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ENGAGE A VOICE, REPRESS FATIGUE; THE COINCIDENT EVOLUTION OF HOMININ VOCALIZATION AND A METABOLIC THRESHOLD

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**ENGAGE A VOICE, REPRESS FATIGUE;
THE COINCIDENT EVOLUTION OF HOMININ VOCALIZATION
AND A METABOLIC THRESHOLD**

Abstract: To what degree has evolution facilitated synchronization of comfortable oral communication with sustainable exercise intensity? An individual able to engage a voice, represses fatigue. The Talk Test, is a practical strategy whereby a subject deliberately speaks during an exercise protocol. It is a common tool in kinesiology and clinical fields because it inherently identifies a pivotal metabolic plateau known as the ventilatory threshold. The coincidence of comfortable ability to talk and perform sustainable sub-threshold exercise intensity, affords immediate feedback to avoid overtraining and allowing complete physiological recovery within one solar day. A sustained, increased vigor above this stage, though possible, requires more than 24 hours of metabolic recovery, and muscular and range of motion restoration due to overuse may require at least 96 hours. It is hypothesized that vocalization during persistence hunting of *Homo erectus*, has been evolutionarily favored and resulted in a natural and accurate metabolic trip-wire against excessive exercise intensity, and by extension, prolonged recovery bouts.

Keywords: Talk Test, Ventilatory Threshold, Over-training, Recovery, *Homo erectus*

Exercise Background

A review of exercise science literature regarding subjects talking while exercising at sub-threshold intensity levels—the Talk Test (TT)—revealed an intriguing coincidence. Talking while performing an exercise protocol of increasing intensity, consistently identifies a maximal threshold level of sustainability just below a point at which oxygen demands and blood concentration of lactate, with further increase in exercise intensity, would increase exponentially (Reed and Pipe 2014).

The first ventilatory threshold (VT1) marks the starting point during exercise at which an increase of ventilatory equivalents of O₂ occurs without an increase in CO₂ expelled. Up to the limit of this region, exercise intensity is at a low level and the individual should be able to speak with relative comfort (Easy). With increased intensity, the subject would experience some discomfort in speaking (Moderate) but eventually reach a second ventilatory threshold (VT2). The hallmark of VT2 is a pattern at which both gases increase (Miyagi, de Souza Malta, and Zagatto 2015). The subject will have distress speaking (Difficult) and continue to experience an increased difficulty with a corresponding increase of exercise intensity (Figure 1).

The TT origins are traced to Professor John Grayson of Oxford University in 1939, who advised British mountaineers to “climb no faster than you can speak,” and to the “breath check test” devised in Canada (Goode et al. 1998). Exercise prescription is a fundamental element in the field of exercise science, and in practical terms, the FIT_iT_y-VP principle is employed

(ACSM, 2013). These components in sequence are Frequency (F; days per week), Intensity (I; level of energy), Time (T_i; minutes per exercise bout), Type of exercise (T_y; e.g. walking, running and cycling), Volume (V; I x T_i x F), and Progression (P; sufficient time, often several weeks, allotted for adaptations to exercise stresses). All elements of an exercise program are reasonably straightforward to quantify except exercise intensity. The TT is a technique used to simplify an exercise program and thus it employs a strategy that addresses intensity, guiding the subject's level of vigor. When the individual can "just respond to conversation," then the exercise intensity may be "just about right" (Persinger et al. 2004).

Within the context of hominin evolution, an obvious practical application connecting all these elements has been during bouts of cooperative persistence hunting. There is no known published paper that has tried to bridge the fields of kinesiology and hominin anthropology regarding a possible evolutionary connection of the natural metabolic trip-wire that vocalization imposes on an individual who is actively exercising. It is hypothesized that vocalization of hominins during persistence hunting has played a role in survivability by inhibiting a selectively disadvantageous status of physical weariness—engage a voice, repress fatigue.

Talk Test

For the athlete in training, the long-lasting element of fatigue from maximal exercise bouts should be executed only when desired and otherwise avoided because they are risky and time-consuming propositions (Edwards et al. 1977) and full metabolic and muscular recovery is required for optimal performance (Bishop, Jones, and Woods 2008).

