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Editorial

An Overlooked Ally in the War on Contractures

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The foe, in this physiological war, is contractures. Contractures being defined as the long-term loss of joint movement caused by structural changes in the soft tissues. These soft tissues include muscles, fascia, ligaments, joint capsules, and tendons. Their development is characterized by normal elastic tissues being replaced by inelastic tissues. The result: a shortening and hardening of these soft tissue structures, progressively leading to stiffness, joint deformation, and eventually, complete loss of movement around the joint [1].

Their prevalence widely ranges between 15% and 70% in older adults [2], more specifically, those with acquired brain injury between 16% and 81% [3], those suffering from cerebral vascular accidents have a 60% incidence, individuals with cerebral palsy having an incidence of 36%, and an incidence range of 11% to 48% for those with spinal cord injury [4].

At face value, with such well documented high incidences, it would appear that in this rapidly growing field of soft robotics, there should be a plethora of published studies showing its efficacy in combatting contractures. Unfortunately, this is not the situation. After review of three databases, numerous studies were found on soft robotics assisting movement of various joints. Examples of these studies being: the elbow [5], finger [6], and lower limb [7]. No inferences were made by these authors for the soft robotics helping to prevent or mitigate contractures. Only two studies were found during the literature search that stated the potential to mitigate or prevent contractures due to the prevention or reduction in muscle spasticity [8,9].

So why not continue using the existing orthotics to help combat contractures and leave soft robotics to assist with physiological motion? This seems to be the conclusion of most scientists studying and developing soft robotics, since there is a dearth of scientific literature on the use of soft robotics to prevent or mitigate contractures.

So, what is the current treatment for contractures? Primarily prevention but management is usually the most common. There are four important concepts in contracture management [1]:

1. Regular periods of active, full available range of movement of the affected joint[s]
2. Passive stretching of muscles and joints
3. Positioning of the affected joint[s] to promote extension and oppose flexion
4. Splinting.

These four concepts can easily fit into many of the soft robotic studies reviewed. These studies all focused, and rightly so, on improving active motion due to spasticity, paresis, or paralysis. Upon close inspection of the methods used in much of the reviewed literature, a simple change in protocol for the use of the garment or device would render it useful for contracture mitigation or prevention. No significant change, and in most of the studies, no change at all in the structure of the soft robotic would be needed for use with prevention or mitigation of contractures.

Let us examine what is the stability in soft robotics that holds the joint[s] stable while it goes through the desired motion. This stability is actuators. Actuators for soft robotics are made from various materials, including silicone rubber, or elastomeric matrices with embedded flexible materials (e.g. cloth, paper, fiber, particles). These can be embedded with sensors, regulators, and control boards, etc. to achieve the desired requirements of the robotic [10]. There are new developing actuators such as, fiber-reinforced elasto-fluidic systems that utilize fluid pressure to the actuator [11] or shape memory alloy (SMA)-driven compliant rotary actuator [12] that provide both passive and self-activated motions. These provide the desired motion (including rotation), forces, elasticity, and diffusion of energy.

So, is the war on contractures a losing battle with researchers looking only for assisting available range of motion? One need to look back a few decades to answer this with a resounding "NO".

In the not so distant, medical past, Continuous Passive Motion [CPM] machines became one of the most frequently cited methods of treatment supported by the developing therapy exoskeletons. This passive mode proved extremely helpful in avoiding the early formation of contractures. Currently, the CPM machine demonstrates itself more effective in the initial phase of soft tissue shortening, to prevent contractures, than existing exoskeletons in the literature [13].

Is it a quantum leap to go from CPM machines that are grounded to wearables? The answer is not a quantum leap but rather a hop, thanks to the rapid pace of engineering research in the soft robotics field. There has been an adoption of exoskeleton technology in creating a design of a hand rehabilitation exoskeleton into a wearable glove [14]. It is precisely this hybridization of exoskeleton with mechatronics wrapped with a material that begins to give life to this wearable that can morph into a contracture prevention or mitigation device. The technology used in recent research takes the form of a control system that can detect the stored contact parameters of joint movements by the force sensors on the fingertips. This would then enable a switch to the passive mode from the active mode (the available active range of motion of the fingers), where the fingers are moved by the actuators to the functional end point range of motion by the exoskeleton. In this passive mode, the goal is to reach this functional end point range of motion [14], much like the CPM machine mentioned earlier.

