

Although difficult to quantify, the level of sedentarism currently experienced by modern, non-hunter-gatherer (non-HG) humans is likely unprecedented. Thus, as far as evolutionary mismatches go, the differences between a movement-rich and movement-void environment must be delineated well for both scientific and practical purposes. Because movement science is relatively young, it is essential that terminology, definitions, and assumptions be explicit and specific.

The difference between exercise, physical activity, and movement

It has been previously noted that the terms “exercise” and “physical activity” refer to different concepts but are often confused or used interchangeably. Caspersen et al. (1985) define “physical activity” as “any bodily movement produced by skeletal muscles that results in energy expenditure” (i.e., calories utilized) and “exercise” as “physical activity that is planned, structured, repetitive, and purposive in the sense that improvement or maintenance of one or more components of physical fitness is an objective.” There is overlap in elements of physical activity and exercise (use of skeletal muscle resulting in continuous energy expenditure, positively correlated with physical fitness), and the type (mode) of movement one selects for either can be the same. For example, one can ride one’s bike to work or go for a bike ride. The physical benefits do not differ between the two scenarios, but if the intention is getting to work (vs. riding for fitness and health benefits), then this action would be categorized as non-exercise

physical activity. Similarly, if one chooses to use a rake instead of a leaf-blower to increase their movement, this bout of raking could be categorized as exercise, although if one had only had a rake to use, this raking would be physical activity.

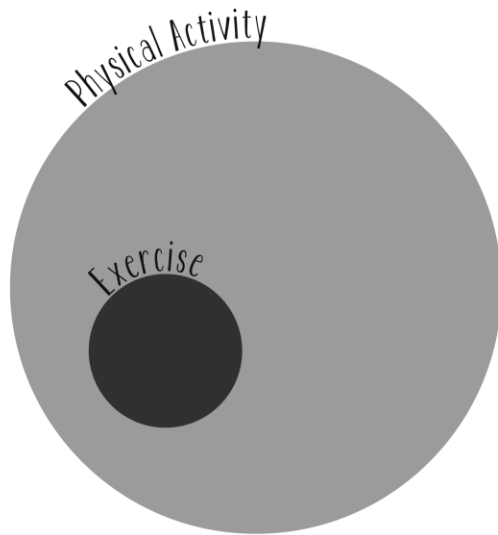


Figure 1. The relationship between physical activity and exercise. Physical activity includes both exercise and non-exercise movements.

Exercise is a sub-category of physical activity (Figure 1); thus, all exercise is physical activity, but not all physical activity is exercise. It's key to recognize that what delineates the two is not the physical motions or adaptations of/to the movement, but the intention one sets beforehand and that the time allotted to exercise is typically separate from time allotted to other societal responsibilities. It's clear modern, non-HG humans need to move more—one study suggests >7 hours of uprightness (stepping, standing or other non-sitting activity) may be an appropriate target to avoid metabolic risks (Tigbe et al. 2017). But adding

multiple-hour bouts of exercise to all or even most days can be impossible given daily responsibilities of work and family. It's also critical to note that within many at-risk socioeconomic groups, there is often no extra time at all for exercise, given scenarios involving multiple jobs, childcare struggles and single parenting. Non-exercise physical activity, then, holds tremendous potential for adding movement, as it allows the mover to meet other responsibilities simultaneously to the physiological.

“Movement” is a term used abundantly in discussions about evolutionary health, yet has not been clearly defined—especially as compared to related terms like “exercise” and “physical activity.” However, the effects and benefits of movement are not limited to caloric expenditure and physical fitness; movement facilitates operations in almost every human system (e.g. immune, digestive, nervous) and so a more inclusive definition is necessary.

I propose that, in addition to the general idea of a body changing its position in space, movement should be additionally defined as “any motion that creates a change in shape of a body or parts of a body”—and need not be bound to an intention or caloric expenditure, or limited to physical fitness variables. Movement is not defined by a physiological outcome, but by a transition in geometry. The human body can move and be moved in numerous ways beyond those that utilize skeletal muscle or contribute to physical fitness performance, yet they could relate to various health outcomes: for instance, horripilation, or “goose

bumps,” in response to cold; the pressure-deformation of parts interfacing with sitting and sleeping surfaces; or loads to the tongue and jaw during breastfeeding or chewing. Yet these movements are currently unrepresented without a definition of movement outside of physical activity.