The TT takes advantage of the phenomenon and is a staple of exercise science (Recalde et al. 2002; Rodríguez-Marroyo et al. 2013). Based on previous research, ventilatory and lactate thresholds can be closely approximated without collecting expired gases or taking blood lactate (Eniseler 2005). Moreover, the TT has high potential for field use, is inexpensive, easy to administer, and subjects when talking—or reading a familiar paragraph such as the Pledge of Allegiance—get immediate feedback as to whether their exercise intensity is below, at, or above threshold values (Recalde et al. 2002). The TT is also effectively used with a wide variety of clientele.

The competitive or recreational athlete at various fitness levels, persons undergoing a lifestyle change, those seeking weight loss, and even cardiac patients during rehabilitation, it is critically important for one to exercise vigorously, but not to excess (Ballweg et al. 2013; Condello et al. 2014; Norman, Hopkins, and Crapo 2008; Zanettini et al. 2013). It is useful for one to know their precise metabolic status and to tailor their exercise bout's intensity such that it is well-planned to best promote desirable outcomes (Yamamoto et al. 2008). The TT has been demonstrated to be an excellent tool for subjects to identify their own threshold levels; to empower them outside of a laboratory setting—regardless of fitness status and even factoring in such variables as normal fluctuations of circadian rhythms during self-paced exercise (Drust et al. 2005; Reilly and Garrett 1995). The literature is abundant in these areas and has served well both practitioner and patient (Peterson et al. 2014; Quinn et al. 2011).

In prolonged, whole-body exercise to exhaustion, ample recovery time is both beneficial and required but time consuming. In studies with distance runners, 48 hours recovery was found to be mandatory following competitive racing for experienced 10-Km runners (Gómez et al. 2002), and in another study of above-average ability 5-Km runners, adequate recovery time was 72 hours (Bosak et al. 2009). In a series of eight resistance training exercise bouts with experienced males, investigators found after 48 hours, only 40% were recovered. In 70% of the cases, participants had not recovered even after 96 hours (McIester et al. 2003).

Time recovery in single-joint studies has been less-favorable. In a study with 192 volunteer subjects (98 males, 94 females), it was found that maximal voluntary contraction (MVC) ability was not fully restored to baseline levels at 132 hours after maximal eccentric contractions of elbow flexors. One cohort's MVC was not restored for at least 33 days, and in another, MVC had not recovered when last tested after 89 days of recovery (Sayers and Clarkson 2001). Muscle soreness was another issue. Muscular overuse was associated with structural damage of the contractile elements with mechanical stress being the major contributing factor (Kuipers, 1994). Other negative responses included a prolonged loss in range of motion and strength, and edema (Clarkson and Hubal 2002), but pain can also arise from other sites such as joints and tendons (Millet 2011).

Talk Test Use

The TT is a valuable tool for the exercise scientist. Investigations have involved well-trained athletes (Jeans et al. 2011), recreational subjects (Foster and Sheel 2005; Recalde et al. 2002), and even when the TT has been used with cardiac re-vascularized patients, it has been demonstrated to be a reliable metric to optimize their aerobic training intensity, which is a key component to their wellness (Peterson et al. 2014; Zanettini et al. 2013). It has been suggested that cardiac patients can use only the talk test to self-monitor exercise intensity levels and remain in appropriate intensity ranges (Doro 2015).

The TT is user friendly, inexpensive, easy to administer and it gives the individual immediate and accurate feedback (Persinger et al. 2004). The TT is non-invasive. It allows the individual's VT and LT to be revealed within narrow limits without gas analyses nor blood draws, both of which are reliable tools for the exercise scientist but also unnecessary in a well conducted TT investigation (Ballweg et al. 2013; Condello et al. 2014). Finally, the TT addresses the most elusive component of the six indices of the FIT_iT_y-VP principle, namely it inherently guards against excessive exercise intensity (Reed and Pipe 2014).

