Running in Tarahumara (Rarámuri) Culture

Persistence Hunting, Footracing, Dancing, Work, and the Fallacy of the Athletic Savage

Daniel E. Lieberman, Mickey Mahaffey, Silvino Cubesare Quimare, Nicholas B. Holowka, Ian J. Wallace, and Aaron L. Baggish

The Tarahumara (Rarámuri) are a Native American people from Chihuahua, Mexico, who have long been famous for running, but there is widespread incredulity about how and why they run such long distances. Some characterizations of Tarahumara running are also based on stereotypical views of athleticism among non-Western peoples, here labeled the "fallacy of the athletic savage." To place Tarahumara running more appropriately into its larger social and functional contexts, we combined our own observations and ethnographic evidence with interviews of 10 elderly Tarahumara runners about running during hunting as well as during footraces. We detail how running played an integral role in persistence hunting, in which groups of hunters employed a variety of methods to chase animals on foot. Running during hunting, moreover, is linked to men's and women's footraces, and both kinds of running are considered powerful forms of prayer. Long-distance running is also related to endurance dances that have important spiritual dimensions. Although the Tarahumara do not train to run in any traditional Western sense, and not all of them are great runners, the Tarahumara, like many Native American peoples, consider running, along with other endurance-based activities, to be important social and spiritual pursuits.

Online enhancements: appendix.

The Tarahumara (who call themselves Rarámuri) are a Native American people from the Sierra Madre Occidental of northwestern Mexico, also known as the Sierra Tarahumara. Tarahumara running has been deservedly famous for over a century to anthropologists and others interested in Native American culture, and their ability and propensity to run long distances received additional worldwide attention from the 2009 book *Born to Run* (McDougall 2009). The first European to write a popular account of Tarahumara running was Frederick Schwatka, who described his travels through the Sierra Tarahumara in his book *In the Land of Cave and Cliff Dwellers* (1893). Schwatka, who by his own account did not have extensive contact with the Tarahumara and considered them "savages," reported that Tarahumara "foot runners" had phenomenal endurance and were employed as couriers, capable of traveling great distances up and down the canyons much faster than could be traveled by mule. There is no evidence that Schwatka observed any Tarahumara running events, but he noted briefly that the Tarahumara hunted deer by running them down, and he marveled at accounts of their ability to run footraces as long as 90 miles in 11 hours 20 minutes, faster than would be possible for a horse.

Ever since Schwatka, visitors to the Sierra Tarahumara have recorded additional and sometimes divergent details about Tarahumara running. Most of these accounts convey a similar sense of astonishment and sometimes incredulity. The most influential of these early reports was the monograph *Unknown Mexico* (1905) by the Norwegian explorer Carl Lumholtz. Lumholtz's characterization of the Tarahumara is generally careful, but his description of their endurance capabilities sometimes verges on hyperbole. He describes Tarahumara individuals who can run 170 miles without stopping, others who carry more than 100 pounds for 100 miles in 70 hours, and one who ran 600 miles in five days.[1] Lumholtz apparently did not directly observe Tarahumara hunts, but he reported that the Tarahumara hunt deer and other animals by running them

1. For perspective, the current world record was set in 2015 by J. Fejes, who ran 606.243 miles in five days on flatter terrain in Hungary, with considerable support.

Daniel Lieberman is a Professor in the Department of Human Evolutionary Biology at Harvard University (11 Divinity Avenue, Cambridge, Massachusetts 02138, USA [danlieb@fas.harvard.edu]). **Mickey Mahaffey** is a farmer and project coordinator for various support programs for Tarahumara (23 Lake Drive F1, Hendersonville, North Carolina 28739, USA). **Silvino Cubesare Quimare** is a Tarahumara farmer and runner who lives in Huisuchi and Guachochi, México (Calle Concido, Guachochi, Chihuahua, Mexico 67243). **Nicholas Holowka** is Assistant Professor in the Department of Anthropology at the State University of New York at Buffalo (380 Fillmore Academic Center, Ellicott Complex, North Campus, Buffalo, New York 14261, USA). **Ian Wallace** is Assistant Professor in the Department of Anthropology at the University of New Mexico (502 West Redondo Drive, Albuquerque, New Mexico 87131, USA). **Aaron Baggish** is Associate Professor at Harvard Medical School and Director of the Cardiovascular Performance Program, Massachusetts General Hospital (55 Fruit Street, Boston, Massachusetts 02114, USA). This paper was submitted 12 III 18, accepted 10 XI 18, and electronically published 27 IV 20.

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down over long distances. However, he did observe some of their footraces, which he describes in detail, including measurements of their running speed. Lumholtz (1905:474) concludes, "No doubt the Tarahumares [*sic*] are the greatest runners in the world, not in regard to speed, but endurance." Lumholtz's admiration for Tarahumara running has since been echoed and sometimes amplified by almost every subsequent description of the Tarahumara including Cassel (1969), Pennington (1963), Groom (1971), Fontana (1979), Kennedy (1996), and Irigoyen-Rascón and Palma-Batista (1994). One journalist in the *National Geographic* describes how Tarahumara runners, after 48 hours of nonstop running, "cross the finish line breathing no harder than I do after climbing a dozen steps" (Norman 1976:707). The one notable exception to this general sense of amazement is Bennett and Zingg's (1935) thorough ethnography, which describes without comment or opinion Tarahumara footraces in considerable detail and mentions only briefly that the Tarahumara run when hunting.

Although Tarahumara running is unquestionably outstanding and has deservedly been widely recognized and celebrated for generations, there has been little consideration of Tarahumara running in its broader functional, social, and spiritual contexts. Although many ethnographers mentioned that the Tarahumara employed long-distance running during hunting, none of these accounts go into much detail about how long-distance running was used to help them hunt, perhaps because few of these observers knew what questions to ask or had the stamina to run with the hunters and thus witness a hunt firsthand (for a notable exception, see Levi [1998:310–316, 1999:96–98] and the comments section in this paper). In addition, no accounts of Tarahumara running have discussed the connections between running during hunting and other forms of running, especially their footraces, or with other kinds of endurance athleticism such as walking, dancing, and working. Further, while several ethnographers, especially Lumholtz (1905), Bennett and Zingg (1935), Kennedy (1996), and Irigoyen-Rascón and Palma-Batista (1994), describe Tarahumara footraces in detail, they do not discuss the spiritual beliefs that shape Tarahumara thinking about running and motivate them to engage in acts of physical endurance. And, with a few exceptions, there has not been much effort to consider how Tarahumara running fits within the larger context of long-distance running in other Native American cultures (Nabokov 1981).

A related and deeper problem with many previous, sometimes hyperbolic descriptions of Tarahumara running are efforts to explain why the Tarahumara are such great runners. No one questions that the arduous physical lifestyle of the Tarahumara, made especially demanding by the rugged environment of the Sierra Tarahumara, contributes importantly to their endurance capabilities. However, explanations of Tarahumara endurance often invoke an additional factor that we label the "fallacy of the athletic savage." This way of thinking is a variant of the myth of the noble savage, the Rousseauian notion that civilization is corrupting (Ellingson 2001; Plymire 2006). Just as Rousseau and others believed that humans in a state of nature are innately good and kind and eschew violence, there is a long tradition of believing "primitive" humans to be naturally athletic with an innate capability and proclivity for extreme physical feats. A troubling basis for some of these preconceptions has been racial stereotypes about pain. According to one nineteenth-century book, "what would be the cause of insupportable pain to a white man, a Negro would almost disregard" (Winchell 1880:178). The belief that Africans raised in the jungle or in slavery did not experience pain in the same way as Europeans has been used to claim that African athletes better overcome the suffering caused by activities such as boxing (see Mead 1985) or long-distance running (see Coakley 2015). Similar views have been commonly ascribed to Australian Aborigines (see Tatz 1995). Unsurprisingly, Native Americans such as the Tarahumara have also been stereotyped as impervious to pain and fatigue, as well as mysteriously in touch with nature (Berkhofer 1973; Mihesuah 1996). As Lumholtz (1905:412) declared, "They certainly do not feel pain in the same degree as we do." Many accounts claim that Tarahumara runners are physically unaffected after extraordinary endurance feats. As one example, the *New York World* newspaper described two Tarahumara men who ran 65 miles in 9 hours 37 minutes in 1926 in Mexico City as finishing "without signs of fatigue a distance that would exhaust most horses" (Fontana 1979:90). Cassel (1969:138) describes "dust-covered" runners after a long footrace as standing about "relaxed, completely at ease, breathing quietly, without so much as a yawn." To be sure, Tarahumara runners are fit, but the idea that any human could run 65 miles without getting tired is obviously absurd and instead indicates a lack of understanding of the different ways that runners manifest fatigue. The lack of panting at the end of a race reflects only that they were running below their aerobic threshold (one would observe the same at the finish line of most marathons). Like all ultrarunners, Tarahumara runners are stiff and sore for several days after a race, sometimes limp, and have trouble sitting down and getting up.

A different form of the fallacy of the athletic savage derives from arguments (sometimes exaggerated) that preindustrial people from non-Western societies, especially hunter-gatherers but also subsistence farmers, are often naturally fit, with excellent musculoskeletal and cardiovascular health (Eaton and Eaton 2003). An extension of this way of thinking is that since humans uncontaminated by civilization are intrinsically athletic, the lack of endurance among Westerners is abnormal. As noted by Plymire (1983:23), "the belief that the Tarahumara's running ability is caused by their primitive nature is fundamental to runners' constructions of the disease of overcivilization and its primitive cure." One of the first studies of Tarahumara physiology, by Balke and Snow (1965) argued on the basis of data from 10 boys that their exceptional feats of endurance were unlikely the result of genetic factors but instead were present only in "unacculturated" and "primitive" Tarahumara. Similar views were expressed by the American cardiologist Dale Groom (1971:313), who traveled in the 1960s to the Sierra to evaluate the physiological basis for Tarahumara

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endurance capabilities and concluded that “the phenomenal feats of physical endurance of these primitive Indian runners afford convincing evidence that most of us, brought up in our sedentary, comfortable civilization of today, actually develop and use only a fraction of our potential cardiac reserve.” As noted by Fontana (1979:90), “The high protein, low meat, vitamin-enriched diet of the Tarahumaras—when they can get enough of their own food—in combination with the natural conditioning of their whole way of life, makes them superb endurance runners and objects of curiosity to western medical practitioners.” Most recently, McDougall (2009:4) characterized the Tarahumara as a “near mythical tribe of Stone Age superathletes,” whose ability to regularly and effortlessly run long distances in the rugged, mountainous terrain of the Sierra Tarahumara derives in part from the absence of shoes, Gatorade, and other commercial products. McDougall (2009:14) goes further to claim incorrectly that “In Tarahumara land, there was no crime, war, or theft. There was no corruption, obesity, drug addiction, greed, wife-beating, child abuse, heart disease, high blood pressure or carbon emissions. They didn’t get diabetes, or depressed, or even old.”

Arguments about genetics have also been applied to the fallacy of the athletic savage—notably, genes that explain the excellence of Jamaicans at sprinting and East African groups such as the Kalenjin at endurance running (e.g., Entine 2001)—and the same case has been made for the Tarahumara (e.g., Cassel 1969; Clegg 1972). To date, efforts to find such genes have been unrevealing. Although genetic variability appears to have some influence on individual athletic capabilities, athletic performance is a highly complex trait affected by thousands of rare gene variants of small effect that mostly vary within, rather than between, populations (Tucker, Santos-Concejero, and Collins 2013). For example, no one has yet identified specific alleles unique to populations such as East Africans (Kalenjin) or Jamaicans that explain their dominance in long-distance running or sprinting, respectively (Wang et al. 2013; Wilber and Pitsiladis 2012). Further, well-studied genes proposed to influence athletic performance (e.g., ACE and ACTN3) exert only minor effects, and they do not predict performance in non-European populations (Pitsiladis et al. 2013). At present, there are sparse genetic data on the Tarahumara. In 2017 Romero-Hidalgo and colleagues presented whole-genome analyses of 12 Native Americans, of whom two were Tarahumara, as well as three non-Native American Mexicans. Although the paper’s focus was on population history, Romero-Hidalgo identified several genetic variants in the Tarahumara that have been associated with musculoskeletal function that may play a role in athletic performance, particularly the ability to tolerate high forces. These researchers note that “while these findings could be related with the well-known high physical resistance of this Native Mexican group they should be interpreted with caution” in the absence of larger sample sizes, comparisons to other populations, and studies that test for a relationship between these genes and performance (Romero-Hidalgo et al.2017:6). From a scientific perspective, the appropriate null hypothesis for Tarahumara running abilities, as with every other population, is that their bases lie primarily in social and environmental factors unless proven otherwise. Full-genome sequence of Tarahumara may eventually shed light on the degree to which genetics influence this population’s athletic ability in any substantive fashion.

