Author Year Country Research Design Sample Size	Methods	Outcome
Electrical Stimulation to Reduce Ischial Tuberosity (IT) Pressure		
Liu et al. 2015 United Kingdom Prospective Controlled Trial N=18	**Population**: 18 participants with suprasacral complete SCI divided into 3 study groups: 1) *Functional Magnetic Stimulation (FMS group)*: Mean age=40.3 yr; Gender: males=5, females=1; Level of injury: C5/6=1, T5=1, T10/11=3; Mean time since injury=8.2 yr. *2) Fintech-Brindley Sacral Anterior Root Stimulator Implant (SARS group)*: Mean age=44.5yr; Gender: males=5, females=1; Level of injury: T3=1, T4=1, T4/T5=1, T7/8=1, T10=1, T10/11=1; Mean time since injury=14.3 yr. *3) Surface Functional Electrical Stimulation (FES group)*: Mean age=41.5 yr; Gender: males=5, females=1; Level of injury: T4/5=1, T5=1, T10=1, T10/11=3; Mean time since injury=8.3 yr. **Intervention: Sacral nerve root stimulation using first 2 modalities and surface stimulation using the last: 1)** *FMS group (n=6)*: FMS using a magnetic stimulator over the sacral area with stimulation frequencies in the available range of 15-25 pps. *2) SARS group* (n=6): SARS consisting of electrical stimulation bilaterally with only the S2 nerve root stimulated at a frequency of 20 pps. *3) FES group* (n=6): FES using a dual-channel neuromuscular stimulator on each side of the gluteus maximus. **Outcome Measures: Measured using an Interface Pressure Mapping system:** peak pressure, gradient at peak pressure, average pressure under the Ischial Tuberosity (IT) before and during stimulation with participant sitting in a standard w/c with a high density foam cushion.	1. During optimal FMS, peak pressures and gradient at peak pressures were decreased in all participants, with a 29% average reduction of IT peak pressure (p=0.002) and a 30% average reduction of gradient at peak pressure (p=0.02) compared to baseline. 2. During optimal SARS, peak pressures and gradient at peak pressures were decreased in all participants, with a 30% average reduction of IT peak pressure (p=0.007) and a 35% average reduction of gradient at peak pressure (p=0.03) compared to baseline. 3. During optimal FES, peak pressure and gradient at peak pressure decreased in all participants, with an average peak pressure reduction of 22% (p=0.003) and average reduction of gradient at peak pressure of 25% (p=0.02) compared to baseline. Higher levels of stimulation amplitude resulted in larger pressure reductions in all participants 4. For 4 patients that were part of both the FMS and FES group, the percentage of peak pressure reduction (p=0.03) and percentage of reduction of gradient at peak pressure (p=0.4) were significantly greater in FMS than FES.
Liu et al. 2006b United Kingdom Prospective Controlled Trial N=5	**Population:** SCI: Mean age=45 yr; Gender: males=4, females=1; Level of injury: paraplegia=5; Severity of injury: complete=5. **Intervention:** Sacral anterior root stimulator (SARS) implant applied bilateral electrical stimulation for 10 seconds (frequency=20 pps; pulse width range=8-800 secs; amplitude of "1"). Second sacral nerve root was stimulated (S_2). **Outcome Measures:** Peak Pressure (PP) & Gradient Peak Pressure (GPP); before and during electrical stimulation using an interface pressure mapping system.	1. There was an average 33% decrease in PP during stimulation (at rest=148.6 mmHg; during functional electrical stimulation (FES) =99.8 mmHg; p<0.01). 2. There was also a mean 38% decrease in GPP during stimulation (at rest=54.6 mmHg; during FES=33.8 mmHg; p<0.05). 3. An increase in pulse width resulted in lower PP. Lowest PP was attained at a stimulation pulse width range from 64-600 secs. 4. No complications were reported.

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Ferguson et al. 1992 Scotland Cohort N=9	**Population:** Mean age=36 yr; Level of injury: tetraplegia=4, paraplegia=5; **Intervention:** Functional electrical stimulation of quadriceps muscle in sitting position. **Outcome Measures:** Knee movement, resting and stimulated pressure.	1. Difference between resting and stimulated pressures at the ischia were statistically significant except for in one participant. 2. Pressure reduction occurred at the right ischia of all subjects. 3. Pressure reduction occurred for the left ischia in 7 subjects. 4. Heavier subjects showed relatively small pressure drops. 5. Average pressure drop at the right buttocks was 44 mmHG and 27 mmHG for the left.
Smit et al. 2013a Netherlands Pre-post N=10	**Population:** Mean age=40.6 yr; Gender: males=7, females=3; ASIA Classification: A=6, B=3, C=1. **Intervention:** Electrical stimulation (ES) using cushion made electrode garment (shorts) with built-in electrodes. Participants took part in two different protocols with differing stimulation-rest intervals (1:1s and 1:4s). **Outcome Measures:** Usability of shorts and IT pressure.	1. Both protocols resulted in an acute significant decrease of pressure during ES compared to no ES. 2. IT pressure at least 32% in both protocols. 3. IT pressure and pressure gradient during ES compared with rest were not significantly different between the time within protocol. 4. Overtime, protocol 1:4 had significantly more of an effect than protocol 1:1. 5. Fatigue occurred more in the 1:1 protocol than the 1:4 protocol. 6. Three participants needed help to put on the ES shorts. 7. No participants found the ES shorts to interfere with daily activities but the stimulator did hinder 5 of the participants in daily activities (e.g., hinder the working of a catheter). 8. All participants reported they experienced protocol 1:4 as more comfortable than 1:1.
