EFEKTIVITAS TERAPI CERMIN UNTUK STROKE SUBAKUT DAN KAITANNYA DENGAN FAKTOR – FAKTOR YANG DIPILIH

Diajukan Untuk Memenuhi Persyaratan Menyelesaikan Pendidikan
Profesi Ners Stase Keperawatan Medikal Bedah

Disusun Oleh :

Gita Pragasari S.Kep	21101030
Nurrohma As'adia S.Kep	21101074
Zhenvio Gilang A. S.Kep	21101106
Muhammad Yusuf S.Kep	21101066
Nur Fakhira Salsabila, S.Kep	21101070
Riska Tamara, S.Kep	21101084
Rusdania Arifah, S.Kep	21101088
Siska Wulandari, S.Kep	21101093

PROGRAM STUDI PROFESI NERS
FAKULTAS ILMU KESEHATAN
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LEMBAR PENGESAHAN

Evidence Based Nursing yang berjudul "Efektifitas Terapi Cermin Untuk Stoke Subakut dan Kaitannya Denagn Faktor-faktor Yang di Pilih di Ruang Raung RSUD Abdoer Rahem Situbondo" telah diperiksa dan disahkan pada:

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Yang Mengesahkan,

Pembimbing Ruangan	Pembimbing Akademik
(…………………………)	([illegible] S.ST., S.Kep., M.Kes)
NIP. 198607112009032	NIDN 19860922 201201 1 019

PEMERINTAH KABUPATEN SITUBONDO R. RAUNG DINAS KESEHATAN

Mengetahui,
Kepala Ruangan

PEMERINTAH KABUPATEN SITUBONDO R. RAUNG DINAS KESEHATAN

(Ahmad Busairi, S.Kep Ns)
NIP. 197505262006 1019.

ii

DAFTAR ISI

BAB I
PENDAHULUAN

1.1 Latar Belakang

Stroke merupakan penyakit atau gangguan fungsional otak berupa kelumpuhan saraf (deficite neurologis) akibat terhamabatnya aliran darah ke otak (Junaidi, 2011). Menurut Ginsberg (2007) stroke adalah sindrom yang terdiri dari tanda atau gejala hilangnya fungsi sistem saraf pusat fokal atau global yang terjadi secara cepat dan mendadak (dalam menit atau pun detik) yang berlangsung lebih dari 24 jam atau menyebabkan kematian. Jadi, stroke merupakan gangguan fungsi saraf yang disebabkan oleh gangguan aliran darah pada otak yang dapat timbul secara mendadak dalam beberapa detik atau secara cepat dalam beberapa menit dan jam.

Hemiparesis adalah salah satu dari sindrom umum yang disebabkan oleh stroke, yang menyebabkan keterbatasan aktivitas dasar kehidupan sehari-hari (ADL) dan Cacat. Stroke orang dewasa yang lebih tua paling beresiko kehilangan kemandirian karena banyak faktor, seperti nyeri, edema, kelemahan, obat-obatan, atau keadaan mental (mood depresif). Masalah seperti itu menggarisbawahi kebutuhan untuk menggabungkan berbagai jenis terapi untuk mendapatkan manfaat terbesar. Strategi terapi yang optimal harus fokus pada mendorong pasien untuk mengulang pelatihan yang berorientasi tugas dengan umpan balik tentang kinerja (Langhorne, dkk., 2009). Untuk mengatasi masalah ini, banyak umpan balik ide visual telah digunakan dalam pengobatan. Ramachandran dkk, 1998 memperkenalkan pengobatan (1998) untuk nyeri tungkai phantom yang bernama Treatment Mirror Visual Feedback (MVF) atau mengobatan cermin dengan umpan balik visual.

Terapi cermin (MT) adalah salah satu terapi berbasis MVF. Di MT, orang dengan hemiparesis dapat mengalami reaksi visual terhadap tugas yang berhasil diselesaikan menggunakan anggota badan mereka yang terkena dampak (Ramachandran & Altshuler, 2009). Studi literatur tentang efek MT terhadap pemulihan fungsi motorik telah menunjukkan efek menguntungkan dalam 2 bulan poststroke dan 6 bulan poststroke. Mereka menunjukkan pengaruh positif pada fungsi motorik dari tangan paretik. Namun, penelitian lebih lanjut diperlukan untuk pemilihan pasien yang lebih optimal, program aplikasi, dan durasi dan intensitas MT (Thieme, Merholtz, Pohl, Barnes, & Dohle, 2012).

1.2 Rumusan Masalah

Bagaimanakah efektivitas terapi cermin terhadap pasien stroke subakut?

1.3 Tujuan

1.3.1 Tujuan Umum

Tujuan dari penelitian ini adalah untuk menentukan efektivitas terapi cermin (MT) digabungkan dengan perawatan yang komprehensif, dan untuk menyelidiki mungkin hubungan fungsional.

1.3.2 Tujuan Khusus

1. Mengetahui efektivitas terapi cermin (MT) pada pasien stroke
2. Menentukan efektivitas MT sebagai tambahan untukpengobatan komprehensif menggunakan skala fungsional.

1.4 Manfaat

1.4.1 Bagi Pasien

Memberi gambaran baru bagi pasien dalam memilih alternatif pengobatan yang diingkan selain tindakan pembedahan. Karena terapi cermin atau MT adalah pelatihan non-invasif yang mudah dilaksanakan program yang dapat ditawarkan kepada pasien yang sesuai dengan terapis fisik, terapis okupasi, atau yangdirekomendasikan oleh perawat.

1.4.2 Bagi Pelayanan Keperawatan

Hasil penerapan EBN ini dapat menjadi alternatif pilihan baru yang bisa diterapkan pada pelayanan keperawatan sehingga perawatan pengobatan pasien dengan stroke.Penelitian ini diharapkan dapat digunakan sebagai program pemulihan pasien stroke yang mengalami hemiparesis serta sebagai bahan masukan dalam proses pendidikan ilmu keperawatan dan sebagai acuan dalam penelitian selanjutnya.

1.4.3 Bagi Perkembangan Ilmu Keperawatan

Hasil penerapan EBN ini diharapkan dapat memperkayakeilmuan dalam keperawatan dan menjadi salah satu acuan dalam pengelolaan masalah pengobatan pada pasien dengan Stroke

BAB II
TINJAUAN PUSTAKA

2.1 Konsep Stroke

2.1.1 Definisi Stroke

Stroke adalah suatu keadaan yang timbul karena terjadi gangguan peredaran darah di otak yang menyebabkan terjadinya kematian jaringan otak sehingga mengakibatkan seseorang menderita kelumpuhan atau kematian. Stroke merupakan deficit neurologis yang mempunyai serangan mendadak dan berlangsung 24 jam sebagai akibat dari *cardiovascular disease* (Batticaca, 2012).

Stroke adalah suatu gangguan fungsional otak yang terjadi secara mendadak (dalam beberapa detik) atau secara cepat (dalam beberapa jam) dengan tanda dan gejala klinis baik fokal maupun global yang berlangsung lebih dari 24 jam, disebabkan oleh terhambatnya aliran darah ke otak karena perdarahan (stroke hemoragik) ataupun sumbatan (stroke iskemik) dengan gejala dan tanda sesuai bagian otak yang terkena, yang dapat sembuh sempurna, sembuh dengan cacat, atau kematian.

2.1.2 Epidemiologi Stroke

Stroke penyebab kematian ketiga di dunia setelah penyakit jantung koroner dan kanker baik di negara maju maupun negara berkembang. Satu dari 10 kematian disebabkan oleh stroke (American Heart Association, 2014; Stroke forum, 2015). Secara global, 15 juta orang terserang stroke setiap tahunnya, satu pertiga meninggal dan sisanya mengalami kecacatan permanen (Stroke forum, 2015). Stroke merupakan penyebab utama kecacatan yang dapat dicegah

Kementerian Kesehatan Republik Indonesia memperlihatkan bahwa stroke merupakan penyebab kematian nomor satu pada pasien yang dirawat di rumah sakit. Menurut Yayasan Stroke Indonesia, setiap tahun diperkirakan 500.000 penduduk mengalami serangan stroke dan 25% di antaranya (125.000 penduduk) meninggal, sisanya mengalami cacat ringan maupun berat. Di Indonesia, kecenderungan prevalensi stroke per 1000 orang mencapai 12,1 dan setiap 7 orang yang meninggal, 1 diantaranya terkena stroke (Depkes, 2013).

2.1.3 Etiologi

a. Trombosis (bekuan darah dalam pembuluh darah otak atau leher
b. Embolisme serebral (bekuan darah atau material lain yang dibawa ke otak dari bagian tubuh yang lain)
c. Iskemia (penurunan aliran darah ke area otak)
d. Hemoragi serebral (pecahnya pembuluh darah serebral dengan perdarahan ke dalam jaringan otak atau ruang sekitar otak).

2.1.4 Patofisologi

Setiap kondisi yang menyebabkan perubahan perfusi darah pada otak akan menyebabkan keadaan hipoksia. Hipoksia yang berlangsung lama dapat menyebabkan iskemik otak. Iskemik yang terjadi dalam waktu yang singkat kurang dari 10-15 menit dapat menyebabkan defisit sementara dan bukan defisit permanen. Sedangkan iskemik yang terjadi dalam waktu lama dapat menyebabkan sel mati permanen dan megakibatkan infark pada otak. Setiap defisit fokal permanen akan bergantung pada daerah otak mana yang terkena. Daerah otak yang terkena akan menggambarkan pembuluh darah otak yang terkena. Pembuluh darah yang paling sering mengalami iskemik adalah arteri serebral tengah dan arteri karotis interna. Defisit fokal permanen dapat tidak diketahui jika klien pertama kali mengalami iskemik otak total yang dapat teratasi.

Jika aliran darah ke tiap bagian otak terhambat karena trombus atau emboli, maka mulai terjadi kekurangan suplai oksigen ke jaringan otak. Kekurangan oksigen dalam satu menit dapat menunjukan gejala yang dapat pulih seperti kehilangan kesadaran. Sedangkan kekurangan oksigen dalam waktu yang lebih lama menyebabkan nekrosis mikroskopik neuron-neuron. Area yang mengalami nekrosis disebut infark. Gangguan peredaran darah otak akan menimbulkan gangguan pada metabolisme sel-sel neuron, di mana sel-sel neuron tidak mampu menyimpan glikogen sehingga kebutuhan metabolisme tergantung dari glukosa dan oksigen yang terdapat pada arteri-arteri yang menuju otak.

Perdarahan intrakranial termasuk perdarahan ke dalam ruang subarakhnoid atau ke dalam jaringan otak sendiri. Hipertensi mengakibatkan timbulnya penebalan dan degenertif pembuluh darah yang dapat menyebabkan ruprutnya arteri serebral sehingga perdarahan menyebar dengan cepat dan menimbulkan perubahan setempat serta iritasi pada pembuluh darah otak. Perdarahan biasanya berhenti karena pembentukan trombus oleh fibrin trombosit dan oleh tekanan jaringan. Setelah 3 minggu, darah mulai direabsorbsi. Ruptur ulangan merupakan risiko serius yang terjadi sekitar akibat 7-10 hari setalah perdarahan pertama.

Ruptur ulangan mengakibatkan terhentinya aliran darah ke bagian tertentu, menimbulkan iskemik lokal, dan infark jaringan otak. Hal tersebut dapat menimbulkan geger otak dan kehilangan kesadaran, peningkatan tekanan cairan serebrospinal (CSS), dan menyebabkan gesekan otak (otak terbelah sepanjang serabut). Perdarahan mengisi ventrikel atau hematoma yang merusak jaringan otak. Perubahan sirkulasi CSS, obstruksi vena, adanya edema dapat meningkatkan tekanan intrakranial yang membahayakan jiwa dengan cepat. Peningkatan tekanan intrakranial yang tidak diobati mengakibatkan herniasi unkus atau serebellum. Di samping itu, terjadi bradikardi, hipertensi sistemik, dan gangguan hipertensi.

Darah merupakan bagian yang merusak dan bila terjadi hemodialisa, darah dapat mengiritasi pembuluh darah, meningen, dan otak. Darah dan vasoaktif yang dilepas mendorong spasme arteri yang berakibat menurunnya perfusi serebral. Spasme serebri atau vasospasme biasa terjadi pada hari ke-4 sampai ke-10 setalah terjadinya perdarahan dan menyebabkan konstruksi arteri otak. Vasospasme merupakan komplikasi yang mengakibatkan terjadinya penurunan fokal neurologis, iskemik otak, dan infark.

2.1.5 Faktor Resiko

1. Faktor Mayor
   a. hipertensi merupakan faktor resiko utama.
   b. Penyakit jantung; gangguan pembuluh darah koroner, dan karotis, gagal jantung kongestif, hipertrofi ventrikel kiri, fibrilasi atrium, penyakit jantung kongestif.
   c. Diabetes mellitus (dikaitkan dengan aterogenesis terakselerasi).
   d. Polisitema.
   e. Riwayat pernah terkena stroke.
2. Faktor Minor
   a. Kadar lemak yang tinggi dalam darah/ kolesterol tinggi.
   b. Hematokrit tinggi (meningkatkan resiko infark serebral).
   c. Kebiasaan merokok.
   d. Obesitas.
   e. Kadar asam urat darah tinggi.
   f. Kurang olah raga.

g. Fibrinogen tinggi.
h. Penggunaan kontrasepsi oral (khususnya dengan disertai hipertensi, merokok, kadar esterogen yang tinggi).
i. Penyalahgunaan obat, khususnya kokain.
j. Konsumsi alkohol.

2.1.6 Klasifikasi

a. Stroke iskemik (infark atau kematian jaringan)

   Serangan sering terjadi pada usia 50 tahun atau lebih dan terjadi pada malam hingga pagi hari.

   1) Thrombosis pada pembuluh darah otak (*thrombosis of serebral vessels*)
   2) Emboli pada pembuluh darah otak (*embolism of cerebral vesels*)

b. Stroke hemoragik (perdarahan)

   Serangan sering terjadi pada usia 20-60 tahun dan biasanya timbul setelah aktivitasfisik atau karena psikologis (mental)

   1) Perdarahan intraserebral (*parenchymatous hemorrhage*)

      Gejalanya:

      a) Tidak jelas, kecuali nyeri kepla hebat karena hipertensi
      b) Serangan terjadi pada siang hari, saat beraktivitas, dan emosi atau marah
      c) Mual atau muntah pada permulaan serangan hemiparesis atau hemiplegia terjadi sejak awal serangan
      d) Kesadaran menurun dengan cepat dan menjadi koma (65% terjadi kurang dari ½ jam – 2 jam; < 2% terjadi setelah 2 jam – 19 hari).

   2) Perdarahan subaraknoid (subarachnoid hemorrhage)

      Gejalanya:

      a) Nyeri kepala hebat dan mendadak
      b) Kesadaran sering terganggu dan sangat bervariasi
      c) Ada gejala atau tanda meningeal
      d) Papiledema terjadi bila ada perdarahan subarachnoid kerena pecahnya aneurisma pada arteri komunikans anterior atau arteri karotis interna.

