WILL THE ASSISTIVE EXOSKELETONS OF THE FUTURE BE BIOMIMETIC?

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Background

A large proportion of the population undergoing rehabilitation is affected by neuromuscular disease. It is even the major population in paediatrics. Although these diseases are very variable, they usually result in muscular weakness and coordination problems. These disorders limit these people in most daily activities, such as walking, drinking/eating, and communicating, despite the existing technical aids, e.g. the MICO robotic arm (Kinova, Montreal). In this context, it has been recognized that portable assistive exoskeletons would provide the necessary complement of muscular forces in their daily life [1].

Recent Advances and questionings

Today, most portable exoskeletons for people with neuromuscular disease are dedicated to the lower limbs: e.g. Re-Walk, the first FDA-approved portable exoskeleton. And at the upper limb, there is still no motorized portable exoskeleton for people with neuromuscular disease. Prototypes are barely emerging, primarily aimed at healthy adults for workplace, sports, or military applications, currently leading to concepts that could not be adapted to people with neuromuscular disease, due to their control strategy, or engine oversizing that we highlighted [2].
Generally amongst the existing portable exoskeletons, questionings arise for the future directions of design:
First, will/should the assistive exoskeletons of the next generation be - or not - biomimetic? Indeed, in terms of size, the concepts of exoskeletons currently range:

- from exosuits, tending to be light and biomimetic, trying to accurately follow the natural action lines of muscles and fit the osteo-articular kinematics (Fig. 1, as we recommended for the upper limb [3]),
- to "Ironman"-like exoskeletons that tend to have large size and mass, benefiting from large lever arms, sometimes far away from the human body.

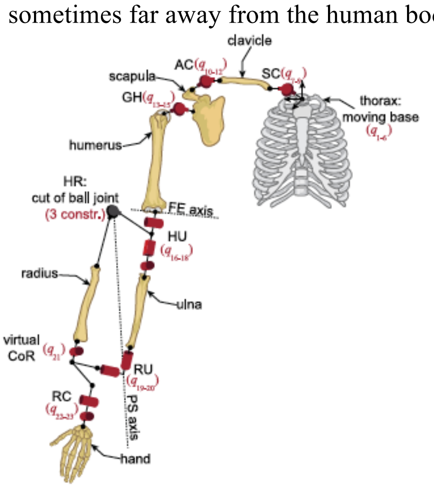

Fig. 1: Upper limb osteo-articular kinematic model [3]

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In terms of power, the state-of-the-art survey that this talk will present will show that even if the current motorized portable exoskeleton enable to enhance performances, none of them has allowed yet the users to spend less energy than without the exoskeleton. This is especially related to the energy that must be spent by the exoskeleton to carry its own load during the human body movement. This current limitation is one of the main challenges to boost the deployment of portable exoskeletons for people with neuromuscular disease.
To answer to the questionings above, this talk will present several didactic examples to help to understand the design guidelines for future developments of portable assistive exoskeletons, in terms of biomimetism, mass, size, etc. E.g., Fig. 2 illustrates the interest in adding a lever arm with a passive element, a spring, to decrease the torques and energy to be provided by an elbow joint engine in an exoskeleton.

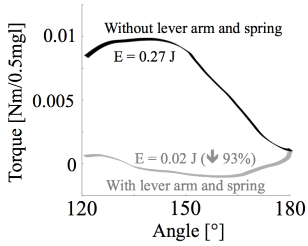

Fig. 2: Torque with or without lever arm with spring

Future directions

Future studies will be performed in optimal synthesis of mechanism to identify exhaustively to which extent the future assistive exoskeletons will be biomimetic.

References

1. Clark et al., I55th ISCoS Int'l Meeting, Vienna 2016
2. Samadi et al., CMBBE 19 (14), 1519-1524, 2016
3. Laitenberger et al. Mult Syst Dyn 33 (4), 413-438, 2015