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LETTER TO THE EDITOR

Response to 'Technology for mobility in SCI ten years from now'

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The manuscript entitled 'Technology for mobility in SCI 10 years from now' by Boninger *et al.*[1] is a forward-looking article addressing an important issue. The article introduces the significance of the problem as well as the technical and socioeconomic challenges associated with developing therapies related to mobility for individuals with spinal cord injury (SCI). In terms of technical areas of development, the authors begin by addressing power sources. They point to the ever-increasing needs of higher-capacity batteries for laptops and personal digital assistants, but also mention some interesting possible future technologies ranging from implanted fuel cells to biomotion-charged batteries as well as charging through body's own chemistry (although not mentioned in the manuscript, presumably this refers to approaches such as harvesting energy from glucose in the body). Given that the authors are discussing futuristic approaches, one other technology that could be covered in this discussion could be thermionics (that is, using temperature gradients in the body to generate electricity).

A discussion of the key technological barrier facing more compact power sources would add balance to this section. In fact, one could argue that this is the most important technical area for advanced, portable systems to aid patients with SCI. In addition, disadvantages of some approaches need more discussion. For example, inductive power can decrease implant size, but at the cost of requiring the patient to wear an external power transmitter.

Next, the areas of processors and sensors are covered and once again these areas are covered from the existing mixed-signal systems integrated circuits to neuromorphic chips. They correctly note that many functions of today's implants are well within current technology. It is important to note the need for high voltage in some implant applications, a need that is counter to the current development trends in consumer microelectronics. In the sensors discussions, wearable sensors including clothing-based sensors are discussed. In terms of manipulators or robotic arm control, it is also good to read that in addition to conventional eye-track control, the authors also mention machine vision and artificial intelligence to reduce the level of control required by the user. The authors continue to further describe algorithms that will be needed with or without the use of robotic arms and mention a very important area of biomimetic algorithms–computation, which mimic the human neurological system (brain and spinal chord). A key aspect of these algorithms will be adaptability.

The authors discuss the impact of specific devices and go into both the challenges and benefits of robotics, exoskeletons, wheelchairs, direct brain interfaces, neural prosthesis, neuromodulation and drug delivery, simulations in virtual reality environments. All these areas are covered succinctly with adequate references for more in-depth reading for readers. Digital camera technology will benefit SCI by assisting in navigation of smart wheelchairs. The dual-use potential for technology designed for military use is highlighted in the discussion of exoskeletons, though the prediction that these will become ubiquitous in the near future is quite optimistic. We agree that virtual reality is an extremely attractive method for training and rehabilitation, and would add another benefit. The cost of making a mistake in a virtual reality simulation is not dangerous to the patient. Thus, if the driver of the virtual wheelchair crashes, he can simply try again.

With regard to brain interfaces and neural prostheses, the issues of device packaging and biomaterials bear greater discussion, as these will be limiting factors, particularly for implantable devices that require more parallel channels. The paper concludes with referring back to the International Classification of Functioning, Disability and Health (ICF) and offers some helpful future avenues to make this classification more available to practicing clinicians and third-party payers. Perhaps one of the most intriguing sections of the chapter is the discussions of the barriers to deployment of the technologies for mobility: (1) market availability, (2) awareness and (3) financial access or cost. The authors caution that expensive devices will be highly scrutinized by insurer, but then later add that the cost of technology has reduced throughout the first decade of this century. At this point, the authors could provide a little more information on what type of costs are associated with taking care of patients with SCI, and based on this what price point for a device that would be assistive to SCI would be acceptable. How many people use wheelchairs in the US or in the world? What is the financial cost of manual wheelchairs that cannot avoid obstacles, cannot reduce pressure sores and are limited by steps and curbs? Clearly, the level of improvement the device provides in activities of daily living will be a large factor in this calculation, and hence some discussion of what primary outcomes would the Food and Drug Administration or Center for Medicare Services accept in order to approve a particular medical device for SCI patients could be expected to be acceptable. This type of information will be invaluable for those who are thinking of developing devices to help SCI patients.

In conclusion, this is a well-written manuscript and the authors should be commended on covering the technologies for mobility for SCI patients. Their vision of the future can become reality with an increased pace of technology development in the areas described.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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1 Boninger ML, French J, Abbas J, Nagy L, Ferguson Pell M, Johnson Taylor S *et al.* Technology for mobility in SCI ten years from now. *Spinal Cord* 2012; **50**: 358–363.