2.1.7 Manefestasi Klinis

Stroke menyebabkan berbagai defisit neurologik, bergantung pada lokasi lesi (pembuluh darah mana yang tersumbat), ukuran area yang perfusinya tidak adekuat, dan jumlah aliran darah kolateral yaitu sekunder atau aksesori (Smeltzer & Bare, 2013).

a. Kahilangan motorik

Stroke merupakan penyakit motor neuron dan mengakibatkan kehilangan kontrol volunter terhadap gerakan motorik. Disfungsi motorik paling umum adalah hemiplegia (paralisis pada salah satu sisi) karena lesi pada sisi otak yang berlawanan. Hemiparesis, atau kelemahan pada salah satu sisi tubuh, adalah tanda yang lain.

b. Kehilangan komunikasi

Fungsi otak lain yang dipengaruhi oleh stroke adalah bahasa dan komunikasi. Stroke adalah penyebab afasia paling umum. Disfungsi bahasa dan komunikasi dapat dimanefestasikan oleh hal berikut :

1) Disartria (kesulitan berbicara), ditunjukan dengan bicara yang sulit dimengerti yang disebabkan oleh paralisis otak yag bertanggung jawab untuk menghasilkan bicara.
2) Disfagia atau afasia (bicara defektif atau kehilangan bicara), yang terutama ekspresis atau represif.
3) Apraksia (ketidakmampuan untuk melakukan tindakan yang dipelajari sebelumnya), seperti terlihat ketika pasien mengambil sisir dan berusaha menyisir rambutnya.

c. Gangguan persepsi

Persepsi adalah ketidakmampuan untuk menginterprestasikan sensasi. Stroke dapat mengakibatkan disfungsi persepsi visual, gangguan dalam hubungan visual-spasial dan kehilangan sensori.

d. Homonimus Hemianopsia (kehilangan setengah lapang pandang)

Dapat terjadi karena stroke dan mungkin sementara atau permanen. Sisi visual yang terkena berkaitan dengan sisi tubuh yang paralisis.

e. Amorfosintesis

Kepala pasien berpaling dari sisi tubuh yang sakit dan cenderung mengabaikan bahwa tempat dan ruang pada sisi tersebut

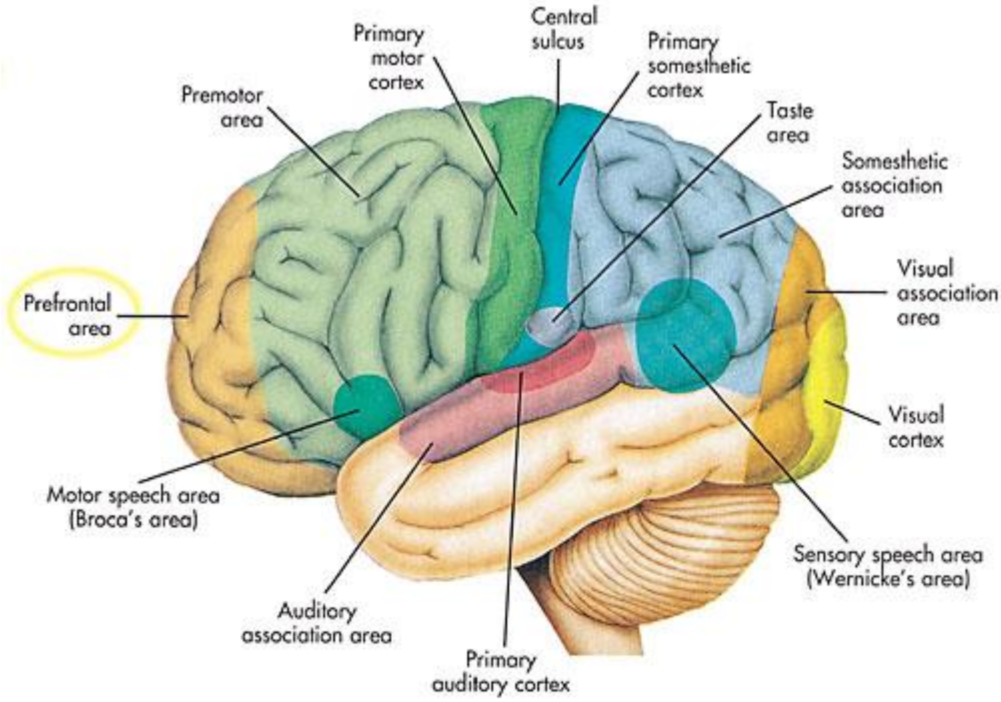
f. Kerusakan Fungsi Kognitif dan Efek Psikologis

Bila kerusakan telah terjadi pada lobus frontal, mempelajari kapasitas, memori, atau fungsi intelektual kortikal yang lebih tinggi mungkin rusak. Disfungsi ini ditunjukan dalam lapang perhatian yang terbatas, kesulitan dalam pemahaman, lupa, kurang motivasi, yang menyebabkan pasien ini menghadapi masalah frustasi dalam profram rehabilitasi mereka.

g. Disfungsi Kandung Kemih

Setelah stroke pasien mungin mengalami inkontinensia urinarius sementara karena konfusi, ketidakmampuan mengkomunikasikan kebutuhan, dan ketidakmampuan untuk menggunakan urinal karena kerusakan control motorik dan postural.

Gejala-gejala yang timbul tergantung lokasi serangan baik itu stroke hemoragik maupun stroke iskemik, hal ini dapat diterangkan dengan gambar sebagai berikut:



1. **Hijau** merupakan pusat gerakan atau motorik.

   Jika area ini yang terkena, penderita akan mengalami kelemahan sampai kelumpuhan dari anggota gerak pada sisi yang berlawanan, sehingga apabila terkena sisi kanan, yang mengalami kelemahan/kelumpuhan anggota gerak sebelah kiri.

2. **Biru muda** merupakan pusat sensibilitas atau perasa

   Area ini merupakan pusat perasa. Seandainya sisi ini yang terkena serangan stroke, pasien akan mengeluhkan rasa kebas sampai mati rasa pada arah yang berlawanan.

3. **Hijau toska di area hijau** disebut area broca atau pusat bicara motoric

   Penderita yang mengalami gangguan didaerah ini tidak dapat bicara tetapi dapat mengerti apa yang kita tanyakan hal ini disebut *afasia motoris*.

4. **Hijau toska di area biru** disebut area wernicke sebagai pusat bicara sensoris.

   Penderita masih dapat bicara, tetapi tidak mengerti apa yang ditanyakan oleh si penanya, sehingga antara pertanyaan dan jawaban tidak sesuai.

5. **Kuning** sebagai area visuosensoris

   Daerah ini jika terganggu akan mengeluhkan adanya gangguan penglihatan yang disebut sebagai *anopsia*, jika terkena satu sisi disebut *hemianopsia*.

6. **Coklat garis-garis** adalah otak kecil sebagai pusat koordinasi.

   Serangan stroke didaerah ini menyebabkan penderita tidak dapat berjalan dengan baik atau mengkoordinasi gerakan baik gerakan tangan maupun kaki.

7. **Krem bawah** disebut batang otak.

   Merupakan tempat jalan serabut-serabut saraf ke target organ, seperti pengatur nafas, tekanan darah, anggota gerak, serta serabut-serabut lainnya. Apabila terjena stroke di daerah ini pasiennya biasanya fatal, sebagian besar tidak tertolong

2.1.8 Pemeriksaan Diagnostik

a. Angiografi serebral. Membantu menentukan penyebab stroke secara spesifik misalnya pertahanan atau sumbatan arteri.
b. Scan Tomografi Komputer (*ComputerTomography scan – CT-scan*). Mengetahui adanya tekanan normal dan adanya trombosis, emboli serebral, dan tekanan intrakranial (TIK).
c. *Magnetic Resonance Imaging* (MRI). Menunjukan daerah infark, perdarahan, malformasi arteriovena (MAV).
d. *Ultrasonografi doppler* (USG doppler). Mengidintifikasi penyakit arteriovena (masalah sistem arteri karotis [aliran darah atau timbulnya plak]) dan arteriosklerosis.
e. Elektroensefalogram (*electroencephalogram* – EEG). Mengindentifikasi masalah pada gelombang otak dan memperlihatkan daerah lesi yang spesifik

f. Sinar tengkorak. Menggambarkan perubahan kelenjar lempeng pienal daerah yang berlawanan dari massa yang meluas, klasifikasi karotis interna terdapat pada trombosis serebral, klasifikasi parsial dinding aneurisma pada perdarahan subarakhoid.
g. Pemeriksaan laboratorium:
    1) Darah rutin
    2) Gula darah
    3) Urine rutin
    4) Cairan serebrospinal
    5) Analisa gas darah (AGD)
    6) Biokimia darah
    7) Elektrolit

2.1.9 Komplikasi

1. Hipoksia serebral

   Diminimalkan dengan memberi oksigenasi darah adekuat ke otak. Fungsi otak bergantung pada ketersediaan oksigen yang dikirimkan ke jaringan. Pemberian oksigen suplemen dan mempertahankan Hb serta Ht pada tingkat normal akan membantu dalam mempertahankan oksigenasi jaringan.
2. Penurunan aliran darah serebral

   Aliran darah serebral bergantung pada tekanan darah, curah jantung, dan integritas pembuluh darah serebral. Hidrasi adekuat (cairan intravena) harus menjamin penurunan viskositas darah dan memperbaiki aliran darah serebral. Hipertensi dan hipotensi ekstrem prlu dihindari untuk mencegah perubahan pada aliran darah serebral dan potensi meluasnya area cedera.
3. Embolisme serebral

   Dapat terjadi setelah infark miokard atau fibrilasi atrium atau dapat berasal dari katup jantung prostetik. Embolisme akan menurunkan aliran darah ke otak dan selanjutnya menurunkan aliran darah serebral. Disritmia dapat mengakibatkan curah jantung tidak konsisten dan penghentian trombus lokal. Selain itu, disritmia juga dapat menyebabkan embolus serebral dan harus diperbaiki.

2.1.10 Penatalaksanaan Medis

Penatalaksanaan pada pasien stroke terdiri dari berbagai macam tindakan. Jenis tindakan yang dilakukan tergantung dari jenis stroke yang menyerang. Apakah pemicunya adalah pasokan darah yang kurang ke otak (stroke iskemik), atau karena bocornya pembuluh darah intrakranial (stroke hemoragik). (Dr. Alferd sutrisno, 2008:75)

Jika terjadi perdarahan tentu tindakan medis yang diambil adalah bagaimana menghentikan perdarahan. Tetapi, jika yang terjadi adalah pembekuan darah/sumbatan pembuluh darah, tindakan medis yang diambil adalah memberi obat yang bisa mengencerkan darah. Untuk memastikan jenis mana yang tengah menyerang penderita, tentu pemeriksan diagnostik perlu dilakukan untuk membantu proses pengobatan stroke. (Dr. Alferd sutrisno, 2008:75-76)

1. Metode Konvensional

   yaitu melalui pemberian obat-obatan, hal ini banyak dilakukan untuk menangani jenis stroke iskemik (meskipun tidak jarang pula dilakukan tindakan operatif/ bedah). Sebaliknya, pada stroke jenis hemorhagik tindakan yang lebih cocok untu dipilih adalah tindakan operatif/ bedah. (Dr. Alferd sutrisno, 2008:76). Jenis metotde/ tindakan konvensional (non-operatif) meliputi:

   a. Obat Anti Trombosis

      yang termasuk dalam keluarga obat-obatan ini adalah aspirin, tiklopidin, warfarin, dan heparin.

   b. Semax

      Pada agustus 1998, gencar diekspos obat baru dengan merek semax. Obat ini merupakan pecahan ACTH (*adrenocorticotropic hormone*) 4-7. Prinsip kerja obat ini adalah memperbaiki metabolisme sel saraf.((Dr. Alferd sutrisno, 2008:78)

   c. Diuretik

      Obat ini digunakan untuk menurunkan edema srebral, yang mencapai tingkat maksimum 3 sampai 5 hari setelah infark serebral.

2. Metode Operatif

   Tujuan tindakan ini adalah untuk memperbaiki pembuluh darah yang cacat. Dengan begitu diharapkan dapat meningkatkan peluang hidup pasien, dan menyelamatkan jiwanya. Meski terjadi perdarahan, tidak otomatis dokter melakukan pebedahan. Pertimbangan pembedahan biasanya dilihat dari:

   a. Letak pembuluh darah yang bermasalah, jika letakpembuluh darah yang bermasalah nerada ditempat yang mudah dijangkau, pembedahan menjadi pelihan terbaik. Misalnya bila terjadi aneurisme di daerah sirkulus willisi, aneurisma ini berpoensi pecah sehingga perlu dilakukan *clipping aneurysm*.

b. Terjadi hemorhagi subarknoid akibat pecahnya aneurisma, pecahnya pembuluh darah inimnegakibatkan otak kebanjiran cairan (hidrosefalus). Untuk mengatasi kondisi ini, diperlukan pemasangan VP shunt (ventuculoperitoneal shunt), yakni alat untuk mengalirkan kelebihan cairan dalam otak ke rongga perut.

c. Apabila perdarahan terletak dilokasi yang sulit dijangkau maka tindakan yang dilakukan baisanya adalah dengan embolisasi (penyumbatan) atau *koiling*.

   Koiling dilakukan dengan jalan memasang per pada pembuluh darah yang mulai bocor. Dengan begitu kebocoran bisa dihantikan. Pemasangan koil dilakukan dengan menggunakan kateter dari pembuluh darah paha.

   Untuk membantu pemulihan, pasien harus ekstra hati-hati. Pasca operasi pemasangan koil pasien dilarang batuk, duduk, atauhal lain yang mengakibatkan peningkatan tekanan darah dan tekanan intrakranial. Sebab, semua itu bisa mengancam gagalnya proses koiling.

3. Penatalaksanaan Pasien Stroke Fase Akut

Pasien yang koma pada saat masuk rumah sakit dipertimbangkan mempunyai prognosa yang buruk. Sebaliknya, pasien sadar penuh menghadapi hasil yang dapat lebih diharapkan. Fase akut biasanya berakhir 48-72 jam. Dengan mempertahankan jalan nafas dan ventilasi adekuat adalah perioritas dalam fase akut ini.

a. Pasien ditempatkan pada posisi lateral atau semi telungkup/sims dengan kepala tempat tidur agak ditinggikan sampai tekanan vena serebral berkurang.

b. Intubasi endotrakea dan ventilasi mekanik perlu untuk pasien dengan stroke masif, karena henti pernafasan biasanya faktor yang mengancam kehidupan pada situasi ini.

c. Pasien dipantau untuk adanya komplikasi pulmonal (aspirasi, atelaktasis, pneumonia) yang mungkin berkaitan dengan kehilangan reflek jalan nafas, imobilitas, atau hipoventilasi.

d. Jantung diperiksa untuk abnormalitas dalam ukuran dan irama serta tanda dan gagal jantung kongestif.

4. Pendidikan pasien dan pertimbangan perawatan dirumah

yang perlu diperhatikan dalam pertimbangan perawatan dirumah pada pasien stroke adalah:

a. Perencanaan Perawatan

   Proses penyembuhan dan rehabilitasi stroke dapat terjadi dalam waktu yang lama,yang membutuhkan kesabaran dan ketekunan dari pasien sendiri dan keluarga. Pasien yang membutuhkan pelayanan beberapa tenaga pelayanan kesehatan profesional, bergantung pada penurunan neurologis yang spesifik yang disebabkan oleh stroke. Perawatan pasien di rumah sering dibantu oleh bantuan perawat, keluarga atau pasangan.

b. Aspek Emosional

   Keluarga diberitahu bahwa pasien akan sering mudah lelah, akan menjadi peka rangsangan dan kecewa dengan kejadian kecil, dan menunjukkan kurang minat terhadap sesuatu. Karena sering mengalami stroke dan dalam tahapan kehidupan lanjut, dan adanya dimensia maka kemungkinan akan terjadi kemunduran intelektual. Depresi akan terjadi dan merupakan masalah yang serius pada pasien stroke.dalam hal ini dapat diberikan obat anti depresan apabila depresi sudah termasuk parah dan dalam waktu yang lama. Namun, keluarga dapat menolong terus menerus untuk mendukung pasien dan memberikan pujian pada setiap kemajuan yang ditunjukkan oleh paisen.

c. Modifikasi Rumah

   Ahli terapi okupasi membantu dalam mengkaji lingkungan rumah pasien dan menganjurkan untuk mengubah tata ruang untuk membantu pasien menjadi lebih mandiri.

d. Sumber Pendukung

   Banyak alat yang menolong diri sendiri yang digunakan untuk membantu pasien dalam melkaukan aktivitas sehari-hari. Kelompok dasar dalam lingkungan dan keluarga merupakan sumber pendukung paling utama. Pasien dianjurkan untuk tetap menjalankan hobi, rekreasi, dan menggunakan waktu luangnya untuk berhubungan dengan teman-temannya untul mencegah isolasi sosial. Semua perawat yang berhubungan dengan pasien harus mendorong pasien agar tetap aktif, taat melakukan program latihan, dan alat bantu disediakan bila memungkinkan

2.2 Konsep Terapi Cermin

2.2.1 Definisi Terapi Cermin

Terapi cermin adalah intervensi terbaru yang berfokus pada pergerakan anggota badan yang tidak rusak terapi cermin adalah bentuk gambaran dimana cermin digunakan untuk menyampaikan rangsangan visual ke otak melalui pengamatan terhadap bagian tubuh seseorang yang tidak mengalami kelemahan (Sengkey, 2014). Terapi cermin merupakan salah satu bentuk pengobatan alternatif pada rehabilitasi stroke yang tergolong relatif baru, prinsip terapi ini adalah pendekatan sensori motor, yaitu dengan cara melihat dan menggerakan anggota gerak yang sehat di depan cermin, sedangkan anggoa gerak yang paresis disembunyikan di belakang cermin, sehingga seolah olah klien melihat gerakan tersebut dari anggota gerak yang mengalami hempiparesis, tujuannya untuk menciptakan ilusi visual pemulihan motorik dari anggota gerak yang mengalami hemiparesis (Caires *et al.*, 2016). Dengan cara ini otak dirangsang untuk kembali mengenali rangsangan sensoris, terutama dari visual (Kim, Lee and Song, 2014).