Apart from evaluating claims about how and why the Tarahumara excel at endurance running, there is an urgent need to document Tarahumara running traditions before they are lost. The Tarahumara have long been subject to oppression and exploitation, and their way of life is currently being affected by external forces. The Sierra Tarahumara is transforming rapidly because of ecological change, roads, increased tourism and logging, expansion of the non-Tarahumara community, drug trafficking by narcotics gangs, and the migration of many younger Tarahumara to cities (Champion 1955; Goldberg 2017; Levi 2001). Persistence hunting has all but disappeared from the region, and footraces are becoming less common and are being replaced by Western-style ultramarathons such as the Ultramaraton de Caballo Blanco in Urique and the Ultramaraton de los Cañones in Guachochi.

Here we attempt to provide an overview of Tarahumara running and its role in many different aspects of Tarahumara life and culture. Our primary goal is to report information on how the Tarahumara ran during hunting obtained from elderly Tarahumara individuals who participated in persistence hunts when they used to be more common, as well as to consider how running during hunting is related to running in footraces, dancing, and other forms of physical activity. To address these questions, we conducted interviews with 10 Tarahumara men between the ages of 50 and 90 years who had participated in footraces and persistence hunts. All interviews were conducted by Mickey Mahaffey and Silvino Cubesare between 2015 and 2016 in the districts (municipios) of Urique, Batopilas, and Guachochi in the state of Chihuahua (fig. 1). The Tarahumara from Urique and Batopilas are classified as *baja* Tarahumara and those from Guachochi are *alta* Tarahumara, cultural groupings with differences in dialects and some variations in traditions. One point to keep in mind is that all the Tarahumara we interviewed are self-described *Pagótame* (washed ones) or *Rewéame* (named ones) who practice a form of syncretic Christianity, and we did not interview any *gentile* (unbaptized) Tarahumara (see Kennedy 1970, 1996; Levi 1998). Each interview was based on a list of 61 questions (appendix, available online) compiled with the assistance of Louis Liebenberg, an expert on persistence hunting (Liebenberg 1990, 2006, 2013). All interviews were conducted in Rarámuri (the native language of the Tarahumara), recorded, and then translated into English by Mahaffey and Cubesare.[2]

2. The questionnaire used for the interviews was compiled with the assistance of Louis Liebenberg, an authority on persistence hunting and tracking, based on his work with Kalahari hunter-gatherers.

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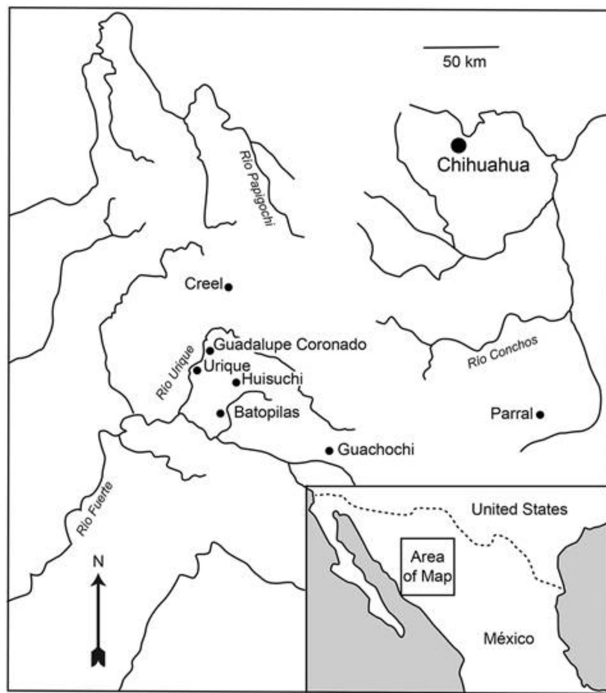

Figure 1. Map of the Sierra Tarahumara showing locations of places mentioned in the text as well as major towns. Map modified from Wyndham (2009).

Other details, especially regarding footraces, come from our collective observations and from published ethnographic accounts (Bennett and Zingg 1935; Irigoyen-Rascón and Palma-Batista 1994; Kennedy 1996). Mahaffey has resided for the last 20 years in Tarahumara communities in the Sierra Tarahumara, farming and helping to organize footraces in six different municipalities. Cubesare is a Tarahumara farmer who lives and works in Huisuchi. He is also a world-class ultramarathon runner and footrace champion and participated in persistence hunts with his father as a young boy. The other coauthors (Daniel Lieberman, Aaron Baggish, Nicholas Holowka, and Ian Wallace) are researchers who have conducted fieldwork in the Sierra Tarahumara. Two of us (Lieberman and Baggish) participated in Tarahumara footraces.

Because the roots of Tarahumara running—as with other forms of long-distance running—potentially lie in hunting, we first describe what is known about the role of running in Tarahumara persistence hunts. Next, we review aspects of running in the traditional footraces, specifically *rarajípare* (the most common men's race) and *ariwete* (the most common women's race). We then consider how running in Tarahumara culture relates to other forms of endurance athleticism including dancing, walking, herding, and agricultural labor, and we conclude by putting running into its broader context. Our basic thesis is that Tarahumara running is one of the last remnants of a widespread tradition of Native American running that is remarkable because of its practical, social, and spiritual roles.

Running and Persistence Hunting

Persistence hunting is an ancient form of pursuing and then dispatching animals that has been used in many cultures, environments, and contexts. The essential strategy behind this form of hunting is generally similar: hunters target suitable individuals from a prey species and then chase them on foot over long distances (Carrier 1984). Although persistence hunting always requires running and a high degree of endurance athleticism, it is practiced in a variety of ways, all of which require tracking skills, cooperation, and strategic use of the landscape. In some cases, animals are chased until they collapse from heat stroke; in other cases, prey are chased until they collapse from exhaustion; and in some cases, animals are driven into ambushes or human-made traps such as ditches or stakes or into natural traps such as cliffs and ravines (Carrier 1984; Liebenberg 1990). Bramble and Lieberman (2004) hypothesized that persistence hunting was a common if not predominant method of hunting by early species of *Homo* in Africa prior to the invention of relatively modern hunting technologies such as spear points, the bow and arrow, hunting dogs, and nets (Shea 2016; Wilkins et al. 2012), and abundant ethnographic evidence indicates that persistence hunting continued to be employed in various ways until recently by hunters in Africa (Heinz and Lee 1978; Liebenberg 1990, 2006; Schapera 1930), Asia (Shah 1900), Australia (Bliege-Bird and Bird 2008; McCarthy 1957; Sollas 1924; Tindale 1974), and the New World (e.g., Hohenthal 2001; Kroeber 1925; Lowie 1924; Meigs 1939; Nabokov 1981). There are also accounts of Europeans resorting to this method of hunting out of necessity, most famously Alexander Selkirk (the inspiration for Robinson Crusoe), who ran down feral goats on a Caribbean island (Kraske 2005), and the Lykov family that survived isolation from other humans in Siberia for 40 years (Peskov 1994).

Because almost nobody today regularly engages in persistence hunting, there is widespread incredulity about its efficacy, leading some to wonder how and why anyone would hunt this way given the alternatives. Therefore, before describing persistence hunting among the Tarahumara, we first review briefly the three key factors that make persistence hunting effective. First, and most fundamentally, humans have evolved a wide range of anatomical and physiological adaptations to run long distances efficiently, repeatedly, and safely at moderate speeds (Bramble and Lieberman 2004; Lieberman 2013). These adaptations include short toes (Rolian et al. 2009), longitudinal arches in the feet (Ker et al. 1987; Stearne et al. 2016), an elongated Achilles tendon (Alexander 2002), an expanded gluteus maximus (Lieberman et al. 2006), a high percentage of fatigue-resistant slow-twitch muscle fibers (O'Neill et al. 2017), and a high density of sweat glands combined with an absence of fur that enables running humans to cool efficiently by sweating (Lieberman 2015; Ruxton and Wilkinson 2011). Although these and other adaptations do not allow humans to sprint as fast as most quadrupedal mammals, they enable humans to run much longer distances than their prey, especially at speeds that require

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quadrupeds to gallop, which is not a gait they can sustain for a long time. One way galloping limits endurance in quadrupedal mammals is through thermoregulation. Running generates considerable heat in animals, and whereas humans uniquely cool by sweating, quadrupedal mammals cool primarily by panting, which they cannot do while galloping (Bramble and Jenkins 1993; Robertshaw 2006; Schmidt-Nielsen 2008). As a result, humans have the ability to drive quadrupedal mammals into a state of hyperthermia by chasing them for extended distances in hot conditions (Carrier 1984). Although hot ambient temperatures favor persistence hunting, humans can also outrun galloping quadrupeds over long distances in cooler conditions by driving them to a state of exhaustion or by causing injury. Even well-trained horses selected for running cannot run long distances at fast speeds without a high likelihood of exhaustion and injury (Loving 1997; Minetti 2003). Kalahari hunter-gatherers preferentially chase mammals in sandy soils because it exhausts their prey more rapidly (Liebenberg 1990), and Saami hunters have even been known to drive reindeer to exhaustion in the winter by chasing them on cross-country skis in powdery snow, which is especially tiring for reindeer (Ijäs 2017). Along these lines, the Tarahumara say they prefer to chase deer over rocky terrain that injures the animals' hooves.

A second factor necessary for persistence hunting is the ability to follow an animal's trail by tracking or predicting where it will run. Tracking is an art few humans learn today, but skilled trackers use a combination of empirical clues (footprints, scent, blood, excretions, and other traces of its passage) as well as knowledge of the animal's habits to predict where the animal has passed (Liebenberg 2013). As described by Hohenthal (2001:144–145), Tipai (Yuman) persistence hunters in Baja California would chase deer by "cutting across the great circles taken by the deer in flight."

The third factor that helps persistence hunters is cooperation combined with a strategic use of the landscape. Most of the ethnographic accounts of persistence hunting cited above describe how hunters work in groups to help each other track, chase, and dispatch their prey. As examples, Kalahari hunters take turns tracking and chasing animals (Liebenberg 1990); Australian aborigines chase kangaroos in pairs, "taking advantage of the animal's tendency to always run in the arc of a wide circle . . . one youth cuts across and takes up the running as the other becomes exhausted" (Tindale 1974:106); and among many Native American peoples such as the Shoshone, some runners would chase prey from behind while others would run on either side of the prey to drive them through ravines or toward cliffs or other natural traps (Lowie 1924; Nabokov 1981). Another common strategy used by persistence hunters is to drive prey toward manufactured traps such as ditches, spikes, nets, or blinds that conceal waiting hunters (Hohenthal 2001; Nabokov 1981; Sollas 1924).

Although almost all visitors to the Sierra Tarahumara, including Schwatka (1893) and Lumholtz (1905), have reported that the Tarahumara engage in persistence hunting, no accounts have reported more than cursory details about how running played a role in this form of hunting. In fact, the most extensive ethnography, Bennett and Zingg (1935), omits information about the process by which the Tarahumara practiced persistence hunting. Other accounts (e.g., Irigoyen-Rascón and Palma-Batista 1994; Pennington 1963) provide general information on how animals were pursued and dispatched but few details about the nature of running involved, such as running speeds, how animals were tracked, and how hunters learned to track. We therefore asked Tarahumara consultants a range of questions (see appendix, online) about their recollections of persistence hunting, especially regarding running. Of the 10 elderly Tarahumara consultants we interviewed, eight said they had participated in persistence hunts when they were young and hunted without dogs or bows and arrows. None had participated in any hunts after 1980, but several consultants claimed that persistence hunting has not entirely ceased, with the last reported hunt they knew of occurring in 2011 in the region near Huisuchi in the Municipio de Batopilas. It is widely agreed that persistence hunting has all but disappeared since rifles, mining, and logging became common in the region, contributing to a rapid decline in wildlife. Consequently, an obvious limitation of our consultants' recollections is that they apprise us only about relatively recent practices, perhaps some of the last persistence hunts that will ever be conducted in the region. It is possible that persistence hunting methods have changed over the last few hundred years and likely that persistence hunting became less common after domesticated goats, sheep, and cows were introduced by Europeans. Despite these limitations, it is important to ask how the last Tarahumara persistence hunters practiced this vanishing method of hunting.

As noted above, although persistence hunting always involves running and tracking, this general form of hunting occurs in different contexts and employs a variety of strategies. Tarahumara persistence hunting is no exception. In terms of season, persistence hunts reportedly occurred in both winter and summer and during dry and wet conditions. Among the Tarahumara we asked, opinions differed on which season was preferable or more common. According to one informant, persistence hunting was "ideal in the drier, hotter months when the deer tired more quickly from the heat and when less underbrush made it easier to follow tracks." However, another Tarahumara reported that he preferred persistence hunts "in the winter and raining season when it was easy to see tracks in the wet ground." Deer were reportedly hunted in all seasons, often when food was scarcer, although one informant expressed a preference for hunting deer "in the early winter when they [the deer] were fat." The Tarahumara, including our consultants, also report chasing wild pigs and collared peccaries (*Pecari tajacu*, javelinas), as well as smaller prey such as rabbits and squirrels. Some ethnographers claim that hunters also sometimes ran down wild turkeys (Bennett and Zingg 1935; but see Pennington 1963). One of our consultants was sometimes hired by farmers to run down and recapture escaped horses.

