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Appendix 10: Neurotechnology Descriptions

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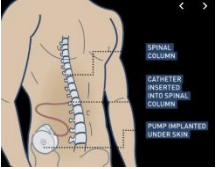
Neurotechnologies

Neurotechnology	Medical term	Description	Benefits	Risks
NON-INVASIVE PROCEDURES				
<p>E1. Electrical stimulation over the surface of the arm or hand</p>  <p>https://www.strokingengine.ca/en/patient-info/functional-electrical-stimulation-upper-extremity-info/</p>	<p>Electrical stimulation (E-stim) OR Transcutaneous Electrical Nerve Stimulation (TENS) OR Neuromuscular Electrical Stimulation (NMES) OR Functional Electrical Stimulation (FES)</p>	<p>Electrical stimulation uses surface electrodes (adhesive pads or stickers) over the skin which are attached to a machine. The machine sends a small amount of electrical current to weak or paralyzed muscles. Tingling sensation is experienced over the skin in the area of stimulation.</p>	<ul style="list-style-type: none"> -Increase in muscle contraction¹ -Increase in blood circulation² -Reduces spasticity³ -Reduce pain⁴ -Increase aerobic fitness⁵ 	<ul style="list-style-type: none"> -Skin irritation⁶ -Burning sensation⁴ -Muscle tears -Pain⁴ -Tingling below application site⁴
<p>E2. Electrical stimulation over the surface of the spine</p>  <p>http://depts.washington.edu/morittlab/?page_id=718</p>	<p>Transcutaneous Spinal Cord Stimulation</p>	<p>Electrical stimulation uses surface electrodes (adhesive pads or stickers) over the skin of the lower back and abdomen that are attached to a machine. The machine sends small amount of electrical current that can stimulate nerves in the spinal cord from outside the body.</p>	<ul style="list-style-type: none"> -Immediate effect while the stimulator is on³ -Controlling locomotion⁷ -Long-lasting effects (up to a week)³ -Reduced pain⁴ -Reduced spasticity³ 	<ul style="list-style-type: none"> -Skin irritation⁶ -Burning sensation⁴ -Pain⁴ -Tingling below application site⁴

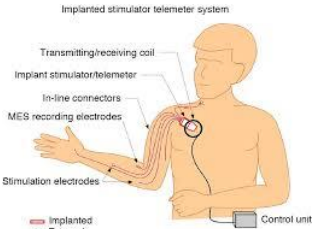

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<p>E3. Electrical stimulation over the surface of the head</p>  <p>https://www.ncbi.nlm.nih.gov.proxy1.lib.tju.edu/pmc/articles/PMC5702643/</p> <p>Stroke, Depression, anxiety, pain, Parkinson's disease</p>	<p>Transcranial Direct Current Stimulation (TDCS)</p>	<p>Electrodes are placed over the scalp directly over the brain area to be stimulated. A small amount of electric current is passed through.</p>	<ul style="list-style-type: none"> -Temporary improvement in emotion and mental functioning⁸ -Fatigue⁹ -Improvement of language in aphasia¹⁰ 	<ul style="list-style-type: none"> -Tickling or burning sensation over the head¹¹ -Headache^{11,12} -Skin lesions or burns¹¹ -Nausea^{11,12} -Difficulty concentrating¹² -Fatigue¹¹ -Redness¹² -Mood changes^{11,12}
<p>E4. Magnetic stimulation over the surface of the head</p>  <p>https://www.medpagetoday.com/psychiatry/depression/56168</p> <p>Cost: \$200 to \$300 per session (20 min) – Needs 5 sessions/wk for 4-6 wks</p>	<p>Transcranial Magnetic Stimulation (TMS), Repetitive TMS (rTMS)</p>	<p>A magnetic coil is placed over the head, creating changing magnetic fields over the surface of the brain. It is used to create electric current at a specific area in the brain. (FDA approved)</p>	<ul style="list-style-type: none"> -Improves mood¹³ 	<ul style="list-style-type: none"> -Cannot be used with metal objects near the head -Headache¹⁴ -Pain over scalp -Loud machine noise -Crying -Seizure¹⁴
<p>E5. Braces that are powered to amplify movements</p>  <p>https://myomo.com/what-is-a-myopro-orthosis/</p>	<p>Myoelectric brace</p>	<p>The electrical signals from weak muscles are converted into large movement of the brace to allow improved movement.</p>	<ul style="list-style-type: none"> -Improved movement^{15, 16, 17} -Allows the patient to perform movement they otherwise are unable to complete^{15, 16, 17} -Effective in improving motor control^{15, 16, 17} -Improvement in self-reported function and 	<ul style="list-style-type: none"> -Pressure sores -Chafing of the skin -Mechanical irritation