To identify all the ways in which sedentarism is affecting human physiology, a category of movement must be made for these essential movement-facilitated tasks. A new definition of movement (as above) organizes physical activity and exercise relative to a broader understanding and shows how both are subcategories of movement (Figure 2). Again, it follows that physical activity (and thus exercise) is movement, but all movement is not physical activity and exercise.

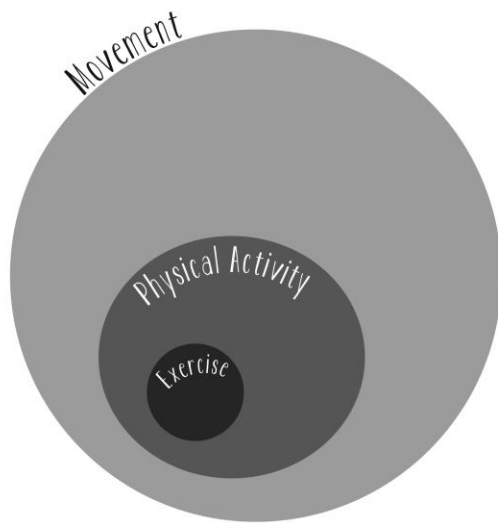


Figure 2. The relationship between movement, physical activity, and exercise. Movement includes exercise, non-exercise physical activity, and non-physical activity movements.

Movement (and sedentarism) is both a whole-body and a local state

The identification and investigation of *mechanotransduction*—a term for the phenomenon of cells sensing and converting mechanical signals (i.e., their deformations) into biochemical responses (Ingber 2003)—is a recent addition to movement science. Movement, while occurring on the whole-body level, is simultaneously occurring, although less perceptibly and often unrelated to musculoskeletal action, on the cellular level. Said another way, movement creates both systemic and local (cellular) responses. It follows, then, that a more complex model of movement is needed, in which whole-body movement is acknowledged to be the viewable sum-total of cellular movements.

Lindholm et al. (2017) created a tightly controlled endurance exercise study using an intraindividual control—having subjects train only one leg via three months of single-leg extensions, four times a week, for forty-five minute sessions. This design can be effective, as it reduces the influence of potential confounding variables such as sleep/rest, diet, non-intervention movement habits, etc. (MacInnis et al. 2017). Muscle biopsies were taken from both legs before and after training, showing that this training protocol reshaped the epigenome and induced significant changes in DNA methylation *in the working leg*.

“Endurance exercise” is a type of movement commonly understood by the general public by its effects. While many forms of movement create a similar

response, “endurance exercise” is often perceived as repetitive motions that increase the heart and breath rate. Thus the benefits of the repetitive motions of exercise are commonly understood to relate to these systemic responses rather than to the motion that creates them. However, in the single-leg cycling study, the cellular adaptations to this endurance exercise training were limited to the parts doing the movement/work—and were not distributed throughout the entire body. Thus a more clear association was made between the health-protective nature of exercise and cellular adaptations to local (of one leg, in this case) movement. Meaning, the whole-body state (i.e., the cardiovascular system’s response to movement) was not the sole influencer of the cellular adaptations to movement—the movement itself was associated with the cellular adaptations.

If there is, in fact, a causal relationship between the health benefits of movement (i.e. the bends or compression of the cells) and the cellular changes in those parts moving, this opens up a theory of both part-by-part fitness and also a theory of cellular or local sedentarism. If someone can be active on a part-by-part basis, then so too can they be sedentary in areas of their otherwise active body (and diseases of parts could be related to sedentarism of parts). This opens up an exciting thread in both exercise and non-exercise movement prescriptions—it might not only “move more”, it could also be “move a greater number of your parts, more.”

Thinking (and applying) outside the whole-body states

The identification of adaptations confined to working parts is key to refining the ever-expanding model of movement dosage (type, duration, frequency, and distribution) necessary for various health outcomes. Therefore, to make steady progress, more robust movement assessments need to be considered when designing and evaluating protocols and results.

