA has been the governing body of international trail running since 2013, and was recognised by WA in 2015, and is defined by WA Rule 251 (formerly Rule 252) and the ITRA rules [10, 11].

In 2018 a classification system was implemented by ITRA, categorising trail races by “km-effort”, depending on race distance and vertical gain. The km-effort is expressed as the sum of the distance in kilometres plus a hundredth of the vertical gain in meters. For example, the km-effort of a race of 65 km and 3500 m ascent is:  $65 + 3500/100 = 100$ . The km-effort is rounded to the nearest whole number. Seven such categories exist, ranging from XXS to



► **Fig. 1** Overview of different off-road running events, consisting of running event characteristics such as surfaces, distances (or timed events), terrain, ascent/descent, environment, and others, and its challenges or demands that may vary between and within the running event types. Adapted from [2]. <sup>1</sup>Nature trail, man-made trail, and/or unsealed road (e. g. Class C or unclassified roads); <sup>2</sup>Injury, illness, signs and symptoms.



► **Fig. 2** Overview of the different off-road running disciplines with their respective governing bodies. The size of the circles roughly depicts the popularity (according to estimates) of each discipline and the overlap of ultramarathon demonstrates its inclusion in different race categories and governing bodies. ITRA (International Trail Running Association); WA (World Athletics, formerly IAAF (International Association of Athletics Federation)); ISF (International Skyrunning Federation); FRA<sup>\*</sup> (Fell Running Association – in England); WMRA<sup>#</sup> (World Mountain Running Association – in exceptional circumstances, races can be held on macadamised surfaces); IAU (International Association of Ultra Runners); FISO (Fédération Internationale de Sports d'Obstacles); IOF (International Orienteering Federation).

XXL, and aim to provide some information about the type of course [10]. A classification system was also introduced by ITRA awarding points to the different categories as a means of ranking athletes.

The largest trail race is the Ultra Trail du Mont Blanc (UTMB®), with over 7000 starters in several race categories. For elite runners, ITRA/WA currently organise annual world championship races. The intention is that from 2021, WA, ITRA and IAU will hold combined world championships with races in the short (S) and the long (L) categories [35].

### Mountain running

Like trail running, mountain running is a discipline regulated by WA (and both were approved as of January 2019 under the same Rule 251) [11]. By definition, the same rules regarding terrain and surfaces apply as in trail running, as well as course markings. The vast majority of mountain running events are conducted off-road. However, some special exceptions do exist where mountain running events can be on a paved surface if there is a large elevation change on the course [11, 35], hence an overlap with road running can occur as depicted in ► **Fig. 2**. The event distance is well defined and ranges from one kilometre up to the marathon distance, and the average incline should include a minimum of 5% and not exceed 25%, with the most preferable average elevation gain being approximately 10–15% [11]. Mountain running events are generally fully supported and organisers must ensure the safety of athletes and officials [11]. They can be classified as uphill ('classic uphill'), uphill & downhill ('classic up & down'), vertical, and long-distance races. The average altitude gain or loss can vary from approximately 50–250 m climb/km. All these categories involve uphill and downhill sections whose inclinations exceed those normally present in a cross country race. In mountain running, the use of additional support equipment is not allowed (e. g. bags, sticks, ropes, and compasses). In the vertical category, the incline should be no less than 25%. The World Mountain Running Association (WMRA) is the governing body for mountain running and was first founded in 1984 under the name of the International Committee for Mountain Running; its name changed to WMRA in 1998. World champi-

► **Table 1** Summary of characteristics of off-road running events.