Exercise Recovery

All the other dimensions of an exercise prescription, although critically important for one to achieve their goals, are relatively easy to monitor. However, intensity of exercise is inherently problematic as investigators typically find athletes working to excess on recovery days (RD) and not intense enough on designated hard days (HD), with the key to execute the preferred

intensity for each exercise bout and with the desired overall balance between the two intensity levels (Foster and Sheel 2005; Jeans et al. 2011; Recalde et al. 2002). The challenges are not trivial.

If an athlete's recovery period is insufficient, then injury risk increases due to muscle fatigue and improper timing of stride unloading and loading (Meeusen et al. 2013; Reed and Pipe 2014; Reinking 2012; Samuelson et al. 2008; Warden, Davis, and Fredericson 2014), but also performance objectives become more difficult to realize (Purvis, Gonsalves, and Deuster 2010). To compound the problem, the individual is not fully prepared to accept the challenges of a HD training session, which in turn, prevents the athlete from adaptations to the HD training stimulus for the simple fact that the HD training stimulus was never evoked (Bosak et al. 2009).

Contributory challenges are complications involving maximal expiratory mouth pressure. The metric declined by 20% in a study with male runners whose average distance covered in 12 min was significantly smaller during exercise with prior expiratory muscle fatigue compared to the control group (Verges et al. 2007). Detraining, injury and even lack of enthusiasm to the point of burn-out or cessation may occur (Lemyre, Treasure, and Roberts 2006), a set of problems to avoid in any good relationship between coach and athlete. The TT allows a coach and athlete to accurately balance RD and HD such that the physical exertion is appropriately intense and allow sufficient rest (Recalde et al. 2002).

The TT has been used successfully to allow athletes to remain cognizant of energy expenditure during endurance exercising (Jeans et al. 2011; Norman et al. 2002; Recalde et al. 2002) and cycling bouts in a laboratory setting (Blanchfield et al. 2014; Rodríguez-Marroyo et al. 2013). The TT allure seems greatest for a coach and athlete when not working shoulder-to-shoulder (Foster, Rodríguez-Marroyo, and de Koning 2017; Woltman et al. 2015) and thereby afford the athlete an independent, straightforward training technique—engage a voice, repress fatigue.

General Survivability

One well-known physiologically self-protective mechanisms is the dive reflex. The response conserves oxygen for sensitive brain and heart tissue and lengthens the time before the onset of serious hypoxic damage (Foster and Sheel 2005). It is a long-held understanding that the evolutionary benefit of the diving response can improve survival not only in near-drowning (Gooden 1992; Samuelson, Nekludov, and Levander 2008) but in conditions of low oxygen availability (Viña 2002, 215-216). Individuals are different and if the variation is heritable, then natural selection forces are applied because in the absence of variation there would be no evolution (Hiebert and Burch 2003).

Another self-protective example, is Takotsubo (broken heart syndrome). There is evidence that this disease, which is caused by severe acute stress—either emotional or physical—is protective of the heart. It has been suggested that because the mid left ventricle becomes hypokinetic under high epinephrine levels and that the negative inotropic effects (force of heart muscle contraction) are beneficial, the response may have evolved as a cardioprotective strategy to limit catecholamine-induced myocardial toxicity during acute stress (Paur et al. 2012). The extremeness of stress exceeds 'flight or fight' responses, which benefit from increased cardiac output. In the case of Takotsubo, its transient nature allows a generally

good prognosis for the individual, and because it is strikingly different from heart failure, research has argued that the physiological protective adaptations have been naturally selected (Paur et al. 2012).

Exercise science has been astute in taking advantage of the TT's benefits. However, it is strongly suspected that the reasons for its efficacy are deeply embedded in our genetic constitution because it has been intermixed with a multitude of selective forces in a long history of hominin evolution—vocalizing during exercise suggests its interrelatedness.

Various challenges facing hominins were undoubtedly many; a non-exhaustive list includes climate and landscape dynamics which resulted in rapid habitat fragmentation (Larrasoana, Roberts, and Rohling 2013), bipedal posture and locomotion, especially for pregnant females (Whitcome, Shapiro, and Lieberman 2007), and energetics and feeding strategies in the context of in total energy expenditure (Leonard and Robertson 1997).