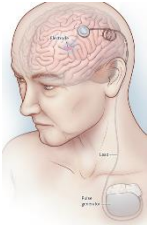
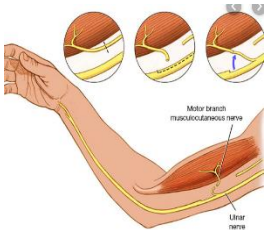
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<p>E6. Brain computer interface with a cap</p>  <p>https://www.odtmag.com/contents/view_breaking-news/2017-08-30/stroke-patients-motor-function-improved-with-brain-computer-interface/</p>	<p>EEG driven brain computer interface</p>	<p>Brain computer interfaces or brain machine interfaces are hardware and software systems that allow brain activity to control a hand brace to move the hand. Some brain computer interfaces are implanted in the brain and others use an external cap.</p>	<p>perception of recovery^{15, 16, 17}</p> <ul style="list-style-type: none"> -Communication¹⁹ -Movement control¹⁹ -Control of external devices¹⁹ -Improved motor function¹⁹ 	<ul style="list-style-type: none"> -BCIs placed outside of the skull have a limited ability to read brain signals²⁰ -Signal connection problems²⁰ -Quality of electroencephalography signals is affected by scalp, skull, and many other layers as well as background noise²⁰ -Skin irritation or hair loss secondary to cap pulling on hair follicles²¹
INVASIVE PROCEDURES				
<p>E7. Baclofen pump</p>  <p>http://www.emdocs.net/core-em-intrathecal-baclofen-withdrawal/</p>	<p>Intrathecal Baclofen Therapy (ITB)</p>	<p>The medicine Baclofen is placed in a round metal disc under the skin of the abdomen and delivered by a pump and a catheter directly into the spine. Refills are done every 1 to 6 months and battery is changed every 5 to 7 years. (FDA approved)</p>	<ul style="list-style-type: none"> -Reduces spasticity²² -Improved ambulation/wheelchair seating -Reduced spasticity-related pain -Improved sleep 	<ul style="list-style-type: none"> -Dosing errors -Weakness²³ -Sleepiness²³ -Upset stomach²³ -Nausea²³ -Vomiting -Headache -Dizziness -Confusion -Catheter, Battery or pump malfunction (CSF leakages)²³ -Hypotonia²³ -Infection -ITB withdrawal syndrome (rare)²³

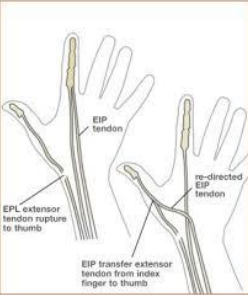
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<p>E8. Implanted stimulators for the nerves of the arm and hand</p>  <p>https://connect.springerpub.com/content/book/978-0-8261-3775-3/part/part05/chapter/ch48</p>	<p>Peripheral nerve and field stimulators (PNFS)</p>	<p>Peripheral nerve and field stimulation involves placing the electrodes directly on nerves or under the skin in the painful region. It is a minimally invasive procedure, requiring a small incision over the targeted area.</p>	<p>-Pain reduction for chronic pain²⁴</p>	<p>30 to 40% rate of complications</p> <ul style="list-style-type: none"> -Hardware complication: movement, breaking or malfunction of the electrode -Infection, pain over electrode -Rare: headache, neurological damage
<p>E9. Implanted stimulators for the spine</p>  <p>https://www.spinalcord.com/blog/what-to-know-epidural-stimulation-spinal-cord-injury</p> <p>Spinal cord injury – traumatic and non-traumatic: Cost: \$15 - 50K without insurance, Covered by some insurance such as Medicare and Blue Cross and Blue Shield</p>	<p>Epidural Electrical stimulation (EES) or Epi-stim</p>	<p>Stimulators for the spinal cord are surgically placed directly on the cord for continuous electrical current.</p>	<p>-Increases muscle contraction^{25, 26}</p>	<ul style="list-style-type: none"> -Programming issues for the device -Movement, leakage of current, & failure of electrode -Nerve injury ^{27,28} -Infection²⁸ -Pain at the site²⁸ -Equipment failure ^{27,28}

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<p>E10. Braces powered by implanted sensors in the brain</p>  <p>https://www.extremetech.com/extreme/102927-brain-computer-interfaces-creep-closer-to-bionic-mecha-dream</p>	<p>Brain computer interface (BCI), Neural-control interface (NCI), Direct neural interface (DNI), Brain machine interface (BMI)</p>	<p>A small chip is surgically placed in the brain and connects to an external brace that can move the arm or hand.</p>	<ul style="list-style-type: none"> -Increased movement Communication²⁹ -Increased perception²⁹ -Increased motor activity²⁹ -Increased sensation²⁹ 	<ul style="list-style-type: none"> -Infection -Anesthesia risk -Scarring over brain -Pain at location site, headaches
 <p>E11. Deep Brain Stimulation for Parkinson's disease</p> <p>https://www.nejm.org/doi/full/10.1056/NEJMct1208070</p>	<p>Deep Brain Stimulation</p>	<p>A brain pacemaker is placed surgically on specific areas of the brain. (FDA approved)</p>	<ul style="list-style-type: none"> -Reduces tremor³⁰ and epilepsy -Reduced dyskinesia³¹ -Increased control with movements 	<ul style="list-style-type: none"> -Infection -Electrode movement, damage or malfunction -Scarring over brain -Worsening of gait, balance, and/or speech³¹
<p>E12. Nerve transfers</p>  <p>https://www.mayoclinic.org/diseases-conditions/brachial-plexus-injury/diagnosis-treatment/drc-20350241</p>	<p>Nerve transfer</p>	<p>A nerve transfer is a surgical procedure where a nerve with a less important role is transferred surgically to another more important nerve that is not functioning.</p>	<p>Regain important movement^{32, 33, 34}</p>	<ul style="list-style-type: none"> -Anesthesia risk -Infection

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<p>E13. Tendon transfers</p>  <p>http://blog.handcare.org/blog/2017/04/26/4-reasons-you-may-need-tendon-transfer-surgery/</p>	<p>Tendon transfer</p>	<p>A tendon transfer is a surgical procedure where a tendon with a less important role is transferred to serve the function of a weak tendon with a crucial role.</p>	<p>Regain important movement³²</p>	<p>-Anesthesia risk -Infection</p>
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