Ada tiga metode terapi cermin, yang pertama disebut latihan unilateral (*unilateral training*), yaitu penderita diminta untuk melihat anggota gerak yang sehat dalam cermin sambil membayangkan bahwa benar-benar melihat anggota gerak yang paresis tanpa meggerakanya, yang kedua, menbayangkan dan menggerakan anggota gerak yang paresis seeprti yang sehat, latihan ini disebut latihan bilateral (*bilateral training*), yang ketiga, membayangkan dan berusaha menggerakan serta digerakan yang pasif oleh pemeriksa. Dari ketiga metode tersebut, metode yang paling lebih efektif yaitu bilateral training daripada unilateral training dalam memfasilitasi pemulihan motorik, agar kedua tangan saat latihan sejuh mungkin tampak serupa, maka tidak boleh memakai cincin, jam tangan atau gelang tangan (Kim, Lee and Song, 2014).

Latihan *mirror therapy* adalah bentuk rehabilitasi/ latihan yang mengandalkan dan melatih pembayangan/ imajinasi motorik klien yang sifatnya menginduksi aktivitas saraf korteks sensori motor (Guo et al, 2016), dimana cermin akan memberikan stimulasi visual kepada otak (saraf motorik serebral yaitu ipsilateral atau kontralateral untuk pergerakan anggota tubuh yang hemiparesis) melalui observasi gerakan tubuh yang akan cenderung ditiru seperti pada cermin pada tubuh yang mengalami gangguan (Dohle et al,., 2010). Sejumlah strategi pengobatan yang saat ini banyak dibahas salah satunya mirror theraphy (Thieme et al,. 2012) sebagai alternatif mirror theraphy telah diusulkan sebagai potensi yang menguntungkan karena klien dapat melakukan ini sendiri dan direkomendasikan sebagai aternatif sederhana dan murah untuk mengobati fungsi motorik (Lin, et al., 2012). Terapi cermn pada awalnya dikembangkan untuk mengurangi nyeri tungkai bayangan dalam amputasi. Refleksi dari lengan yang utuh dalam cermin memberi klien sensasi memiliki yang mampu bergerak, yang menyebabkan penurunan rasa sakit. Pada tahun 1999, Altschuler dkk memperkenalkan *mirror therapy* untuk terapi hemiparesis pada pasien stroke.

2.1.2 Prosedur *Mirror Therapy*

Prosedur umum mirror therapy adalah klien duduk di depan cermin yang sejajar dengan garis tengah yang menghalangi pandangan anggota badan yang mengalami kelemahan otot yang diposisikan dibelakang cermin. klien melihat ke satu sisi cemin lain, dan melihat pantulan anggota ggerak yang normal dimana orientasinya sebagai anggota badan yang mengalami kelemahan. Cara ini cocok untuk menciptakan ilusi visual dimana pergerakan atau sentuhan ke anggota tubuh yang nomal dapat dianggap mempengaruhi anggota tubuh yang mengalami kelemahan. klien melakukan gerakan anggota badan yang normal dan mengamati pantulan cermin yang ditumpangkan diatas ektremitas yang tidak terlihat. Gerakan dilakukan selama 30 menit untuk ekstremitas atas dan bawah 5 kali seminggu (Sengkey, 2014).

2.1.3 Gerakan *Mirror Therapy*

Gerakan pada mirror theraphy dibedakan menjadi dua bagian, yaitu :

a. Ekstremitas Atas

   Penderita stroke duduk pada cermin yang sejajar denganya dan berpotongan dibidang tubuh bagian sagital di daerah dada. Bagian reflektif cermin menghadap ke sisi yang normal. Pada saat klien melihat ke cermin, yang mereka lihat hanyalah sisi ekstremitas yang tidak normal. Klien menatap cermin yang mencerminkan tangan normal. Terapis memberi perintah untuk menggerakan kedua anggota gerak, baik yang normal maupun yang mengalami hemiparise. Anggota gerak yang mengalami hemiparise tidak bergerak tapi refleksi cermin terhadap anggota gerak yang normal memberikan orientasi bahwa itu adalah anggota gerak yang mengalami hemiparise.

b. Ekstremitas bawah

   Penderita stroke bisa duduk di kursi. Cermin di tempatkan diantara kaki pasien untuk membagi tubuh hemiparise dan non hemiparise. Pasien diinstruksikan untuk melakukan plantar dan dorsofeksi pada kedua kaki. Anggota gerak yang mengalami hemiparise tidak bergerak tapi refleksi cermin terhadap anggota gerak yang normal memberikan orientasi bahwa itu adalah anggota gerak yang mengalami hemiparise (Sengkey, 2014).

2.1.4 Konsep *Mirror Therapy*

Konsep mirror theraphy telah diperkuat secara neurofisiologis. Cermin tersebut memberi klien masukan visual yang tepat bahwa refleki cermin dari lengan normal yang digerakkan terihat seperti lengan yang mengalami hemiparise bergerak dengan normal. Proses yang mendasari gambaran motorik serupa dengan gambaran aktif selama pergerakan. Jaringan syaraf tiruan yang terlibat dalam gambar motorik dan pelaksanaannya saling tumpang tindih, terutama didaerah premotor, parietal, ganglia basal dan cerebelleum. Penggunaan cermin dapat merekrut korteks promotor terhadap rehabilitasi motorik. Kotrkes promotor memiliki fitur yang menunjukkan bahwa, mungkin merupakan penghubung dari gambaran visual di cermin ke rehabilitasi motorik. Peran terapi cemin dalam pengaruh gangguan sensorik masih belum jelas karena masukan visual yang diberikan oleh pantuan cemin di kombinasikan dengan sensasi tangan pasien tang berubah atau tidak melalui korpus jollosum atau melalui aktivasi neuron cermin (Sengkey, 2014).

Saraf motorik bekerja untuk mengatur urutan otot berkedut untuk menghasilkan gerakan terampil sederhana seperti: mencapai kacang tanah, mendorong batu, atau memasukkan apel ke mulut. Bagian dari neuron cermin ini juga berfungsi saat orang tersebut hanya melihat orang lain melakukan gerakan yang sama. Cermin neuron perlu melibatkan beberapa interaksi antara beberapa modalitas (penglihatan, perintah motorik, dan propriosepsi) yang menunjukkan bahwa mereka mungkin terlibat dalam efisiensi terapi cermin pada stroke. Kelumpuhan stroke sebagian disebabkan oeh kerusakan permanen yang sebenarnya dalam kapsul internal. Kemungkinan tambahan adalah lesi selalu tidak lengkap. Mungkin ada sisa neuron cermin yang berahan namun tidak aktif atau aktivitasnya terhambat dan tidak mencapai ambang batas. Jadi, terapi cermin merupakan bagian dari efifibilitasnya untuk merangsang neuron ini, sehingga memberikan masukan visual untuk menghidupkan kembali neuron motorik (Sengkey, 2014).

BAB III
METODE PENELITIAN

3.1 Strategi Pencarian *Literature*

3.1.1 Protokol dan Registrasi

Penelitian ini merupakan dalam bentuk *evidence base nursing* mengenai efektifitas terapi cermin terhadap pasien stroke subakut. Protokol dan evaluasi dari *evidence base nursing* akan menggunakan ceklist PRISMA sebagai upaya dalam menentukan pemilihan studi yang telah di temukan dan disesuaikan dengan tujuan dari *evidence base nursing*.

3.1.2 *Database* Pencarian

Pencarian literature artikel dilakukan pada bulan juni 2022. Data yang digunakan pada penelitian ini adalah data sekunder yang diperoleh bukan dari pengamatan langsung, tetapi diperoleh dari hasil penelitian yang telah dilakukan oleh peneliti-peneliti terdahulu. Pencarian literature dalam *evidence base nursing* ini menggunakan tiga database yaitu Science direct, medsurgusing, proquest, Portal Garuda, dan Google Scholar.

3.1.3 Kata Kunci

Pencarian artikel menggunakan Keyword dan Boolean operator (AND, OR NOT or AND NOT) yang digunakan untuk memperluas atau menspesifikasi pencarian, sehingga mempermudah dalam menentukan artikel atau jurnal yang digunakan.

BAB IV

ANALISA JURNAL

4.1 Analisa jurnal efektivitas terapi cermin untuk stroke sub akut dan kaitannya dengan faktor – faktor yang di pilih

No.	Judul	PICOT
1.	**Effect of afferent electrical stimulation with mirror therapy on motor function, balance, and gait in chronic stroke survivors: a randomized controlled trial**	**P** : Thirty stroke survivors were randomly assigned to two groups: the experimental group (N.=15) and the control group (N.=15) (Tiga puluh penderita stroke secara acak dibagi menjadi dua kelompok: kelompok eksperimen (N.=15) dan kelompok kontrol (N.=15) **I** : total of 30 subjects were randomly assigned to either the experimental group (N.=15) or the control group (N.=15). In the experimental group, AES combined with MT (designed to reflect the healthy side) was performed for 30 minutes, followed by AES combined with gait training for 30 minutes. This 60-minute session was repeated 5 times a week for 4 weeks, for a total of 20 sessions. In the control group, sham AES combined with sham MT (with no reflection on the mirror) was performed for 30 minutes, followed by sham AES combined with gait training for 30 minutes. (total 30 subjek secara acak ditugaskan ke kelompok eksperimen (N.=15) atau kelompok kontrol (N.=15). Pada kelompok eksperimen, AES dikombinasikan dengan MT (dirancang untuk mencerminkan sisi sehat) dilakukan selama 30 menit, diikuti oleh AES yang dikombinasikan dengan pelatihan gaya berjalan selama 30 menit. Sesi 60 menit ini diulang 5 kali

		seminggu selama 4 minggu, dengan total 20 sesi. Pada kelompok kontrol, sham AES dikombinasikan dengan sham MT (tanpa refleksi di cermin) dilakukan selama 30 menit, diikuti oleh sham AES yang dikombinasikan dengan pelatihan gaya berjalan selama 30 menit.); **C** : - **O** : The experimental group showed significant differences in muscle strength, Modified Ashworth Scale, and Berg Balance Scale results, and velocity, cadence, step length, stride length, and double support time of their gait ($P<0.05$) in the pre-post intervention comparison. Significant differences between the two groups in muscle strength, Berg Balance Scale, gait velocity, step length, and stride length ($P<0.05$) were found. (Kelompok eksperimen menunjukkan perbedaan yang signifikan dalam hasil kekuatan otot, Modified Ashworth Scale, dan Berg Balance Scale, dan kecepatan, irama, panjang langkah, panjang langkah, dan waktu dukungan ganda dari gaya berjalan mereka ($P<0,05$) dalam perbandingan intervensi pra-pasca . Ditemukan perbedaan yang signifikan antara kedua kelompok dalam kekuatan otot, Skala Keseimbangan Berg, kecepatan berjalan, panjang langkah, dan panjang langkah ($P<0,05$).) T : 2018, Rehabilitation center. South korea
2	Mirror therapy in chronic stroke survivors with several impaired upper limb function : a randomized controlled trial	**P** : A total of 31 chronic subjects poststroke with severely impaired upper limb function were randomly assigned to either an ex- perimental group (N.=15), or a control group (N.=16).

		(Sebanyak 31 subjek kronis pasca stroke dengan gangguan fungsi ekstremitas atas yang parah secara acak dimasukkan ke dalam kelompok eksperimen (N.=15), atau kelompok kontrol (N.=16).) **I** : Twenty-four intervention sessions were performed for both groups. Each session included 45-minute period of MT (experimental group) or passive mobilization (control group), administered three days a week. Participants were assessed before and after the intervention with the Wolf Motor function Test, the fugl-Meyer Assessment, and the Nottingham Sensory Assessment. (Dua puluh empat sesi intervensi dilakukan untuk kedua kelompok. Setiap sesi termasuk periode 45 menit MT (kelompok eksperimen) atau mobilisasi pasif (kelompok kontrol), diberikan tiga hari seminggu. Peserta dinilai sebelum dan sesudah intervensi dengan Tes fungsi Motorik Serigala, Penilaian fugl-Meyer, dan Penilaian Sensori Nottingham.). **C** : - **O** : Improvement in motor function was observed in both groups on the time (P=0.002) and ability (P=0.001) subscales of the Wolf Mo- tor Function Test. No differences were detected in kinesthesis or stereognosis. However, the experimental group showed a significant improve- ment in tactile sensation that was mainly observed as an increased sensitivity to light touches. (Peningkatan fungsi motorik diamati pada kedua kelompok pada subskala waktu (P=0,002) dan kemampuan (P=0,001) dari Tes Fungsi Motorik Serigala. Tidak ada perbedaan yang terdeteksi dalam kinestesis atau stereognosis. Namun, kelompok

		eksperimen menunjukkan peningkatan yang signifikan dalam sensasi taktil yang terutama diamati sebagai peningkatan kepekaan terhadap sentuhan ringan.) **T** : 2016, Rehabilitative outpatient unit, Spain
	Mirror Therapy Using Gesture Recognition for Upper Limb Function, Neck Discomfort, and Quality of Life After Chronic Stroke: A Single-Blind Randomized Controlled Trial	**P** : We studied 36 patients who were diagnosed with hemiplegia due to stroke and were admitted to a hospital in Daejeon, Korea. Power analysis was completed using the G*power program (version 3.1.9.2; Germany). Effect sizes were calculated before subject recruitment using mean and SD from the pilot study that ranged from 0.55 to 0.8. The power was set at 0.8, resulting with a sample size of 12 patients in each group for a 3-group clinical trial. The inclusion criteria of the subjects were as follows: 1) event occurred >6 months previously; 2) sufficient cognition to participate in the training, which was defined as a Mini-Mental State Exam (MMSE) [18] scores of 24 or higher; 3) frequency score of the upper extremity of the motor activity log <2.5, and; 4) no visual impairment and field defect. The exclusion criteria of the subject were as follows: 1) other neurological problems or orthopedic injuries; 2) aphasia that makes intervention difficult; 3) recent participation in other rehabilitation research or drug experiment; and 4) research participation rate <80%. (Kami mempelajari 36 pasien yang didiagnosis dengan hemiplegia karena stroke dan dirawat di rumah sakit di Daejeon, Korea. Analisis daya diselesaikan menggunakan program G*power (versi 3.1.9.2; Jerman). Ukuran efek dihitung sebelum perekrutan subjek menggunakan mean dan SD dari studi percontohan yang

		berkisar 0,55-0,8. Kekuatan ditetapkan pada 0,8, menghasilkan ukuran sampel 12 pasien di setiap kelompok untuk uji klinis 3-kelompok. Kriteria inklusi subjek adalah sebagai berikut: 1) kejadian yang terjadi >6 bulan sebelumnya; 2) kognisi yang cukup untuk berpartisipasi dalam pelatihan, yang didefinisikan sebagai nilai Ujian Mini-Mental State (MMSE) [18] 24 atau lebih tinggi; 3) skor frekuensi ekstremitas atas log aktivitas motorik <2,5, dan; 4) tidak ada gangguan penglihatan dan defek lapangan. Kriteria eksklusi subjek adalah sebagai berikut: 1) masalah neurologis atau cedera ortopedi lainnya; 2) afasia yang mempersulit intervensi; 3) partisipasi baru-baru ini dalam penelitian rehabilitasi atau eksperimen obat lain; dan 4) tingkat partisipasi penelitian <80%.) **I** : Before the intervention, the subjects were provided sufficient ex-planation regarding participation in the study, and only the patients who agreed to participate in the study were involved in the intervention. The randomization was performed by selection of an opaque closed envelope wherein the group assignment was written, and the sealed envelope was given to the physical therapist. Thirty-six stroke patients who had been admitted to a rehabilitation clinic in the Republic of Korea were randomized into either the GR mirror therapy group (n=12), the conventional mirror therapy group (n=12), or the control group (n=12) group (Figure 1). The experiment began the day after randomization. General surveys of the subjects and pre-intervention tests were conducted. Each participant underwent a training program consisting of 15 sessions, 30 min per day, 3 days per week, for 5 weeks.