Evolutionary Adaptations of Hominins

Published literature lacks studies that have analyzed the evolution of hominins within the context of a cooperative hunting bout, whereby vocalization functions as a natural metabolic tripwire to prevent—or highly discourage—the individual from pressing onward with their exercise intensity without facing severe risks because of protracted recovery requirements. The ability to hunt cooperatively at sub-threshold exercise levels would be adaptive. This would be especially true when the hunt was prolonged such as in situations of multi-day persistence hunting and when the primary hunting bout was unsuccessful because adequate recovery time after exhaustive exercise efforts may be at least 72 hours (Bosak et al. 2009). Furthermore, a large mammal such as a greater kudu (*Tragelaphus strepsiceros*) which can exceed 100 Kg (Hayward, O'Brien, and Kerley 2007), would provide a sizable nutritional windfall. *T. strepsiceros*' estimated ratio of energy return on investment ranged from 26:1 to 69:1—a sufficient net energy gained for a persistence hunting family to last 6.7 to 11.2 days (Glaub and Hall 2017).

The ethnographic point is underscored further when the following analyses are considered. First, regarding the ideal human running speed for a given distance (least metabolic cost) when applied to persistence hunting, would be less desirable than optimal walking speed (Steudel-Numbers and Wall-Scheffler 2009). There is a curvilinearity pattern in the cost of running and neither extinct nor extant hominin populations are as flexible in the chosen speeds of persistence hunting pursuits. Moreover, there is a difference between males (3.7 ms^{-1}) and females (2.9 ms^{-1}). Elite human sprinters are comparatively slow, capable of sustaining maximum speeds of only 10.2 ms^{-1} for less than 15 s (Bramble and Lieberman 2004), but other mammals have better speed and endurance: horses, dogs and antelopes can maintain maximum galloping speeds of $15\text{--}20 \text{ ms}^{-1}$ for several minutes (Norton-Griffiths 1979). Secondly, the running speed of hominins influences foraging behavior. Evidence suggests endurance running was selected for in the genus *Homo*, and the genes were probably present by the appearance of *Homo erectus* at approximately 1.9 million years ago (MYA) (Lieberman et al. 2007a). Persistence hunting success facilitated by signaling to the others—either orally or

mechanically—suggests large prey pursuits to be worthwhile because of their inherent high-nutritional-return value (Grimstead 2010).

Implications for optimal foraging theory as applied to our hunter–gatherer ancestors provide insight into anthropology and archaeology because they suggest how investigators should quantify search and travel times (Brown, Liebovitch, and Glendon 2007). In contrast, it would be dangerous to assume an average or expected value for each set of relative parameters suitably characterizes it; the forager employs strategies for rate-maximizing and risk-minimizing goals, but the environment is stochastic and thus capture rates unpredictable (Winterhalder 1986). The modern ethnographic record is a limited, and sometimes misleading. The most formidable challenge is to explain the past in terms of confirmable hypotheses (Lieberman et al. 2007a). The TT as a testable tool, offers potential to that end.

Bipedalism

In terms of the evolutionary history of hominin ancestors, it is appropriate to begin in Africa about 4 MYA, in the Pliocene Epoch—when hominins first walked upright. Analysis of the Laetoli footprints demonstrated energy expenditure of bipedalism was likely an important selection pressure on hominin bipeds by 3.6 MYA (Raichlen et al. 2010). Hominins walked with human-like kinematics, however results were inconclusive which hominin taxon made the footprints. Computer modeling analysis has provided additional insights. Heel impressions were substantially deeper than forefoot impressions in the Laetoli footprints—as predicted by a three-dimensional (3D) model—and fully upright gait, confirmed, where walking was erect. The diagnostic footprint characteristics such as force transfer were uncommon, if not absent in any living non-human ape (Crompton et al. 2012).