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An important source of variation was how the hunts were conducted. In general, hunts began by searching for tracks in places where animals prefer to drink and forage. Once fresh tracks were located, the persistence hunt commenced, with two main hunting strategies being employed. The most commonly reported strategy was corralling, which was done in the ravines (arroyos) that are ubiquitous in the Sierra Tarahumara. In the words of one informant, the hunters "set ten to twelve sharpened wooden stakes at an angle in the ground and hid them with leaves. Three or more runners chased the deer into the spears. . . . One or more hunters run along the bottom of the ravine and one or more on each side to try to direct the deer towards the stakes." An alternative version of this form of corralling was to drive a deer "into the river and kill it with clubs or stones." Some consultants also mentioned running animals into caves. The second major strategy, similar to that reported in the Kalahari, was to "run the deer to exhaustion and kill it." None of our consultants made a distinction between exhaustion or hyperthermia, but they did comment that animals in this state were so incapacitated that they could be killed with just rocks, clubs, or other weapons.

Enormous variation was reported in terms of distance. Unfortunately, we have no measurements of these distances, as the Tarahumara report the length of hunts in terms of hours or days, but several consultants reported that hunts were "usually four to six hours" or as short as "two or three hours." Given typical running speeds (see below), we estimate the maximum length of these hunts between 12 and 36 kilometers. Many of the consultants, however, reported that hunts occasionally lasted "two to three days." On these hunts, they "started early morning and ran until it was too dark to see the tracks. They rested at night and picked up again [the next day] where they last saw tracks." Unfortunately, the hunters we interviewed did not quantify what percentage of persistence hunts lasted more than a day or to what extent these longer hunts were motivated by reasons other than scarcity of food—an important consideration given that the caloric benefit of these longer hunts may not have outweighed the costs.

One important point to emphasize is that running speeds for these hunts were moderate and that the hunters often walked part of the distance. Our consultants report that they ran at a "steady pace" or that "depending on terrain ran as fast as possible when tracks were clear and slower when looking for tracks." On runs with the Tarahumara, Lieberman and Baggish observed intermittent purposeful sprints in order to chase a fast-moving ball (during rarajípare) but used GPS devices to measure average running speeds of approximately 9.6 kilometers per hour (a 10-minute mile), a gradual jogging pace. All the hunters reported that they walked frequently during hunts, especially when they lost their prey's tracks. Tarahumara runners also prefer to walk when ascending very steep terrain. In general, these speeds and the combination of walking and running are typical of those used by persistence hunters in the Kalahari (Liebenberg 2006) as well as by ultramarathon runners.

All persistence hunts were done in groups, but group size varied considerably, with as few as three and as many as 15 participants. According to one very experienced hunter, "As a group, the best is to have at least nine runners, one group of three in the bottom of the ravine and groups of three on each side." In terms of completion, "Generally everyone finished because only the strongest and fittest in the community attempted the hunt," but two of the consultants reported that hunters sometimes dropped out of the chase because of fatigue. Some hunts also included dogs that were used to help drive the animals. Four consultants said their persistence hunts were never unsuccessful, two consultants reported only one failure (once when a coyote got to the deer before the hunters), and one reported that hunts ended only when deer got to areas the hunters could not reach, in which case the hunters recognized that "It was not the deer's time to die."

As previously reported, Tarahumara hunters typically ran in huaraches, sandals that used to be made from plant fibers (yucca) or animal hides but today are made from rubber automobile tires (Holowka, Wallace, and Lieberman 2018; Levi 1998; Wallace et al. 2018). Clothing usually consisted of a loincloth or a tunic. Prior to a persistence hunt, the runners prepared themselves physically by drinking pinole, a traditional beverage made of finely ground dried corn that is mixed with water, as well as eating beans, tortillas, and chicken soup. All the consultants reported that during hunting they drank water from streams that they mixed with pinole that they carried with them; one runner reported that he ran with a gourd canteen.

While running is fundamental to persistence hunting, tracking is just as important and is widely considered the hunters' greatest challenge, eliciting many comments from the consultants we interviewed. The hunters recurrently emphasized their respect for deer and the difficulties of following their tracks, whose path is impossible to predict. As one hunter said, "The deer is very smart and knows how to confuse humans." Despite claims that the deer try to "fool the hunters" by reversing direction or stepping in the same tracks, the hunters described various methods by which they were able to follow their prey and assess its physical state. To quote one hunter: "The tracks are different when the deer is running fast or slow. When it tires the tracks are smaller because they walk on the tips of their hooves, or the hooves have worn down so much the tracks are smaller." Hunters state they can read the movements of the deer by the spacing and depth of the tracks, whether walking or running, strong or tired. Almost all the hunters noted that as the hunt progresses, deer start to bleed: "Towards the end of the hunt [I] looked for blood in the tracks or evidence that the deer had none or very little hooves left." When questioned, hunters stated it was impossible to predict the path of the deer and that hunting required not just the presence of tracks but also the ability to interpret them, skills they had learned when they were young from their fathers or other elders.

Our consultants unanimously conveyed the impression that they enjoyed persistence hunting and that hunts often had an

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important social element. When discussing persistence hunts from years ago, they reminded us of retired athletes reminiscing about their glory days and proud of their achievements. Although some persistence hunts were conducted to provide "food for the family," one hunter reported that some hunts were conducted "to secure meat for the traditional fiestas and it was shared with the whole community; the skins are also valuable for making drums, seating, clothing. Antlers [were] used as tools and headdresses for dances that were taught to them by the deer." In the past, sacrificing a deer was also an important part of many ceremonies (today deer have been replaced by goats).

Another aspect of the social nature of persistence hunts is their relationship to the rarajípare footraces. According to their statements, on some occasions the runners had not known when they were summoned whether they were going to participate in a footrace or a hunt. In the words of one consultant, "The hunters met together the night before the hunt to dance *Yúmari*, same as before a rarajípare. When the organizer called for a rarajípare it could mean a ball race or a hunt; the runners did not know which it would be until the night before in the team meeting." The origin and meaning of these words add some information to these connections. According to the Tarahumara, it was the deer himself (*chomari*) who taught the Tarahumara how to dance *Yúmari* (which is pronounced "*júmari*," using the English phoneme /j/), a near homophone with significance for the Tarahumara. As Jerome Levi (personal communication) pointed out, persistence hunts are often described as *naháto*, which means to "chase" or "run after," but which also connotes "pursuing" or "driving" animals like goats. Consequently, Tarahumara hunts may be perceived to be as much about hunting deer as herding or pursuing them.

Running in Footraces (Rarajípare and Ariwete)

Although Tarahumara running gained worldwide attention from ultramarathons, this Western-style race in which individuals compete against each other to run a given distance is not a Tarahumara tradition. Instead, the long-established Tarahumara footraces, known as rarajípare for men and ariwete for women, are part of an ancient, widespread, and diverse tradition of Native American running that is deeply community oriented. Fortunately, considerable information is available on rarajípare and ariwete, in part because the races are conspicuous, important communal events intended to be spectated, and they are still practiced today, although not as commonly as in the past. As a result, there are excellent ethnographic descriptions of these races going back over a century (Bennett and Zingg 1935; Irigoyen-Rascón and Palma-Batista 1994; Kennedy 1969, 1996; Lumholtz 1905), and our consultants had much to say on rarajípare and ariwete, to which we have added our own observations from having organized, participated in, and watched many of these races, primarily in the municipalities of Urique, Batopilas, and Guachochi. Because footraces vary regionally within the Sierra Tarahumara and have probably changed over time, we feel it is useful to add the observations of our consultants and ourselves to those that have been previously published.

Today footraces are held in some but not all Tarahumara communities approximately two to eight times a year, but many of our consultants report that shorter races were more common in the past: "In the past we ran almost every weekend, but now only on special occasions." Smaller races, which have become less common, were typically held in a pueblo, whereas on special occasions major races were held between pueblos and occasionally were organized between Tarahumara pueblos and other neighboring peoples such as the Tepehuán (Pennington 1963). Larger interpueblo races are organized on behalf of a community "usually by the *gobernador* and his seconds." Race organizers (*chokeame*) have the responsibility "to initiate enthusiasm, organize the event, and supply *tesguino*" (corn beer), but if they "lost three times in a row they were not allowed to organize more races." Races are held in any season, and in all kinds of terrain, ranging from relatively flat courses on top of mesas to steep and hilly courses within valleys. Sometimes races include just a men's rarajípare, but larger men's races are often preceded by a women's race, the ariwete. Occasionally, an ariwete and rarajípare may occur simultaneously.

Several aspects of rarajípare and ariwete follow a consistent pattern but vary considerably in terms length and duration. Both races are always run in laps (*vueltas*) that are typically approximately 5 kilometers but sometimes longer, depending on the location of the race and the community. An oval-shaped circuit is preferred, but when limited by terrain, the course is linear and run in an out-and-back fashion. Shorter rarajípare, which as noted above rarely occur anymore, were described as being usually five to six laps, whereas longer rarajípare were described as being between 12 and 30 laps. Our measurements of average Tarahumara running speeds, approximately 9.6 kilometers per hour, are relatively slow compared to most Western-culture running races. We use these data to estimate that the shorter, more common rarajípare were 25–30 kilometers (15–18 miles), and the very longest rarajípare could have been approximately 150 kilometers (93 miles). These distances correspond approximately to reports that the shorter rarajípare took about three hours to run, whereas the longest, least common rarajípare "started from the middle of the day and went until the next morning," thus as much as 15 to 18 hours. The elders we interviewed report one famous race in Guachochi that supposedly lasted 72 hours! The women's ariwete races are typically shorter and less variable, about five to eight laps (25–45 kilometers), and last as much as four and a half hours.

In all rarajípare, teams of runners use their toes to kick a wooden ball (*komakali*) about the size of a baseball along the course without ever using their hands (fig. 2). A good description of the kicking motion is a "foot-flick" in which the runner places his toes underneath the ball and rapidly flexes his ankle while extending his knee and flexing his hip. Indeed, the word rarajípare derives from the words *rara* (foot), *hi* (take or seize) and *pa* (throw or fling) (Thord-Gray 1955). If the

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Figure 2. Nighttime scene during a rarajípare race in Huisuchi. Note the runner kicking the ball with a flicking motion as others accompany him with torches to illuminate the way. Photo credit: Marcos Ferro.

terrain is open and relatively free of rocks and bushes, they will kick the ball distances of 50 meters or more; if the terrain is rough or the trail very narrow, they kick it shorter distances to maintain control. If the ball breaks, the team is allowed to wait while one member of the team runs to grab another ball at the starting line and then begin again from where they stopped. In all pueblos, to lose the ball or touch it with one's hands is to lose the race, a very real possibility when referees (*jueces*) are stationed along the course, as is sometimes the case in major races. However, runners in some communities are allowed to use wooden sticks, *palos*, to help place the ball on the top of the foot. In the ariwete, women use hooked sticks to flick a hoop made from strands of the stiff, fibrous yucca plant or sprigs from the *guásima* tree (*Guazumaulmifolia*) that are wrapped tightly with colorful cloth (fig. 3). The first team to run a predetermined number of laps wins, but in some races, victory can also come when an opposing team forfeits the race by losing the ball or the hoop, being lapped, or getting caught using their hands or engaging in some other form of cheating.

To the casual observer, Tarahumara footraces may seem chaotic and unorganized, but each team includes individuals with distinct, clearly defined roles. Race participation in rarajípare and ariwete is very different than Western-style races, reflecting the community-wide nature of these events. At the core of each rarajípare is a team of runners (*rarajípame*)—that usually consists of about five to 10 individuals but can include as many as 20 individuals. In addition to the core runners, a rarajípare team also includes a *cabecia* (a manager/coach), *apuntadores* (assistants to the runners), and *owirúame* (healers, *curanderos* in Spanish). As noted by Pintado (2004, 2012), *owirúame* are one of several distinctions Tarahumara make among types of shamans.

Our consultants reported that they began racing rarajípare at the age of 10 to 12 years, but in the large races between pueblos the core team of runners are typically men in their twenties to fifties and sometimes even older. Although only the core runners attempt to complete the entire race, and in longer races sometimes only three or four finish, other members of the community, including all ages and sexes, often join the race for several laps. These additional runners are not allowed to kick the ball, but instead run alongside their friends and family to take part in the fun of the event, give the runners support, and carry torches at night. The extra runners often shout encouragements such as "*Iwériga, iwériga*!" or "*Iwérisa*!" as they joyously follow their team. As noted by Levi (2004), the word *iwériga* not only means "soul" but also "breath," and *iwérisa* means "have stamina." Both words thus point to the spiritual and physiological interconnections Tarahumara recognize between life, breath, soul, and strength. According to traditional Tarahumara beliefs, when the God *Oronúame* (The One Who Is Father), created the Tarahumara from clay, he gave them the breath of life, and Tarahumara shamans sometimes cure people by blowing on them.