		After 5 weeks, the final assessments were performed. All 3 groups underwent traditional physical therapy, including motor learning and neurodevelopmental treatment. (Sebelum intervensi, subjek diberikan penjelasan yang cukup tentang partisipasi dalam penelitian, dan hanya pasien yang setuju untuk berpartisipasi dalam penelitian yang terlibat dalam intervensi. Pengacakan dilakukan dengan pemilihan amplop tertutup buram di mana tugas kelompok ditulis, dan amplop tertutup diberikan kepada terapis fisik. Tiga puluh enam pasien stroke yang telah dirawat di klinik rehabilitasi di Republik Korea diacak ke dalam kelompok terapi cermin GR (n=12), kelompok terapi cermin konvensional (n=12), atau kelompok terapi cermin konvensional (n=12). kelompok kontrol (n=12) kelompok. Percobaan dimulai sehari setelah pengacakan. Survei umum subjek dan tes pra-intervensi dilakukan. Setiap peserta menjalani program pelatihan yang terdiri dari 15 sesi, 30 menit per hari, 3 hari per minggu, selama 5 minggu. Setelah 5 minggu, penilaian akhir dilakukan. Semua 3 kelompok menjalani terapi fisik tradisional, termasuk pembelajaran motorik dan perawatan perkembangan saraf.) **C** : - **O** : Upper-extremity function, depression, and quality of life in the GR mirror therapy group were significantly better than in the control group. The changes of neck discomfort in the conventional mirror therapy and control groups were significantly greater than in the GR mirror therapy group (Fungsi ekstremitas atas, depresi, dan kualitas hidup pada kelompok terapi cermin

		GR secara signifikan lebih baik daripada kelompok kontrol. Perubahan ketidaknyamanan leher pada kelompok terapi cermin dan kontrol konvensional secara signifikan lebih besar daripada kelompok terapi cermin GR) **T** : 2019, South korea
	Effects of mirror therapy combined with neuromuscular electrical stimulation on motor recovery of lower limbs and walking ability of patients with stroke: a randomized controlled study	**P** : Sixty-nine patients with foot drop. (Enam puluh sembilan pasien dengan foot drop.) **I** : Patients were randomly divided into three groups: control, mirror therapy, and mirror therapy + neuromuscular electrical stimulation. All groups received interventions for 0.5 hours/day and five days/week for four weeks. (Pasien secara acak dibagi menjadi tiga kelompok: kontrol, terapi cermin, dan terapi cermin + stimulasi listrik neuromuskular. Semua kelompok menerima intervensi selama 0,5 jam/hari dan lima hari/minggu selama empat minggu.) **C** : - **O** : After four weeks of intervention, Brunnstrom stage (P = 0.04), 10-meter walk test (P < 0.05), and passive range of motion (P < 0.05) showed obvious improvements between patients in the mirror therapy and control groups. Patients in the mirror therapy + neuromuscular electrical stimulation group showed better results than those in the mirror therapy group in the 10-meter walk test (P < 0.05). There was no significant difference in spasticity between patients in the two intervention groups. However, compared with patients in the control group, patients in the mirror therapy + neuromuscular electrical stimulation group showed a

		significant decrease in spasticity (*P* < 0.001). (Setelah empat minggu intervensi, tahap Brunnstrom (P = 0,04), tes berjalan 10 meter (P <0,05), dan rentang gerak pasif (P <0,05) menunjukkan peningkatan yang jelas antara pasien dalam terapi cermin dan kelompok kontrol. Pasien pada kelompok terapi cermin + stimulasi listrik neuromuskular menunjukkan hasil yang lebih baik daripada kelompok terapi cermin pada tes jalan kaki 10 meter (P <0,05). Tidak ada perbedaan yang signifikan dalam kelenturan antara pasien dalam dua kelompok intervensi. Namun, dibandingkan dengan pasien dalam kelompok kontrol, pasien dalam terapi cermin + kelompok stimulasi listrik neuromuskular menunjukkan penurunan spastisitas yang signifikan (P <0,001).) **T** : 2017, Inpatient rehabilitation center of a teaching hospital, Wuhan, China
	Effect of activity-based mirror therapy on lower limb motor-recovery and gait in stroke: A randomised controlled trial	**P** : Thirty-six chronic poststroke (15.89 ± 9.01 months) hemiparetic subjects (age: 46.44 ± 7.89 years, 30 men and functional ambulation classification of median level 3). (Tiga puluh enam pasien pasca stroke kronis (15,89 ± 9,01 bulan) subjek hemiparetic (usia: 46,44 ± 7,89 tahun, 30 laki-laki dan klasifikasi ambulasi fungsional level median 3).) **I** : Activity-based MT comprised movements such as ball-rolling, rockerboard, and pedalling. The activities were provided on the less-affected side in front of the mirror while hiding the affected limb. The movement of the less-affected lower limb was projected as over the affected limb. Conventional motor therapy based on neurophysiological approaches was also provided to the experimental group. The control group received only conventional management.

		(MT berbasis aktivitas terdiri dari gerakan-gerakan seperti menggulingkan bola, rockerboard, dan mengayuh. Kegiatan yang disediakan di sisi yang kurang terpengaruh di depan cermin sambil menyembunyikan anggota tubuh yang terkena. Pergerakan ekstremitas bawah yang kurang mempengaruhi seperti di atas ekstremitas yang terkena. Terapi motorik berdasarkan pendekatan neurofisiologis juga diberikan kelompok eksperimen. Kelompok kontrol hanya menerima manajemen konvensional.) **C** : - **O** : Postintervention, the experimental group exhibited significant and favourable changes for FMA-LE (mean difference = 3.29, 95% CI = 1.23–5.35, p = .003) and RVGA (mean difference = 5.41, 95% CI = 1.12–9.71, p = .015) in comparison to the control group. No considerable changes were observed on 10-MWT. (Pascaintervensi, kelompok eksperimen menunjukkan perubahan yang signifikan dan menguntungkan untuk FMA-LE (perbedaan rata-rata = 3,29, 95% CI = 1,23-5,35, p = 0,003) dan RVGA (perbedaan rata-rata = 5,41, 95% CI = 1,12-9,71, p = 0,015) dibandingkan dengan kelompok kontrol. Tidak ada perubahan signifikan yang diamati pada 10-MWT.) **T** : 2017, Rehabilitation institute. India

BAB V

PEMBAHASAN

5.1 Efektivitas terapi cermin untuk stroke sub akut dan kaitannya dengan faktor – faktor yang di pilih

Dari kelima jurnal yang di telaah dengan karakteristik responden berusia 30 tahun keatas mengalami hemiparesis pada ekstremitas atas maupun bawah yang disebabkan oleh stroke, dengan rentang waktu sakit yang telah lebih dari 1 bulan setelah mengalami stroke, dari kelima artikel yang ditelaah didapatkan hasil yang signifikan atau berpengaruh terhadap perubahan kemampuan motoric.

Konsep mirror theraphy telah diperkuat secara neurofisiologis. Cermin tersebut memberi klien masukan visual yang tepat bahwa refleki cermin dari lengan normal yang digerakkan terihat seperti lengan yang mengalami hemiparise bergerak dengan normal. Penggunaan cermin dapat merekrut korteks promotor terhadap rehabilitasi motorik. Kotrkes promotor memiliki fitur yang menunjukkan bahwa, mungkin merupakan penghubung dari gambaran visual di cermin ke rehabilitasi motorik. Peran terapi cemin dalam pengaruh gangguan sensorik masih belum jelas karena masukan visual yang diberikan oleh pantuan cemin di kombinasikan dengan sensasi tangan pasien tang berubah atau tidak melalui korpus jollosum atau melalui aktivasi neuron cermin (Sengkey, 2014). Saraf motorik bekerja untuk mengatur urutan otot berkedut untuk menghasilkan gerakan terampil sederhana seperti: mencapai kacang tanah, mendorong batu, atau memasukkan apel ke mulut. Bagian dari neuron cermin ini juga berfungsi saat orang tersebut hanya melihat orang lain melakukan gerakan yang sama. Cermin neuron perlu melibatkan beberapa interaksi antara beberapa modalitas (penglihatan, perintah motorik, dan propriosepsi) yang menunjukkan bahwa mereka mungkin terlibat dalam efisiensi terapi cermin pada stroke. Mungkin ada sisa neuron cermin yang berahan namun tidak aktif atau aktivitasnya terhambat dan tidak mencapai ambang batas. Jadi, terapi cermin merupakan bagian dari efifibilitasnya untuk merangsang neuron ini, sehingga memberikan masukan visual untuk menghidupkan kembali neuron motorik (Sengkey, 2014).

Prosedur umum mirror therapy adalah klien duduk di depan cermin yang sejajar dengan garis tengah yang menghalangi pandangan anggota badan yang mengalami kelemahan otot yang diposisikan dibelakang cermin. klien melihat ke satu sisi cemin lain, dan melihat pantulan anggota ggerak yang normal dimana orientasinya sebagai anggota badan yang mengalami kelemahan. Cara ini cocok untuk menciptakan ilusi visual dimana pergerakan atau sentuhan ke anggota tubuh yang nomal dapat dianggap mempengaruhi anggota tubuh yang mengalami kelemahan. klien melakukan gerakan anggota badan yang normal dan mengamati pantulan cermin yang ditumpangkan diatas ektremitas yang tidak terlihat. Gerakan dilakukan selama 30 menit untuk ekstremitas atas dan bawah 5 kali seminggu (Sengkey, 2014).

Dari fakta dan teori diatas peneliti beropini bahwa penerapan terapi cermin pada pasien stroke memiliki pengaruh, dari penelitian yang telah dilakukan, terapi cermin ini mengandalkan imajinasi atau pembayangan motoric pasien, cermin disini sebagai pemberi stimulus visual kepada otak untuk pergerakan tubuh yang mengalami hemiparase. Dari jurnal yang ditelaah dapat disimpulkan bahwa penerapan terapi cermin akan efetif jika dilakukan kurang lebih 15-60 menit dengan frekuensi dalam satu minggu 3-4 kali dan dilakukan selama 4-6 minggu dengan kriteria kekuatan otot minimal 2. Tubuh manusia diatur oleh otak, ketika ada salah satu anggota gerak yang mengalami kerusakan maka otak akan membiarkannya, cara kerja terapi ini adalah menstimulus otak dengan memanfaatkan cermin sebagai pengantar stimulus, otak dapat menangkap sinyal dan hal ini akan membuat anggota gerak yang mengalami kerusakan akan pulih, atau ada perbaikan, pentingnya melakukan terapi cermin dengan kurun waktu yang sesuai dengan penelitian, semakin sering otak distimulus, maka akan semakin baik hasil yang akan didapat dari terapi tersebut.

BAB VI

KESIMPULAN DAN SARAN

6.1 Kesimpulan

Mirror therapy terbukti efektif dalam peningkatan kekuatan otot pasien post stroke. *Mirror therapy* efektif diberikan pada semua pasien dengan jenis stroke yang mengalami hemiparesis. *Mirror therapy* efektif dilaksanakan selama 15-60 menit dengan 3-5 hari dalam 2-6 minggu dengan syarat kekuatan otot minimal 2 dan tingkat ambulasi fungsional antara 3-5 pada ekstremitas bawah.

6.2 Saran

a. Saran Teoritis

Penelitian ini dapat menambah informasi mengenai intervensi keperawatan yang tepat pada pasien stroke sehingga bermanfaat bagi pengembangan ilmu keperawatan, serta memberikan tambahan studi kepustakaan yang dapat digunakan sebagai referensi penelitian selanjutnya.

b. Manfaat Praktis

Penelitian ini dapat menjadi bahan masukan bagi rumah sakit terkait intervensi keperawatan apa saja yang dapat dilakukan pada pasien stroke yang mengalami hemiparase, serta dapat diaplikasikan dalam pelayanan di rumah sakit, penelitian ini diharapkan dapat menambah wawasan, pengetahuan dan dapat sebagai dasar teori atau rujukan untuk penelitian selanjutnya.

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Lampiran Jurnal

Original Article

CLINICAL REHABILITATION

Effects of mirror therapy combined with neuromuscular electrical stimulation on motor recovery of lower limbs and walking ability of patients with stroke: a randomized controlled study

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Qun Xu, Feng Guo, Hassan M Abo Salem, Hong Chen and Xiaolin Huang

Abstract

Objective: To investigate the effectiveness of mirror therapy combined with neuromuscular electrical stimulation in promoting motor recovery of the lower limbs and walking ability in patients suffering from foot drop after stroke.

Design: Randomized controlled study.

Setting: Inpatient rehabilitation center of a teaching hospital.

Subjects: Sixty-nine patients with foot drop.

Intervention: Patients were randomly divided into three groups: control, mirror therapy, and mirror therapy + neuromuscular electrical stimulation. All groups received interventions for 0.5 hours/day and five days/week for four weeks.

Main measures: 10-Meter walk test, Brunnstrom stage of motor recovery of the lower limbs, Modified Ashworth Scale score of plantar flexor spasticity, and passive ankle joint dorsiflexion range of motion were assessed before and after the four-week period.

Results: After four weeks of intervention, Brunnstrom stage ($P = 0.04$), 10-meter walk test ($P < 0.05$), and passive range of motion ($P < 0.05$) showed obvious improvements between patients in the mirror therapy and control groups. Patients in the mirror therapy + neuromuscular electrical stimulation group showed better results than those in the mirror therapy group in the 10-meter walk test ($P < 0.05$). There was no significant difference in spasticity between patients in the two intervention groups. However, compared with patients in the control group, patients in the mirror therapy + neuromuscular electrical stimulation group showed a significant decrease in spasticity ($P < 0.001$).

Department of Rehabilitation Medicine, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China

Corresponding authors:
Xiaolin Huang, Department of Rehabilitation Medicine, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, 1095#, Jiefang Avenue, Wuhan 430030, China.
Email: xiaolinh2006@126.com

Hong Chen, Department of Rehabilitation Medicine, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, 1095#, Jiefang Avenue, Wuhan 430030, China.
Email: chenhong1129@hotmail.com

Conclusion: Therapy combining mirror therapy and neuromuscular electrical stimulation may help improve walking ability and reduce spasticity in stroke patients with foot drop.

Keywords
Foot drop, mirror therapy, neuromuscular electrical stimulation, stroke

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Introduction

At least 80% of patients with stroke experience varying degrees of weakness in the legs,[1] and inability to dorsiflex the foot (foot drop) is often a persistent problem.[2] It is thought to be caused by feebleness of the anterior muscles, spasticity of the posterior muscles of the leg, or both.[3] Despite compensation in the gait pattern, such patients are at an increased risk for falls. Accordingly, the prevention and treatment of foot drop are very important.

Mirror therapy, a new modality, has been attracting attention owing to its simplicity and low cost. It is considered to be effective in increasing the grip strength, range of motion, movement speed, and hand dexterity in patients with stroke.[4,5] Although various clinical trials have established that mirror therapy is useful in improving the motor function and activities of daily living in patients with stroke, this therapy is primarily focused on the upper extremities,[6,7] and its validity for reducing spasticity remains unclear. Therefore, further evidence and research are required to investigate whether mirror therapy could be a promising intervention for rehabilitation of the lower extremities after stroke.

Neuromuscular electrical stimulation is another therapeutic method that has been used over the past several decades for reducing spasticity and treating the impaired motor function of patients with stroke.[8,9] Several studies have highlighted the potential efficacy of neuromuscular electrical stimulation for foot drop and indicated that it is a useful aid for recovery from spasticity after stroke.[10,11]

Although some studies have applied mirror therapy combined with neuromuscular electrical stimulation to the upper extremities,[12–14] only one previous study investigated the lower extremities and walking ability.[15] In the study by Lee et al., mirror therapy and neuromuscular electrical stimulation were applied simultaneously, and the bilateral dorsiflexion movement was controlled by the less affected side. Their study suggested the effects of mirror therapy combined with neuromuscular electrical stimulation on muscle strength and balance in hemiplegic stroke patients.

Our study was designed to investigate the function of mirror therapy on lower extremity motor recovery and walking ability in patients with stroke-related foot drop of the ankle. Besides, it is hypothesized that use of neuromuscular electrical stimulation as an additive would be more effective than mirror therapy alone or only conventional rehabilitation therapy. Therefore, we evaluated the feasibility and efficacy of neuromuscular electrical stimulation combined with mirror therapy. Our findings offer patients the promise of improved correction of foot drop and a better regained ability to walk safely.

Methods

This study was registered at Chinese Clinical Trial Registry, ID number ChiCTR-INR-16009807. The research protocol was approved by the Ethical Committee of Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China (certificate of approval number TJ-C20140412).

Patients with foot drop after stroke were recruited from the Inpatient Rehabilitation Center of Tongji Hospital after they provided informed consent to participate in the study. All patients were diagnosed with stroke, as confirmed using computed tomography or magnetic resonance imaging.

The main inclusion criteria for patients were as follows: (1) first episode of unilateral stroke with hemiparesis, (2) more than one month after stroke onset, (3) the Modified Ashworth Scale for plantar flexor spasticity is higher than 1 and lower than 4,[16] (4) the Functional Ambulation Categories score is between 3 and 5 (inclusive),[17] and (5) the ability to understand and follow simple verbal instructions.

The exclusion criteria were (1) any preexisting neurological disorder other than stroke, (2) any psychological or medical condition that would affect the patient's ability to comply with the study protocol, (3) impaired vision or aphasia, and (4) fixed contracture of the ankle or foot.

Enrolled patients were randomly assigned to three groups: control group ($N=23$), mirror therapy only group ($N=23$), and mirror therapy combined with neuromuscular electrical stimulation group ($N=23$). A third party who was unaware of the study content noted down the group names which were generated by the SPSS statistical software. The group names were loaded into the sequentially numbered, opaque, sealed envelopes one by one. After signing of the informed consent form, the envelope was opened by another independent clinician to decide the group for the patient. The interventions were administered by an occupational therapist who was not involved in the assessment of the patients. All outcome measures before and after treatment were assessed by a physician who was blinded to the allotment.