| Running discipline           | Trail running  | Mountain running   | Fell running  | Skyrunning   | Cross-country running                               | Orienteering   | Obstacle course racing   | Ultramarathon running   |
|------------------------------|--|--|---|--|---|--|--|---|
| International governing body | ITRA, recognised by WA                                       | WMRA, recognised by WA   | FRA <sup>*</sup> , not recognised by WA                                   | ISF, not recognised by WA  | Recognised by WA                                    | IOF, not recognised by WA  | FISO, not recognised by WA   | IAU <sup>*</sup> , ITRA <sup>***</sup> , recognised by WA                     |
| Race distance                | Any  | Up to 42.195 km  | < 10 km to any  | ≤ 99 km  | 4–10 km   | N/A  | > 50 m to any  | > 42.195 km   |
| Race time                    | N/A  | N/A  | from a few minutes to multiple days                                       | N/A  | N/A   | By winning time, ranging from approx. 12–100 min   | N/A  | Timed events, e. g. 6 hrs, 12 hrs, 24 hrs; or multi-stage or multi-day events |
| Race category                | XXS-XXL categories (based on km-efforts)                     | Classic uphill, classic up & down, vertical, long-distance races   | Distance categories L, M, S and orienteering, and ascent categories (A–C) | Sky (20–49 km with 1300 m vertical climb (VC)), Ultra (50–99 km with 3200 VC), Vertical (uphill races of a maximum distance of 5 km) | Men and women 10 km championship races              | Foot orienteering (short, middle and long races)   | Several events, with different obstacles (walls, water, carrying objects, crawling, jumping, etc). Adventure racing includes expeditions over several days | Single distance, multi-stage, multi-day, timed events                         |
| Running surface              | Natural environment with ≤ 20–25% of paved or asphalted road | Natural environment with ≤ 25% of paved or asphalted road, large elevation change  | Road surface ≤ 20–40% of total race distance                              | Mountain environment above 2000 m above sea level  | Grass areas, macadamised surfaces are to be avoided | Off-road, off-path, natural terrain, rough ground with navigation skills. Short races also in urban settings | Any-road, urban environment, parks, track, off-road, beach, natural environment  | Any- off-road, trail, road, and track   |
| Elevation                    | Not specified  | Average incline should include a minimum of 5% and not exceed 25%, with the most preferable average elevation gain of 10–15% | Not less than 50 m climb/km on average, to not less than 20 m climb/km    | Takes place in above 2000 m elevation, with average incline up to 6% over entire course  | Recommended elevation of 10 m/loop                  | Not specified  | N/A  | N/A   |
| Runners/ year                | > 9,000,000 <sup>#</sup><br>~ 13,000,000 <sup>§</sup>        | N/A  | > 10,000  | > 50,000   | N/A   | N/A  | N/A  | approx. 357,000   |

FISO (Fédération Internationale de Sports d'Obstacles), FRA (Fell Running Association), IAU (International Association of Ultrarunners), ISF (International Skyrunning Federation), IOF (International Orienteering Federation), ITRA (International Trail Running Association), WA (World Athletics), WMRA (World Mountain Running Association). \* Organization representing England, \*\* Road races \*\*\* Trail races # USA alone § estimated figures worldwide from ITRA.

onship races are held in all disciplines, whereas classic uphill and classic up & down events traditionally alternate at world championships [11, 35].

### Skyrunning

Skyrunning comprises races performed in a mountain environment above 2000 m above sea level (ASL) inclusive of extremely technical trails [36]. However, if the course has an average inclination of 6% over the entire course, it can take place below 2000 m ASL. Skyrunning is regulated by the International Skyrunning Federation (ISF) [9], which is not recognized by WA. ISF divides the recognised races into three main disciplines: (i) Sky (20 to 49 km with 1300 m vertical climb (VC)), (ii) Ultra (50–99 km with 3200 VC), and (iii) Vertical (uphill races of a maximum distance of 5 km). Unlike mountain running and trail running, skyrunning can approach very technical mountain environments (e. g. glacier, moraine, scrambling sections equipped with ropes, etc.). There are several ISF-sanctioned and trademarked events, such as the Skyrunner® World Series, Vertical Kilometer® World Circuit, biennial world championships, and Vertical World Circuit (skyscraper racing) [9].

### Fell running

Fell running, also known as hill running, is a running discipline that takes place off-road, often including significant and difficult climbs. It can be classified by event duration (from a few minutes to 24 h; categories S, M, and L), event distance (short races of less than 10 km to marathon, or multi-day ultramarathon), different ascent categories (not less than 50 m climb/km on average, to not less than 20 m climb/km; categories A to C), and amount of macadamised surfaces used in relation to total off-road race distance, not exceeding 40% if a significant ascent is included (no less than 20 m climb/km). There are also categories for orienteering and mountain marathon multi-day events in wild mountainous country (MM). The latter competitions are often held with pairs of runners, and competitors must carry all the equipment and sustenance for overnight camping. Navigation skills are often required and survival equipment is often mandatory [8, 11]. There are several governing bodies in the United Kingdom, with the Fell Runners Association (FRA) being the biggest and oldest, having links with British Athletics, but it is not recognised internationally by WA [11]. The most important fell running event in the UK is the Ben Nevis race, held in Scotland since 1937. Although fell running shares some common features with trail, mountain, and cross country running, they present a distinct entity as shown in ► **Fig. 2**.