In our interviews the male runners unanimously agreed that the support of the community was indispensable to the outcome of rarajípare. Community members provide food, encouragement, torches at night, and the impetus to continue when fatigue sets in, as well as medicine to help the runners overcome cramps and other injuries (for details, see Irigoyen-Rascón and Paredes 2016). In the words of one experienced runner, "The best runners participated as actual runners but the entire community participates by running as helpers, preparing food and *tesguino*, serving runners during the race, cheering, and betting." As the men sheepishly described, women provide

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Figure 3. Ariwete race in Urique. As with rarajípare, some of these runners have joined in the race temporarily to accompany the core team of runners (those carrying sticks). The hoop is visible above and slightly to the right of the man in a white tunic. Photo credit: Marcos Ferro.

a special kind of support termed *poder de mujer* (woman power) in which a dozen or more women will surround an exhausted male runner for several kilometers during a race, matching him stride for stride, chanting in cadence. In ariwete, the core runners are mostly young women aged 10 to 20 years who do not yet have children. As with rarajípare, members of the community often join in ariwete for a lap or two to encourage the runners.

In keeping with their importance, the planned, larger footraces between pueblos involve considerable preparation. The day before the race, each *cabecia* assigns men to cut thick branches from *guásima* trees that grow from midcanyon to the bottom, or from oak or madrone trees in the mountaintops, from which they carve wooden balls (about the size of a baseball) with machetes and knives. Before the race, the wooden balls are soaked in water, often with a mixture of chiles and *lechuguilla* (a distilled form of agave tequila), to keep them from shrinking, to "cure" them of any evil spirits, and to ward off spells cast by the other team. Generally, each team prepares three or four balls for the race. Leaders of the two teams often walk through the course to determine the length and number of laps and agree on rules such as whether to use sticks (*palos*). For long races, they also prepare and place along the course large piles of *ocote* sticks or pieces of dried *pitaya* (a type of cactus) to use as torches during the night.

When a large interpueblo race is organized, each team, including the *apuntadores* (assistants) and *curanderos* (healers) assembles the evening before with a shaman and their *cabecias* (managers). As noted above, some of our consultants reported that in former times it was sometimes not until these meetings that runners would learn whether they would be running in a footrace or a persistence hunt. At these meetings, the team shares food, generally beans, corn tortillas, pinole, and chicken soup, as well as a few cups of *tesguino*, but the most important prerace ritual is *yúmari*, a pre-Columbian ceremonial dance ritual enacted to petition *Onorúame* for rain and good crops and to give thanks. In fact, all the consultants stressed that the actual races, both rarajípare and ariwete, are extensions of the *yúmari* ritual, and they are considered a powerful form of prayer. As one consultant reported of these prerace meetings, "They danced *yúmari* for several hours to ask blessings from *Onorúame* and prepare the legs for the race. The *cabecia* or *curandero* spoke to the team, exhorting them to remember they are running for *Onorúame*, to remember to not get angry, and to help each other as a team." Often the *curanderos* cleanse or purify the runners by smudging them with incense and serving strong, herbal teas to rid them of fear and timidity. At the end of the meeting, the *curanderos* bless the balls for rarajípare and the rings for ariwete with a candle ceremony (*velacion*). To give the participants extra strength for important races, the men light candles three nights prior to the race and the women four nights prior to the race (because Tarahumara believe men and women have three and four souls, respectively). Races, however, are also competitive, especially between pueblos, and another function of these meetings is to discuss strategies for the race such as having the best runners stay toward the back of the pack until later in the race to let the younger runners move the ball in the early laps.

As reported by other observers (Bennett and Zingg 1935; Irigoyen-Rascón and Palma-Batista 1994; Kennedy 1996; Lumholtz 1905; Pennington 1963), sometimes spells are cast against the other team before large, highly competitive rarajípare races. One spell is to sprinkle shavings from the peyote cactus or dust or pieces of bones from a grave on the path of the

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race. The belief is that when the opposing teams step on these, the dust, bones, or peyote will suck the strength from the runners' legs and cause them to falter. Mahaffey and Cubesare have seen runners who refused to eat food prepared by anyone other than their own cooks for fear that the food has been contaminated or laced with peyote by the opposing team. At races, teams often accuse others of casting spells and being *sukurúame* (witches or sorcerers).

Nonrunners also participate in prerace rituals. The excitement among people in the community in the week or so building up to a large interpueblo footrace is palpable, and everyone (men and women, young and old) talks about who will win and how far they will run and recounts stories from races past. The night before the race, while the team makes their preparations other members of the community often dance and cook pozole (a soup) in large clay pots over fires. At one race in Guadalupe Coronado in 2017, Mahaffey observed 20 to 30 supporters from the visiting team from Guapalayna dancing all night before and then during the race, which lasted seven hours. As previously reported, another important component of larger footraces, especially between communities, is betting (Bennett and Zingg 1935; Irigoyen-Rascón and Palma-Batista 1994; Kennedy 1996; Pennington 1963). Before both races and during the first few laps of the race, people wager clothes, goats, cows, chickens, donkeys, sacks of corn and beans, money, and other items. In the past, more animals were wagered, but today nonlivestock bets are thrown on piles that can grow taller than a person.

Races, however, start with little fanfare, and participants wear the same clothes they normally wear on nonrace days. Traditionally, women wear skirts and the men wear loincloths and colorful tunics, but today more Tarahumara wear Western clothes including shorts and T-shirts. Although designated runners in rarajípare always wear traditional sandals (huaraches), other members of the community who join in the race for a lap or two might wear running shoes or sometimes even boots; some of these runners also wear jeans. Some of the designated runners wear rattling belts made of deer hooves or metal bells that infuse the runners with the speed of deer, help keep them awake, make a delightful sound, and are believed to protect them from the spells (*brujerias*) cast by the opposing team.

During the race most of the community hangs out near the starting line, where people cook, eat, drink, build bonfires, dance, cheer on the runners, and provide them with *pinole*, soup, burritos, and medicine as they pass. However, as noted previously, spectators constantly join in the race for several laps to have fun, encourage the runners, and at night to light their way with either pine torches or perforated canisters (*kachimba*) filled with chunks of lighted pine pitch. As the race goes on, many of the runners suffer from cramps and are tended to by healers who massage them with ointments and give them herbal medications (for details, see Irigoyen-Rascón and Paredes [2016]). Then as the weaker runners begin to drop out of the race, only the best runners remain, kicking and tracking the ball in a trancelike state of pure concentration, agility, and impressive endurance. As the race draws to a close, excitement mounts, and more spectators join in behind the core runners to be a part of the finish. Winners and losers alike then rest and drink *tesguino* along with the rest of the community as the bets are dispersed to the winning team. The winners never exult.

In short, like other Native American footraces, rarajípare and ariwete are far more than just running competitions. As with other aspects of Tarahumara life, running is an important part of Tarahumara spirituality, which emphasizes using rituals to maintain a dynamic equilibrium between opposing forces (Levi 2001). Rarajípare and ariwete are thus potent forms of prayer. Several consultants likened the effort of guiding the unpredictable ball over the lengthy race to navigating the complex, chaotic journey of life. Extreme forms of endurance, including long-distance running, have been shown to induce an altered state of consciousness in some runners that includes a heightened state of awareness and out-of-body feelings (Dietrich 2003, 2006; Ijäs 2017), and our impression is that these long footraces sometimes induce a similar state in the Tarahumara runners.

Beyond their spiritual significance, the races serve other functions. As one consultant stated, his primary reason for running rarajípari was that he "loved to run" but also it "was a way for the communities to come together, an opportunity to win goods or money from the bets, and place prestige on the community." In this regard, it is useful to consider that most Tarahumara farms are isolated and dispersed far from other members of the pueblo, not to mention other pueblos. The best runners in the community often become leaders. In a generally egalitarian society, being a champion runner offers one of the few traditional routes to gain social status (Levi 2013). Finally, we hypothesize that the men's footraces once played an important function in training the Tarahumara for persistence hunting. Tracking the dusty ball during the race may teach participants to track footprints and other forms of spoor while running. As noted above, the word *náhato*, which is often used to describe hunting, also means to chase, pursue, or to run after something like a goat, a deer, or a ball by directing its movement on foot. Since everyone, including youth, are welcome to join the race for as long as they can, the rarajípare is a way for youngsters to develop the ability to run long distances.

Running in Relation to Other Forms of Endurance: Working, Walking, Herding, and Dancing

Whenever we have asked Tarahumara how they train for footraces, the question almost always puzzles them, and they invariably answer that they never train to run. When asked if they ever practiced running, all our consultants answered no, though several answered that they "practiced foot throwing as a boy." Tarahumara children often run when they play, as most children do, and for fun they will often mimic running in a rarajípare. However, to our knowledge, no adult Tarahumara train in the Western sense to improve their running skills or to

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stay fit. In addition, only a small fraction of Tarahumara in any given pueblo can and do run the long distances associated with rarajípare and ariwete, and less than half of the Tarahumara who enter the increasingly popular Western-style ultramarathons finish. Further, even the best rarajípare and ariwete runners struggle during races and suffer from exhaustion, cramps, injuries from falling, and other problems. Therefore, to understand how and why some Tarahumara are so exceptional at long-distance running, it is useful to consider running in the more general context of physical activity, both in terms of what people do and also how they think about physical activities that require endurance, such as running and dancing.

The Tarahumara still practice traditional subsistence farming, and most Tarahumara, including the elder individuals we interviewed, are first and foremost hard-working farmers. In addition, the Sierra Tarahumara is a remote, extremely mountainous region, most of which has yet to be integrated strongly with Mexico's market economy. Although road construction has increased markedly in recent decades, many parts of the Sierra Tarahumara are still far from roads, and few Tarahumara have vehicles. Young boys and girls typically begin herding goats, sheep, and cows when they are five or six years old and thus spend most days climbing up and down rocky mountainsides. Farming is almost always done entirely without motorized machines. Before plowing begins, the land has to be cleared of weeds and rocks by hand and hoe. Most fields are prepared in the blazing sun either with hoes and picks or using oxen or mules that pull wooden plows so heavy that a person of average strength cannot lift them to their knees. An added challenge of plowing is that almost all fields are rock filled, and many are steeply graded. After plowing, the families plant seeds, work for weeks in tandem pulling weeds by hand, turning the soil around the new plants, and placing goat manure. At harvest, the crops are picked by hand and then prepared. For example, corn ears have to be shucked and then the kernels ground. On top of farming, almost all other forms of labor are also done by hand. Women grind corn seven days a week, cook, wash dishes and clothes, and carry firewood and buckets of water. Men also cut firewood, carry water, build or repair fencing, carry cargo on their backs to sell in nearby towns, haul staples back to their homes, and constantly care for the livestock.

In addition to doing arduous agricultural work, many Tarahumara, especially men who work in the fields, regularly walk long distances. Although they are sometimes known as the "running people," a more accurate description might be the "walking people." As soon as their mothers no longer strap them to their backs, Tarahumara children traverse long trails with their parents, hopping from stone to stone and trudging up steep inclines. Many Tarahumara still live connected to each other only by trails. As more roads are bulldozed across the Sierra, some Tarahumara hitch rides in the back of pickup trucks or take the bus and train when going to the city, but the vast majority of Tarahumara walk nearly everywhere they go in mountainous terrain, often laden with up to 40 kilograms of cargo. Accelerometry measurements on a sample of 21 Tarahumara men age 35 ± 12 SD years indicated that the average number of steps per day was $18{,}800 \pm 4{,}500$ SD, approximately 15 kilometers (Shave et al. 2019). Our consultants, all between the ages of 50 and 90, claimed they still walk on average 50 kilometers a week. One of these elderly consultants reported that he climbs about 1,100 meters from Munerachi at the bottom of the canyon (854 meters above sea level) to Sorachique (1,972 meters above sea level) at the rim several times a week. Another, the Presidente Seccional of Urique, reported that he walks around 30 hours every week to make his rounds to the communities in his jurisdiction. Unsurprisingly, many Tarahumara have excellent cardiovascular health (Groom 1971; Shave et al. 2019), but it is important to recognize that this is a population in transition, with increasing levels of obesity and other indicators of chronic disease (Christensen et al. 2012).

Finally, although the Tarahumara are famous for endurance running, the most common and widely appreciated form of non-work-related physical activity is dancing. As Lumholtz (1905:558) remarked, "dance with these people is a very serious and ceremonious matter, a kind of worship and incantation rather than amusement." Unlike many kinds of Western dance traditions, Tarahumara dancing is best described as endurance dancing. The men we interviewed reported that they attend six to 12 dance fiestas per year, with each dance usually lasting 12 to 24 hours. Pintado (2012) reports that some communities have as many as 30 dances per year. As previously noted, the most important and traditional ritual is *yúmari*. From our observations, this ceremony typically starts around 7:00 p.m. with musicians, dancers, and one or several *owirúame* leading prayers and petitions. The *yúmari* is usually held in front of a home on a patio or dance area that is prepared by the hosts, with three crosses, symbols that apparently predate Christianity and which are thought to represent the human form with arms outstretched in openness to *Onorúame* (Lumholtz 1905). Dances can sometimes go on all night and into the next day but do involve rests. The Tarahumara believe that during the *yúmari* ritual, *Onorúame* arrives due to their labor of dancing, praying, and drinking *tesguino*. The dancing generally continues until all the *tesguino* is gone (see Kennedy 1963). The energy spent dancing during the Easter celebration (*Semana Santa)* ceremony is also thought to impart energy and strength to *Onorúame's* winter-long struggle with his older brother, the Devil.