It would appear that there is great potential for a commercially available wearable to fill this "ally" position in the war on contractures. With all this great potential [15,16] in the fight against contractures of the hand, how much longer must we wait for commercial availability? What about other joints, which are much less kinematically challenging than the hand?

While the casualties continue to mount, will a cry for a call to arms from those on the battle lines, mobilize researchers and manufacturers to make some minor modifications to create a combined active and passive mode wearable?

It is my hope that this "call to arms" will lead to a formidable arsenal of weapons to combat this hideous enemy that leads to disfigurement and dysfunction.

Bibliography

1. Benjamin J Seidel., *et al*. "Contractures". *PM and R Knowledge NOW* (2020).

2. Gnass I., *et al*. "[Joint contractures in older age. A systematic literature review] [German]". *Zeitschrift für Gerontologie + Geriatrie* 43.3 (2010): 147-157.

3. Pohl M and Mehrholz J. "A new shoulder range of motion screening measurement: its reliability and application in the assessment of the prevalence of shoulder contractures in patients with impaired consciousness caused by severe brain damage". *Archives of Physical Medicine and Rehabilitation* 86.1 (2005): 98-104.

4. Pingel J., *et al*. "New perspectives on the development of muscle contractures following central motor lesions". *The Journal of Physiology* 595.4 (2017): 1027-1038.

5. Koh TH., *et al*. "Design of a Soft Robotic Elbow Sleeve with Passive and Intent-Controlled Actuation". *Frontiers in Neuroscience* 11 (2017): 597.

6. Heung HL., *et al*. "Soft Rehabilitation Actuator with Integrated Post stroke Finger Spasticity Evaluation". *Frontiers in Bioengineering and Biotechnology* 8 (2020): 111.

7. Mohd Azuwan Mat Dzahir and Shin-ichiroh Yamamoto. "Recent Trends in Lower-Limb Robotic Rehabilitation Orthosis: Control Scheme and Strategy for Pneumatic Muscle Actuated Gait Trainers". *Robotics* 3 (2014): 120-148.

8. Fan-Zhe Lowa., *et al*. "Design, characterisation and evaluation of a soft robotic sock device on healthy subjects for assisted ankle rehabilitation". *Journal of Medical Engineering and Technology* 42.1 (2018): 26-34.

9. Chingyi Nam., *et al*. "An Exoneuromusculoskeleton for Self-Help Upper Limb Rehabilitation After Stroke (2020).

10. https://biodesign.seas.harvard.edu/soft-robotics

11. Bishop-Moser JL. "Design of Generalized Fiber-reinforced Elasto-fluidic Systems, A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy (Mechanical Engineering) in the University of Michigan (2014).

12. Kittinanthapanya R., *et al*. "A Novel SMA Driven Compliant Rotary Actuator Based on Double Helical Structure". In Proceedings of the IFToMM Symposium on Mechanism Design for Robotics, Udine, Italy (2018): 11-13.

13. Almusawi H and Husi G. "Design and Development of Continuous Passive Motion (CPM) for Fingers and Wrist Grounded-Exoskeleton Rehabilitation System". *Applied Sciences* 11 (2021): 815.

14. Zhang F., *et al*. "Design of an Active and Passive Control System of Hand Exoskeleton for Rehabilitation". *Applied Sciences* 9 (2019): 2291.

15. Hernández-Santos C., *et al*. "Development of a Wearable Finger Exoskeleton for Rehabilitation". *Applied Sciences* 11 (2021): 4145.

16. Rudd G., *et al*. "A Low-Cost Soft Robotic Hand Exoskeleton for Use in Therapy of Limited Hand–Motor Function". *Applied Sciences* 9 (2019): 3751.

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