For example, the Hadza—a modern group of hunter-gatherers in Tanzania subsisting predominantly on wild food—are often studied by researchers trying to quantify activity levels associated with decreased risk factors of disease. Recently, Hadza members were asked to wear heart rate monitors over four two-week periods to measure their activity levels.

When analyzed in one-minute sections, the subjects averaged approximately 221 minutes of light (40–54% MHR) physical activity, 115 in moderate (55–69%), and 20 minutes in vigorous (70–89%) physical activity per day (Raichlen et al. 2017). The presentation of this data was biased toward the benefits associated with the stress of moderate and vigorous physical activity on the cardiovascular system—without any consideration that the most abundant activity, light activity (almost four hours), might be a contributing factor to Hadza health outcomes. The activities themselves received only a cursory nod. The paper notes, although without measurement, that Hadza men tend to walk greater distances compared to women, whose physical activity and corresponding heart rate likely come from

walking while carrying heavy loads (offspring, water, firewood, food). The authors assume the moderate and vigorous heart rates are themselves protective, but it's actually unclear at this point if the protective nature of the Hadza's abundant physical activity is related to the work of the heart to facilitate the movement, to the movements themselves (the loads placed upon varied body parts and thus a wide distribution of local cellular adaptations), or to the combination of the two. Given that exercise studies often provide explicit or implied recommendations to replicate a percentage of heart rate max of the movement (vs. the movements themselves), delineation of movement is essential.

We are starting to see more thorough movement recommendations that consider the mode or type of physical activity when it comes to evolutionary mismatch. O'Keefe et al. (2011) have suggested a pursuit of "organic physical fitness" via participating in activities that mimic HG physical activities in terms of their caloric expenditure: gardening in lieu of tuber-digging, interval training in lieu of hunting and carpentry in lieu of shelter construction. Given recent understandings of the mechanotransduction phenomenon and the local cellular effects of movement, it's likely that the benefits of these movements are not tethered solely to the cardiovascular state or caloric expenditure once perceived as the primary benefit to movement, but also to the local adaptations arising from the geometries (and resulting cellular deformations/loads) utilized while performing them—each movement "moving" various locations of the body, moving (and

adapting) more cells, rendering more parts of the body active rather than sedentary.

Movement ecology and the relationship between habitat and movement

Ecology is a branch of biology that deals with the relationship of organisms to one another and their physical surroundings. Movement ecology, then, is the study of movement and how it relates to other organisms and the environment in which movement occurs. Movement ecology, like all ecological models, calls for broader considerations—expanding models from the simple to the more complex. As previously mentioned, complexity can be added by considering an individual as a collection of parts. We can also deepen our model of movement mismatch by considering movements that fall outside of physical activity and exercise categories—movements that are cell-moving but are not bound to caloric expenditure or even use of the musculoskeletal system—and also by introducing the idea that context (i.e., movement habitat) matters.

One's physical habitat includes (but is not limited to) the shapes of what you take rest upon/place your body within, shapes of what you walk/move over, temperature, what you hear, and how far you can see. When we add physical geometry (utilized shapes) as an element of movement, we must consider the effect of ground texture, terrain, temperature, tasks, and even other humans on movement, and we must also acknowledge the movement-limiting state of our

current habitats. What little there is of modern non-HG movement is most often performed over artificially flat and level surfaces, within climate-controlled containers, enveloped in environmental pressure-reducing footwear and clothing, and atop thickly cushioned surfaces with heights adjusted so as to require almost a single geometry over and over again. To most robustly define movement mismatch, we must remove (in theory) numerous technologies as almost every activity in a general H-G lifestyle begets movements flying under our culturally conditioned exercise radar.