Three popular dances are *pascol*, *tutuburi*, and *matachine*, which are performed at Tarahumara ceremonies to give thanks, for healing, for blessing the dead, for blessing races, and to bless their farm work and fields. *Matachine*, which may have been influenced by missionaries, is an elaborate dance with costumes made from crepe paper and headdresses with deer horns. It is performed inside the church and outdoors; *pascol* and *tutuburi* are performed only outside the church on the designated patio dance area. The strong footsteps *pascol* requires are said to help create the world (Pintado 2012). At the fiestas when these

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dances occur, the dancers rest occasionally to drink *tesguino* and give the musicians a break. The leaders keep the dancers moving for the duration of the ceremony, and the best dancers step lightly to the music and spin gracefully in circles. A few dances last longer than 24 hours: two of our consultants from the community of Tatahuichi recounted dances that lasted two days and two nights, and we have observed dances during *Semana Santa* that lasted as long as 30 hours.

All in all, long-distance running is just one of many kinds of endurance physical activity that is a part of Tarahumara life. It is reasonable to hypothesize that the endurance capabilities and agility of Tarahumara runners partly derive from hard daily work that includes lots of walking in an extremely mountainous environment as well as marathon dancing sessions. Tarahumara dancing also helps them be good runners and vice versa.

Tarahumara Running in Perspective

Running has long been important to Tarahumara culture, and the Tarahumara are deservedly famous for their ability and proclivity to run long distances. However, it should be clear that Tarahumara running is by no means a distinct activity that can be understood without considering its historical, cultural, and biological contexts.

First and foremost, the roots of Tarahumara running likely extend back to a widespread, ancient tradition of persistence hunting that is shared with other Native American peoples. As summarized by Nabokov (1981), persistence hunting was practiced throughout the New World, and almost every Native American community held footraces that were important socially, spiritually, and economically. Long-distance running was also important throughout the New World for warfare and for sending messages between far-flung communities. Despite their former prevalence, these traditions continue to surprise people today as much as they astonished the first Europeans to observe them, such as Roger Williams (1863 [1643]:74), who described Narragansett people as "generally quick on foot, brought up to running . . . I have knowne many of them run betweene foure scoure or an hundred miles in a Summers day, and back within two dayes: they doe also practice running of Races; and commonly in the Summer, they delight to goe without shoes, although they have them hanging at their backs." Over the last few hundred years, however, most of these running traditions have dwindled or disappeared. In this sense, Tarahumara running is special primarily because it has endured, perhaps because the Tarahumara inhabit such a remote region. As a result, persistence hunting traditions continued longer in the Sierra Tarahumara than in other parts of North America, as did other forms of running such as traditional footraces. Tarahumara running is additionally remarkable because of the especially challenging landscape of the Sierra Tarahumara. It is difficult to exaggerate the steepness and depth of the canyons, some of which plunge more than 1,000 meters. Walking and running long distances in this environment help develop strength and stamina.

The longstanding importance of running in persistence hunting may help explain the prominence of footraces, especially rarajípare. Footraces are part of almost every culture, but the kind of running rarajípare demands is similar to the kind of running required of persistence hunters. As when hunting, rarajípare runners work as teams, covering extremely long distances at a very gradual pace typical of ultramarathoners while tracking an elusive, hard-to-find dust-covered ball in the same environments in which they also hunt. Although rarajípare races have probably become less common and otherwise changed in unknown ways over the last few hundred years as livestock and plows and other novel technologies were introduced to the Sierra Tarahumara, they may have helped the Tarahumara learn many of the skills necessary to be persistence hunters. It is probably not coincidental that there are many linguistic, spiritual, and practical interconnections between footraces and persistence hunts.

Equally important to running in Tarahumara culture is dancing. To serve as a *monarco*, or lead dancer, requires extreme stamina and is often performed by the best runners because of their agility, leg strength, and endurance. The people of the community enter the dance and rest when desired, but the *monarcos* are required to lead the dance from start to finish. Tarahumara dance is performed by constant, rapid foot movement lasting at least 12 hours, often much longer, and always lasts throughout the night. In some areas, the *Semana Santa* ceremony includes running, wrestling, consuming corn beer, and dancing, and commonly lasts more than 30 hours.

Despite many deep connections between long-distance running, persistence hunting, and dancing in Tarahumara culture, it would be a mistake to consider Tarahumara running as merely an extension of these activities. Instead running is also an activity that has important social, spiritual, and sometimes economic value, as it is for many other Native American peoples (Nabokov 1981). The rarajípare and ariwete footraces are not just the Tarahumara's principle form of sport but also prominent and highly esteemed communal events. Just as some American and European children grow up wanting to be star football, soccer, or baseball players, Tarahumara children grow up wanting to be champions of rarajípare and ariwete. Even more importantly, running is spiritually meaningful, a form of prayer, a symbol of the journey of life. It is impossible to measure the extent to which these attitudes and beliefs help motivate runners to dig deep and find the strength to keep going for long distances that many people from other cultures find impossible to imagine. Contrary to some (but not all) of the popular depictions noted above, Tarahumara runners are just as challenged as Western ultramarathoners, and they too suffer from injuries, cramps, nausea, and other problems when racing long distances. Those who endure do so in part because they find it rewarding. All of the men we interviewed stated that they "loved to run."

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The challenges Tarahumara face when running contrast with some of the misconceptions about Tarahumara running that have long permeated portrayals of their running by astonished visitors. Some popular accounts convey the impression that the Tarahumara run everywhere and that the average Tarahumara regularly runs 50 or 100 kilometers. Nothing could be further from the truth. To be sure, playing children often run, but most women give up racing as soon as they have children (many still participate in ariwete but not competitively). Adult Tarahumara men today run only during the few footraces that are still held, and only a few of them run long distances. Further, while adult Tarahumara never train in a typical Western fashion by practicing to improve their running form and increase their speed and stamina, it is reasonable to infer that the way they walk, work, herd, and dance is their principle form of training for endurance running. The few Tarahumara runners who race outside the Sierra Tarahumara do well in trail ultramarathons that demand the ability to run long distances at a slow, steady pace, but they do not do well at standard-length marathons (26.2 miles) or shorter distances.

In conclusion, the Tarahumara are not great endurance runners because they have special aboriginal talents or because their biology is somehow unique. Instead, the ability of some Tarahumara to run extraordinary distances derives from hard work, physically active lifestyles, determination, and the spiritual and social values they place on endurance running. It is also possible that their use of minimal shoes helps them develop a running style that is arguably better for preventing injury (Lieberman 2014). However, inferring that all Tarahumara are great long-distance runners solely because of their use of minimal shoes, diet, walking habits, and heavy workloads falsely suggests that Tarahumara and other Native American runners' abilities have nothing to do with motivation, hard work, and talent.

Another disquieting trend that has followed in the footsteps of their newfound fame has been exploitation of Tarahumara running. Tarahumara runners have been used extensively to promote and market various products such as sandals, energy bars, and pinole in ways that do not always benefit the Tarahumara. Some races in the United States and elsewhere have featured Tarahumara runners to promote ultramarathons. Most tragically, because of their endurance, Tarahumara runners have been sought out and often coerced by narcotics gangs to transport drugs across the US border. As documented recently by Goldberg (2017), they have been hired to run all night through treacherous desert terrain, dodging rattlesnakes and coyotes, and hiding during the day.

In the long run, Tarahumara running is part of an ancient widespread tradition that deserves first to be understood and then celebrated, nurtured, and emulated. We have much to learn from Tarahumara running. Most fundamentally, the Tarahumara do not engage in running as a form of exercise to be endured in order to get fit, stave off illness, and avoid decrepitude (all of which it helps accomplish). Instead, the Tarahumara hold running in high regard as a social and spiritual activity. If the roots of Tarahumara running lie in persistence hunting, then their long-distance running was initially a way to provide food, which they consider to be a gift from the gods and their ancestors, and perhaps later it evolved into a community-based event with other social functions. It is thus not surprising that many of these same elements are increasingly common in major big-city marathons that have become celebrations of fitness and community as well as to raise money for charity. In this way, traditions like those of the Tarahumara that value running help make the world a better place.

Acknowledgments

We are grateful to Louis Liebenberg for help with formulating the questions we asked the runners and hunters; to David Carrasco, Jerome Levi, Manuel Dominguez-Rodrigo, and the referees for comments; and to the many people in the Sierra Tarahumara who have helped us, including Christine Aguilar, Marcel Brown, Irma Chavez, Aimee Drane, Marcos Ferro, Humberto Ramos, Alonso Ramos, David Ramos, Arnulfo Quimare, Robert Shave, and Gabriel Yañez. Funding for this research was provided by grants from the Hintze Family Charitable Foundation and the American School of Prehistoric Research.

Comments

Mikko Ijäs
Department of Geoscience and Geography, University of Helsinki FI-00014, Gustaf Hallstromin katu 2, Helsinki, Finland (mikko .ijas@helsinki.fi). 14 III 19

The wonderful article "Running in Tarahumara (Rarámuri) Culture" by Lieberman, Mahaffey, Cubesare, Holowka, Wallace, and Baggish is an important addition to the more or less sporadic previous anthropological knowledge we have had on the current state of indigenous running cultures of northern Mexico. The authors have managed to fill a massive gap we have previously had in our materials, and this is a great improvement. The authors have rightfully raised awareness on Western stereotypical views on the Tarahumara (Rarámuri) labeling it as the "fallacy of the athletic savage." I also believe that it has been a massive advantage that the research group decided to include the native Silvino Cubesare Quimare to this process. Acknowledging the indigenous cultures from within is important and precious in current studies.

The authors have categorized Tarahumara running into several categories that are dealt with individually. Running is an integral part of the Tarahumara culture, and it is a major part of the important cultural activities in which they engage.

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In this article the authors have covered such activities as persistence hunting, men's and women's footraces (known as rarajípare for men and ariwete for women), long-distance travel on foot, hard manual labor of subsistence farming, and endurance dancing. These activities contribute to the endurance running abilities of the Tarahumara. The authors have also pointed out how these activities are interconnected: one activity supports the capacity to excel in another and vice versa.

It is also important to acknowledge some of the possible reasons why the Tarahumara engage in these endurance activities such as footraces and 24-hour dances. Three features that should be highlighted are these:

1. Persistence hunting. All other endurance activities might have been linked to persistence hunting, and if this is the case, it is clear that footraces have promoted the necessary fitness for hunting.

2. Running as a form of prayer. For the Tarahumara the endurance-based activities have served myriad social and spiritual needs, and running has been seen as a powerful form of prayer. This is similar to the other North American native cultures (e.g., Nabokov 1981).

3. Running as a self-fulfilling activity. One of the consultants told how his primary reason to participate in the footraces was that he "loved to run." I assume this is something other Western runners can also relate to.

What is important is that the Tarahumara have managed to keep the ancient running traditions alive up to this date. There are many other Native American groups like the Navajo, Hopi, Apache, Yurok, and Tohono O'odham (previously known as Papago), among many others, who were also known for their running traditions (Nabokov 1981). Some of these cultures are still holding on to these traditions and also revitalizing them.

For myself, the most important feature in this article is the meticulous pursuit to solve the mystery of persistence running among the Tarahumara. Anthropologists throughout the history of writing about the Tarahumara have mentioned how they ran down deer in the rough terrain of the Sierra Tarahumara, but none of them had ever witnessed such an event. This article does a great favor by contributing new material on persistence running among the Native Americans. This is clearly one of the key assets of this article. Unfortunately, the custom of persistence running has pretty much dwindled away from the Sierra Tarahumara, but the authors have done their best to gather as much information as possible on the practice while it still remained in the memories of some individuals they consulted. These recollections are providing the anthropological community with priceless information.

Persistence hunting has most likely been a pivotal part of the whole fabric of cultural behavior of the Tarahumara, as the article acknowledges. Some sort of endurance hunting has always been one of the key features in indigenous hunter-gatherer subsistence, and it is tempting to deduce that it might have been the originator of some other cultural features, such as trance-dancing of the Kalahari (Ijäs 2017) or *Yúmari* dancing of the Tarahumara, or even the footraces. Persistence hunting clearly serves the need for survival from the subsistence point of view, but cultural needs are equally important. The means that bind people together and contribute to social cohesion and overall psychological well-being are pivotal for humans. Therefore it is safe to claim that dancing and racing are more or less equally important as persistence hunting.

Among the hunter-gatherers of the Kalahari, the all-night healing dances are the essence of their culture. In their culture hunting, tracking, and dancing are interconnected and inseparable. In a tiny egalitarian society in which everything is shared, the presence and active involvement of everybody is necessary for the successful ceremony. Persistence dancing purges psychological tension. Dancing is a community event and the whole group is actively involved in the process (Katz 1982:34).

In many Native American cultures, running traditions were tied together with vision quests, spiritual awakening, and enhancement of group cohesion. Running also served more practical purposes like persistence hunting, travel, long-distance communication, and even warfare. These events also had another meaning to the people. Experiencing mild altered states of consciousness such as sensations of enhanced unity and harmony was also pivotal for many of these cultures. Stronger hallucinations were also evident for some of these cultures, such as the Tohono O'odham, who ran long distances to evoke vivid hallucinations (Nabokov 1981).

