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Wearable Robots in rehabilitative therapy: A step towards transhumanism or an ecological support?

Wearable Robots em fisioterapia: um passo na direção de transumanismo ou um instrumento ecológico?

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ABSTRACT

In the present paper we want to argue that Wearable Robots (i.e., technological devices used to restore the possibility of walking and re-establishing "normal" human life) should not necessarily be anthropomorphic, in order to respect human autonomy, freedom, and nature. Moreover, we argue that this non-anthropomorphism does not necessarily lead to transhumanism. To adequately discuss this topic, we are called to consider various aspects embedded in the question: the difference between restoring and enhancing, i.e., the difference between considering human nature as normative, or will (or wish) as the main criterion of choice; the difference between exceeding the limits of human nature (i.e., *human enhancement*) and restoring human functions; and, finally, the nature of the function itself. We will introduce a "weak" notion of autonomy and freedom, dealing with rehabilitation and motility, in order to assess the use of Wearable Robots in rehabilitative medicine. Hence we will argue that the less constraints that patients have, the freer they are. All these aspects also imply an anthropological and ecological view, since they have to do with the relationship of the human being with its environment.

Keywords: human ecology, Wearable Robots, Transhumanism, anthropomorphism, Arne Næss, environment.

RESUMO

No presente artigo, queremos discutir como o desenho de *Wearable Robots*, ou seja, dispositivos tecnológicos utilizados para restaurar a possibilidade de caminhar e para restabelecer a vida humana "normal", a fim de respeitar a autonomia, a liberdade ea natureza humana, não devem necessariamente ser antropomórfico, não é necessário que conduza a transumanismo. Para discutir adequadamente este tema, vamos considerar vários aspectos da questão: a diferença entre restaurar e melhorar, ou seja, a diferença entre considerar a natureza humana como normativa, ou a vontade (ou os desejos) como o principal critério de escolha; a diferença entre a exceder os limites da natureza humana (ou seja, o *human enhancement*), e restaurar funções humanas; a natureza da função em si. Vamos introduzir uma noção "fraca" de autonomia e liberdade, que lidam com a reabilitação e mobilidade,

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a fim de avaliar o uso de *Wearable Robots* na medicina de reabilitação. Por isso vamos argumentar que as menos restrições os pacientes têm, mais livres que são. Todos estes aspectos implicam também uma ideia antropológica e ecológico, já que têm a ver com a relação do ser humano com seu ambiente.

Palavras-chave: ecologia humana, *wearable robots*, transhumanismo, antropomorfismo, Arne Næss, ambiente.

Introduction: Wearable robots, autonomy, and freedom

In this paper we want to argue that Wearable Robots, i.e., technological devices used to restore the possibility of walking and re-establishing "normal" human life, in order to respect human nature and to be ecological, should not necessarily be anthropomorphic, which in turn does not necessarily lead to transhumanism. First, we need to clarify what we mean by the term "exoskeleton". Very briefly, an exoskeleton is a robotic wearable skeleton, designed on the basis of the human body's shape and functions in order to adapt to its movements perfectly.

Ultimately, it is an external support that guarantees freedom of moving and walking, perfect adherence to the human body, and good controllability. Basically, "an exoskeleton consists of a metal frame, sensors, actuators, and control electronics" (Kumar *et al.*, 2012, p. 2034), and is nowadays used in several fields, "including power augmentation for military or medical assistance, rehabilitation and in haptic interfaces" (De Rossi *et al.*, 2010). Let us clarify that we will only refer to exoskeletons intended for assistive and rehabilitation purposes, and specifically on their design, while neglecting, for the sake of this paper, the moral implications of powered exoskeletons' use for military purposes (Cornwall, 2015).

From a general point of view, in fact, "a number of disorders affect motor patterns in the limbs. [...] They result in muscular weakness and contractures. People with these disorders significantly depend on their caregivers for personal care" (Kumar *et al.*, 2010, p. 2033). The aim of exoskeletons in rehabilitative therapy, therefore, is to help patients to recover their ability to move and walk with autonomy and freedom (Li *et al.*, 2015; Arene and Hidler, 2009). We also want to emphasize that these supporting devices are used only for a limited time: the subject wears the robot only during therapy sessions, and under medical supervision. In this context Wearable Robots (henceforth simply "WRs") are meant to provide assistance as necessary (and not to inhibit voluntary movements), and to help the patients to complete tasks that they would not be able to perform autonomously.

These two dimensions are particularly important in determining the design of WRs (Sergi *et al.*, 2011; van den Kieeboma *et al.*, 2011), since their aim is to rehabilitate human motility whenever possible. In this regard, we could say that in WRs the interaction between human beings and robots is completely dynamic; the central subject is still the patient—not the robot—and biomechanics would not be considered a mere constraint.