The locomotion of a committed biped *Australopithecus afarensis* (Lucy) (Johanson, Taieb, and Coppens 1982) was supported by a reconstructed 3D, upright, straight-legged model, concluding the species could have walked in a manner similar to modern humans (Nagano et al. 2005). These results provided the earliest direct evidence of kinematically human-like bipedalism, and extended-limb bipedalism evolved long before the appearance of the genus *Homo* and it is more energetically efficient than ape-like bipedalism. These early hominins were the first to have a locking knee joint and no extant ape can walk on two legs except briefly, because of the rapid fatigue brought forth because their knee joint must be flexed (Jungers 1991). With the ability to straighten the leg, a cascade of evolutionary benefits followed, although some of these advantages also introduced considerable risks. While early hominins were first walking upright, they also became better adapted to walk well on the African savanna (Tuttle 1981).

Several aspects should be kept in mind. First, the climate was shifting and forests shrank in size as savannas widened (Reed 1997). Trees were becoming more scattered. Finally, early hominins venturing out in the savanna and adapting to life in the open, would be less adroit in tree climbing, though not suggesting a lack of anatomical traits since plastic ankle dorsiflexion allowing force production during vertical climbing is not limited to the extant great apes. The dorsiflexion ability could be among the primary mechanisms allowing hunter–gatherers,

including the present, to better access arboreal resources (Venkataraman, Kraft, and Dominy 2013).

Tools and Brain Size

Hominins have undergone a continuous process of addition of new kinds of cognitive capacity, including those relating to manufacture and use of tools and to the establishment of linguistic faculties (Iriki and Taoka 2012). By 2 MYA in the lower Pleistocene Epoch (Gibbard, Head, and Walker 2010), stone tools appeared in the fossil record—a good indicator of advancement of intelligence (Richmond and Strait, 2000; Washburn, 1967), although more recent research has extended this date. The presence of stone-tool-modified bones and, by implication, the use of stone tools at Dikika in Ethiopia dates to 3.4 MYA, a period in which there was no established expansion of brain size beyond that of a great ape (McPherron et al. 2010). The brain should be viewed as part of an evolving holistic ecosystem in which expansion in response to selective pressures has shown an overall tendency to a more robust phenotypic system. Expansion of the brain that accompanied additions of new functional areas would have supported such continuous evolution incorporating new cognitive capacities—including tool use and language (Iriki and Taoka 2012). A gap of almost 1.5 million years exists between tool-making (Olduvai) and bipedalism (Hadar); the discovery of *A. afarensis* demonstrated a causal relationship is lacking (De la Torre 2011).

A large brain and high level of activity requires a high calorie diet (Bunn 2006). Early hominins could not live solely on vegetable matter, but to secure high protein food, they would have to make themselves vulnerable to becoming a prey item and thus living in the open had its drawbacks. Megafauna (>40Kg) in the Pleistocene Epoch were numerous although there is solid evidence abnormal megafaunal loss appears in the Early Pleistocene in Africa around 1 MYA (Malhi et al. 2016). Fossilized hominin skulls being scarred by predator's teeth, has verified hominins were hunted (Cole 2006). Cooperativity might have been possible before the evolution of large brains, but complex forms of cooperative hunting requiring advanced planning probably emerged later in hominin evolution. There are meaningful links between relevant characteristics of early hominins, such as increase in relative brain size, and foraging and ranging behaviors, persistence hunting in open landscapes (Smith et al. 2012). Evidence supports the notion meat consumption was tightly linked to the physiology that shaped the evolution of our genus and meat is the only source that can provide a year-round supply of protein in sufficient quantities necessary for humans living in an African savanna (Domínguez-Rodrigo et al. 2014).

Language and Thermoregulation

Two other evolutionary traits emerged that helped to define hominin uniqueness: language and thermoregulation. A proper language is recent. It might be 100,000 years old (Gentilucci and Corballis 2006) or only 50,000 years old when fully modern speech anatomy is first evident in the Upper Paleolithic fossil record (Lieberman et al. 2007b), but a proto-language probably dates to about 500,000 years ago (Holden, 2004). Vocalizations and their application to the TT are the focus of this paper, they are ancient and evolutionarily conserved. The point is

relevant. Fish vocalize and their ancestry dates to the Cambrian explosion more than 500 million years ago (Bass et al. 2008).

Research indicates both vocalizations and hand gestures have a long history and should not be overlooked (Arbib et al. 2008). There is an understanding of general human speech which is typically accompanied by manual gesture (Gentilucci and Coballis 2006), and a clearly defined role of vocalization in maternal functions (Falk 2004).

