



**EISCSA State-of-the-Art Session:
“Deficit related strategies in walking and running”**

**The development of bipedal walking and running and its consequences
in modern society**

Christian T. Haas^{1,2} (EISCSA Scientific Board)
Jan Taeymans³ (EISCSA Scientific Board)

¹ Hochschule Fresenius, University of Applied Sciences, Idstein, Germany
² Center for Biomedical Engineering, Goethe-University, Frankfurt, Germany
³ Thim van der Laan University College, Landquart, Switzerland

Correspondence to: haas@hs-fresenius.de or j.taeymans@physioschule.ch

The ability to walk upright bipedally is undoubtedly a key component in humans' evolution. However, hypotheses and theories about the origins and reasons for developing a bipedal walking pattern differ. Some anthropologists argue that our ancestors used to walk already bipedally when they were still living in the forest (Thorpe et al. 2007). Others are the opinion that switching from the forest to the savanna (2-3 million years ago) brought a new competitive situation with some animals which forced the homo to adapt to the new environmental conditions. Thus they became bipedal and learned to walk or run over long distances (Bramble & Liberman 2004). The common consequence of all theories is that the ability to walk bipedally brought an advantage in foraging. In the savanna an upright walking position made it much easier to scan the environment continuously, finding fruits in the trees or identifying prey animals while hunting. Furthermore, along with successful hunting bipedality gave our ancestors the chance to bring the meat – or collected fruits – “home”. Bramble and Liberman (2004) proposed that especially running ability boosted human evolution since running increased hunting success and hence ensured acquiring high protein meat meals which were important for brain growth.

Even nowadays walking and running influence multiple physiological functions of crucial importance. Regular endurance running or even walking have positive effects on cardiovascular functions reducing obesity, heart diseases, or diabetes related health problems (Booth et al. 2000 for review). Furthermore, numerous neuroplastic processes are fundamentally interrelated with walking and running (e.g. Dishman 2006, Dishman et al. 2006, Vaynman & Gomez-Pinilla 2005).

Over the last decade multiple animal- as well as human-studies showed evidence that running activities upregulate the release of neurotrophic factors (Vaynman & Gomez-Pinilla 2005 for review). These biochemical substances are of essential importance for nerve growth and neural survival. Interestingly, running movements lead to higher neurotrophic factor releases than swimming or just standing (Hutchinson et al. 2004). It is likely that muscle spindle afferences and muscular reflex answers during running play a key role therein (Vaynman & Gomez-Pinilla 2005). It is furthermore of crucial preventive and rehabilitative importance that these neurotrophic factor releases occur not only in the muscles and the peripheral nervous system but also in the spinal cord and different supraspinal areas (Murer et al. 2001, Tillerson et al. 2001, Ying et al. 2005). Using a mice experiment, Aderbal and colleagues (2008) showed that flat running (5 days/week over 8 weeks) increased brain derived neurotrophic factor (BDNF)

levels in the hippocampus by 68.5 % compared to controls. However, downhill running – which is characterized by strong muscle spindle afferences - resulted in higher BDNF releases (137%) in the hippocampus. Furthermore BDNF levels were also enhanced in the striatum (49.9%) after downhill running but not after flat running. Such biochemical reactions are of crucial therapeutic importance for various neurodegenerative disorders. Moreover it could be shown in multiple experimental setups that physical exercises – which are related with neurotrophic factor releases – have strong neuroprotective effects e.g. in Parkinson's disease (Murer et al. 2001, Tillerson et al. 2001, Cohen et al. 2003). In consequence, motor symptoms were reduced in the exercising groups compared to the controls.

Further positive effects (reduced symptoms) of running exercise were identified in depressed patients. Similar to pharmaceutical treatments, running exercise was found to upregulate BDNF in the hippocampus (Russo-Neustadt et al. 2000, 2001, 2005 for review) which is of crucial importance since these subjects have pathologically reduced levels of brain derived neurotrophic factor (Karege et al. 2002, 2005, Brunoni et al. 2008, Lee & Kim 2010). Russo-Neustadt and colleagues (2000, 2001, 2005 for review) concluded that both interventions (pharmaceutical or running exercise) have similar antidepressant effects. However, a combination of both treatments led to the best therapeutic effects.

Because walking and running exercise have multiple positive effects in various diseases one can argue that walking or running inability produce also secondary harmful results. This hypothesis was tested e.g. in Parkinson's disease animal studies. It was found that forced non use of the locomotor system and immobilization potentiates neurodegeneration and disease severity (Tillerson et al. 2002).

A further interrelation between walking and health enhancing effects becomes obvious when having a look at quality of life. Schrag et al. (2000) found in their study analyzing Parkinson's disease patients that gait impairment, postural instability, and history of falls are strongly associated with quality of life. Similar results were reported in Multiple Sclerosis (MS) patients: The more patients are physically active in daily life – which is strongly characterized by walking ability – the higher is the quality of life (Motl et al. 2009, Motl & McAuley 2009). A comparative analysis of different symptoms (walking/mobility disorder, pain, fatigue etc.) showed that walking impairment is of highest concern for quality of life in MS (Zwibel 2009). Sutliff (2010) found out that maintaining mobility is one of the highest priorities in these patients as it is – amongst others – associated with independence and social contacts.

It can be concluded that the ability to walk and run was part of and also contributed to human evolution. It is likely that walking, running and brain growth were interrelated in our ancestors some 2 to 3 million years ago. Even nowadays, there is a bulk of evidence that daily life walking and running as well as walking and running exercises are strongly related with cardio-vascular and neural functioning, quality of life and wellbeing. Hence, it is of crucial importance to conserve or even improve upright locomotor abilities in humans.

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