For now it is possible to conclude that the dimension of autonomy effectively emerges from the dynamic interaction between patients and their environment. With a simplistic argument, we can state that the fewer constraints or barriers (WHO, 2001) patients have, the more autonomous they are. These constraints are, properly speaking, environmental or physical (bodily) barriers that prevent individuals from carrying out their functions (WHO, 2001), i.e., in this particular case, the function of walking. To use a well-known image in philosophy of education analogously, "Autonomy", here, is a "weak notion" (the complete opposite of a "strong notion" of autonomy, as Winch suggests—Winch, 2005, p. 68-71), and means the capacity to perform a function without any substantial constraint, external or internal, i.e., it has to do with human illnesses and health (Carel, 2014).

This implies a view of the relationship between human beings and their environment very close to that expressed by the Norwegian philosopher Arne Næss: the human being is a significant part of the environment, and its relation with its environment is essential to it. Næss (1989, p. 164) thus wrote:

> *The identity of the individual, 'that I am something', is developed through interaction with a broad manifold, organic and inorganic. There is no completely isolatable I, no isolatable social unit. To distance oneself from nature and the 'natural' is to distance oneself from a part of that which the I is built up of. Its 'identity', 'what the individual I is', and thereby sense of self and self–respect, are broken down. Some milieu factors, e.g. mother, father, family, one's first companions, play a central role in the development of an I, but so do home and the surroundings of home.*

Conceiving the human being as an ecological being, i.e., as a being that has significant relations with its environment, helps us to reframe the notion of corporeity (Russo, 2012): indeed, we can no longer say that the environment starts where the boundary of our skin ends, because we live *an environment* much more than we live *in it*.

WRs would thus function as facilitators, as they are used in order to remove existing internal barriers within the human body (not the ontological limits, obviously), and barriers emerging in the human's relation with its environment. Hence the removal of these barriers would probably facilitate patients' interaction with the external world, empowering their ability to respond to environmental stimuli.

As we have pointed out, all these aspects have something to do with the notion of autonomy, or to be more precise, with a relational characterization of autonomy, since the human being cannot easily be conceived as a being separated from its environment. Therefore, this elementary characterization of autonomy is actually closer to Plessner's notion of "adaptability" (Plessner, 1975) and its basic aspect, the animal "centrality". According to Plessner, human beings swing between "centrality" and "exocentricity", between having their centre within themselves and, at the same time, outside themselves. Non-human animals and human beings share this ability to react to environmental stimuli, which is "centrality". This first aspect represents the logical condition of possibility of the second aspect, the exocentricity, i.e., "the ability of human beings to adopt an attitude toward themselves, a capacity for self-reflection, which at the same time is the basis for the human ability to stand back from things and treat them as objects, *as* things" (Pannenberg, 2004, p. 37).

Indeed the body is our first "instrument" of contact with the environment. One of the most important features of the body is self-motility, which plays a role for the body that self-consciousness plays for the mind. With reference to the notion of pre-reflective intentional "motility" outlined by Merleau-Ponty (Reuter, 1999; Kelly, 2002), we want to stress "the intentional character of movement: if motility is fundamental, it is because it accomplishes the transcendence of consciousness toward the world in a manner that is anchored in incarnation, not in thought" (Carman and Hansen, 2005, p. 245).

To be clear, we can temporarily conclude that WRs, in so far as they help human beings in maintaining their autonomy, assist them in recovering basic functions (in particular "motility"); furthermore, since they remove barriers in the human relation to the environment, they facilitate the achievement of noble purposes and the "humanization" of human nature. Following Næss (1984, p. 9), our hypothesis here is that "each life form has its own nature, which determines what kind of life gives maximum satisfaction." For this reason, even the human being has its nature, that is to say, it has its own ecology (order of nature). This also allows us to talk about human ecology (Valera, 2013).

Can an exoskeleton be non-anthropomorphic?

Before discussing the presence of transhumanism in the use of WRs in rehabilitation, we have to settle a linguistic question: can an exoskeleton be non-anthropomorphic? According to the definition given in Dollar and Herr (2008), an exoskeleton is "an active mechanical device that is *essentially anthropomorphic* in nature, is 'worn' by an operator and fits closely to his or her body, and works in concert with the operator's movements". Starting from this definition, it would seem that a WR would necessarily be anthropomorphic, i.e. it would "fit like a glove" to the human figure. Here is the question: does the departure from the morphology of the human body necessarily lead to a "dehumanization" of the human being?