It is well-established early hominins co-existed with megafauna and not all of them were docile. There is published data illustrating *H. erectus* with predatory teeth damage which is not wholly unexpected. Based on forensic analysis of predatory families Ursidae, Felidae, Canidae, and Hyenidae, predation on hominins appears to be a common, sometimes violent, scenario during the Pleistocene. It is reasonable to assume that predation bore a constant influence upon hominin evolution including behavioral changes (Camarós et al. 2016).

H. erectus was large-bodied and large-brained. Its ranging patterns were significantly enlarged over those of earlier hominins and energetic costs suggest the occurrence of a shift to a higher-quality diet (Antón 2003). The selective pressures would favor cooperativity and communication—both audible and mechanical in open grassland habitat—especially considering that meat is one of the highest quality foods humans eat and it is among the most difficult resources to harvest from the environment (Stiner et al. 2009).

The advantages afforded to a predator would be vast if it could hunt effectively during the heat of the day because of its abilities to thermoregulate. Most non-primate mammals have a limited quantity of sweat glands, and these are typically apocrine and found in the axillary region and do not play a significant role in thermoregulation. Eccrine glands are found all over the human body and are highly effective in producing sweat (Folk and Semken 1991).

Early hominins were evolving toward less body hair, and coupled with an extraordinary ability to sweat, *H. erectus* became a highly effective cooling machine. Bipedalism brought forth a reduced radiant heating effect from the sun as total skin exposure was approximately one-half of that incurred by a quadruped (Wheeler 1984). A final advantage of *H. erectus* hunting primarily in the daylight hours: potential prey items were not good thermoregulators, and in fact probably hastened some species' extinction (Pimiento et al. 2017).

Persistence Hunting and Endurance Running

H. erectus evolved to pursue fauna through persistence-styled hunting (Liebenberg 2008). The exhausted prey animal could be approached after several hours of pursuit and a clean, high percentage and low risk kill in which the hunters would be close enough to throw projectiles from close quarters (Bramble and Lieberman 2004). Although hominin scavenging is not a central theme, feeding strategy must have placed favorable selective pressures upon hominins because a genetically well-endowed distance runner would benefit as a long-distance competitor, relying on environmental cues such as circling vultures to identify scavenging opportunities (Bramble and Lieberman 2004).

Moreover, it is logical to infer that for early hominin pounding tools, similar behavioral steps could have occurred during the emergence of the first lithic industries (Carvalho et al.

2009). For a persistence hunting hominin at close quarters of a heat exhausted mammal, tools would be better conserved as successful throws at prey from stone implements would be much more likely than misses, and further, the time-consuming processing of the animal could begin immediately thereafter (Ferraro et al. 2013; Zink et al. 2014;).

The meat mechanical tenderization (pounding with a stone tool) and cooking (dry roasting) are two important components of the hominin diet because tenderization significantly decreased tuber toughness and roasting decreased several material properties of tubers correlated toughness. The use of food processing techniques by early *Homo* reduced masticatory (Zink et al. 2014).

The largest antelope, the giant eland (*Tragelaphus derbianus*), are 900 Kg (Johnson et al. 2010). Persistence hunting also suggests social grouping (Wynn 1993). Interestingly, there is a lack of evidence of *H. erectus* preserving meat for later consumption, perhaps an indication that informal societies existed and group hunting—as compared to a solo effort—would likely yield a higher successful kill percentage. There is corroborating support. Oldowan and Acheulean industrial complexes, which are known for their slow pace of progress between 2.5 and 0.3 MYA, for their limited mobility and regional interaction, represent sound testimony to their small home ranges (Ambrose 2001).

Thermoregulatory strategies of *H. erectus* were beneficial, but there were other evolutionary adaptations. Among the apes, *H. sapiens* has the smallest gut and teeth. As hominins brain size evolved, the metabolic expense to maintain them also increased, hominins evolved smaller guts but we also increased our societal and cooperative behavior (Milton 1987).