### Orienteering

Orienteering may encompass four different modality disciplines: foot, trail, ski, and mountain bike orienteering. The International Orienteering Federation (IOF) is the international governing body for the sport and is recognised by the International Olympic Committee (IOC), but not by WA [32]. In foot orienteering there is no marked route and the orienteer must navigate with a map and compass while running, often through rough ground, or unprepared forest terrain, or through open hills. Short-, middle-, and long-distance events exist, either for individuals or teams [32]. Orienteering events are primarily based on target winning times ranging

from approximately 12–15 min for short races, 30–35 min for middle races, and 70 and 100 min for long races. Short distances predominantly take place on road, urban, or park terrain, while others are off-road, with annual world championship events. Trail orienteering was originally developed for people with limited mobility, but its participation by able-bodied competitors is now well established. Exact participation numbers are not available; however the IOF estimates that around 2 million orienteers participate globally in all four disciplines.

### Obstacle course racing

Obstacle course racing (OCR) is a sport in which athletes travel on foot and run, overcoming various obstacles by walking, crawling, slithering, scrambling, swimming, or otherwise propelling themselves across, under, or over the obstacles as prescribed by the race organiser [33]. They can be conducted on a track, road surfaces, in rural or urban environments, off-road, on beaches or in wilderness environments, and include various events and distances ranging from 50 m to hundreds of kilometres, or are timed events (e. g. 4–24 h). The Fédération Internationale de Sports d'Obstacles (FISO) is the international governing body for OCR and was founded in 2018. World championship events are held in various disciplines. Adventure racing is a discipline of OCR, which includes events ranging from a few hours to expeditions up to 1 000 km. Adventure racing is typically conducted in natural terrain with obstacles such as mountains, deserts, rivers, and/or oceans [33]. Additionally, these events typically consist of varying modalities (e. g. running, mountain biking, kayaking, rock climbing, abseiling, etc.). Events can be held as individual or as team events. No exact participation numbers are available but may attract several million participants worldwide.

### Cross country running

Cross country running is a discipline governed by WA (Rule 250) and takes place off-road, in open or woodland areas, covered predominantly by grass, with natural obstacles [11]. The World Cross Country Championships are held over 10 km for men and women, with shorter distances for younger age groups (e. g. U20 men 8 km and U20 women 6 km). The racecourse is made up of approximately 1500 to 2000 m loops, with a recommended elevation of 10 m climb/loop and this should include natural obstacles. Macadamised surfaces are to be avoided, but if this is impossible within the course design, the route must be covered by grass, earth, or mats. The course must be clearly marked and should have a width of 5 m. Organisers must ensure the safety of athletes and officials and races are fully supported [11]. Cross country running is both an individual and a team sport.

### Ultramarathon running

Ultramarathon running is defined by distance (i. e. any foot race longer than the traditional marathon distance of 42.195 km) rather than by terrain as the other off-road running disciplines. Therefore, no specific restrictions exist with regards to surface, terrain, and/or elevation change. Ultramarathons may be held on a track, road and/or trail. Events predominantly held on macadamised road surfaces, such as the 100 km World Championships (under WA Rule

240) [11], are overseen and governed by the International Association of Ultrarunners (IAU), the international governing body for ultradistance running [37], which operates under the patronage of WA [11]. The nomenclature used by WA and IAU is ultra running. Other major IAU competitions include 50 km World Championships, 24 h World Championship, and ratifications of 100 km world records [37].

Most ultramarathons are held off-road in natural environments, and depending on specific environmental conditions (e. g. surface, distance, and elevation change), can fall within the categories of trail running, skyrunning, or fell running within the defined framework of their respective governing bodies (► Fig. 2). Most ultramarathons fall into the category of trail running, and ITRA and WA organise world championships races.

