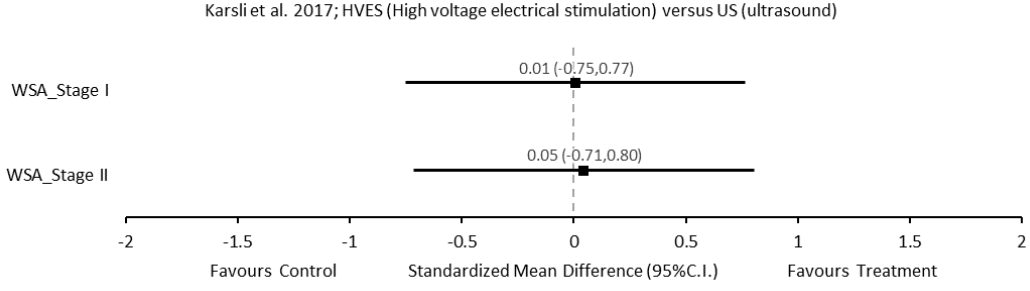


Author Year Country Research Design Score Sample Size	Methods	Results
Systematic Reviews		
<p>Lala et al. 2016 Canada Review of published articles until Jan2014 AMSTAR=6 N=15</p>	<p>Method: Systematic review of literature including randomized controlled trials (RCTs) and clinical non-controlled trials assessing electrical stimulation therapy (EST) for pressure injury (PU) treatment. Databases: CINAHL, The Cochrane Library, Dissertation & Theses, EMBASE, ProQuest – Nursing & Allied Health, PubMed, SCOPUS. Level of evidence: Level 1a (2 RCTs), Level 2 (4 RCTs, 3 PCTs), Level 3 (2 retrospective controlled studies), Level 5 (4 case series). Questions/measures/hypothesis: To determine the effectiveness of EST on the healing of PUs in individuals with spinal cord injury in comparison with control groups.</p>	<ol style="list-style-type: none"> 1. A meta-analysis of three studies found that EST resulted in a significantly larger decrease in PU size compared to standard wound care or sham EST (p<0.001). 2. One retrospective control study and one RCT also found that those treated with biphasic pulsed current healed significantly faster than those treated with low intensity direct current, sham, or conservative therapy. 3. A meta-analysis of four RCTs found that healing of a PU with EST was 1.55 more likely than with standard wound care or sham EST (p=0.01). 4. Three RCTs found that PUs receiving high-voltage pulsed current had a larger percent decrease in wound surface area compared to a sham group. <ol style="list-style-type: none"> 1. Only one study reported minor adverse events related to EST treatment and none reported on the potential of EST to alleviate pain or improve quality of life.
<p>Liu et al. 2016 United Kingdom Review of published articles from 1985-Jul2014 AMSTAR=6 N=8</p>	<p>Method: Systematic review of literature including randomized controlled trials (RCTs) and non-randomized clinical controlled trials (CCTs) assessing electrical stimulation (ES) for pressure injuries (PUs) in spinal cord injury (SCI) patients. Databases: Medline, EMBASE, CINAHL, PsycInfo, Cochrane Central Register of Controlled Trials. Level of evidence: Jadad: Low risk of bias (2 RCTs), Moderate risk of bias (4 RCTs), High risk of bias (2 CCTs). Questions/measures/hypothesis: To assess the effect of ES as an adjunctive therapy to improve healing rates for PU in people with SCI; to explore whether different types of ES currents and electrode placement have any influence; to examine whether ES treatment worsens PU in SCI compared to no treatment.</p>	<ol style="list-style-type: none"> 1. Pooled analyses of seven trials showed that ES resulted in a significantly higher weekly healing rate than sham/no ES (p=0.001). 2. Pooled analysis of six trials showed that pulsed current ES resulted in a significantly higher weekly healing rate than those without ES treatment (p=0.0005). 3. One CCT found that pulsed current ES resulted in a significantly higher weekly healing rate compared to direct current ES (p=0.03). 4. Meta-analysis of four trials found that both placing electrodes directly on the wound (p=0.01) and placing on intact skin (p=0.01) significantly increased the weekly healing rate compared to those that did not receive ES. 5. Two trials showed that ES resulted in significantly higher numbers of completely healed ulcers (p=0.02) but non-significantly lower numbers of ulcers worsening compared to no ES. <ol style="list-style-type: none"> 2. Only one study reported minor adverse events related to ES.