Smit et al. 2013b Netherlands Pre-post N=12	**Population:** Mean age=38.1 yr; Gender: male=12; ASIA Classification: A=6, B=3, C=1. **Intervention:** Electrical stimulation (ES) induced gluteal and hamstring activation and pressure relief movements (PMRS) – push-ups, bending forward and leaning sideways. **Outcome Measures:** IT pressure, ischial oxygenation and blood flow (BF) were measured.	1. Compared with rest, IT pressure was significantly lower during all PMRs. 2. ES-induced gluteal and hamstring muscle activation reduced IT pressure. 3. No significant differences between PRM and ES conditions. 4. Nine of the 12 participant's oxygenation data was collected. PMRs significantly increased mean oxygenation compared to rest but ES did not. 5. PMRs increased BF significantly but ES did not cause a significant change.
Smit et al. 2012 Netherlands Pre-post N=10	**Population:** Mean age=33.7 yr; ASIA Classification: A=8, B=1, C=1. **Intervention:** Electrical stimulation (ES) using cushion made electrode garment (shorts) with built-in electrodes. Just gluteal (g) or gluteal and hamstring (g+h) muscles were activated. **Outcome Measures:** Ischial tuberosities pressure (ITs pressure).	1. In all participants, both protocols of g and g+h ES-induced activation resulted in a significant decrease of IT pressure. 2. IT pressure after g+h muscles activation was reduced significantly by 34.5% compared with rest pressure. 3. Significant reduction of 10.2% after activation of g muscles only. 4. Pressure gradient reduced significantly only after stimulation of g+h muscles (49.3%). 5. G+h muscle activation showed a decrease in pressure relief over time compared with g muscles.

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Gyawali et al. 2011 Canada Pre-post N=17	**Population:** Mean age=37.2 yr; Gender: males=10, females=7; Level of Injury: cervical=13, thoracic=4. **Intervention**: Intermittent electrical stimulation (IES; 40 Hz) on the gluteus maximus muscles. Two paradigms of IES were used: continuous (7 or 13s) and bursting (3s on, 3s off). **Outcome Measures:** (1) Surface pressure using a pressure-sensing mattress; (2) T2*-weighted MRI scans to measure oxygenation.	1. Both IES paradigms significantly reduced pressure over the IT ($p<0.05$), with the mean range of pressure reductions being 10-26%. 2. Both IES paradigms significantly increased signal intensity compared to baseline ($p<0.05$) showing an increase in tissue oxygenation.
Bogie & Triolo 2003 USA Pre-post N=8	**Population:** SCI: Age=27-47 yr; Gender: males=7, females=1; Severity of injury: AIS: A=6, B=2. **Intervention:** The exercise regimen included 3 different stimulation patterns. Duration of exercise was varied over the 8 wk training period as the muscles became conditioned. **Outcome Measures:** Mean interface pressure, mean ischial region interface pressure.	1. Overall, with chronic neuromuscular electrical stimulation (NMES), mean interface pressure showed no significant differences between baseline and post exercise levels. 2. Mean ischial region interface pressure had a uniform tendency to decrease post exercise assessment, $p<0.01$.
Van London et al. 2008 Netherlands Case Series N=13	**Population:** Age range: 20-74 yr; Gender: 12 males, 1 female; Cause of injury: SCI; Level of injury: C4-C7 (n=5), T5-T11 (n=8), tetraplegia and paraplegia; Type of injury: 8 complete, 5 incomplete. **Intervention:** Participants received 2 surface electric stimulation protocols with 15 minutes rest between: 1) left and right gluteal muscles stimulated alternately; 2) left and right gluteal muscles stimulated simultaneously. **Outcome Measures:** Interface pressure (3x3 sensor area under I.T.s); Maximum pressure (highest pressure in the 3x3 sensor area); ,pressure gradient (pressure difference between points; pressure spread (comparison of 3x3 sensor area to surrounding area within 1 SD), instantaneous effect of stimulation between the 2 protocols (alternating and simultaneous), difference in change between protocols after 30 minutes.	1. No significant difference between left and right for any measure used. 2. Change in pressure under IT (interface pressure) significantly decreased ($p<0.001$) between rest periods and alternating stimulation (106+/-30 mmHg to 88+/-30 mmHg); and a significant decrease ($p<0.001$) between rest period and simultaneous stimulation (100+/-30 mmHg to 81+/-33 mmHg. 3. Maximum pressure decreased in both alternating (by 21+/-16 mmHg, $p=0.001$) and simultaneous (by 25+/-19 mmHg, $p=0.001$). 4. Pressure spread did not differ significantly for either protocol between stimulation and rest ($p=0.123$, alternating; $p=0.197$, simultaneous). 5. Pressure gradient decreased ($p=0.002$) between rest period and alternating stimulation (65+/-46 mmHg to 53+/-41 mmHg) and decreased ($p=0.001$) between rest period and simultaneous stimulation (67+/-52 mmHg to 53+/-46 mmHg). 6. No significant change during either alternating or simultaneous protocols between beginning and end of the protocol for interface pressure at IT, pressure distribution, pressure gradient or maximum pressure for the alternating protocol. 7. A significant decrease ($p=0.04$) in maximum pressure by 2+/-4 mmHg from beginning to end of simultaneous protocol 8. There were no significant differences between stimulation protocols in the effect between beginning and end.