A notable exception constitutes timed ultra-endurance running events (e. g. 6 h, 12 h, 24 h, or multiple day), and continuous or multi-staged events that are frequently summarised as ultramarathon events. These events generally do not fall within a specific defined governing body; however, because the majority are held on off-road surfaces, they are grouped into the larger category of ultramarathon (► Fig. 2 – within ultramarathon but not encompassing any other off-road events or governing bodies).

Typically, continuous ultramarathons provide at least some level of support via aid stations [38]. Multi-stage ultramarathons are generally associated with crossing exotic terrain (e. g. arctic, mountain, desert/semi-arid, forest, jungle, coastal, volcanic, and/or savannah/bushland), countries, or even continents [6, 15, 22, 39]. Such events can be classified as either semi-supported (i. e. event organisers transport runners' specified volume of necessities be-

tween stages, with ad libitum food and fluid provisions) or self-sufficient (i. e. runners must carry all necessities, with minimum food requirement regulations ( $\geq 2000$  kcal/day), and water ration provisions ( $\sim 12$  L/day). The events are normally characterised by harsh trail course topographies, challenging environmental conditions (e. g. sub-zero, hot humid climates ( $\geq 30.0$  °C with 50–90% relative humidity), and altitude attainment of  $\geq 3000$  m), loaded running (e. g. up to 15 kg pack weight), and rough sleeping conditions (e. g. confined, unfamiliar, open outdoors, tent, or hammock) [39–44]. Extreme distances have been covered; for example, the longest official ultramarathon in the world is the multi-stage 'Self-Transcendence 3100-Mile Race', and Serge Girard is the runner who covered the longest distance of 27 012 km in one year.

## Recommendations for describing off-road running events

As outlined, there are clear distinctive features in the different off-road running disciplines, which are graphically summarised in ► Fig. 2 and detailed in ► Table 1. We recommend that when describing off-road running events, there should be clear reference to distance, surface (e. g. percentages of off-road surfaces to total race surface), elevation change and altitude, type of event (e. g. continuous vs. staged), type of support, name and year of the race, governing body and terminology as outlined in ► Table 2. This will provide clarity when discussing off-road running events and will facilitate comparisons between research at different off-road running events.

► Table 2 Recommendations for describing off-road running events.