Interventions

All patients underwent a conventional stroke rehabilitation program conducted by therapists for 4 hours/day and five days/week for four weeks. The conventional program consisted of physical therapy, occupational therapy, and neurodevelopment facilitation.

In addition to the conventional stroke rehabilitation program, patients in the mirror therapy group received 30 minutes of mirror therapy training. Patients were in a sitting position with a mirror (60 × 90 cm) positioned between their legs and perpendicular to their midline. The reflecting side of the mirror was adjusted to show the unaffected leg. A therapist reminded the patients to flex and extend the ankle, at the same time observe the reflection of the unaffected leg in the mirror (Supplementary Fig. 2A).

Patients in the control group performed the same training for the same duration; however, the nonreflecting side of the mirror was used; the therapist also reminded the patient to move their leg as in the mirror group.

Patients in mirror therapy + neuromuscular electrical stimulation group underwent the same training program as that undergone by patients in the mirror therapy group; however, the mirror therapy was combined with 30 minutes of neuromuscular electrical stimulation treatment for the paretic limb. The electrodes measured 5 cm × 5 cm; one electrode was placed over the common peroneal nerve and the other electrode was positioned on the midpoint of the anterior tibialis muscle of the affected leg. The frequency was 50 Hz and the intensity was 10 mA (or was sufficient to elicit the dorsiflexion and eversion of the affected ankle).[15,18] The durations of simulation and rest were 5 seconds separately. The current application was synchronized with active exercises, following the indications given by the therapist. On examination of the ankle dorsiflexion of the affected leg induced by neuromuscular electrical stimulation, the therapist reminded the patients to dorsiflex the unaffected ankle and to observe the movement in the mirror (Supplementary Fig. 2B).

Outcome measures

Primary outcomes. The primary outcomes were 10-meter walk test (in m/min) and the Brunnstrom stages of lower extremity.

The 10-meter walk test was used to assess the walking ability and gait speed of the patients.[19] For this test, patients should be able to walk least 10 m at their own comfortable speed. A stopwatch was started when the subject crossed the start point and stopped when he or she crossed the end-point in order to measure the time taken in seconds to walk the middle 6 m of a 10-m walkway. Three tests were performed per subject and the mean speed was calculated. The Brunnstrom stage scores were used for assessment of motor recovery of the lower extremities.[20,21]

Secondary outcomes. We used the Modified Ashworth Scale to quantify the spasticity of the ankle muscles.[16] The Modified Ashworth Scale is a 6-point rating scale with scores ranging from 0 to 4. Score 0 indicates "no increase in muscle tone," while score 4 indicates "affected limb is rigid during flexion or extension."[22]

Passive ankle joint dorsiflexion range of motion was assessed using a hand-held goniometer. The axis of the goniometer was placed 2 cm below the medial malleolus, and its moving arm was placed along the long axis of the first metatarsal bone. Its fixed arm was placed along the long axis of the leg. Patients were instructed to achieve a knee angle of 60° during the assessment. The therapist then dorsiflexed the ankle joint passively until any resistance was felt. The moving arm was then relocated to the first metatarsal to measure the total free range of motion of ankle dorsiflexion. The average of three measurements was calculated and considered to be the dorsiflexion range of motion.[23]

Statistical analysis

All data were analyzed using IBM SPSS version 22.0 statistical software. Independent *t*-tests and non-parametric test were used to compare the baseline characteristics of the patients. The mean changes in the measured parameters after treatment among the three groups were tested using analysis of variance (ANOVA) for the measurement data and Kruskal–Wallis *H*-test for the ranked data. The comparison between any two groups was analyzed by Student–Newman–Keuls test for the measurement data and Nemenyi test for the ranked data. $P<0.05$ was considered statistically significant.

Results

The flow diagram of this study is depicted in Figure 1. A summary of the demographic and clinical features of the patients ($N=69$) is shown in Table 1. All patients completed the study. There were no significant differences in age, gender, duration of stroke, side of hemiplegia, and stroke type at baseline in any of the groups ($P>0.05$).

An intergroup comparison was conducted on the pretreatment values of the clinical evaluation parameters (Table 2). No significant differences were observed at the baseline among the three groups ($P>0.05$).

Primary outcomes

The mean changes in the measured parameters after treatment among the groups were tested (Table 2). One-way ANOVA was conducted to compare the effects of different treatments on 10-meter walk test. ANOVA showed that the effect of different treatments on 10-meter walk test was significant, $F(2,66)=25.18$, $P<0.001$. A post hoc analysis showed that patients in both the mirror therapy group ($P<0.05$) and mirror therapy + neuromuscular electrical stimulation group ($P<0.05$) had a significant improvement in the 10-meter walk test compared to the control group. Moreover, compared to patients in the mirror therapy group, patients in the mirror therapy + neuromuscular electrical stimulation group showed more significant amelioration in the 10-meter walk test ($P<0.05$) (Supplementary Fig. 3).

Also, the Brunnstrom stage test showed significant difference among the three groups ($P<0.001$). In the Brunnstrom stage test, patients in both the mirror therapy group ($P=0.04$) and mirror therapy + neuromuscular electrical stimulation group ($P<0.001$) had a better improvement than that shown by patients in the control group; however, there was no significant difference in the improvement between the two intervention groups ($P=0.16$) (Supplementary Fig. 3).

Secondary outcomes

For the passive ankle joint dorsiflexion range of motion, the ANOVA results showed that the effect of different treatments on passive range of motion was significant, $F(2,66)=10.96$ ($P<0.001$). Post hoc analysis revealed that the passive range of motion increased more in the mirror therapy group ($P<0.05$)

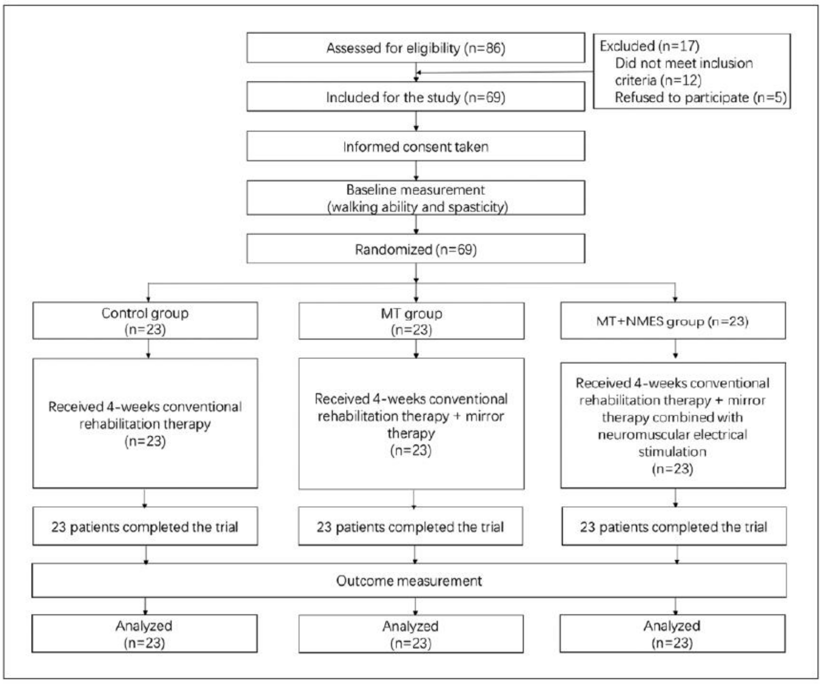

Figure 1. Flow diagram of the study.
MT group: mirror therapy group; MT + NMES group: mirror therapy + neuromuscular electrical stimulation group.

Table 1. Characteristics of stroke patients.

	Control group (*N* = 23)	MT group (*N* = 23)	MT + NMES group (*N* = 23)	*P* value
Age (years)	56.09 ± 8.12	53.7 ± 8.98	55.00 ± 10.98	0.71
Gender (female/male)	8/15	7/16	7/16	–
Duration of stroke (days)	45.78 ± 6.50	42.76 ± 5.65	43.25 ± 5.95	0.51
Type (hemorrhage/ischemia)	6/17	5/18	7/16	–
Paretic side (left/right)	10/13	8/15	7/16	–
Body mass index (kg/m^2)	23.50 ± 1.20	23.10 ± 0.80	23.60 ± 0.76	0.72

MT group: mirror therapy group; MT + NMES group: mirror therapy + neuromuscular electrical stimulation group.
Values are mean ± SD.

Table 2. Measured parameters pre- and posttreatment in each group and *P* value of mean changes among group.

	Control group (*N* = 23)			MT group (*N* = 23)			MT + NMES group (*N* = 23)			*P* value
	Pretest	Posttest	Mean changes	Pretest	Posttest	Mean changes	Pretest	Posttest	Mean changes	
10MWT (m/min)	24.62 ± 3.71	28.12 ± 4.48	3.55 ± 2.41	25.81 ± 5.36	33.02 ± 5.77	7.21 ± 2.72	25.81 ± 4.54	34.35 ± 6.75	9.31 ± 3.22	<0.05
BS	2.35 ± 0.57	2.83 ± 0.65	0.48 ± 0.59	2.35 ± 0.57	3.39 ± 0.58	1.0 ± 0.67	2.22 ± 0.42	3.61 ± 0.50	1.39 ± 0.50	<0.05
MAS	2.83 ± 0.78	0.57 ± 0.90	−0.26 ± 0.62	2.96 ± 0.64	2.43 ± 0.66	−0.52 ± 0.67	2.61 ± 0.50	1.57 ± 0.51	−0.83 ± 0.49	<0.05
PROM	9.61 ± 1.80	11.43 ± 1.12	1.83 ± 1.30	10.35 ± 2.57	13.04 ± 1.55	2.96 ± 1.43	9.57 ± 1.53	12.87 ± 1.01	3.57 ± 1.08	<0.05

10MWT: 10-meter walk test; BS: Brunnstrom stage of motor recovery of the lower limbs; MAS: Modified Ashworth Scale score of plantar flexor spasticity; PROM: passive ankle joint dorsiflexion range of motion.
MT group: mirror therapy group, MT + NMES group: mirror therapy + neuromuscular electrical stimulation group.
Values are mean ± SD.

and the mirror therapy + neuromuscular electrical stimulation group ($P<0.05$) than in the control group, and no significant difference was found in passive range of motion between the two intervention groups ($P>0.05$) (Supplementary Fig. 3).

Although the results of the Kruskal–Wallis *H*-test for the Modified Ashworth Scale showed significant difference among the three groups ($P<0.001$), patients in the mirror therapy and control groups did not differ significantly with regard to the spasticity of plantar flexors ($P=0.41$). Patients in the mirror therapy + neuromuscular electrical stimulation group demonstrated significantly lower spasticity than that demonstrated by patients in the control group ($P<0.001$). On the contrary, compared to patients in the mirror therapy group, patients in the mirror therapy + neuromuscular electrical stimulation group showed no significant reduction in spasticity ($P=0.14$) (Supplementary Fig. 3).

Discussion

This study demonstrated that mirror therapy brings about prominent improvements in motor recovery of the lower extremities and in the walking ability of patients suffering from foot drop after stroke. Moreover, compared to mirror therapy alone, neuromuscular electrical stimulation combined with mirror therapy produced better results with respect to decreasing the spasticity of the ankle flexor muscles and improving the walking ability of the patients.

Many studies have researched the effects of mirror therapy as an intervention for rehabilitation after stroke. The evaluation tools included 10-meter walk test, passive range of motion, Modified Ashworth Scale, and Brunnstrom stage before and after the intervention. The 10-meter walk test measures the indoor walking speed. We measured the Brunnstrom stage to evaluate the motor recovery of the lower extremity. Based on our clinical experience and the data of previous studies, we predicted that few patients had sufficient dorsiflexion.[24] Therefore, we measured the passive range of motion. Finally, we assessed the spasticity of ankle flexor muscles by using the Modified Ashworth Scale.

It is noteworthy that during the entire study, no subjects reported discomfort with the mirror therapy or neuromuscular electrical stimulation. We found that compared to patients in the control group, patients in both the intervention groups showed improvements in the 10-meter walk test and Brunnstrom stage. Sütbeyaz et al.[25] first reported the effects of mirror therapy on paretic lower extremity. They reported that motor function in inpatients with subacute stroke was significantly improved. The concept underlying the mechanism of mirror therapy is that observing mirrored movements causes additional neural activity in motor areas located in the affected hemisphere, resulting in cortical reorganization and improved function.[26] Guo et al.[27] reported that the mirror-induced visual illusion of ankle movements activated the frontal gyrus, parietal lobule, and superior temporal gyrus in the ipsilateral hemisphere. Their study showed that mirror therapy–induced neural activation of the ipsilesional sensorimotor cortex may facilitate motor recovery of the lower limb in patients with stroke. Therefore, these suggestions may support the use of mirror therapy applied in our study.

The effects of neuromuscular electrical stimulation are probably caused by a combination of peripheral and central effects.[9] The peripheral effects of neuromuscular electrical stimulation include conversion of type II muscle fibers to type I muscle fibers,[28] increase in contractile force and fatigue resistance, and increase in muscle mass.[29] Neuromuscular electrical stimulation can promote cortical reorganization through a central mechanism by activating both motor and sensory nerve fibers.[30] It has been demonstrated that task-specific exercise protocols can induce brain reorganization. As reported, repetitive movement mediated by neuromuscular electrical stimulation has the potential to facilitate motor relearning.[31]

Spastic drop foot is a functional impairment causing significant morbidity by impairing gait, limiting activities of daily living, and contributing to injuries.[32] In this study, our results showed a significant enhancement of lower extremity Brunnstrom stage, passive ankle joint dorsiflexion range of motion, and 10-meter walk test in patients after mirror therapy compared to that shown by subjects in the control group; however, no reduction of spasticity was observed in the control or mirror therapy group. This finding is also consistent with that of several previous studies that reported the invalid effect of mirror therapy on spasticity.[5,25,33] Several studies have proven the effective use of neuromuscular electrical stimulation for limb spasticity.[8] The effects of neuromuscular electrical stimulation on the reduction of spasticity may be explained by its actions on increasing agonist Ib fiber activation via mechanisms that facilitate recurrent inhibition via Renshaw cells, on antagonist reciprocal inhibition, and on increasing cutaneous sensory stimulation.[34,35] Our results supported that neuromuscular electrical stimulation in combination with other modalities shows positive effects on decreasing spasticity, which may improve the walking ability of patients with stroke.

Neuromuscular electrical stimulation, when applied through surface electrode, activates motor fibers forward, which may induce postsynaptic activity in the affected anterior horn cells.[36] Some previous studies showed that mirror therapy activated the motor cortex of the lesion hemisphere.[37] We suppose that the activation of motor cortex induced by mirror therapy may increase the conductivity of residual pyramidal tract and induce presynaptic activity in the affected anterior horn cells. Therefore, when neuromuscular electrical stimulation is applied along with mirror therapy, it may provide an artificial way of ensuring synchronized presynaptic and postsynaptic activity in the affected anterior horn cells, which may increase the conductivity of synapses between the pyramidal tract and anterior horn cells.

Study limitations

This study has several limitations. First, we only evaluated the clinical outcome scales before and after the therapy; further follow-up is needed in the future study. Second, the small number of participants might limit the results. Third, in this study, a therapist was responsible for reminding patients to move the ankle and observe the movement in the mirror, with voice instructions. This might not exclude some effects on mirror therapy. Another limitation of our study is that we did not evaluate the active range of motion of the ankle joint or the muscle strength of the ankle dorsiflexor.

Clinical Messages

- Mirror therapy with therapist reminding patients to move their leg may be more effective in improving motor recovery and walking ability than not having it.
- The addition of neuromuscular electrical stimulation seems to add benefit in terms of mobility and spasticity in stroke patients with foot drop.

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Author Contributions

C.H. and X.L.H. conceived and designed the study. H.M.A.S., F.G., and Q.X. performed the study. Q.X. analyzed the data. F.G. and Q.X. wrote the paper. C.H. and X.L.H. were the guarantor of the paper.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Mirror Therapy Using Gesture Recognition for Upper Limb Function, Neck Discomfort, and Quality of Life After Chronic Stroke: A Single-Blind Randomized Controlled Trial

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ABCE **Ho-Suk Choi**
ADEFG **Won-Seob Shin**
CDF **Dae-Hyouk Bang**

Department of Physical Therapy, Collage of Health and Medical Science, Daejeon University, Daejeon, South Korea

Corresponding Author: Won-Seob Shin, e-mail: shinws@dju.kr
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Background: Mirror therapy for stroke patients was reported to be effective in improving upper-extremity motor function and daily life activity performance. In addition, game-based virtual reality can be realized using a gesture recognition (GR) device, and various tasks can be presented. Therefore, this study investigated changes in upper-extremity motor function, quality of life, and neck discomfort when using a GR device for mirror therapy to observe the upper extremities reflected in the mirror.