In this article the consultants acknowledge that rarajípare and ariwete are potent forms of prayer. Several consultants in the article reported how the footraces were like metaphors to "navigating the complex, chaotic journey of life." In my own research (Ijäs 2017) I have claimed how persistence hunting and other extreme forms of endurance activities (including long-distance running and dancing) have played an important part in human cultural evolution, and some of the allegorical fragments of these activities are possibly seen in early representations of visual art.

Jerome M. Levi
Department of Sociology and Anthropology, Carleton College, 1 North College Street, Northfield, Minnesota 55057, USA (jlevi@carleton.edu). 27 II 19

To say this is a welcome contribution to over a century of commentary on the remarkable running abilities of the Tarahumara—or Rarámuri as they call themselves—is an understatement. The article is theoretically sophisticated, empirically grounded, topical, and timely—especially given the recent surge of popular interest in the Rarámuri's legendary skills as marathon runners following the publication of Christopher McDougall's national bestseller *Born to Run* (2009). One of the things that makes this a unique addition not only to Rarámuri ethnography but more generally to the literature on both the

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biological and cultural aspects of human running is its appreciation of the need to comprehend the whole phenomenon of running in relation to a broader conceptual framework. To this end, I applaud the authors' appreciation of how Rarámuri footracing is actually part of a larger cultural complex that is not only about athleticism but exists in functional relation to persistence hunting, dancing, sociality, spirituality, work, and the acquisition of social status. As such, they correctly portray Rarámuri running as defining a critical nexus uniting four key domains of culture, namely, economy, social organization, politics, and religion. Were this not enough, the article furthermore tackles one of the more persistent Western myths concerning non-Western alterity; that is, it rightly critiques the romantic (if not blatantly racist) image of the "athletic savage." In all, no future study of Rarámuri running can proceed without taking seriously the arguments presented in this article.

Early in the paper, Lieberman et al. write: "Although many ethnographers mentioned that the Tarahumara employed long-distance running during hunting, none of these accounts go into much detail about how long-distance running was used to help them hunt, perhaps because few of these observers knew what questions to ask or had the stamina to run with the hunters and thus witness a hunt firsthand." The authors are quite correct in making this statement. However, I am partly responsible for this lacuna in the ethnographic record, for although I did accompany a group of Rarámuri hunters on a two-day persistence deer hunt in the gorges southeast of the Río Batopilas in the mid-1980s, I never wrote up this material for publication, although passing references to it have been made in some of my articles. Thus, at the request of the authors, and in order to supply what appears to be the first ethnographic description of a Rarámuri persistence hunt based on participant-observation, I offer the following:

> The hunt I witnessed began in the highlands in the early morning at the *ranchería* known as *Koráchi* (*Cuervo*, Crow in Spanish) in the remote canyon country accessible only by foot trails southeast of Batopilas, Chihuahua, populated largely by *gentiles* (nonbaptized Rarámuri). About 10 men participated in the hunt. None of them had any firearms except for their bows and arrows, although later in the day a Rarámuri man joined us who brought along a borrowed rifle. Nor did they carry any water or blankets in the event the hunt should continue the next day (which it did), although each man did bring along a small bag of dried *pinole* (ground parched corn). It was not long before one of the men picked up fresh deer tracks and soon all were in hot pursuit of the animal, dashing down the mountainside. At this point I began to lag behind since I was carrying recording equipment, including a camera with a large and heavy telephoto lens. When I finally caught up with them in the late afternoon at an arroyo that was supposed to have some water in it but in fact was dry, they had lost the deer but continued the search farther down the gorge where we eventually spent the night. Before we all bedded down for the night, I asked if they thought we would have any luck the next day and bag any *chomarí* (deer). At that point I was gently reprimanded by one of the hunters, who said that one should never say the word for deer while hunting them, as they have excellent hearing and will retreat farther away. Refraining from mentioning the names for powerful objects, or the use of euphemisms to refer to them, is a recurring form of coding communication in Rarámuri worldview.

The next morning the hunt resumed, but now there were new developments. Several mestizos were also out hunting and had encountered part of our group who had gone ahead. They struck a deal with the Rarámuri hunters to the effect that if the Rarámuri would act as trackers, runners, and beaters who would drive the animal to a designated spot, the mestizo hunters, who explained they would be waiting there in the bushes, would dispatch the deer with their rifles, and in exchange for this service the Rarámuri would get some of the meat. The Rarámuri agreed to engage in this interethnic hunt (which evidently is not an uncommon occurrence), although later the Rarámuri hunters told me they really didn't have much choice: either they cooperate and get some, albeit inferior, parts of the deer, or they go off on their own and likely get none. This way, they added, there was mutual benefit, for each group was engaged in a task in which they excelled—Rarámuri acknowledging that they are better trackers and runners, while mestizos are better marksmen, especially since they are equipped with rifles.

By early afternoon, the Rarámuri had again picked up the spoor of the deer and were hurtling themselves down the mountain above us, where I and several other Rarámuri had stationed ourselves near the mestizo hunters. The Rarámuri runners divided themselves into two groups that formed a kind of V shape with the escaping quarry at the point, so as to maneuver the deer in a kind of pincer movement toward the waiting mestizo riflemen. First one group of runners, amid a great deal of whooping and hollering, would chase the deer over the folds on the side of the mountain toward the other group of hunters, at which point the other group would encounter the frightened animal and drive the deer back toward the first group of hunters, thus proceeding in this zigzag fashion back and forth down the mountainside. In a flash, a small, terrified deer appeared in a clearing and ran straight toward the mestizo hunters, who shot and killed it with their rifles.

Louis Liebenberg
CyberTracker Conservation, PO Box 1211, Noordhoek, Cape Town 7985, South Africa (louis@cybertracker.org). 22 III 19

Perhaps the most significant finding of this paper is that running is an important part of Tarahumara spirituality. The

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relationship between persistence hunting, endurance running, and spirituality can be attributed to the fact that long-distance running can induce an altered state of consciousness experienced as an out-of-body feeling (Dietrich 2003, 2006; Ijäs 2017), as well as the way trackers project themselves into the mind of the animal when they practice speculative tracking (Liebenberg 2006, 2013).

This is illustrated by the way the Kalahari San tracker Karoha Langwane described it: "When the kudu becomes tired you become strong. You take its energy. Your legs become free and you can run fast like yesterday; you feel just as strong at the end of the hunt as in the beginning." This describes what is often referred to as the "runner's high." When the hunter finally runs the animal to exhaustion, it loses its will to flee and either drops to the ground or just stands looking at the approaching hunter with glazed eyes. Karoha explained that when the kudu's eyes glaze over, it is a sign that it feels that there is nothing it can do anymore: "What you will see is that you are now controlling its mind. You are getting its mind. The eyes are no longer wild. You have taken the kudu into your own mind."

Another Kalahari San tracker, !Nate Brahman, explained that "tracking is like dancing" (referring to the San trance dance). This may correspond to what the authors describe as the Tarahumara endurance dancing.

Systematic tracking involves the systematic following of tracks in terrain where footprints and signs are relatively easy to see. Speculative tracking involves anticipating the animal's movements by looking at the terrain ahead, following an imaginary route, saving much time by only looking for signs where the tracker expects to find them. Trackers may visualize animals moving through the landscape and ask themselves what they would do if they were the animals, and where they would have gone. When tracking an animal, the tracker attempts to think like the animal in order to predict where it is going. The tracker visualizes the motion of the animal and feels that motion in his (or her) own body. In persistence hunting this may be experienced as an out-of-body feeling. My own experience of the persistence hunt (Liebenberg 2006, 2013) would suggest that these feelings are not culture bound.

The paper gives very little detail on the answers to the questions in the appendix on persistence hunting, numbered 17 to 25. These questions would indicate that hunters engaged in speculative tracking and not just systematic tracking. The lack of detail may be because the meaning of the questions got lost in translation. One of the interviewers (Mahaffey) did not participate in persistence hunting, while the second interviewer (Cubesare) participated in persistence hunts with his father as a young boy. Maybe the questions were misunderstood when translated, resulting in lack of detail. Furthermore, none of the hunters participated in any persistence hunts after 1980, so much of the detail may have been forgotten.

At one point the authors state that, when questioned, hunters stated that it was impossible to predict the path of the deer, which would suggest that they practiced systematic tracking. However, earlier one hunter is quoted saying that "The deer is very smart and knows how to confuse humans." This way of interpreting animal behavior is more consistent with speculative tracking (i.e., the tracker would ask, What would I do if I was the animal?). Mountainous terrain with canyons lends itself to speculative tracking. First, rocky substrate associated with mountainous terrain makes systematic tracking very difficult. Second, canyons and mountain valleys make it easier to predict the general paths that an animal may have followed. It is therefore unlikely that they only practiced systematic tracking.

Due to that fact that persistence hunting is no longer practiced by the Tarahumara, it may not be possible to obtain detailed accounts of how they experienced the hunt. But comparisons with persistence hunters in the Kalahari may help us better understand the relationship between persistence hunting, endurance running, and spirituality.

Dustin Quinn Martin
Wings of America, 901 West San Mateo, Suite M, Santa Fe, New Mexico 87505, USA (dustin@wingsofamerica.org). 5 IV 19

"Running in Tarahumara (Rarámuri) Culture" unveils the cultural realities of a misrepresented community of "super-athletes." By refocusing outsiders' gaze away from the prowess of Rarámuri runners in modern "ultramarathons," the authors help readers understand that the endurance of their subjects is cultivated by a lifestyle and spiritual belief system deeply rooted in their landscape—not a grueling training regimen and/or diet hidden from the rest of the world in some far-flung Eden.

Through their sharing of memories about persistence hunting and ceremonial racing (rarajípare and ariwete), the article's informants make it clear that running for their people serves more as a medium for social interaction, intergenerational knowledge sharing, and prayer than as "sport" contested to test and prove competitors' ability and worth. This distinction is important not only for recognizing the true beauty and value of the tradition but also for repudiating what the authors refer to as the "fallacy of the athletic savage." This sensationalized vision of "primitive" athletes from the region is dangerous because "inferring that all Tarahumara are great long-distance runners solely because of their use of minimal shoes, diet, walking habits, and heavy workloads falsely suggests that Tarahumara and other Native American runners' abilities have nothing to do with motivation, hard work, and talent." Only after examining the functional, social, and spiritual uses of running in Tarahumara culture does it become possible to understand how and why these runners prepare for and engage in competition differently from "Western" competitors. They offer a vision of what it means to compete for something bigger than one's self and personal goals. For the

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Tarahumara running is a means of prayer for the health of their community and their natural surroundings.

Apart from humanizing a group of people and their running tradition, this article underlines the dearth of research from the academic community on American Indian running culture. Though the authors make important progress in demystifying Rarámuri people and culture, their assertion that ”Over the last few hundred years, however, most of these [Native American] running traditions have dwindled or disappeared” is categorically false. As an article anthropologic in nature, it is not surprising that “Running in Tarahumara (Rarámuri) Culture” favors the tradition of the Rarámuri over others because of its remote locale and “ancient” appearance. But they go too far by implying that running long distances is no longer a means for other Native Americans to connect with each other, their landscape, and their deities in ways similar to the Tarahumara. One only has to look back to 2016 and the “prayer relays” organized by Bobbi Jean Three Legs and other Native youth activists to bring attention to the issue of the Dakota Access Pipeline (DAPL) to be sure that long-distance running is still a thriving and potent tool employed by Native Americans to assert their indigenous identities and values in the present while acknowledging the strength and resilience of their ancestors. Aside from setting the record straight on a tradition that has been grossly fetishized by the competitive running community over the last decade, I hope this article serves as inspiration for other researchers to undertake the challenge of documenting other Native American running traditions to show how, as the authors note, running can “help make the world a better place.”

Jérôme Morneau
Office of Indigenous Affairs, Department of Energy and Natural Resources, 2071 Leonard De Vinci, suite 200, Sainte-Julie, Québec, Canada (jeromemorneau@hotmail.com). 22 III 19

These findings brought me to reassess historical accounts of a form of persistence hunting used by indigenous people in North America that is reminiscent of these strategies. Caribou, moose, or whitetail are most vulnerable during winter months. To save energy, they reuse the same trails (*ravage* in Québec French) to move between their food supply and rest areas. A group of hunters would force deer out of their trails and pursue them to exhaustion in the deep snowpack. In a time of limited technology, it was by all accounts one of the most efficient hunting strategies, considering energy spent and success rate. Below is a summary derived from historical accounts ranging from 1605 to 1792 and from Saint Louis (MO, USA) to the Labrador coast (Canada) that give credit to the hypothesis that our ancestors evolved to kill big game by running them to exhaustion with minimal weaponry and continued to use variations of the strategy until recently.

Like skis in northern Europe, snowshoes are the key to success. Without this technology that allows the hunter to stay afloat, it is doubtful they would have had any advantage at all over their prey. Nearly all accounts agree on one thing: chances of success increase with the thickness of the snow. Some report the advantage provided by a layer of ice over the snow that slows down or harms the legs of the prey (Lahontan 1728; Perrault 1978). One adds that with a solid “crust,” “a child can do it” (LeJeune 1897).