Individual Studies		

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<p>Karsli et al. 2017 Germany RCT PEDro=4 N_{initial}=35 N_{final}=27</p>	<p>Population: Mean age=32.6 yr; Gender: males=22, females=5; <i>HVES Group (n=15)</i>: Injury etiology: SCI=8, TBI=1, Stroke=1, Myelitis=1, SCI+TBI=4; Mean time with pressure injury: 2.76mo; Ulcer location: Sacral=7, Ischial=5, Trochanter=6, Heel=5, Lateral malleolus=1, Head of fibula=1; Pressure injury stage: II=5, III=13, IV=7. <i>US Group (n=12)</i>: Mean age=38.2 yr; Gender: males=22, females=5; Injury etiology: SCI=6, TBI=4, Stroke=2; Mean time with pressure injury: 2.30mo; Ulcer location: Sacral=5, Ischial=8, Heel=6, Lateral malleolus=3; Pressure injury stage: II=9, III=13.</p> <p>Intervention: Patients were randomized to receive either high-voltage electrical stimulation (HVES), applied for 60min, 3x/wk, versus ultrasound (US), applied 3x/wk. All patients received standard wound care in addition to treatment.</p> <p>Outcomes: Wound Surface Area (WSA).</p> <p>Effect Sizes: Forest plot of standardized mean differences (SMD±95%C.I.) as calculated from pre- and post-intervention data.</p> 	<p>3. The WSA improved significantly after treatment in both groups for stages I, II and III (p<0.05).</p>
<p>Houghton et al. 2010 Canada RCT PEDro=9 N=34</p>	<p>Population: Mean age=23-74 yr; Gender: male=20, female=14; Time since injury=1-51 yr; Severity of injury: complete and incomplete; Ulcer location: IT, sacrum, coccyx, hip, leg; Duration of ulcer=0.3-20 yr.</p> <p>Intervention: Stimulation with monophasic high voltage pulsed current (HVPC) 19,200 min/day 7 days/wk with standard wound care (interdisciplinary team assessment) or standard wound care alone (SWC).</p> <p>Outcome Measure: Percent decrease in wound surface area.</p>	<ol style="list-style-type: none"> 1. Percent decrease in wound surface area was significantly greater (p=0.048) in those treated with HVPC+SWC (70 ± 25%); versus those with only SWC (36 ± 61%). 2. Proportion of Stage III, IV, X pressure injuries improving by at least 50% was significantly greater in the HVPC+SWC than in the SWC (p=0.20)
<p>Cukjati et al. 2001 Slovenia RCT PEDro=5 N=217</p>	<p>Population: Mean age: 28-59 yr; Injury etiology: 71.7% SCI; Time since injury: 2-38 mo; Wound area >1cm² and at least 4 wk duration; Ulcer location: trochanter, sacrum, gluteus, other; Ulcer duration: 3-18 wk.</p> <p>Intervention: <i>Biphasic-current stimulation (AC group)</i> (N=136) received biphasic current by placing electrodes on intact skin across the wound. <i>Direct-current stimulation (DC group)</i> (N=35) received direct current (0.6mA) through positive electrode placed over wound and 4 negative electrodes placed on intact skin around the wound. Stimulation was applied 0.5hrs, 1hr, or 2 hours/day 7 days/wk. Comparisons were made to the</p>	<ol style="list-style-type: none"> 1. AC group healed significantly faster than the sham group (p=0.018) and at the same rate as the DC group (p=0.170) with the 2-hour wound treatment. 2. AC group healed significantly faster than DC group with 1-hour treatment (p=0.001). 3. Wound healing rate depend upon wound area, grade, shape, patient's age, elapsed time from SCI to wound appearance, and elapsed time from

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	<p>Conservative treatment group (N=54) and sham group (N=23).</p> <p>Outcome Measure: Wound healing rate.</p>	<p>wound appearance to beginning of treatment.</p>
<p>Adegoke & Badmos 2001 Nigeria RCT PEDro=6 N=7</p>	<p>Population: Mean age=21-60 yr; Mean ulcer surface area=15.8 mm; Ulcer location: greater trochanter and sacrum.</p> <p>Intervention: Stimulation with interrupted direct current (IDC) and nursing care or placebo IDC and nursing care; 3-45 minute treatments 1x/wk for 4 wk.</p> <p>Outcome Measures: Percent decrease in wound surface area.</p>	<ol style="list-style-type: none"> 1. Surface area of pressure injuries of IDC group decreased by 22.2% versus 2.6% in placebo IDC group. 2. Most of the decrease in surface area occurred during the first two wk of the study (IDC group 15.4 to 13.3 mm², % change 15.8%; placebo IDC group 15.4 to 15.1 mm², % change 1.9%).
<p>Karba et al. 1997 Slovenia RCT PEDro=6 N=50</p>	<p>Population: Pressure injury ≥ 500 mm²; Pressure injury stage: III or IV.</p> <p>Intervention: DC+ group receiving positive stimulation electrode overlaid on ulcer; DC+/- group received the same stimulation but two electrodes were placed on healthy skin across the wound; SHAM group had electrodes placed on the wound but no current.</p> <p>Outcome Measures: Relative rate of healing.</p>	<ol style="list-style-type: none"> 1. The DC+ group reported significantly (p=0.028) greater relative healing rate (7.4%/day) compared to SHAM group (4.2%/day), while the DC+/- group (4.8%/day) had similar relative healing rates as the SHAM group .