In terms of running, hominins are poor sprinters and can scarcely out-sprint other mammals (Bramble and Lieberman 2004), some of which can maintain galloping speeds of 15–20 ms⁻¹ for several minutes (Norton-Griffiths 1979). Hominins have excelled at endurance running because of evolution: open range hunters, who vocalized, chased—and avoided—large mammals, and did so successfully at sub-threshold energetic levels (Steudel-Numbers and Wall-Scheffler 2009).

For hominins to exceed VT1 or VT2 for a prolonged period was not selectively advantageous, but for brief exercise bouts, *H. sapiens* can greatly exceed these thresholds and coaches in various sports deliberately do so when invoking a HD. In this way, adaptation, remodeling (Egan et al. 2013) and realization of training goals are reasonable expectations if a proper balance between intensity levels is maintained (Foster and Sheel 2005; Jeans et al. 2011; Recalde et al. 2002).

Conclusion

It is speculated, though not substantiated as causal, that the selective pressures of vocalization and endurance exercise performed throughout hominin evolutionary history during cooperative persistence hunting, contributed to the coincidental events of comfortable oral communication and threshold limit of exercise that is exploited by studies in kinesiology.

Beyond the level of comfortable oral communication lies the selectively disadvantageous physiologic status of fatigue (Bishop, Jones, and Woods 2008; Bosak et al. 2009; Edwards et al.

1977; Gómez et al. 2002). Post-exercise recovery of following sustained maximal intensity is time-consuming, perhaps well-beyond 48 hours in duration (Bosak et al. 2009; Edwards et al. 1977) and early hominins could ill-afford such a luxury. In vocalization they could self-monitor sub-threshold intensity and benefit from other circumstances such as their ability to thermoregulate (Stiner et al. 2009), and the nutritional gain from a large mammal which could offer a minimum energy return on investment of 26:1 (Glaub and Hall 2017).

Exercise scientists are wise to exploit the use of vocalization as an inherent metabolic suppressor to guide an individual to sub-threshold exercise intensity level (Foster and Sheel 2005; Jeans et al. 2011; Recalde et al. 2002). The TT has been implemented with competitive and recreational athletes at various fitness levels, persons undergoing a lifestyle change, seeking weight loss, cardiac patients during rehabilitation (Ballweg et al. 2013; Condello et al. 2014; Norman, Hopkins, and Crapo 2008; Zanettini et al. 2013), a key component to their wellness (Peterson et al. 2014; Zanettini et al. 2013), and it has withstood circadian rhythms variables (Drust, 2005; Reilly and Garrett 1995).

The testability of the TT presents a compelling opportunity for investigation, especially because acceptance of new ideas is naturally constrained when they are theoretical (Lieberman et al. 2007a). In clinical situations the TT is an invaluable tool (Ballweg et al. 2013; Condello et al. 2014; Goode et al. 1998; Lemyre, Treasure, and Roberts 2006; Norman, Hopkins, and Crapo 2008; Persinger et al. 2004; Peterson et al. 2014; Quinn and Coons 2011; Reed and Pipe 2014; Zanettini et al. 2013). The TT addresses the most elusive component of the six indices of the FIT_iT_y-VP principle in that it establishes an inherent trip-wire against excessive exercise intensity (Reed and Pipe 2014).

Endowed with an efficient thermoregulatory system (Folk and Semken 1991), the wherewithal to carry water or at least to find it as needed during a persistent hunt, tool-making skill (Gibbard, Head, and Walker 2010; Richmond and Strait 2000; Washburn 1967), and to engage a voice and repress fatigue—lay out a foundation conducive for *H. erectus* to be an endurance exercising machine inherently able to hold the line metabolically by running at sub-threshold levels (Lieberman et al. 2007a).

By vocalizing during one of *H. erectus*' most practical activities, they would stay below VT1 and VT2 levels (Goode et al. 1998; Miyagi, de Souza Malta, and Zagatto et al. 2015; Reed and Pipe 2014). Moreover, they would increase the likelihood of a successful persistent hunt, acquire sufficient protein quantities necessary for living in an African savanna (Bunn 2006; Domínguez-Rodrigo et al. 2014), and keep their metabolic recovery to minimal time durations (Bosak et al. 2009; Edwards et al. 1977).

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