Few record details about the distances covered by a hunting party. However, the baron de Lahontan, who wintered with an unidentified group in present-day Québec, recounts that the hunt begins with scouts searching for fresh tracks, as far as 12 kilometers from the base camp (Lahontan 1728). The discovery of promising tracks sounds the beginning of the chase for the whole party. Another 8 kilometers of (probably fast-paced) walking can be necessary to catch up with the herd of five to 20 moose. Here begins the excitement, says the baron, who relishes the sight of the animal struggling in chest-deep snow. From the moment the party first sees the moose to the final blow, about 1 kilometer is needed if the snow is packed and its cover icy. On the other hand, if the snow is fresh and loose, the chase can easily go on for 15 kilometers. By the end, a hunter involved in all phases can cover up to 35 kilometers.

Details about pace and times are scarce, but we know the chase can last for two to four days, interspersed with rest periods: “they rest only four or five hours, then pursue again; which space of time, being too short for the [caribou] deer to obtain either food or rest, they are commonly jaded out by the fourth day” (Cartwright 1792). The ordeal is said to be much shorter with moose, which does not have the benefit of the large hooves of the caribou that act like snowshoes; he is exhausted as soon as he is startled (Lahontan 1728).

Prior to the use of guns, the final blow was given with clubs, spades, knives, or bows and arrows (Champlain [in 1605] 1870; LeJeune 1897). A fur trader describes the use of clubs as late as 1783, near Saint Louis, Missouri (Perrault 1978). Early on, the final leg of the chase was shortened by the use of guns (Lahontan 1728). My family’s tradition reports that in the 1930s, my grandfather got in trouble with gamekeepers for poaching whitetails in a *ravage* using only a knife.

As is the case with many other ethnographic accounts mentioned in the previous articles, cooperation is critical. Algonquian usually spent the winter time in small groups of two or three families who hunted together. Some may have used an encircling strategy, as do the Innus with caribou: “Some post themselves to leeward of the herd, while others go to windward, and drive them down; by which means, it seldom happens that they all escape” (Cartwright 1792). It appears likely that the group saved their best runners for the final stretch, allowing them to stay behind a vanguard who beat a snowshoe trail throughout the approach.

Though the help of dogs is sometimes alluded to, and can certainly improve the success rate (Roberts 2017), the observers never fail to mention the exhaustion of the prey (due to the

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snowpack) as the main factor. Tracking skills are not an issue in wintertime, except maybe during a heavy snowstorm.

A new base camp was set in the vicinity of the slaughter, where women and children, who followed closely, took the relay and prepared the meat: "They will remain there until they have eaten them all; when, if they have not provided another supply elsewhere, they look out afresh" (Cartwright 1792). The outstanding success rate of this technique seems undeniable. Lahontan and his (unnumbered) group killed 66 moose in three months, and the baron says it could easily have been more.

Like Lieberman and his colleagues, anthropologists should consider looking into oral traditions for traces of persistence hunting and to measure what is left of these endurance feats in the modern cultures of these groups. For example, a form of sun dance that goes on for three straight days stills exists today in some communities. Moreover, *Canadiens* certainly borrowed a few tricks, as my family lore will have it.

However, moral bias would probably be a barrier in such a study. Just like our fitness-crazed time has overhauled the *nobles sauvages* into superathletes, pervasive management has turned ancient hunters into wise and infallible wildlife managers. The apparent unfairness of going after vulnerable deer in their *ravage* would undoubtedly be frowned upon today. My grandfather pleaded that it was to feed his large family during the Great Depression. Hunting is now almost exclusively thought of as a sport, and few hunters would probably want to confess such feats today, even their ancestors'.

Ana Paula Pintado Cortina
Instituto Nacional de Antropología e Historia, Mexico Córdoba No. 45, Colonia Roma Norte, Delegación Cuauhtémoc, Mexico D.F. CP 06700 (anapaulapintado69@yahoo.com). 10 III 19

The originality and importance of this paper written by Lieberman, Mahaffey, Cubesare, Holowka, Wallace, and Baggish is that it explains how Tarahumara endurance is not about having an innate capability but is a result of a way of life that involves many activities within their cultural traditions, such as walking, dancing, herding, working, and hunting. In addition, the value of this work is normally not examined by physical anthropologists concerned with supporting their scientific information with ethnographical data. Furthermore, Cubesare and Mahaffey—the former is a tarahumara runner and the other a person living in the Tarahumara region—were both invited to participate in this paper in order to share their ethnographical knowledge. So far no articles referring to Tarahumara endurance have made the connection between this activity and their other cultural traditions. Thus, the authors clearly show the ways in which distance running "is just one of many kinds of endurance physical activity that is a part of Tarahumara life. It is reasonable to hypothesize that the endurance capabilities and agility of Tarahumara runners partly derive from hard daily work that includes lots of walking in an extremely mountainous environment as well as marathon dancing sessions. Tarahumara dancing also helps them be good runners and vice versa. . . . The Tarahumara do not engage in running as a form of exercise to be endured in order to get fit, stave off illness, and avoid decrepitude (all of which it helps to accomplish). Instead, the Tarahumara hold running in high regard as a social and spiritual activity."

The authors' description of persistence hunting is also important: "is an ancient form of pursuing and then dispatching animals that has been used in many cultures, environments, and contexts. [It] was a common if not predominant method of hunting by early species of *Homo* in Africa prior to the invention of relatively modern hunting technologies." They also explain three key factors that make persistence hunting effective, which show how being a hunter is not about a natural gift, but rather it involves impressive skills and profound knowledge. In addition, they give a provocative description of the deer hunters as people that profoundly respect these animals. "The deer is very smart and knows how to confuse humans . . . by reversing direction or stepping in the same tracks." Furthermore, the authors mention that runners may be invited either to ball races or hunting, by using the same word, rarajípare, so the runners "did not know which it would be until the night before in the team meeting." In Tarahumara this is translated as either "deer runner" or "ball runner." However, when I asked two Tarahumaras (Rarámuri/Ralámuli, one a linguist and the other a teacher) about the etymology as well as the meaning of *rarajipa*, they both said that the term is used only for running with the ball and not for hunting: "It means throw with foot," and hunting is *sirubo* (José Morales, Rogelio Cruz, personal communication, 2018). Linguist Gabriela Caballero also confirms this (personal communication, 2018). Probably the use of *rarajipa* for deer hunting is a strategy to "fool the deer"; it being so intelligent, this is done to avoid warning the animal.

The authors state that normally the runners are the best dancers: "To serve as a *monarco*, or lead dancer, requires extreme stamina and is often performed by the best runners because of their agility, leg strength, and endurance." I would say that all the around, dancers are often the best runners. This is because they dance far more often than run. In addition, in my experience listening to people, they often say that the best dancers are the best runners.

This paper offers an important perspective that goes beyond generalized ways in which Tarahumara capability is seen in the mainstream, as the authors say, "the fallacy of the athletic savage." Most of the articles on Tarahumara resistance see this as a fetish, without much regard for real Tarahumaras as human beings in all their complexity and knowledge of running.

This fetish way of viewing Tarahumara runners started, as the authors mention, long ago, but Micah True in his "Ultra Marathon de Caballo Blanco" made them super famous. While doing fieldwork, I met True in 2000 in Batopilas, at the time he was starting to organize the race. His objective was to economically help the Tarahumaras, and I do think he achieved

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his goal. But as it happens, discrimination toward indigenous people is not solved by just giving money. It is also about respect and treating people as equals and not as "museum pieces." When I went to the Caballo Blanco ultramarathon I was surprised how the Tarahumaras did not take part in enjoying the event. For example, they were seated on sidewalks while foreigners were in restaurants. This reminded me of an article written by ultrarunner Michael Versteeg (2015) titled "Why I Ran: the 2015 Ultra Marathon de Caballo Blanco." This was despite the fact that the race was officially canceled the day before by organizers, supposedly due to a gun battle between rival cartels. Even though the race was canceled, the local Urique municipal and state government put the race back on track. Subsequently, the Tarahumaras stayed and the foreigners left. It has turned into a local event with majority Tarahumara runners. Versteeg decided late that morning of the race to run, he said, and it was the first time he ran so easy and free. He wanted to run in support of the Tarahumaras, who did not seem to care about the violence, because this was their reality. Suddenly, he felt closer to the Tarahumaras because he looked at them with a different lens; he got rid of his "athletic savage" vision, as the authors mention, and he saw them as real people with a difficult situation but with enormous strength, far beyond their physical aspects, as people who live and enjoy life despite everything and who have profound knowledge and a complex way of thinking. In effect, this is why this article is important, because it shows a more accurate and profound dimension of Tarahumara endurance.

Catherine Willems
School of Arts KASK, Ghent, Josef Kluyskensstraat 4, B-9000 Ghent, Belgium (catherine.willems@hogent.be). 4 IV 19

The Tarahumara (Rarámuri)—native Americans living in the Sierra Tarahumara, a mountainous region of northwestern Mexico, known in the Western world for excellence in endurance running—represent a group in transition in terms of running habits, life, and culture. As both tangible and intangible cultural heritage is swept away or commoditized by market forces, Lieberman et al. evaluate and demystify claims about why the Tarahumara excel at endurance running and also aim to document their running traditions before they are lost. In doing this the authors move away from stereotyping and show how critical reflection on cultural roots, biological contexts, and a focus on physical environment (for walking, running, and other endurance practices) can contribute to safeguarding cultural heritage.

The myth that "primitive" humans are naturally athletic is part of popular folklore and is perpetuated by books like *Born to Run* (McDougall 2009), superficial research, and commercial interests (such as selling huarache sandals and energy bars). The authors call the portrayal of Tarahumara as exotic superathletes with extraordinary running capacities, who never get tired, feel pain, or get exhausted, the "fallacy of the athletic savage." Just like long-distance runners elsewhere, motivation, hard work, and talent are also important for the Tarahumara, especially given the harsh environment of the Sierra Tarahumara. Indeed, not all Tarahumara are great runners.

The avoidance of stereotyping by Lieberman and coworkers is welcome and important in a contemporary world of labels and generalization. Indigenous people are all too often "objectified," disrespectfully classified, and—most of all—misunderstood, in part because Westerners tend to gather knowledge about them, not with them. Indeed, along with the breadth of research and the richness of data, what makes this new study particularly interesting is the fact that all authors are linked to the community and have done fieldwork in the region.

Using authentic information from interviews with elderly Tarahumara and insights from their earlier studies, Lieberman and coworkers describe the role of running in Tarahumara culture and bring us straight into the intriguing but often misunderstood world of persistence hunting and endurance running. While one could wish to know more about some aspects—such as the selection of the 10 interviewees, the relevance of their religious status (baptized or not), and differences between the physical environments of *baja* and *alta* Tarahumara (as the hunting and running events require skill in tracking and strategic use of the environment)—the conclusions regarding the social meaning of running, community, and culture are compelling and allow comparisons with communities elsewhere. As recognized by the authors, one such group is the San, who live in the Kalahari, a semiarid desert in southern Africa (mostly Botswana and eastern Namibia).

Owing to the physical remoteness provided by the Sierra Madre (or Kalahari), the persistence hunt and/or traditional footraces survived longer in Tarahumara (or San) than in more readily accessible regions. But in the past decades these cultures have been facing challenges of transition.

While persistence hunting has now nearly disappeared among the Tarahumara and as traditional footraces are becoming less common and are gradually replaced by Western-style marathons, the authors shed light on the common (social) ground of running in different activities. In contrast to Western ultramarathons and other endurance events, in which individuals compete against each other, these races are team activities that are still deeply community oriented and linked to the ancient hunt. Togetherness and apprenticeship are valued aspects of the races and the hunt, and before each run (or in ancient times either a run or a hunt), a ceremonial dance ritual is held in order to bring good spirits to the team and to preserve the dynamic equilibrium of the community.

This natural integration of community, team activity, and spirituality in running/hunting can also be found in the San, where healers (once in trance) used to give guidance for persistence hunting. As healer/hunter Joseph IKun IKunta, chief of Nhoma, told me: "To be a healer is also linked to the hunt. The evening before the hunt when you go in trance during a dance—and when you go to sleep afterwards—it looks as if

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you are dreaming, but it is the ancestors telling you where to go and hunt the next morning" (Nhoma, Namibia, March 18, 2019). Another element that connects the stories of the Tarahumara and the San is footwear. For running and hunting the Tarahumara and the San go barefoot or wear so-called minimal sandals—huaraches and *N!ang nIosi*, respectively—which nowadays consist more and more of car tire rubber but which used to feature a leather rawhide. Consistent with other studies of the biomechanical effects of barefoot walking (e.g., D'Août 2018; D'Août et al. 2009), Lieberman (2014) and Holowka, Wallace, and Lieberman (2018) demonstrated that wearing huaraches not only protects feet but also leads to stronger intrinsic muscles, which helps prevent injuries.

Moreover, it is likely that much like the *Kolhapuri chappal* in India (Willems 2013), the *N!ang nIosi* of the JuI'hoan in Namibia, and the *Nuvttohat* (reindeer boot) of the Sami in northern Finland, or, indeed, their 3-D-printed equivalents (Willems 2018), the huarache is optimal for local conditions and purpose. The huarache adapts to the shape of the foot—in contrast to often rigid universal footwear—but comparative performance tests of the earlier leather sandal, the car tire version, and derivatives inspired by the original design are still needed.