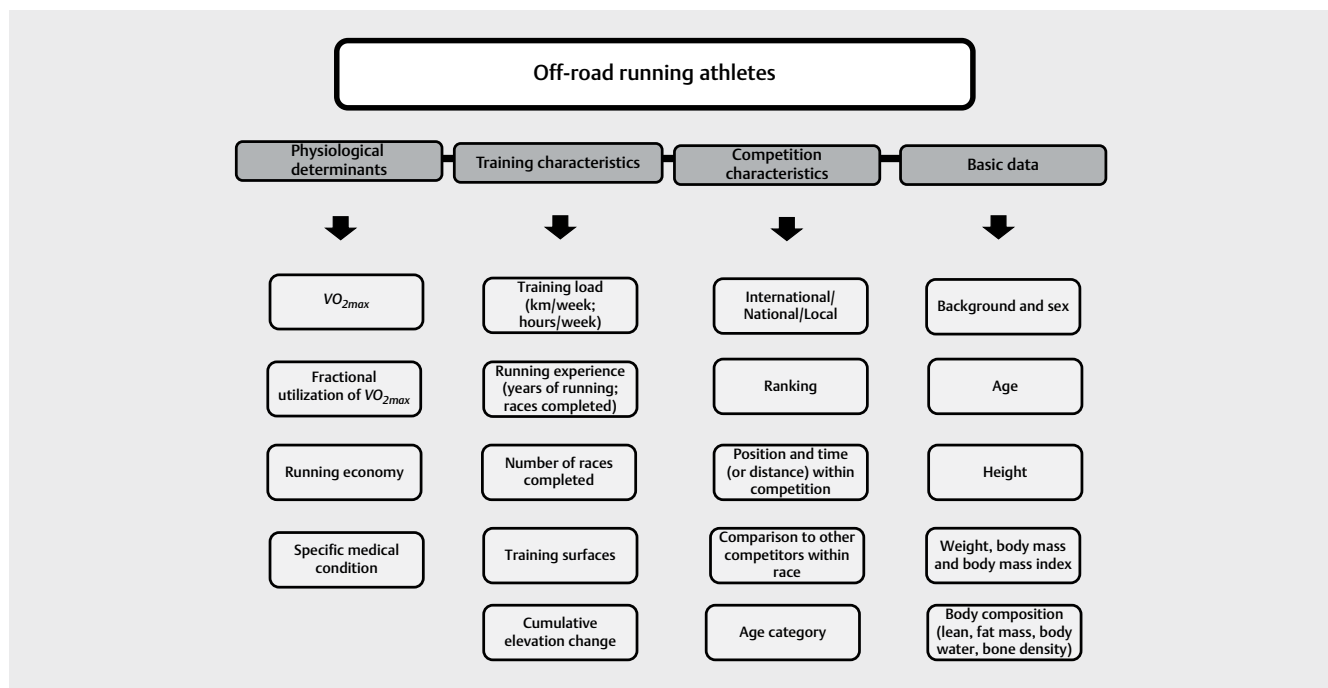
|   |   |
|---|---|
| <b>Distance</b>   | <ul style="list-style-type: none"> <li>Provide specific race distance, preferably in the metric system (km).</li> </ul>   |
| <b>Surface</b>  | <ul style="list-style-type: none"> <li>Provide and quantify running surfaces in relation to full race distance. Include distinct and/or subtle change along the course.</li> </ul>  |
| <b>Elevation change</b>                                 | <ul style="list-style-type: none"> <li>Provide accumulated ascent and descent and quantify as total elevation gain (in m) and total elevation loss (in m). If a loop course, then those values should be equal.</li> </ul>  |
| <b>Continuous vs. staged</b>                            | <ul style="list-style-type: none"> <li>A continuous race covers a single distance without interruption, whereas a staged race or multi-stage race covers various distances or specified time periods on different days. In multi-stage events, the number of stages and distance per stage should be defined.</li> </ul>  |
| <b>Self-sufficient vs. semi-supported vs. supported</b> | <ul style="list-style-type: none"> <li>If a race participant is required to carry all equipment and sustenance, this should be described as a self-sufficient race, including minimal/maximal equipment load, energy availability, and water provisions. If the event organizers are supporting some of the transport of equipment and sustenance, and/or allowance for an individual support crew, this would be classified as a semi-supported race in contrast to a fully supported race where participants do not need to carry any additional equipment; this should be described in detail.</li> </ul>  |
| <b>Year and name of event</b>                           | <ul style="list-style-type: none"> <li>Inclusion of the year of the event and the event name because some events may vary across time.</li> </ul>   |
| <b>Governing body</b>                                   | <ul style="list-style-type: none"> <li>Inclusion of the name of the governing body a race is held under and further description according to governing bodies' nomenclature (e. g. XS race in trail running).</li> </ul>  |
| <b>Terminology</b>                                      | <ul style="list-style-type: none"> <li>Use of the term "ultramarathon" is imprecise because it refers only to a generic race distance (over marathon distance) and should be avoided without precise definition of the aforementioned. Other terms such as ultra endurance running or ultra running are also terms that adequately describe endurance running but should also include the aforementioned recommendations to provide further details.               <ul style="list-style-type: none"> <li>Use of the term "trail" is vague and should include a description of the surface and terrain.</li> <li>Use of the term "off-road" in running events should be accompanied by a precise description of the surface.</li> </ul> </li> </ul> |
| <b>Environmental conditions</b>                         | <ul style="list-style-type: none"> <li>Include temperature in degrees Celsius (°C), relative humidity (RH), PO<sub>2</sub> and/or O<sub>2</sub> saturation in altitude, wind velocity (m/s), at start, finish, and at key points along the course (e. g. highest and/or lowest point) dependent on the event distance.</li> </ul>   |

## Recommendations for defining off-road running athletes

Defining off-road running athletes will enable a more precise and meaningful interpretation of existing studies and data and put the athlete's competitiveness and competition results into perspective. We therefore propose the following classification system as depicted in ► **Fig. 3**. These recommendations summarise and include a number of variables and determinants that may help to better classify these athletes, because their preparatory strategy for competition may vary according to the definition and competitive level of the individual [45]. Athletes can be defined and classified loosely or quite restrictively [46], and various means of classifications exist. One basic method of classifying athletes is according to background, sex, and age. Further, the intent of exercise or level of competition can be classified [46], for example non-competitive, recreational, and/or competitive athletes. Competitive runners are athletes that compete in a range of local, regional, national, or international championships, and can be defined by event level (e. g. international athletes or elite athletes) or by existing classification or ranking systems by their respective governing bodies [10, 11]. Investigations in elite athletes often involve small sample sizes [17, 47]. Race times compared to other competitors and position within a specific competition can give a further indication of the level of competitiveness of an athlete. Defining training characteristics can give further objective information of an athlete. For example, running experience, number of previous event completions, training patterns (e. g. km/week, hours/week, ascent/descent, and/or cumulative elevation gains), and training surfaces [48–50].