Material/Methods: A total of 36 subjects with chronic stroke were randomly divided into 3 groups: GR mirror therapy (n=12), conventional mirror therapy (n=12), and control (n=12) groups. The GR therapy group performed 3D motion input device-based mirror therapy, the conventional mirror therapy group underwent general mirror therapy, and the control group underwent sham therapy. Each group underwent 15 (30 min/d) intervention sessions (3 d/wk for 5 weeks). All subjects were assessed by manual function test, neck discomfort score, and Short-Form 8 in pre- and post-test.

Results: Upper-extremity function, depression, and quality of life in the GR mirror therapy group were significantly better than in the control group. The changes of neck discomfort in the conventional mirror therapy and control groups were significantly greater than in the GR mirror therapy group.

Conclusions: We found that GR device-based mirror therapy is an intervention that improves upper-extremity function, neck discomfort, and quality of life in patients with chronic stroke.

MeSH Keywords: **Quality of Life • Rehabilitation • Stroke**

Full-text PDF: https://www.medscimonit.com/abstract/index/idArt/914095

Background

In patients with acute stroke that occurred >6 months previously, 85% have upper-limb disorders, and 55% to 75% have upper-limb disorders [1]. The upper-limb movement function is decreased due to weakening of upper-limb muscles, which is primarily caused by changes in the central nervous system and secondarily by weakness due to inactivity and reduced activity [2,3].

Activities of daily living are limited due to body dysfunction, and most stroke patients have limited social interaction; these disorders reduce the quality of life [4–6]. In addition, stroke patients may experience depression due to reduced motivation [6]. Depression results in loss of interest and joy, anxiety, fear, hostility, sadness, and anger, which negatively affect functional recovery and rehabilitation in stroke patients [7].

Constraint-induced movement therapy, action observation training, and mirror therapy have been recently studied as therapies for upper-extremity motor function [8]. These interventions are used to increase the use of paralyzed limbs to overcome disuse syndromes, observe and imitate movement, and change the neural network involved in movement. Providing various tasks in upper-extremity rehabilitation is necessary and virtual reality is used as a method for providing various tasks [9,10].

Interventions using virtual reality require cognitive factors, such as judgment and memory, as the task progresses. It can use visual and auditory stimuli, and can induce interest and motivation, helping stroke patients to be mentally stable and motivated [11]. Gesture recognition (GR) is a topic that studies the reading of these movements using algorithms. These GR algorithms mainly focus on the movement of arm, hands, eyes, legs, and other body parts. The main idea is to capture body movements using capture devices and send the acquired data to a computer [12]. A remarkable example is shown in physical rehabilitation, where the low-cost hardware and algorithms accomplish outstanding results in therapy of patients with mobility issues. A 3D motion input device is required for upper-body rehabilitation in virtual reality. The Leap motion controller, a GR input device, has been recently released, which monitors hand and finger movements and reflects them on the monitor [13]. In addition, game-based virtual reality can be realized using a GR device, and various tasks can be presented.

Mirror therapy has been used as a therapeutic intervention for phantom pain in amputees. The painful and paralyzed body parts are covered with a mirror. The mirror is placed in the center of the body, and the movement of the paralyzed body is viewed through the mirror. The patient has a visual illusion that the paralyzed side is normally moving [14]. Mirror therapy for stroke patients was reported to be effective in upper-extremity motor function and daily life activity performance [15]. However, conventional mirror therapy methods require high concentration and can become tedious, making active participation difficult [16]. In addition, conventional mirror therapy differs from the actual situation wherein a mirror positioned at the center of the body should be viewed with the head sideways. Because patients are in a suboptimal posture, they may have neck discomfort after mirror therapy. The body has muscle strength disproportion when maintaining poor posture for a long time. This results in inadequate tension on adjacent muscles and joints, resulting in movement restriction, reduced flexibility, pain, and changes in bone and soft tissue [17].

This study investigated the effect on upper-extremity motor function, quality of life, and neck discomfort by using GR device mirror therapy in patients with chronic stroke, and evaluated the efficacy of this technique.

Material and Methods

Participants

We studied 36 patients who were diagnosed with hemiplegia due to stroke and were admitted to a hospital in Daejeon, Korea. Power analysis was completed using the G*power program (version 3.1.9.2; Germany). Effect sizes were calculated before subject recruitment using mean and SD from the pilot study that ranged from 0.55 to 0.8. The power was set at 0.8, resulting with a sample size of 12 patients in each group for a 3-group clinical trial. The inclusion criteria of the subjects were as follows: 1) event occurred >6 months previously; 2) sufficient cognition to participate in the training, which was defined as a Mini-Mental State Exam (MMSE) [18] scores of 24 or higher; 3) frequency score of the upper extremity of the motor activity log <2.5, and; 4) no visual impairment and field defect. The exclusion criteria of the subject were as follows: 1) other neurological problems or orthopedic injuries; 2) aphasia that makes intervention difficult; 3) recent participation in other rehabilitation research or drug experiment; and 4) research participation rate <80%.

Clinical procedures

Before the intervention, the subjects were provided sufficient explanation regarding participation in the study, and only the patients who agreed to participate in the study were involved in the intervention. The randomization was performed by selection of an opaque closed envelope wherein the group assignment was written, and the sealed envelope was given to the physical therapist. Thirty-six stroke patients who had been admitted to a rehabilitation clinic in the Republic of Korea were randomized into either the GR mirror therapy group (n=12), the conventional mirror

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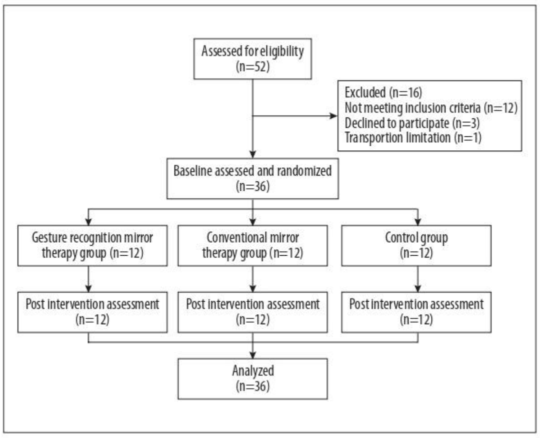

Figure 1. Flowchart of participants through the trial.

therapy group (n=12), or the control group (n=12) group (Figure 1). The experiment began the day after randomization. General surveys of the subjects and pre-intervention tests were conducted. Each participant underwent a training program consisting of 15 sessions, 30 min per day, 3 days per week, for 5 weeks. After 5 weeks, the final assessments were performed. All 3 groups underwent traditional physical therapy, including motor learning and neurodevelopmental treatment.

The GR mirror therapy group used a Leap motion controller (Leap Motion, Inc., USA), a monitor, a mirror, and a Leap Motion App Home. The Leap motion controller is a device with a camera that recognizes the reflected wave of infrared light and detects motion. It can recognize 2 hands and 10 fingers with a 0.01 mm precision and a 200 frames/s speed, and recognizes hand movements by storing the recognized information in the frame unit (Figure 2). There are 6 types of game programs used for intervention: 1. Playground I, 2. Playground II, 3. Playground III, 4. Block Destruction I, 5. Block Destruction II, and 6. Cube Wave. Game programs include actions, such as recognizing a hand, building a block on a moving object, picking up a petal, removing a block, pushing a block by hand, and lifting a hand (Figure 3). The subject sits in a chair without a backrest while looking at the flat mirror in the 45° direction, and the box is covered with the invisible hand. Subsequently, turning the monitor in the 90° direction, the subject can see the mirrored monitor to see the left and right reversed monitor screen. Subjects looked at the left and right screen of the monitor, and moved the right hand on the Leap motion controller to randomly play the game based on the subject's choice. Each game program was performed for approximately 4 min, and the subject rested for approximately 1 min after the game program was finished.

The conventional mirror therapy group underwent training using the general mirror therapy method [19] in which the patient sits on a chair without a backrest and mirror side is placed on the center line of the patient on the table [16]. The affected hand was placed in the mirror box so that the hand could not be seen, and the non-affected hand was placed in front of the mirror side to reflect the shape of the hand on the mirror. The mirror therapy program consists of 10 movements. Three sets of these programs were performed, and 12 operations were performed per set [19]. In the control group, patients underwent sham therapy in the same environment as the mirror therapy group so as not to see the affected hands (Figure 2). All 3 therapy programs included 9 movements: lifting the arms, moving the arms to the left and right, bending and stretching the elbows, raising and lowering the hands, lifting the wrists, lowering the wrists, flexing the wrists inward, flexing the wrist, and finger gripping.

Outcome measurements

The manual function test (MFT) is composed of upper-limb movement (4 items), grasp (2 items), and resin manipulation (2 items) as upper-limb function and motion ability measurement test tool for hemiplegic stroke. The test–retest reliability was 0.99 and 0.84 for the affected and unaffected sides, respectively. The test–retest and inter-test reliability of stroke patients was 0.95, and correlation with recovery Brunnstrom stage was >0.8 [20].

Neck discomfort score (NDS) was used to measure the degree of subjective neck discomfort. The score rating scale is clearly rated numerically as compared to the Visual Analog Scale. The 10-cm horizontal line was divided by 1 cm intervals, wherein

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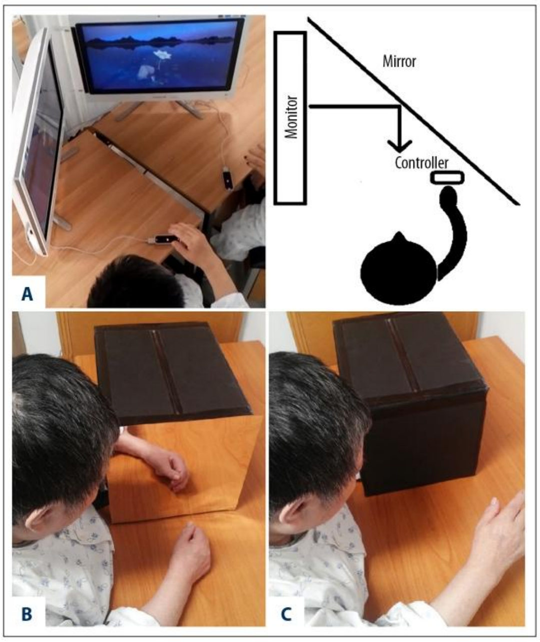

Figure 2. (A) Gesture recognition mirror therapy group, (B) Conventional mirror therapy, (C) Control group.

0 cm level means uncomfortable feeling with no discomfort. We asked the subjects to rate their neck discomfort. The neck discomfort change was measured pre-intervention, post-intervention, and after a 30-min rest.

Short-Form 8 (SF-8) was used to assess life satisfaction with health, which can be answered within 10 min with a reliable test tool, can be evaluated at all ages, and is not affected by cultural differences. It is a comprehensive health-related quality of life instrument that measures the 8 major areas of life satisfaction: overall health status, physical functioning, physical role limitation, pain, vitality, social functioning, mental health, and emotional role restriction. It is a simple questionnaire, in which a higher score shows better function. The reliability Cronbach's α of the SF-8 was 0.82 [21,22].

Statistical methods

For this study, the PASW Statistics ver. 18.0 program (IBM Co., Armonk, NY, USA) was used for data analysis. The general characteristics of subjects were described using the mean and standard deviation values, and the Shapiro–Wilk test was performed to verify the normality of the subjects. The paired *t* test was used to compare between 2 groups before and after intervention, and one-way ANOVA was used to compare differences in the amount of change between each group. The Scheffe method was used for as a post hoc test when differences were found between groups. The significance level was set at α=0.05.

Ethical considerations

This study was conducted with the approval of the Institutional Review Board of Daejeon University (1040647-201606-HR-032-03).

Results

No significant differences were found for gender, age, height, weight, onset type, paralysis, duration of illness, or perception among the 3 groups ($p>0.05$). The general characteristics of the study subjects are shown in Table 1.

The scores of the upper-extremity exercise functions before the intervention were homogeneous in the 3 groups (Table 2). After the 5-week intervention, all 3 groups showed statistically significant increases in upper-extremity motor function ($p<0.05$).

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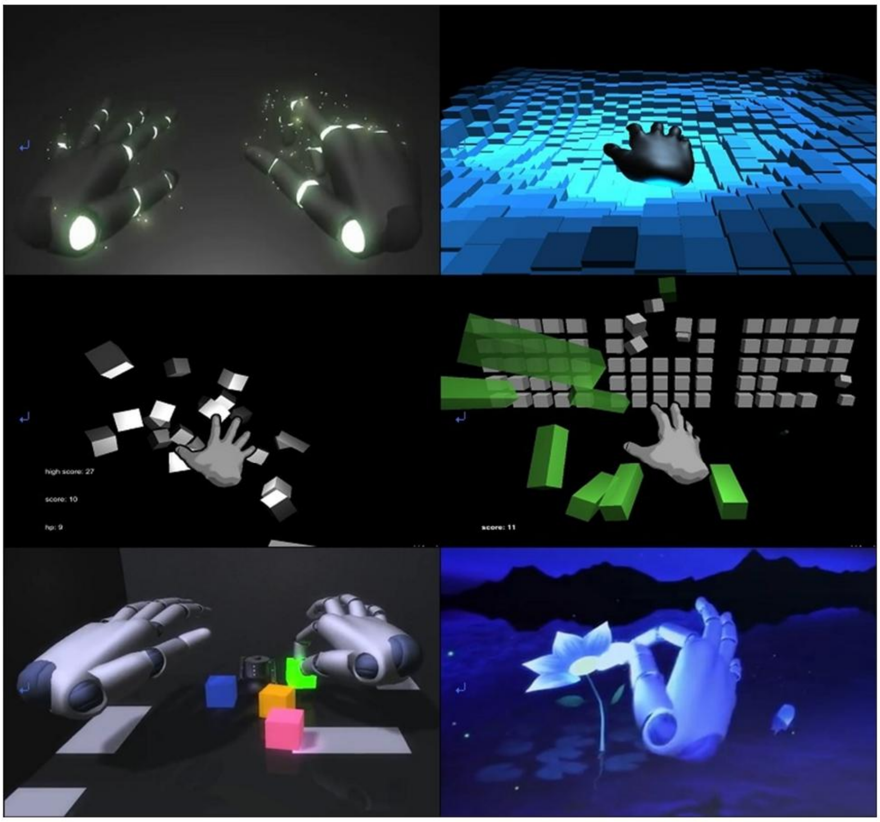

Figure 3. Game programs for gesture recognition mirror therapy.

The difference between the GR mirror therapy group versus the conventional mirror therapy and control groups was statistically significant ($p<0.05$) ($F=16.612$, $p<0.05$).

The scores on the pre-intervention prevalence of neck discomfort were the same in the 3 groups (Table 2). Changes in neck discomfort among the 3 groups were as follows ($F=32.501$, $p<0.05$): no statistically significant difference was found in the GR mirror therapy group ($F=1.709$, $p>0.05$); the difference in neck discomfort between the conventional mirror therapy and control groups was higher than that in the conventional mirror therapy group, but was not significant ($p>0.05$); and no difference was found between the 3 groups after a 30-min rest ($F=0.094$, $p>0.05$).

The changes in quality of life among the 3 groups after 5 weeks of intervention are shown I Table 2. A statistically significant increase was found in the quality of life after intervention in the conventional mirror therapy and GR mirror therapy groups ($p<0.05$). The difference between the 3 groups was significantly higher in the GR mirror therapy group than in the control group ($F=3.673$, $p<0.05$).

Discussion

This study investigated changes in upper-extremity motor function, quality of life, and neck discomfort when using a GR device for mirror therapy to observe the upper extremities reflected in the mirror. The 5-week intervention confirmed the

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Table 1. General characteristics of subjects.

Characteristic	Gesture recognition mirror therapy group (n=12)	Conventional mirror therapy group (n=12)	Control group (n=12)	χ^2/F
Gender (Male/Female)	7/5	7/5	9/3	0.963
Age (y)	58.00±15.15	59.58±11.87	59.33±13.63	0.047
Height (cm)	168.89±10.09	165.78±10.23	166.56±3.40	0.598
Weight (kg)	61.66±11.85	60.82±10.93	66.00±14.55	0.588
Paretic side (right/left)	4/8	5/7	5/7	0.234
Symptom onset (month)	28.91±15.80	26.33±15.51	29.00±19.21	0.096
MMSE (score)	26.92±2.15	26.50±2.32	26.50±2.11	0.147

Values are presented as number only or mean ±SD. MMSE – mini–mental state examination.

Table 2. Outcome measurements pre-post intervention comparison of three groups.