Let me end on a more philosophical note and, indeed, advocacy for the people that are central to our studies but often forgotten. Advancing a natural healthy movement and gait by learning from indigenous communities is one thing. Safeguarding the skills needed for running in hunts and races is another. But ensuring benefits and robust livelihoods for artisans and local communities deserves more attention, especially in view of globalization and ever-lurking exploitation. Tarahumara running has become a lucrative export product, generating substantial cash revenue, but the local communities hardly benefit from the heroic status of their runs. The research by Lieberman and coworkers supports the vision that running in all its meanings can help revitalize threatened cultures, not as museum pieces, not as a myths, but as communities with a powerful design and social fabric where sharing, ecological concern, and human connections are highly valued.

Felice S. Wyndham
School of Anthropology and Museum Ethnography, University of Oxford, 51/53 Banbury Road, Oxford OX2 6PE, United Kingdom (felice.wyndham@gmail.com). 2 IV 19

Disassembling Inherited Frames of Attention: Comments on "Running in Tarahumara (Rarámuri) Culture"

This article usefully explores how travel writers and outsider researchers have mythologized Rarámuri athleticism, highlighting the racist and colonial narratives about what outsiders have considered to be extraordinary abilities for centuries. The authors report on many important details from their interviews with 10 elder men about Rarámuri running. They correctly identify footracing as embedded in diverse aspects of community lifeways and speculate that competitive racing may have originated in formerly more common techniques of persistence hunting.

Before sharing some thoughts about endurance running, for interested readers' sake I would like to correct the authors' introductory claim that "there has been little consideration of Tarahumara running in its broader functional, social, and spiritual contexts." On the contrary, this is one of the most written-about subjects in Rarámuri scholarship. Relevant publications, in addition to those the authors cite, include Deimel (1994) and Merrill (1988:133–134, 178–181), who contextualize running in religious/ontological frames. Pennington (1981) posits a relatively recent introduction of *rarajipa* by Jesuit missionaries and compares Rarámuri running with other indigenous North American and Mesoamerican running traditions. I have written about persistence deer hunting in the recent past and the practice's relationship to spiritual semiotics and landscape (2011:401). Kummels (2001) provides an excellent literature review and, importantly, structures any discussion of Rarámuri running practices as essentially diverse, varying not only by region/community but also temporally: as accommodating emergent social, economic, and identity needs for individuals, communities, and the Mexican state. Another relational, situated treatment is Rivera-Morales, Guadarrama, and Sotuyo's recent (2019) work, which includes an extensive bibliography of Spanish-language scholarship on Rarámuri endurance running.

The material culturist Pennington examined mid-1500s to mid-1700s missionary accounts and found no reference to rarajípari—only to rubber ball games. He posited that rarajípari is a relatively recent practice introduced by Jesuit missionaries attempting to curb what they perceived as gambling (1981:6). If I were to add my own speculation about origins of endurance footracing, a historical ecology perspective of the Sierra Tarahumara as part of a larger continental network of interaction and influence (Schaafsma and Riley 1999:6; Wyndham 2011:416) would cue roots in regional trade and courier practices. It would be especially interesting to analyze reports of this historically important socioeconomic work linking extensive networks of indigenous and mestizo communities that entailed great athletic abilities. As early as the 1530s there are reports of ubiquitous fast long-distance foot travel by both men and women in this region for trade, labor, and communication, including seasonal labor migrations from central New Spain to what is now New Mexico (Herrick 2018:276). It is likely that Rarámuri ancestors, especially those near the great trade center of Paquimé, worked as couriers and carriers in these regional networks. Even farther out on a limb, I might hypothesize that these occupations contributed to ethnogenesis in the turbulent decades of the fifteenth and sixteenth centuries, a notion supported by etymologies of the ethnonym "Rarámuri" as relating to "foot runners" (among many, see Merrill [1988:204–205]).

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It is unfortunate that the authors were only able to interview men. Though mostly appropriate with regard to endurance hunting, doing so contributes to a persistently gender-skewed understanding of Rarámuri running in community contexts. In Rejogochi, the Rarámuri community where I worked as an ethnographer between 1997 and 2005, women's footraces were as common as men's, and perhaps the most frequently held were those for children. Women of all ages competed, and several elders in their sixties or seventies were renowned for their running abilities. This is extremely variable between communities: Janneli Miller (personal communication, 2019) reports few to no women's races in Aboreachi, where she has done long-term ethnography, while Irigoyen-Rascón and Paredes (2015:94) mention special categories of racing for pregnant or recently postpartum women where he worked. Lieberman et al. intriguingly report on the acknowledgment of the importance of women's "power" support in men's races; these details shared by the unnamed expert interviewees in this article are invaluable. Racing opens space for socializing, redistribution of wealth, and the revitalization of identity and relations with the spirit world, and it extends for days prior to and after the actual racing. Women's intellectual, physical, and social labor underpins all these dimensions but is often invisible to outsiders—a key reason to value firsthand experiences of Rarámuri women and ethnographic understandings based in participant observation.

In Rejogochi, racing is related to the seasons; it is said to help bring the rains. Thus, many races, like dances, are instigated to help irrigate spring plantings in late May and June and throughout the summer. Racing is related to identity—it structures a community and larger community networks into "sides" that function as fluid temporary identities. In Rejogochi, as in many communities, teams are divided geographically using deictics of "upvalley/upstream" or "downvalley/downstream" from an arbitrary landmark. As I lived downstream of the school—a designated neutral point for betting and support stations—I was expected to support any "downstream" runner. Support included an obligation to wager; to provide racing aids such as flashlights, ocote sticks, rubbing alcohol to rejuvenate runners' legs, and pinole; and, importantly, to run with one's "side" to lend strength, staying up until the race is finished, and "tipping" the winner if one has good winnings because of their success. When the racing teams are from different communities, these geographically traced affinities shift to be valley to valley or low country to high country.

Early explorers used self-indulgent colonial constructs of savagery and civilization to view Rarámuri footracing, and popular literature (e.g., McDougall 2009) has perpetuated profitable myths of aboriginal superprowess (thoroughly critiqued in Plymire [2006] and more generally in Wyndham [2011]). Any methodology to shatter these false narratives needs to be dialogic and present interview data as historically and geographically situated. Though it includes invaluable perspectives shared by the Rarámuri elders and interviewer, by presenting its material anonymously and undifferentiated by community of origin, this article does not do enough to disassemble the inherited frames of attention that assume Rarámuri have always lived in isolated subsistence economies and have essentially shared culture across the region and that women's ariweta racing is an add-on to men's *rarajipa*. This work does stimulate further conversation about possible origins of running traditions and the contributions of persistence hunting to these and more generally to human athletic history.

To conclude, a general thought for all of us outsiders writing about the Sierra: How can we improve the potential for two-way conversations with local thinkers on the topics we write about? I encourage us to support the repatriation of Rarámuri-language interviews on this and other topics so that younger generations can access and dialogue with both their elders' narratives and outsider perspectives and fuel the next generation of autochthonous practice and interpretation.

Reply

We thank the commentators for their supportive, constructive, and rich additions to this paper. We are gratified by their widespread agreement with our central theme, that Tarahumara (Rarámuri) running, like many other aspects of Tarahumara culture and biology, has too often been mischaracterized by what we label the "fallacy of the athletic savage." Let's banish this false and dehumanizing notion. Running is important in Tarahumara culture, and some Tarahumara individuals are among the world's best long-distance runners, but it is incorrect to stereotype and commodify the Tarahumara as a "hidden tribe" of "superathletes" who naturally run long distances because they are uncontaminated by Western civilization. Tarahumara running—like everything else about the Tarahumara—needs to be understood in its larger social, economic, spiritual, and ecological contexts.

Of all the comments, we especially wish to highlight Jerome Levi's fascinating account of his experience participating in a persistence hunt in the mid-1980s. Beyond his gripping firsthand description of this two-day hunt, which echoes many of the details provided by our consultants, Levi's account highlights how varied persistence hunting can be, including collaborating with armed mestizo hunters and relying on techniques outside of running animals to heat exhaustion. Such firsthand descriptions are needed to dispel widespread and persistent incredulity about the role of running in hunting even in the recent past (e.g., Pickering and Bunn 2007). Further, these accounts highlight just how little we know about ancient running and hunting. The available ethnographic descriptions of hunting and running are sparse, often brief, and rarely include the sort of detail we would like to know about the many ways in which people used to hunt before modern projectile and firearm technologies in different parts of the world.

We are also grateful for the details added by Liebenberg and Morneau of persistence hunts in the Kalahari and temperate North America, including during the winter. Morneau's

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summary of ethnographic and ethnohistoric accounts of how hunters chased down caribou and moose in the snow using technologies like snowshoes adds rich new information and highlights the importance of cooperation and taking advantage of environmental conditions that favor humans' unique physiological capabilities for endurance. Given rapid ongoing cultural and environmental changes, we need to rely increasingly on these and other ethnographic accounts and to continue collecting oral histories before it is too late. But, as always, a major problem is knowing what questions to ask.

Among the many details provided by Levi's and Morneau's comments, we wish to draw special attention to the evidence that persistence hunting doesn't always rely on driving animals to heatstroke as predicted by the standard thermoregulation model. As these accounts describe, and our Tarahumara consultants also explained, there are many ways to run animals to their demise including by driving them toward traps, stakes, and other hunters with guns. In addition, one can exhaust animals in cold climates, especially deep snow. All of these methods, however, involve a combination of running (or skiing/snowshoeing) and tracking.

Liebenberg raises the interesting distinction between speculative versus systematic tracking and suggests that the environment that the Tarahumara inhabit and their anticipation of deer movements indicates use of more speculative methods. Unfortunately, we do not have enough information to interrogate these different methods of tracking, but we agree both must be important to the Tarahumara and vary depending on circumstances including terrain, season, and a hunter's skill.

We thank Martin for pointing out that endurance running is still an important means for many Native Americans to connect with each other, their landscape, and their spiritual beliefs. We agree with his characterization of the ways long-distance running still plays important roles politically, spiritually, and culturally in many communities. Pintado provides another example of this point when she describes how the Caballo Blanco ultramarathon transformed from being a largely imported event organized and run by and for outsiders into a local race with mainly Tarahumara runners. To go a step further, we agree strongly with the commentators that there is a need to support and pay greater attention to these dimensions of Native American running rather than primarily focusing on races or the spectacle of ariwete and rarajípare. To concentrate on Native American running primarily in terms of the distances they run, the footwear they use, and the foods they consume is to miss its larger meaning. Indeed, all the commentators agree with our argument that there is a strong connection between endurance running and spirituality, and that running can be a form of prayer, a point made especially strongly by Ijäs. To clarify this point, we are not arguing that running a rarajípare or engaging in a persistence hunt is the same as a spoken prayer, but the act itself has a meaningful spiritual dimension. If one believes, as the Tarahumara do, that there is no separation between the spirit and the body, then running, dancing, walking, and even farming can be spiritual. As Ijäs points out, in endurance running as well as dancing, these connections are often intensified because of physiological and mental challenges, their meditative nature, their natural setting, and the trancelike state long-distance running can induce.

We thank Pintado for the many details she provides, including her comment about the word *rarajipa* relating to both hunting and the ball race. We are not linguists and relied on just the information we were given by our informants, and we agree with Pintado (and Levi) that it is not entirely clear how this dual meaning makes sense from an etymological point of view. Regardless, we agree that what is important is that the Tarahumara we interviewed see a connection between these different kinds of running. It also goes without saying that the 10 people we interviewed are a tiny, modern sample of people who cannot possibly be representative of an ancient, widespread culture.

We thank Willems for adding to our argument that it is also a disservice to the Tarahumara to commodify them for the purposes of selling books, shoes, and energy foods by portraying them as an isolated, "hidden tribe" without violence, disease, or other problems (including aging). This may be a convenient and lucrative narrative, but it is simply untrue. Instead, the Tarahumara have long confronted hunger, disease, violence, and other problems, and they have interacted with outsiders for hundreds of years. In addition, their way of life and environment are rapidly changing, with consequential effects on their communities and their health. We wonder to what extent such mischaracterizations help promote their continued marginalization.

We very much agree with Wyndham that detailed studies of women runners are long overdue. We started this project with the intention of focusing on persistence hunting, and it was only after we identified and interviewed the older men who had hunted when they were younger that we realized we could not write about this topic without considering running in its broader context, including in footraces. There is much more to learn, and we hope that future work will expand our knowledge of women's running both among the Tarahumara running and elsewhere. Along these lines, we are grateful to the commentators for pointing out additional references.

Finally, we cannot express too strongly our thanks to the Tarahumara individuals and communities that have shared their experiences, thoughts, opinions, and wisdom. Running is an important part of Tarahumara culture, but it is just one dimension among many that merit our attention and from which we can learn.

—Daniel E. Lieberman, Mickey Mahaffey, Silvino Cubesare Quimare, Nicholas B. Holowka, Ian J. Wallace, and Aaron L. Baggish

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