To solve this problem we first have to clarify the difference between "form" and "shape": the former is the translation of the Greek word "*eidos*", which refers to Plato's "ideas", universal and immutable; the latter is the translation of "*morphé*", which concerns the "figure", particular and contingent. The problem we have to face is, *prima facie*, a linguistic one, as David Ross (1966, p. 74) points out:

> *Form for Aristotle embraces a variety of meanings. Sometimes it is used as sensible shape, such as when a sculptor is said to impose a new form on his material. But more often, perhaps, it is thought of as something which is an object of thought rather than of sense, as the inner nature of a thing which is expressed in the definition, the plan of his structure. […] On the whole,* morphé *points to sensible shape and* eidos *to intelligible structure, and the latter is the main element in Aristotle's notion of form.*

Continuing with Aristotle, we could conclude that an *eidos* (form) requires a certain *morphé* (shape) and a certain kind of chemical constitution, whereas a certain shape is not a necessary condition for the form (Marcos, 2012, p. 64-66). That is to say, a change in the form necessarily implies a modification in the shape, while a modification in the shape does not necessarily imply a change in the form. Though the shape is accidental, the form is essential, as Aristotle highlights: "If we turn from artifacts to organisms, it is even clearer that form cannot be just the same as shape. For the same organism can change its shape many times in its life; if Aristotle think loss of the form is destruction of the organism, he cannot allow it to change its form as often as it changes its shape. The form must be the right sort of thing to persist throughout the organism's life and to be the internal origin of change" (Irwin, 1988, p. 100). According to this distinction, the departure from the morphology of the human body would not necessarily lead to a dehumanization of the human being: we lose the shape (something accidental), but we still retain the form (something essential).

In this regard, we can talk about non-anthropomorphic WRs, which can temporally modify the human shape, even without modifying its form: we can say that the robot and the human being co-evolve simultaneously, changing their shape.

A WR, indeed, is a robot for the lower limbs that integrates kinematic, dynamic, and control solutions produced by a co-evolutionary optimization process, and custom compliant actuators enriching the dynamical properties of the robot so that walking arises as an emerging dynamic behaviour. Therefore, a WR would imply an open-ended design process where both robot morphology and control co-evolve and are optimized in a simulation environment, where the dynamical properties of the human body are also taken into account. In a sense, the human body and the robot have to be treated as a *symbiotic system* (Licklider, 1960; Popović, 2015), where the biological and the artificial components dynamically interact with one another (meaning that they exchange assistive forces), while interacting as a single whole with the external environment.

In order to be more dynamic in this co-evolution, WRs have to be non-anthropomorphic in their structure, i.e., robot joints cannot be co-located with human joints, and the number of robot links has to be greater than the number of the links in human legs. The adoption of a suitable non-anthropomorphic structure brings a number of advantages; the main ones are: easier wearability, meaning that small anthropometric changes are intrinsically compensated by the ability of the robot to slightly adapt its configuration, thus helping patient's autonomy and freedom of movement; and dynamic advantages, meaning that the heaviest parts (actuators) can be located close to the trunk, thus reducing the oscillating masses.

As a consequence of the non-anthropomorphic character of WRs, their motion does not resemble the human gait, although there is still a one-to-one correspondence between robot and human configurations. By tuning the control parameters it is possible to modify the type and level of assistance, evaluating whether it is acceptable or not, in connection with the patient's residual motor possibilities. In this sense a WR co-evolves with the patient, interacting with the human body smoothly and effectively, without inhibiting (or interfering with) its autonomy.

For the reasons discussed so far, these kinds of non-anthropomorphic exoskeletons would also be more ecological, as they could easily respond to environmental stimuli and co-evolve with the subject (they will not force it to make a movement, but rather will go along with it). Such WRs are ecological in the sense that they help human beings to preserve their own environment, their vital space, as they give them back their motility and autonomy:

> *In rehabilitation robotics, the term 'environmental control' refers to a disabled user's capacity to actively interact with his or her external environment […]. When lower limb function is also reduced (or lost), the physical (and psychological) loss of control is profound, and makes a disabled user dependent on others in virtually every respect (Dario* et al.*, 1996, p. 48).*

A step towards transhumanism?

The last question concerns effects that arise from the use of these supporting devices: are they a prelude to transhumanism? The question is justified, not so much for the advanced technologies embedded in the devices, but rather because of the symbiotic relation that emerges between human beings and WRs (since WRs are specifically designed to co-evolve with the patient).