<p>Baker et al. 1996 USA RCT PEDro=4 N=80</p>	<p>Population: Mean age=17-76 yr; Gender: males=66, females=14; Time since injury: 1-420 mo; Severity of injury: complete and incomplete; Total number of wounds=192; Ulcer location: foot, thigh, ischial and sacral.</p> <p>Intervention: Stimulation of A (asymmetric biphasic), vs. B (symmetric biphasic) vs. microcurrent (MC) group originally thought to incorporate stimulation below effective level became the 3rd treatment group when some early therapeutic effect was noted. All remained on their stimulation protocols until their ulcers healed, the MD intervened or subject withdrew from study. Control group received sham for 4 wk then were entered into either A or B groups. Electrical stimulation treatment for all subjects consisted of 1.5 hr of stimulation 5 days/wk.</p> <p>Outcome Measures: Mean rate of healing.</p>	<ol style="list-style-type: none"> 1. No statistical differences were noted between the initial or discharge ulcer areas or in the mean healing rates among the four treatment groups. 2. Comparing the descriptive data by classifying them as good or poor healing responses failed to identify any statistically significant differences between the 2 groups. 3. When looking at the good response group, the group A protocol was most effective as compared to the MC and C protocols (p<0.05). No significant differences were found between B protocol and other treatments. 4. Those in the control group who had wounds healed by either protocol A or B showed that the healing rate was greater (43.3% Δ/wk) than it was during the control period (9.7% Δ/wk).
<p>Jerčinović et al. 1994 Slovenia RCT PEDro=5 N=73</p>	<p>Population: Mean age: 18-68 yr; Severity of injury: >1 mo; Ulcer location: sacrum, legs, trochanter, gluteal, other.</p> <p>Intervention: Stimulation with biphasic current (n=61) 2 hrs/day 5 days/wk for 4 wk in addition to conventional therapy was compared to the control group receiving conventional therapy alone (n=48).</p> <p>Outcome Measures: Mean rate of healing.</p>	<ol style="list-style-type: none"> 1. The healing rate of the electrical stimulation group (5.7\pm7.1 %/day) was significantly higher (p=0.007) than the control group (2.7\pm3.6 %/day) 2. There were 58 out of 81 pressure injuries (61 electrical stimulation group and 20 cross-over group) which received electrical stimulation closed completely.
<p>Griffin et al. 1991 USA RCT PEDro=7 N=17</p>	<p>Population: Mean age=10-74 yr; Gender: male=17; Time since injury=3-1820 wks; Severity of injury: complete and incomplete; Ulcer location: pelvic (sacral/coccygeal or gluteal/ischial) ulcers; Duration of ulcer=1-116 wk.</p> <p>Intervention: Stimulation with high voltage pulsed current (HVPC) or placebo HVPC for one hour a day for 20</p>	<ol style="list-style-type: none"> 1. Surface area of pressure injuries of HVPC group decreased by 80% versus 52% in placebo HVPC group. 2. Percentage of change decrease in the wound surface area (WSA) exhibited by the HVPC group was greater than

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	consecutive days. All patients received equivalent dressing changes. Wounds were mechanically debrided as necessary. "Efforts" were made to relieve pressure, but this was not described. Outcome Measures: Percent decrease in wound surface area.	placebo group at day 5 (p=0.03), day 15 (p=0.05) and day 20 (p=0.05).
Stefanovska et al. 1993 Slovenia Prospective Controlled Trial N=150	Population: SCI with one or more pressure injuries (otherwise, not specified). Intervention: Currents were applied across the wounds by a pair of self-adhesive skin electrodes. DC group (n=18) treated with direct currents (600µA) for two hours daily. AC group (n=82) were treated with low frequency pulsed currents for two hours daily. CO group (n=50) received "conventional" treatment (not described) for the first mo. Outcome Measures: Mean rate of healing.	1. The healing rate for the AC group (n=42, 5.43%/day) was significantly better than the other two groups DC (n=12, 4.62%/day, p=0.03), CO (n=34, 2.87%/day, p=0.00), after excluding those with very deep, superficial or long-term wounds.
Recio et al. 2012 USA Case Series N=3	Population: Adults with SCI and recalcitrant pressure injuries; Ulcer location: heel, ischium, IT. Intervention: High voltage electrical stimulation (HVES) was applied directly into the wound bed for 60 minutes 3-5 times/wk until completely healed. Outcome Measures: Healing recalcitrant pressure injuries.	2. HVES enhanced healing of Stage III-IV pressure injuries that were unresponsive to SWC. 3. Long-standing (11-14 mo) pressure injuries were completely healed after 7-22 wk of treatment with HVES.