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Review paper

What made us physically active? Part II

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Abstract

Introduction: Evolutionary medicine applies modern evolutionary theory to provide insight into human health and disease. It contributes significantly to our understanding of their origins, causes and mechanisms and feeds into the discussion about insufficient physical activity of modern humans and the epidemics of so called life style diseases.

Aim: We discuss the evolution of the human musculoskeletal system, its role in human survival and the genesis of modern *Homo sapiens* to illustrate the fact that current level of human physical activity does not match our bodies' evolutionary past.

Material and methods: The literature on this subject.

Results and discussion: The evolution of the human skeleton and muscular system allowed for strenuous walking and long-distance running. Bipedalism and the ability to run rendered humans dependant on physical activity to preserve health. The current lack of activity leads to ill health and many of civilisation diseases.

Conclusions: Daily exercise appears to be the best medicine for the diseases of civilisation in the 21st century.

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1. INTRODUCTION

There is a dramatic mismatch between the modern and the Paleolithic environment in which human body and physical activity evolved. The scale of insufficient physical activity and sedentary behaviour is truly alarming.[1–4] Lieberman suggests that only evolutionary theory and data could explain the ultimate mechanisms of a recent global phenomenon of a dramatically increased level of physical inactivity and sedentary behaviour.[3] More often than not, modern medicine focuses on the 'here and now.' It solves individuals' current health problems, searches only for contemporary causes of diseases and offers mainly symptomatic treatment. Conversely, evolutionary medicine considers the long-term ecological relationships and analyses health and diseases in the wider historical context. This allows for a better understanding of the origin of human diseases and tries to answer the perennial questions of when and why we get ill.[1,5] Unfortunately, evolutionary medicine is nearly completely absent from the Polish medical school curricula. This might explain why healthcare professionals often fail to notice the mismatch between the past and present levels of physical activity and the correlation between current sedentary behaviour and the pandemic of non-communicable diseases at the break of 20th and 21st century (Table 1). It might explain why one tends to treat symptoms of the disease to a much greater extent than its root causes, many of which we still cannot comprehend.[1,6,7]

The question of human adaptation to physical inactivity and the 'dose' and type of health enhancing physical activity was recently reviewed by Lieberman.[3] We join the worldwide discussion about the reasons of the current pandemic of physical inactivity and sedentary lifestyle.[1–3,6–9]

Table 1. Civilisation diseases and disorders associated with physical inactivity.[6,7]

CHRONIC NON-COMMUNICABLE DISEASES
Cardiovascular
1. Coronary heart disease
2. Chronic heart failure
3. Hypertension
4. Cerebral apoplexy (stroke)
5. Peripheral arterial disease (intermittent claudication)
6. Deep vein thrombosis
7. Premature cardiac death
Pulmonary
8. Chronic obstructive pulmonary disease
9. Asthma
10. Cystic fibrosis
Digestive
11. Gall bladder disease
12. Diverticulitis
Metabolic
13. Diabetes mellitus type I and II
14. Gestational diabetes mellitus
15. Metabolic syndrome
16. Nonalcoholic liver fatty disease
Musculoskeletal
17. Fibromyalgia
18. Osteoarthritis
19. Rheumatoid arthritis
20. Bone fractures/falls
21. Osteoporosis
22. Low back pain
Neurological
23. Alzheimer disease
24. Parkinson disease
25. Multiple sclerosis
26. Chronic fatigue syndrome
27. Depression
28. Schizophrenia
29. Anxiety, phobia
Female and male reproductive system
30. Pre- and eclampsia
31. Polycystic ovarian syndrome
32. Erectile dysfunction
Cancer
33. Colon
34. Breast
35. Endometrial
36. Prostate

2. AIM

We present an abbreviated history of the evolution of human musculoskeletal system and focus on its role in *Homo* genus survival and subsequent 'conquest of the world'. We highlight the role of obligate bipedality and endurance running in the genesis of the modern *Homo sapiens* to illustrate the fact that many aspects of modern lifestyle, including physical inactivity, do not match our bodies' evolutionary past.

3. DISCUSSION

3.1. From walking Australopithecus to running modern men

As discussed in the first part of our review, the musculoskeletal morphological changes had started in very early hominins 7 million years ago (Ma) and were almost complete in *H. erectus*, which originated around 2.0 Ma (Table 2).[9–12] It is speculated that the nutritional habits of *H. erectus* gradually changed towards habitual meat and fat consumption

Table 2. Anthropometric characteristics of humans.[12,13,18]

Informal groups	Representative taxa (splitting taxonomy)		Epoch	Cranial capacity (cc)	Body mass, kg F–M	Stature, cm	Development
Transitional hominis	*Homo rudolfensis*	2.4–1.8 Ma		753	56–60	–	Obligatory terrestrial bipedality, endurance running, very limited arboreal facility
	Homo ergaster	1.9–1.5 Ma		854–863	58 (54–60)	–	
	Homo erectus sensu lato	1.9 Ma – 200 Ka		980–1016	57 (52–63)	156–170	
Pre-modern *Homo*	*Homo heidelbergensis*	1.0 Ma – 300 Ka	Pleistocene 2.6 Ma – 100 Ka	1198	62 (56–77)		Agricultural revolution 10 Ka – 200 years ago
	Homo neanderthalensis	300–25 Ka		1512	66–77	148–177	Industrial revolution 200–20 years ago
	Homo sapiens idaltu *Homo sapiens fossilis*	400–200 Ka		–	–	–	Cybernetic revolution 20–0 years ago
	Homo floresiensis	74–12 Ka		552	34	110	
Anatomically modern *Homo*	*Homo sapiens*	200–0 Ka	Holocene ~100 – 0 Ka	1355	65 (54–65)	170–180	