Considering a category of movement outside of physical fitness should also interweave various threads in physical therapy and exercise science, as well as other evolutionary mismatch investigations, with movement as it relates to the understanding of biological fitness. For example, many physical therapies are practices designed to mechanically transduce tissue ranges of motion that better match with joint ranges of motion. “Pressure deforming exercise” like foam rolling or other pressure-deformatory therapies could be replacing pressure-deformatory movements that occur naturally when people interact with landscapes unaltered by humans (for example, sitting on rocky ground or pressing your arms into bushes and tree bark). In evolutionary dentistry and childhood development realms, palate and cranial facial formation (and resulting breathing practices), occlusion, orthodontics, and tooth health are often related to breastfeeding and chewing movements. There are many therapies that are, quite

simply, replacements for movements we've consciously and unconsciously outsourced to various technologies.

There are also non-physical components to movement ecology; there are the stimuli for movement: a need for food, shelter, protection, family, and community. Each of these human needs results in movement to meet the need (e.g., gather, dig, climb, pound, carry, touch, mash, rip, tear, chew, traverse swaths of land for food). Without the stimuli to initiate movement reflexively, humans are forced to manufacture willpower (over comfort and energy conservation).

As for the future of movement prescription, it is crucial to note that both physical and non-physical aspects of habitat have been recently engineered to be almost entirely movement-free for some. Thus we are not only mismatched in terms of quantity and qualities of physical movement—the purpose and impetus for our movement is entirely unprecedented. When it comes to exercise and physical activity adherence, habitats reengineered not only for more movement but also for non-exercise (greater purpose) movement might be key (Lee et al. 2016).

How do we think (and move) outside the exercise box?

Measures of physical activity and exercise are often whole body in nature due to the demands of equipment portability, ease of use, and lower expense. Thus

measures (and movement prescriptions) are often reduced to total minutes moved, steps per day, or intensities (light, medium, vigorous) experienced. Recognizing movement to be simultaneously a whole-body and a cellular phenomenon will require measuring local effects of movement simultaneously to fully understand the mechanism between movement and health. Some simple recommendations to create more robust movement data include presenting data on geometrical variance (identifying which body parts were used to achieve total minutes moved and intensities) and also on types of movement, e.g., carrying children, water, wood, food—alongside “whole-body” measures. To further consider movement mismatch from an ecological perspective, we must consider that movement, in its “natural state,” is a reflex.

On a practical level, it’s worth noting that, relative to our capacity for movement—both in terms of time and our individual potential geometries and loads—we are not moving very often or very much of ourselves. Most currently exercising might be moving very few of their body parts, despite intensities (whole-body responses) reached by doing a narrow range of motion (using some parts) at high repetitions. While the use of traditional exercise practices to diversify movements is currently utilized by some, and there has been a recent trend in movement modalities that include complex movements in complex environments, these are still exclusively exercise scenarios for well-being and don’t reflect a very robust utilization of movement.

Given a more robust definition of movement and the understanding that movement can relate to other non-fitness outcomes in the body, exercise prescriptions, it seems, might not be adequate—and for those with less privilege might not even be possible. In a culture of cars, robotic vacuums, hired landscapers, supermarkets, and pre-grown/packaged/cooked food, most of the responsibilities we hold (work, family, hobbies) have become movement-free, or consist only of a narrow range of repetitive motions performed during work hours only. Our lifestyle has resulted in us and the parts of our bodies being almost entirely sedentary. Non-exercise movement prescriptions, including changes to habitat to facilitate a greater response in parts movement and total quantity of movement, could be the way of the future for movement therapies and personal training.

Compared to nuanced nutritional mismatches, where most humans have been at least consistently eating (consuming caloric nutrients, even if the range of nutrients varies), we—including the exercisers among us—are experiencing an almost total movement famine. Given the impact movement has on all physiological systems, including the acquiring and processing of dietary nutrients, it's worth noting the importance of movement mismatch discussions. We clearly need to move more, but not only move more; to distribute movement over a

greater area of our body, areas not typically considered in an exercise or physical fitness paradigm. Given that the capacity for human movement is equal to all minutes per day and is almost infinite in geometrical possibilities, discussions need to broaden far beyond daily or “ultimate” workouts. Given that the ways humans move and are moved is much greater than athletic motions of the musculoskeletal system, discussions and research on human movement need to broaden beyond *physical* fitness variables and start including movements as they relate to variables of *biological* fitness. This is a call to start thinking, researching, and moving outside of the exercise box.

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