Before addressing the present question, we have to be more precise about the term transhumanism: what is transhumanism? And what is the difference between transhumanism and posthumanism? Birnbacher (2008, p. 95) seems to describe transhumanism as a transitional phase towards a complete transformation of humanity:

> *'Transhumanism' can be defined as a movement that wants us to get on the way to 'posthumanity' by going* beyond *humanity in its present form. Transhumanists want us to enter upon a process that will ultimately lead to 'posthumanity' by attempting, now and in the near future, to transcend certain limits inherent in the human condition as we know it.*

Therefore, the process that would overcome humankind once and for all, leading, by means of technological improvement (Valera, 2014, p. 486), to "the perfect [hu]man", to an immortal being, without any limits, would be of the transhumanist matrix (Valera and Tambone, 2014, p. 365). In this regard,

> *contemporary transhumanists argue that human nature is an unsatisfactory 'work in progress' that should be modified through technological means where the instrumental benefits for individuals outweigh the technological risks. This ethic of improvement is premised on prospective developments in four areas: Nanotechnology, Biotechnology, Information Technology and Cognitive Science—the so-called 'NBIC' suite (Roden, 2010).*

In order to answer to the previous question—is the use of WRs in rehabilitative therapy a prelude to transhumanism?—we have to discuss the aim of using WRs, assessing, therefore, their ability to achieve this aim. The kind of WRs we are considering are designed to restore, as accurately as possible, a natural function in human beings: the ability of walking (motility). This is, obviously, a good purpose. However, there is a thin line between restoring and enhancing: what is the difference between the two? In the former, we consider human nature as normative, whereas, in the latter, we take the will (or wish) as the main criterion of choice. Taking human nature as a norm similarly means, in this case, fighting illnesses and considering them "deviations from the norm". The fight is carried out as an attempt to bring the functions back to the initial state and entails a previous medical diagnosis and a careful assessment of the patient's current condition. We are not talking about exceeding the limits of human nature (i.e., *human enhancement*), but rather, restoring them. Not about an instrument that could fulfil human wishes, but rather, about recovering motility: this is not, thus, a transhumanist aim.

Second, we have to remember that WRs are not meant to be permanent supports: they are used in rehabilitation until human functionality is restored, and not in order to achieve a contamination (or hybridization) of the human being with the robot.

In this regard, this use is very far from the transhumanist idea, for which "the human body has been left behind and humans are free to configure and augment themselves however they see fit" (Benko, 2005, p. 2) and for which, at the same time, "the human is no longer […] the adoption or the expression of man but rather the result of a hybridization of man with non-human otherness" (Marchesini, 2007, p. 54). For these reasons, we can say that the use of WRs for therapeutic purposes would not lead to transhumanism, since its aim is to restore a function that is "natural" for human beings (i.e., motility).

In a certain sense, if this use of WRs has to do with human nature, i.e., if it facilitates the development of human capabilities, we can also state that it is ecological, since it allows the proper human character to emerge. The use of a WR for rehabilitative therapy is ecological as it helps to recover a function that is "natural" for the *homo sapiens species*, since a human being who loses its ability to walk is, in a certain sense, lost: it wishes to recover this ability, not only in order to achieve many other purposes, but also because it is a "walking being", as Merleau-Ponty points out. It is more ecological for human beings to walk rather than not walk; and to walk *as* human beings usually walk.

Moreover, this use respects the human dimensions of autonomy and freedom. A human being is autonomous and free, and, moreover, a human being *wants*, in every condition, to be autonomous and free. That means that human beings want to fulfil their purposes, and this means not having constraints that prevent them from achieving their goals. In the condition we described above, patients with motor disorders would be more or less autonomous and free as the WRs permit them. The less constraints they face, the freer they are. They do not need an instrument that forces their steps, but rather, a structure that *sustains* them.

When thinking about the shape of WRs, it is more ecological to have the optimal morphological features, not necessarily resembling those of the human body, in order not to disconcert the observer. Recent researches in "pet robot" design show that, if a robot looks too much like an appliance, people expect little from it; if it looks too human, people expect too much from it (Goetz *et al.*, 2003; Saygin *et al.*, 2010). Clearly, none of this is new, since as early as 1970 Mori hypothesized the so-called "uncanny valley" effect (Mori, 1970): "The physical appearance of robots that are supposed to communicate, cooperate, and coexist with humans should be designed with due consideration of the emotional and psychological impact on human observers". In this regard, "designers should seek a moderate level of realism for the physical appearance of robots […] in order to avoid falling into the uncanny valley" (Seyama and Nagayama, 2007, p. 338). In short, an exoskeleton should be non-anthropomorphic because it is not, actually, a human being.

And last, WRs should really be ecological tools, as they assists human beings in recovering their "ecological niche" (*Umwelt*) through the human body, which is the main way humans enter into the world (*Welt*) (Scheler, 2009).

All these elements lead us to think that it is appropriate—at both the ecological and ethical levels—to design non-anthropomorphic WRs, in order to respect human ecology, i.e., human autonomy and freedom and their relationship with the environment.

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