Comments: Ma – million years ago; Ka – thousand years ago; F – Female; M – Male.

because of its larger brain size and increased demand for energy. However, about 2 Ma humans were able to kill animals mainly by 'persistence hunting.' *Homo erectus* had to adapt to walking and running long distances in a dry and hot habitat.[1–3,11–13] Gradual anatomical modification of *H. erectus* body allowed it to store and release energy in the lower limbs, helped keep the body's center of mass stable and overcome the thermoregulatory challenges of long distance running. *Homo erectus* and its descendents *H. heidelbergensis* and *H. sapiens* became excellent long-distance walkers and endurance runner.[10,11,14] Other changes affected the shape of *H. erectus*' thorax, waist and foot. Its pectoral girdle and shoulder become human-like. Scapulae were positioned more dorsally; glenoid fossae faced anteriorly. Glenohumeral joint was oriented more laterally and the humeral head faced posteriorly displaying only low to modest torsion. The elbow functioned in parasagittal plane placing no restrictions on the use of forelimbs. The range of upper limb motion, particularly in the posterior direction, enabled effective tool-manipulation and stone-throwing. Finally, the leg-generated torques were more effectively counter-balanced by the arm swing during the aerial phase of running.[11,14–16] Because of a fully ground-based lifestyle *H. erectus*' upper limbs ceased to be as muscled as in the case of hominins. Wrists became more elastic, fingers shorter and the grasp of the hand more precise and stronger. The *H. erectus* could effectively use a stick or a club, throw and aim rocks, spears and javelins at longer distances and create more complicated tools for defence from predators, big game hunting or building shelter. *Homo erectus* became motorically fit enough to walk and run a substantial distance. It migrated out of Africa and spread throughout the globe.[13,15–19] The new shape of the waist and thorax improved stability of the *H. erectus* body during running. The waist became narrower then in *Australopithecus*. A slim waist decreased the inertial angular moments for thorax rotation improving running performance.[10,11,14] The thorax remained narrow despite significant increase in general body dimensions. Together with long legs and hairlessness it resulted in better thermoregulation than in *Australopithecus*. A strong bell-like thorax appeared only thousand years later in *H. neanderthalensis* living in cold Eurasia due to the elongation of *H. erectus*' relatively short clavicles, transition of the shoulders more forward and development of strong hyperpolar trunk muscles (Table 2).[10,11,15,20] Another set of *H. erectus*' adaptation to long-distance running included an elongated spine and enlarged hip and knee joint surfaces, narrow pelvis, more sagittally curved iliac blades, larger and deeper acetabulae, enlarged cranial part of gluteus maximus, elongated Achilles tendons, a strong plantar aponeurosis and full plantar arches with shorter toes. These morphological modifications noticeably enhanced the stability of the body required to keep it from falling, diminished undesirable trunk movements during running, reduced joint stress and mechanical work during stance and create an effective spring- and energy-storing and releasing the shock absorbing mechanism in the feet.[10,14,21–25]

3.2. Life-giving movement

As outlined in the first part of our review an upright, bipedal gait facilitated hominins adaptation to the changing climate and paleoenvironment and the development of a purely human ability of an uninterrupted, multi-hour run.[9] It is a common belief that around 2 Ma *H. erectus*' body lost the majority of hair and increased the number and density of the eccrine sweat glands. Efficient thermoregulation was crucial during running to avoid deadly heatstroke.[3,11,14,26] Upright posture and bipedal movement freed the upper limbs from their role of supporting the body of hominins during movement. This facilitated more complicated and precise movements of the hands and arms to produce complicated tools and weapons, alter their life environment, start and store fire, obtain and prepare food and defend from the attackers and predatory animals.[13,16–19] Effective and successful hunting became possible. Acquisition of calorie-rich foods was necessary for further development of the brain, the most energy consuming human organ. Encephalization, a rapid and step-like increase in the brain volume of *H. erectus*, sparked the dynamic development of the intellect, culture and human civilization (Table 2).[10–12,17,27] Over millions of years, diverse environment in which our ancestors lived, together with bipedality, fit upper limbs and the ability of an exhaustive run created a human being that needs to be active to survive. Over almost 7 million years the bodies of humanoids and humans had to adapt to systematic, long-lasting, low or medium intensity aerobic physical activity interrupted by bouts of short, very intensive physical activity. Strong muscles developed and started to influence many metabolic, immune, cardiovascular, respiratory, nutritional and neurological processes.[6,8] Physical and physiological activity became intimately linked. Nowadays, lack of a regular (daily) few-kilometre walk, march or run often leads to serious health disorders and so-called civilization diseases.

4. CONCLUSIONS

We are born to move, walk and run. It is high time to incorporate these activities into our everyday life including leisure time. For the first time in our evolution and history we must be physically active not to find shelter or food but to stay healthy and survive. This is a completely new challenge for *H. sapiens*.[1–3,6–8]

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