A more robust and objective marker of classification is defining athletes by physiological determinants [51, 52]. The classical determinants of performance are defined by the athlete's maximal oxy-

gen consumption  $\dot{V}O_{2max}$  its fractional utilization, and running economy. This is well researched in road running and distances up to the marathon [51, 52]; but in off-road running, especially ultra-endurance running distances, it is less well established. In ultra-endurance running,  $\dot{V}O_{2max}$  values in elite runners are similar to those observed in other elite endurance athletes (i. e.  $> 75 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$  and up to an extreme value of  $92 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ ) [53]. However, relatively low  $\dot{V}O_{2max}$  values have also been observed thus far compared to other endurance sports (e. g. ranges between  $45\text{--}60 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$  [19, 54–58]). It is recognised that  $\dot{V}O_{2max}$  is positively related to ultra-endurance performance outcomes [55, 56, 59, 60]. As in shorter endurance events, the fraction of  $\dot{V}O_{2max}$  sustained over extended periods of time is another determining factor [55, 56, 59, 60]. Lactate thresholds, as a measure of fractional utilisation of  $\dot{V}O_{2max}$ , are also important determinants in performance in off-road running (e. g. trail running) [18, 61]. Running economy is another valid physiological parameter used to explain off-road running performance outcomes, especially in ultramarathon running [55, 60], along with body composition [62]. Hence the inclusion of all these physiological data is important in assessing research studies, especially if they deal with performance prediction or assessment and we recommend including them in the description of the study. Additionally, where a medical condition is present, this should also be clearly described, alongside its physiological determinants and outcomes [14, 63]. A unified classification system (see ► **Fig. 3**) could prove beneficial in avoiding misinterpretations of the results and biased comparisons resulting from different studies. We therefore recommend that for future scientific reports or communications, the following descriptors be included so that pertinent details are evident to the reading audience (as detailed in ► **Table 3**).



► **Fig. 3** Classification system of defining off-road running athletes.



► **Table 3** Recommendations for describing off-road running athletes.

|   |
|---|
| <p><b>Basic data</b></p> <ul style="list-style-type: none"> <li>Provide basic data on athletes such as background, age, biological sex, weight, height, body mass, body mass index (BMI), and body composition (lean fat mass, body fat mass, body water, bone density)</li> </ul> <p><b>Competition characteristics</b></p> <ul style="list-style-type: none"> <li>Provide information about race, level of competition (championship race, national or international competition) and place and time of athlete within competition in relation to other competitors or within age category. If athletes are part of a ranking system, e.g. ITRA ranking, provide classification. This should be provided especially in studies relating to performance and training parameters.</li> </ul> <p><b>Training characteristics</b></p> <ul style="list-style-type: none"> <li>Provide data on training characteristics especially in studies relating to performance and training, including training load (km/weeks, or hours/week), training surfaces, and cumulative elevation changes, as well as running experience (years of running) and number of races completed.</li> </ul> <p><b>Physiological determinants</b></p> <ul style="list-style-type: none"> <li>Provide information on physiological determinants especially in studies relating to physiological parameters such as <math>VO_{2max}</math>, fractional utilization of <math>VO_{2max}</math>, and running economy.</li> </ul> |
|---|

## Conclusion

In this position statement by the Ultra Sports Science Foundation, we provide guidance on defining off-road running events based on distance covered, terrain, altitude change, environmental conditions, and competition rules and standards by the respective governing bodies. We provide further guidance on defining off-road running athletes based on basic biometric data, training and competition characteristics, and physiological determinants. We recommend the adoption of these definitions and nomenclature for future scientific research, providing a universal and consistent language.

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## Conflict of Interest

The authors declare that they have no conflict of interest.

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