Variables	Gesture recognition mirror therapy (n=12)	Conventional mirror therapy group (n=12)	Control group (n=12)	F	Post-hoc
Manual function test					
Pre	8.92±2.54	9.50±2.15	9.00±1.95	0.240	
Post	13.42±2.50	12.33±2.02	10.08±1.93	7.410	
t	9.950*	5.977*	3.463*		
Change	4.50±1.57[#,##]	2.83±1.64[#]	1.08±1.08	16.612*	A>B>C
Neck discomfort score					
Pre	1.65±0.68	1.50±0.67	1.73±0.42	0.462	A=B=C
Post	2.07±0.45[#,##]	3.72±0.46	3.28±0.50	32.501*	A<B,C
Rest	1.83±0.51	1.82±0.54	1.75±0.54	0.094	A=B=C
F	1.709	76.161*	39.649*		
Short form 8					
Pre	38.23±9.96	39.00±13.56	37.39±6.17	0.072	
Post	42.60±8.67	42.00±11.68	37.45±6.62	1.121	
t	4.192*	2.460*	0.044		
Change	4.37±3.61[#]	2.92±4.23[#]	0.05±4.27	3.673*	A,B>C

Values are presented as mean ±SD. [#] Significant difference compared with the control group (p<0.05); [##] Significant difference compared with the conventional mirror therapy group (p<0.05); * p<0.05.

positive effect of upper-limb movement function and quality of life in patients with chronic stroke.

The MFT was used to measure upper-extremity motor function. After the intervention, the GR mirror therapy, conventional mirror therapy, and control groups were significantly improved. The amount of change after intervention was significantly greater in the GR mirror therapy group than in the conventional mirror therapy and control groups. Significant improvement in the upper-limb movement function was also observed in the mirror therapy group, as the effect of the mirror therapy and the intervention program of the 3D motion input unit provided tasks and feedback to the subject. The control group also showed a significant increase in upper-limb movement

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function after the intervention, but this is thought to be due to the movement of the subject using the target action of the proximal part in performing the sham therapy. In addition, the difference between the conventional mirror therapy group and the control group was significant because the visual stimulation through the mirror therapy had a positive effect on upper-limb movement function [23]. The upper-limb movement function was improved by mirror therapy, whereas the mirror therapy showed passive observation of movements and imitation of behavior and stimulation of cerebral cortex and spinal area. Previous studies also showed improvement of upper-limb movement through mirror therapy. The GR mirror therapy group showed significantly more improvement than the conventional mirror therapy and control groups. GR mirror therapy has many more movement processes using the wrist and hand than in the conventional mirror therapy. In addition, the conventional mirror therapy program was more biased toward the motion than the speed and accuracy of the motion. However, the GR mirror therapy group is required because of the accuracy and speed to perform tasks in program configuration [19]. A previous study reported an improvement in coordination, dexterity, hand use ability, and grasp force using a Leap motion controller with stroke patients [12,24].

No statistically significant difference was found in the change of NDS between the conventional mirror therapy and control groups, but no difference was observed between the 3 groups after 30-min rest. This is because, unlike the GR mirror therapy group with the mirror on the front, the conventional mirror therapy and control groups are thought to have increased neck discomfort because the box located on the affected side should be turned to the side of the head [25]. The subjects were more interested in their therapy than were other patients because of the electronic devices used in the virtual reality game program, and they enjoyed playing the game program, which had a positive psychological effect. After the intervention, a significant increase was found in the conventional and control groups. In the GR mirror therapy group, was no difference was found.

As a result of measuring the quality of life using SF-8, a significant improvement was found in the conventional mirror therapy and GR mirror therapy groups after the intervention, and the change before and after the intervention showed that the GR mirror therapy group was comparable with the control group. This is because the motivation and rehabilitation intention of the subjects were improved due to the virtual reality game program and the mirror therapy; the subjects played the game program in virtual reality, which had a positive influence due to voluntary intervention participation [26,27]. Use of virtual reality in stroke patients has been found to improve quality of life, performance, satisfaction, motivation, and interest. Quality of life was shown to be improved by applying a virtual reality-based exercise program to children with brain damage [27].

The clinical significance of this study is that it can be clinically applied to improve upper-limb movement function in stroke patients in clinical practice. The virtual reality game program and the preparation of the mirror therapy are simple, and the cost is low because expensive equipment is not needed [13]. In addition, it can encourage voluntary participation of the subjects by inducing interest in the virtual reality game program, and can be used by people with severe paralysis. In addition, because mirror therapy is performed while looking at the front, conventional mirror therapy produces less neck discomfort.

The limitations of this study are as follows. First, generalizing the results is difficult because the number of subjects was small. Future studies will need to involve more participants. Second, expecting the same results for acute and subacute patients is difficult because the study was conducted on patients who had chronic stroke. Third, because it was intended for hospitalized patients, it would have reflected the effects of basic hospitalization and medication, which should be compensated for, and absence of follow-up after the end of intervention did not allow for determination of the durability of effects. Future studies should investigate the effect of mirror therapy using various devices, and more effective mirror therapy program are needed.

Conclusions

The results of this study suggest that mirror therapy with a GR device has a positive effect on upper-extremity motor function and quality of life of patients with chronic stroke. Mirror therapy was found to produce less neck discomfort. Future studies on upper-extremity exercise function, quality of life, depression, and neck discomfort stroke patients are necessary.

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Mirror therapy in chronic stroke survivors with severely impaired upper limb function: A randomized controlled trial

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3 authors, including:

Enrique Noé
IRENEA- Instituto de Rehabilitación Neurológica

Roberto Llorens
Universitat Politècnica de València

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Carolina COLOMER, Enrique NOé, Roberto LLORENS

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Mirror therapy in chronic stroke survivors with severely impaired upper limb function: A randomized controlled trial

Carolina Colomer,[1] Enrique Noé, [1] Roberto Llorens[1,2]

[1]Servicio de Neurorrehabilitación y Daño Cerebral de los Hospitales NISA. Fundación Hospitales NISA. Río Tajo 1, 46011 Valencia, Spain.

[2]Instituto Interuniversitario de Investigación en Bioingeniería y Tecnología Orientada al Ser Humano, Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain.

Congresses

This study has never been presented in any congress

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Conflicts of interest

The authors have no conflict of interest to declare.

Corresponding author

Name: Carolina Colomer

Email: carol@neurorhb.com

Address: Hospital Nisa Valencia al Mar. Río Tajo 1, 46011 Valencia (Valencia)

Tel: +34 96 335 25 00 / Fax: +34 96 335 25 01

Abstract

BACKGROUND: Mirror therapy has been proposed to improve the motor function of chronic individuals with stroke with mild to moderate impairment. With regards to severe upper limb paresis, mirror therapy has shown to provide limited motor improvement in the acute or sub-acute phase. However, no previous research has described the effects of MT in chronic individuals with stroke with severely impaired upper limb function.

AIM: To determine the effectiveness of mirror therapy on chronic stroke survivors with severe upper-limb impairment in comparison with passive mobilization.

DESIGN: A randomized controlled trial.

SETTING: Rehabilitative outpatient unit.

POPULATION: A total of 31 chronic subjects post-stroke with severely impaired upper limb function were randomly assigned to either an experimental group (n=15), or a control group (n=16).

METHODS: Twenty-four intervention sessions were performed for both groups. Each session included 45-minute period of mirror therapy (experimental group) or passive mobilization (control group), administered three days a week. Participants were assessed before and after the intervention with the Wolf Motor Function Test, the Fugl-Meyer Assessment, and the Nottingham Sensory Assessment.

RESULTS: Improvement in motor function was observed in both groups on the time (p=0.002) and ability (p=0.001) subscales of the Wolf Motor Function Test. No differences were detected in kinesthesis or stereognosis. However, the experimental group showed a significant improvement in tactile sensation that was mainly observed as an increased sensitivity to light touches.

CONCLUSIONS: In comparison with passive mobilization, mirror therapy in chronic stroke survivors with severely impaired upper-limb function may provide a limited but positive effect on light touch sensitivity while providing similar motor improvement.
CLINICAL REHABILITATION IMPACT: Mirror therapy is a therapeutic approach that can be used in the rehabilitation of severely impaired upper limb in chronic stroke survivors, specifically to address light touch sensitivity deficits.

Keywords

Stroke; Upper Extremity; Hemiparesis; Chronic Brain Injury

Introduction

Functional impairment of the upper limb is reported in approximately 85% of stroke survivors[1] and affects participation in daily living activities and quality of life.[2] Six months after onset, 30-60% of individuals do not regain functional use, and only 5-20% will achieve full recovery of arm function.[3] Rehabilitation of severe arm paresis in chronic stroke survivors is, therefore, especially challenging.[4] Useful reorganization of cortical areas involved in arm function occurs in response to active exercise and to motor and attentional inclusion of the affected arm in task oriented movements.[4,5] Because severe paresis impedes active training of the hand, traditionally, rehabilitation strategies in these subjects have almost exclusively aimed to compensate for the deficit by training the opposite limb in daily tasks.[4,6] As synaptic connectivity is highly use dependent, this absence of stimulation on the chronic paretic arm results in reduced sensorimotor representation in the available neural circuits over time[7] and consequently diminishes the possibilities for sensorimotor clinical progress.[6] Accordingly, a reduction in sensorimotor abilities might partly be an effect of non-use of the affected limb.[7] In fact, lack of movement has been considered to be a form of "learned paralysis".[8,9]

Mirror therapy (MT) could address these issues because it does not require active movements of the affected arm. A mirror is placed along the midsagittal plane between the two limbs, and the subject is encouraged to move the less affected limb while watching its reflection in the mirror, thus providing the visual illusion that the affected limb mirrors the movement of the other limb. Neuroimaging techniques have revealed the capacity of MT to elicit cortical activation in the hemisphere contralateral to the mirrored arm (ipsilateral to the moving arm), even in absence of movement,[10] and have found evidence of interesting and varied cortical changes induced by MT.[11-13] These results have motivated the application of MT to sensorimotor rehabilitation after stroke. Previous research has shown that MT can improve the motor function of chronic individuals with stroke with mild to moderate impairment.[14,15] Moreover, interventions involving stroke survivors with severe upper limb paresis have been shown to provide limited motor improvement in the acute[10,16] or sub-acute phase.[16] However, no previous research has described the effects of MT in chronic individuals with stroke with severely impaired upper limb function. We hypothesize that MT can be beneficial for sensorimotor function of severely affected upper limbs of chronic stroke survivors.

The objective of the present study was to determine the effectiveness of MT in chronic stroke survivors with severe upper-limb impairment in comparison to a passive mobilization intervention.

Materials and methods

Participants

Participants were recruited from the chronic stroke outpatient management program that was run by a specialized neurorehabilitation center. The inclusion criteria for the current study were: 1) chronicity > six months; 2) severe paresis of the upper limb, as defined by the Brunnstrom Approach[17] as stages I or II) and by the Upper Extremity subscale of the Fugl-Meyer Assessment (FMA)[18] as scores below 19; 3) sensory impairment in the affected upper limb, as assessed by clinical examination; 4) ability to maintain a sitting position for at least 60 minutes; 5) a fairly good cognitive condition, as defined by scores on the Mini-Mental State Examination[19] above 23. Participants were excluded if they had: 1) impaired comprehension that hindered sufficient understanding of the instructions, as defined by Mississippi Aphasia Screening Test[20] scores below 45; 2) severe visual impairments; 3) upper limb pain that limited participation in the rehabilitation protocol; 4) spatial neglect; 5) self-awareness disorders; and 6) emotional circumstances that impeded adequate collaboration. Sample size was calculated for a two-sample t test assuming 75% power, a common standard deviation of 50, a mean difference between groups on the Wolf Motor Function Test (WMFT) of 50 seconds, and a loss rate of 10%.

The study was approved by the Institutional Review Board of the specialized neurorehabilitation center. Written consent was obtained from all of the subjects who satisfied the inclusion criteria and accepted the offer to participate in the study. Participants were randomly assigned to an experimental or a control group. The allocation sequence was concealed from an independent researcher. A sealed envelope identifying the group of each participant was given to the therapists to inform them of the allocation. Randomization was computer-generated using a basic random number generator in a ratio of 1:1.

Intervention protocol

All of the participants were undergoing a long-term care physical therapy program consisting of five one-hour sessions a week that focused on balance and gait training. During this clinical trial, participants underwent 24 sessions, each 45-minutes long, and administered three days a week in addition to the physical therapy. Subjects belonging to the experimental group underwent a MT program and those belonging to the control group received passive mobilization of the affected upper limb. Treatment intensity was dose-matched for both groups, allowing 60-second breaks every five minutes. All of the participants trained in a dedicated area of the physical therapy unit free of distractors. For the MT, a triangular prism-shaped device with a mirror on one side was fixed on a conventional table. Participants sat down close to the table in chairs with a back and without armrests. Participants hid the affected arm inside the device and the mirror was oriented so that they were able to see the reflection of their other arm. Participants were encouraged to observe the mirror while executing different movements with their less affected limb. Exercises were indicated verbally and consisted of a series of flexo-extension and prono-supination movements of the shoulder and forearm and gross and fine movements of the wrist, hand, and fingers, with and without objects (balls, cups, and other). These activities included transitive movements, gross motor tasks, and intransitive movements.[14] Participants in the control group received passive mobilization of the paretic upper limb. Passive range of motion exercises were provided in those segments where no active movement was detected to meticulously reproduce a range of articular movements and muscle and soft tissue elongation. In case of residual active movement capability, participants were encouraged to perform the movements with the assistance of the therapists.

Assessment

All of the participants were assessed by a physical therapist, blind to the treatment, the day before the intervention and the day after the intervention. The primary outcome measure was the WMFT. Both time and ability subscales were considered. Secondary outcome measures assessed the upper limb motor function using the FMA, and the sensory impairment of the hemiparetic upper extremity using the tactile, kinaesthetic, and stereognosis subscales of the Nottingham Sensory Assessment (NSA).[21] The tactile subscale assessed light touch, pressure, pinprick, temperature, tactile localization, and bilateral simultaneous touch. Scores in the NSA ranged from 0 to 48 in the tactile subscale, from 0 to 12 in the kinesthetic subscale, and from 0 to 22 in the stereognosis subscale. Higher scores represent more preserved sensory sensation.

Statistical analysis

Demographical and clinical comparisons between the control and the experimental groups were performed with independent sample t-tests and Chi-squared or Fisher exact tests, as appropriate. Repeated measures analyses of variance (ANOVA) with time as the within-subjects factor and treatment option (control versus experimental) as the between-subjects factor were performed for the FMA and the subscales of the WFMT and NSA. The main effects were evaluated for time, treatment option, and the time-treatment option interaction. ANOVA findings that violated the sphericity assumption were accommodated by Greenhouse and Geisser's conservative degrees of freedom adjustment. For each repeated-measures ANOVA, we present the partial eta squared (η^2_p) as a measure of effect size; values may range between 0 and 1, with higher values representing higher proportions of variance explained by the independent variable.

The α level was set at 0.05 for all analyses (two-sided). All analyses were computed with SPSS for Mac, version 15 (IBM, Armonk, NY, USA). Investigators performing the data analysis were blinded.

Results

A total pool of 97 outpatients attended the long-term care program during the recruitment. Of those, 34 subjects (35.1%) met inclusion criteria. None of them refused to participate in the study, and consequently all of them were randomized. Each group consisted of 17 participants. Two participants of the experimental group were discharged, and one participant of the control group suffered a cardiac arrest. Consequently, these participants discontinued the program and were excluded from the study. Their data were, therefore, not included in the study. Finally, data from 31 participants, 16 in the control group and 15 in the experimental group, were included in this study (Figure 1). The final sample consisted of 26 males and 5 females, with a mean age of 53.6±8.4 years, and a mean chronicity of 551.1±377.5 days. A total of 23 participants presented an ischemic stroke, and eight participants presented a hemorrhagic stroke (Table 1). No significant differences in demographical (gender and age) or clinical (etiology, hemiparetic side, chronicity, Brunnstrom, and FMA) data at inclusion were detected between the groups. All of the participants were right-handed.

With regards to the primary outcome measure, scores in the time and ability subscales of the WMFT significantly improved after the treatment period in each group, but this improvement failed to reach a significant difference between groups (Table 2). The percentage of change was 5.8% in the control group and 4.7% in the experimental group for the time subscale, and 15.6% in the control group and 18.9% in the experimental group for the ability subscale.

Regarding to secondary outcomes, no differences were found in motor performance after the treatment, as measured by the FMA, neither within any group nor between the two groups (Table 2). Regarding sensory assessment, the kinesthetic and the stereognosis subscales of the NSA showed no significant difference (Table 2). However, the results in the tactile subscale revealed a statistically significant improvement after treatment for both groups. Interestingly, the improvement experienced by the experimental group was significantly higher than that experienced by the control group ($p<0.01$). A more in-depth analysis of the tactile subscales found that scores in the light touch test promoted this result (Table 3). No significant differences were detected in any subscale of the NSA between subjects with left or right hemiparesis, neither at the beginning nor at the end of the intervention.