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Liu et al. 2006a United Kingdom Case Series N=10	**Population**: *Sacral Anterior Root Stimulation (SCI group)* (n=5): Gender: 4 males and 1 female; Level of injury: T3-T11 (complete paraplegia); Time since injury: 9-24 yr. *Functional Magnetic Stimulation (non-disabled group)* (n=5): Age range: 29-60 yr; Gender: 5 males. **Intervention:** Non-disabled group received Functional Magnetic Stimulation; SCI group received Sacral Anterior Root stimulation; Seat pressures recorded before, during and after stimulations seated in a standard w/c with foam cushion. **Outcome Measures:** Peak pressure and associated gradient compared before, during and after stimulation.	*SCI group*: 1. A significant decrease (33% reduction; p=0.002, paired 2-tailed t-test) in peak pressure from rest to stimulation was observed (148.6+/- 10.0 mmHg to 99.8 +/-6.7 mmHg) 2. A significant decrease (38% reduction; p=0.03, paired 2-tailed t-test) of gradient at peak pressures from rest to stimulation was observed (54.6+/-8.8 mmHg to 33.8+/-7.8 mmHg). *Non-disabled group*: 3. A significant decrease (p=0.03, paired 2 tail t-test) in peak pressure comparing before and during stimulation was observed (123.6+/-8.3 mmHg vs. 98.7 +/-8.2 mmHg) 4. A significant decrease in gradient peak pressure (p<0.01, paired 2 tailed t-test) was observed comparing before and during stimulation (35.0 +/-7.1 mmHg/cm to 27.4 +/-6.6 mmHg/cm).
Electrical Stimulation to Increase Tissue Blood		
Liu et al. 2006a United Kingdom Prospective Controlled Trial N=6	**Population:** Mean age=35-62 yr; Gender: males=5, females=1; Level of injury: T3-T1; Severity of injury: complete=6; Time since injury=9-24 yr. **Intervention:** Sacral anterior root stimulator implant applied bilateral electrical stimulation to S2 nerve root for 10 seconds (frequency=20 pps; pulse width range 8-800 seconds; amplitude of "1"). **Outcome Measures:** Cutaneous Hemagloblin (IHB); Oxygenation (IOX) before and during electrical stimulation.	1. IHB significantly increased during stimulation (before stimulation, M=0.8; during stimulation, M=0.9; p=0.005). 2. IOX also increased (before stimulation, M=1.1; during stimulation, M=3.0; p=0.02).
Mawson et al. 1993 USA Prospective Controlled Trial N=32	**Population:** Mean age=18-57 yr; Site of ulcer: sacral=7, heel=2, other=1; Ulcer grade: 1-4. **Intervention:** Study was carried out on SCI patients lying on egg crate mattresses. Sensor was applied to the skin at approximately the second sacral segment along the midline using a two-sided airtight seal. Two electrodes and conductive sponges, measuring 4 cm in diameter were used for administering electrical stimulation. **Outcome Measures:** Transcutaneous Oxygen Levels ($P_{TC}O_2$).	1. Experiment 1: Subsequent experiments were performed using 75 volts as no additional effect on $P_{TC}O_2$ was seen when 100 volts was used. 2. Experiment 2: Compared to final baseline $P_{TC}O_2$ reading (mean ± SD) of 49±21mmHg, the level reached at the 30min period of high voltage pulsed galvanic stimulation (HVPGS) was 66±18 mmHg -- 35% higher (p<0.00001). 3. The level fell slightly following the first 15 minutes post stimulation period (p<0.00001). 4. Experiment 3: No change in $P_{TC}O_2$ with simulated HVPGS. 1. Experiment 4: No significant differences were observed (p=0.66 in all comparisons) when experiment 2 and 4 results were compared.

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Bogie & Triolo 2003 USA Pre-Post N=8	**Population:** Mean age=27-47 yr; Gender: males=7, females=1; Level of injury: C5/6 to T9; Severity of injury: AIS: A=6, B=2. **Intervention:** Electrical stimulation delivered via an implanted neuroprosthesis, which included gluteal electrodes, 8 wk of conditioning exercises followed. **Outcome Measures:** Transcutaneous Oxygen Levels.	2. Baseline mean unloaded tissue oxygen levels increased by 1-36% at post exercise assessment for 5/8 subjects. 3. Differences between baseline and post exercise tissue oxygen levels did not show any statistical significance.