Discussion

This paper describes the effectiveness of a MT intervention in chronic stroke survivors with severe hemiparesis in comparison with passive mobilization. Although the MT intervention provided similar results to mobilization interventions in motor performance, the experimental intervention could promote greater changes in the tactile sensation, specifically regarding light touch.

Motor function

The improvement provided by MT for motor function was similar to the improvement provided by the mobilization intervention. Significant changes were detected in both groups by the WMFT, but not the FMA. Changes detected in the time subscale of the WMFT for both groups were lower than the Minimally Clinically Important Difference (MCID),[22] and more importantly, final timed scores, though lower than initial scores, were still very high, as expected for subjects with such severe motor impairment. Changes in the ability subscale in the control group were slightly inferior to the MCID, which was previously established as 17% for the acute phase,[22] but were higher than the MCID in the experimental group. The general nature of the FMA could explain the inability of this scale to detect changes as subtle as those detected in our study. The characteristics of our sample could have prevented greater improvement. First, all of the participants were chronic stroke survivors. Although chronicity is not believed to be an excluding factor, less recovery is expected as time since injury increases and endogenous recovery mechanisms diminish.[23] Second, all of the participants presented a severe upper limb motor impairment, evidenced by a baseline FMA score below 19. Initial severity of motor impairment has been considered the most important prognostic variable of upper limb recovery after stroke.[24-26] Specifically, an FMA above 18 points at four weeks after onset is an independent predictor of dexterity within six months.[24] More importantly, initial FMA scores between 21 and 35 can predict improvement after a MT intervention.[27] Finally, somatosensory impairment, which was present in all of our participants as well, has also been found to be a predictor of the absence of limb dexterity one year after the injury,[25] and has been related to poorer functional ability.[28,29] Previous research with similar interventions involving stroke survivors in the acute[10] or sub-acute phase[16] with severe upper limb paresis reported no significant differences between groups in the motor domain, except for individuals with plegic fingers.[10] The combination of MT with bilateral arm training in an acute population was reported to increase the effectiveness of the intervention.[30] In contrast, positive effects were found in motor performance and motor control after MT in chronic individuals with mild to moderate hemiparesis.[14,15] All of these results suggest that the severity of the impairment, rather than the chronicity, could determine the effects of the MT in the motor impairment.

Sensory function

Although no significant improvement was detected in any group regarding kinesthesia and stereognosis, the MT provided a statistically significant improvement in the tactile sensation to participants in the experimental group, mainly promoted by an improvement in the ability to sense light touches. Despite the chronicity and the limited duration of the treatment, the effect size of the difference between groups for the tactile sensation subscale was moderate. Furthermore, a detailed analysis of its items showed a considerable effect size for light touch sensitivity. The authors hypothesize that these improvements can be related to the visual enhancement of touch, which suggests that tactile perception could be augmented by viewing the stimulated parts.[31] Visual feedback can exert a strong modulatory influence over the motor system when there is a conflict, which can, in turn, override other modalities, such as proprioception.[32] Neuroimaging techniques have shown the dominance of vision over proprioception during motor programming.[32] Interestingly, this mechanism has previously been confirmed in healthy and brain damaged individuals with lower somatosensory sensitivity,[31] as is the case in the present study. The participants were required to pay special attention to the intervention task, which could have been another factor that contributed to the improvement in tactile sensitivity. Attention to touch could have led to increased activation in somatosensory cortical areas, including the primary somatosensory cortex.[33] Interestingly, the role of attention in MT has been previously reported to have a positive impact on hemineglígence.[10,16,34]

An improvement in temperature sensation was also detected in our study but without showing differences between groups, and a similar result had been previously reported in a stroke population with mild to moderate paresis after MT.[14] This change may have been attributed to multimodal neurons in the posterior parietal and premotor cortical areas that respond to sensory stimuli, which modulate the somatosensory cortex network and contribute to the recovery of the somatosensory system. The severity of the impairment could have influenced the different results.

Limitations

The limitations of this study must be taken into account when analyzing the results. First, the sample size, which consisted of 31 participants, can be considered small even though it is similar to other studies.[10,14] Second, the chronicity and the severity of the motor impairment restricts the extrapolation of the results to other population, because these factors seem to determine the effects of the MT, as described throughout the text.

Third, the progress of the participants was not determined in a follow-up assessment. Finally, the MCID of the NSA scale has not been validated, which complicates the evaluation of the functional impact of the significant changes detected in this scale.

Nonetheless, the improvement in light touch sensitivity after the MT intervention may be relevant, because somatosensory deficits occur in approximately 50% of stroke survivors and can limit functional recovery.[31] MT could therefore be a tool to enhance sensory function in very chronic individuals with severely affected upper limb function.

Conclusions

Our results suggest that MT can provide limited but positive effects in light touch sensitivity in chronic stroke survivors with severely impaired upper limb function while providing similar motor improvement. Our results and previous research in the field suggest that MT may be more effective for motor improvement in mild to moderate hemiparesis, even at chronic stages, rather than in severe paresis, where MT may provide benefits to tactile sensitivity.

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Tables

Table 1. Characteristics of the participants.

Table 2. Clinical data.

Table 3. Results in the tactile subscale of the Nottingham Sensory Assessment

Figures

Figure 1– CONSORT flow diagram

Progress through the phases of the parallel randomized trial of both groups.

Tables

Table 1. Characteristics of the participants.

Characteristic	Control group (n=16)	Experimental group (n=15)	Significance
Gender (n, %)			NS (p=0.532)
Male	13 (81.2%	13 (86.7%)	
Female	3 (18.8%)	2 (13.3%)	
Age (years)	53.3±10.5	53.8±5.5	NS (p=0.891)
Etiology (n, %)			NS (p=0.352)
Ischemic stroke	13 (81.2%)	10 (66.7%)	
Hemorrhagic stroke	3 (18.8%)	5 (33.3%)	
Hemiparesis (n, %)			NS (p=0.173)
Left	14 (87.5%)	10 (66.7%)	
Right	2 (12.5%)	5 (33.3%)	
Chronicity (days)	520.0±262.5	584.2±478.7	NS (p=0.601)
Brunnstrom (n, %)			NS
Stage I	0	0	
Stage II	16	15	
Flugl-Meyer Assessment	9.0±4.4	8.5±4.7	NS (p=0.803)

Age and chronicity are defined in terms of mean and standard deviation. Etiology and gender are expressed as a percentage of the total number of participants. NS: non-significant.

Table 2. Clinical data.

	Initial assessment	Final assessment	Significance (p, effect size)
WMF-time			T** (p=0.002, η^2_p=0.29)
Control	1492.7±65.1	1405.8±70.8	
Experimental	1615.2±67.2	1539.8±72.8	
WMF-ability			T** (p=0.001, η^2_p=0.31)
Control	10.9±1.7	12.6±1.8	
Experimental	8.7±1.7	10.1±1.8	
FMA			NS
Control	9.0±1.1	9.5±1.1	
Experimental	8.5±1.2	8.6±1.1	
NSA-tactile			T** (p=0.001, η^2_p=0.38); GxT* (p=0.027, η^2_p=0.16)
Control	23.9±4.5	25.1±4.3	
Experimental	17.8±4.7	21.9±4.4	
NSA-kinaesthetic			NS
Control	4.7±0.8	5.0±0.9	
Experimental	6.6±0.8	6.3±1.0	
NSA-stereognosis			NS
Control	5.2±1.8	5.3±1.8	
Experimental	4.2±1.8	4.4±1.8	

Results are given in terms of mean and standard deviation. T: time effect. GxT: group by time effect. *: p<0.05, **: p<0.01. NS: non-significant.

Table 3. Results in the tactile subscale of the Nottingham Sensory Assessment

	Initial assessment	**Final assessment**	**Significance (p, effect size)**
Light touch			T** (p=0.000, η^2_p=0.43); GxT** (p=0.000, η^2_p =0.36)
Control	4.2±0.8	4.3±0.7	
Experimental	3.5±0.8	4.3±0.7	
Pressure			NS
Control	4.4±0.8	4.5±0.7	
Experimental	4.2±0.8	4.3±0.8	
Pinprick			T** (p=0.001, η^2_p=0.34)
Control	4.3±0.8	4.6±0.7	
Experimental	3.8±0.9	4.3±0.7	
Temperature			T* (p=0.023, η^2_p =0.17)
Control	4.2±0.8	4.5±0.7	
Experimental	3.3±0.8	4.0±0.8	
Tactile localisation			NS
Control	4.8±0.8	5.6±0.8	
Experimental	3.8±1.2	4.0±1.1	
Bilateral simultaneous touch			NS
Control	6.1±0.9	6.0±0.9	
Experimental	5.2±1.3	5.6±1.3	

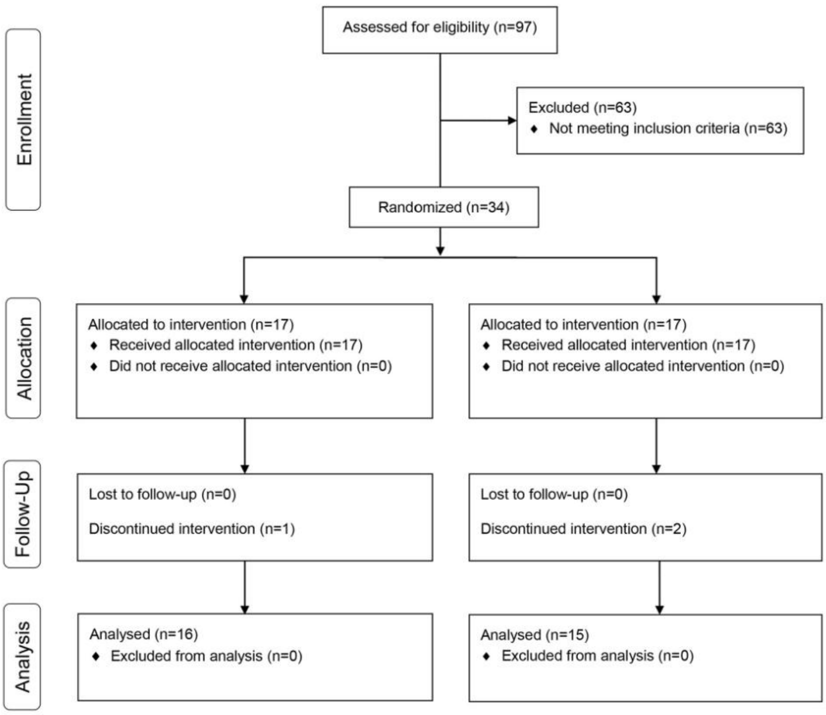
Results are given in terms of mean and standard deviation. T: time effect. GxT: group by time effect. *: $p<0.05$, **: $p<0.01$. NS: non-significant.

CONSORT 2010 checklist of information to include when reporting a randomised trial*

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	1
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	1
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	3
	2b	Specific objectives or hypotheses	3
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	7
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	NA
Participants	4a	Eligibility criteria for participants	6
	4b	Settings and locations where the data were collected	8
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	7,8
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	8
	6b	Any changes to trial outcomes after the trial commenced, with reasons	NA
Sample size	7a	How sample size was determined	6,7
	7b	When applicable, explanation of any interim analyses and stopping guidelines	
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	7
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	7
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	7
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	8
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those	8

		assessing outcomes) and how	
	11b	If relevant, description of the similarity of interventions	
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	9
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	NA
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	9
	13b	For each group, losses and exclusions after randomisation, together with reasons	9
Recruitment	14a	Dates defining the periods of recruitment and follow-up	NA
	14b	Why the trial ended or was stopped	NA
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	Table 1
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	Table 1
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	Table 2; Table 3
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	NA
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	NA
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	10
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	14
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	14
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	10-14
Other information			
Registration	23	Registration number and name of trial registry	NA
Protocol	24	Where the full trial protocol can be accessed, if available	NA
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	NA

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see www.consort-statement.org.


Enrollment
Assessed for eligibility (n=97)
Excluded (n=63)
Not meeting inclusion criteria (n=63)
Randomized (n=34)
Allocation
Allocated to intervention (n=17)
Received allocated intervention (n=17)
Did not receive allocated intervention (n=0)
Allocated to intervention (n=17)
Received allocated intervention (n=17)
Did not receive allocated intervention (n=0)
Follow-Up
Lost to follow-up (n=0)
Discontinued intervention (n=1)
Lost to follow-up (n=0)
Discontinued intervention (n=2)
Analysis
Analysed (n=16)
Excluded from analysis (n=0)
Analysed (n=15)
Excluded from analysis (n=0)

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DongGeon LEE, GyuChang LEE

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Effect of Afferent Electrical Stimulation with Mirror Therapy on Motor Function, Balance, and Gait in Chronic Stroke Survivors: A Randomized Controlled Trial

Running head: Electrical Stimulation with Mirror Therapy

DongGeon Lee [1], GyuChang Lee [2]*

[1]Department of Physical Therapy, Graduate School of Kyungnam University, Changwon, Republic of Korea
[2] Department of Physical Therapy, Kyungnam University, Changwon, Republic of Korea

***Corresponding author:**
Prof. GyuChang Lee
Department of Physical Therapy, Kyungnam University, 7 Kyungnamdaehak-ro, Masanhappo-gu, Changwon, Gyeongsangnam-do, 51767 Republic of Korea
E-mail address: leegc76@kyungnam.ac.kr

Competing interests

The authors declare that they have no competing interests.

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ABSTRACT

BACKGROUND: When solely mirror therapy is applied for a long period of time, spatial perception and attention to the damaged side may decrease, and the effect of mirror therapy may be limited. To overcome this limitation, it has recently been suggested that the combination of mirror therapy with mirror treatment is effective.

AIM: The aim of this study was to investigate the effects of afferent electrical stimulation with mirror therapy on motor function, balance, and gait in chronic stroke survivors.

DESIGN: A randomized controlled trial

SETTING: Rehabilitation center

POPULATION: Thirty stroke survivors were randomly assigned to two groups: the experimental group (n = 15) and the control group (n = 15).

METHODS: Participants of the experimental group received afferent electrical stimulation with mirror therapy, and participants of the control group received sham afferent electrical stimulation with sham mirror therapy for 60 minutes per day, 5 days per week, for 4 weeks. Motor function was measured using a handheld dynamometer and the Modified Ashworth Scale, balance was measured using the Berg Balance Scale, and gait was assessed using the GAITRite at baseline and after 4 weeks.

RESULTS: The experimental group showed significant differences in muscle strength, Modified Ashworth Scale, and Berg Balance Scale results, and velocity, cadence, step length, stride length, and double support time of their gait ($p < 0.05$) in the pre-post intervention comparison. Significant differences between the two groups in muscle strength, Berg Balance Scale, gait velocity, step length, and stride length ($p < 0.05$) were found.

CONLCUSIONS: Mirror therapy with afferent electrical stimulation may effectively improve muscle strength and gait and balance abilities in hemiplegic stroke survivors.

CLINICAL REHABILITATION IMPACT: Afferent electrical stimulation combined with mirror therapy can be used as an effective intervention to improve lower limb motor function, balance, and gait in chronic stroke survivors in clinical settings.

Key words: Stroke; Electrical stimulation; Motor skills; Postural balance; Gait

Introduction

Though stroke mortality rates have declined over the past few decades with the development of medical technology, there are more stroke survivors now than before despite the increased frequency of the occurrence of strokes, because of the increased survival rate of the aging population..[1] Stroke is a major cause of serious long-term disabilities in survivors, and more than 60% of survivors experience limitations in daily life.[2] Post-stroke impairments, such as motor paralysis, sensory impairment, and cognitive and perceptual degradation, can have negative effects on independent function; among which motor paralysis is the most important factor affecting the ability to perform activities of daily life.[3]

The major motor function impairments resulting from strokes are muscle weakness, muscle tone increase, balance ability impairment, and gait impairment. These impairments are the main causes of persistent disabilities.[4, 5] Recovery of balance and gait, in particular, are two of the most important goals in rehabilitation, and various interventions are needed to improve these abilities.[6, 7]

Mirror therapy (MT) has been used as an intervention for the rehabilitation of stroke survivors.[8, 9] Mirror therapy is an intervention in which a stroke survivor watches their limbs on the non-affected side in a mirror to recover movement of the paralyzed side by creating a visual illusion. [8, 9] MT can exert a strong influence on the motor network, mainly through increased cognitive penetration in action control.[9] Altschuler et al.[10] demonstrated the effectiveness of MT on range of motion, movement speed, and accuracy of the upper limb joints post-stroke. Stevens and Stoykov[11] also reported improvements in the Fugl-Meyer Assessment Scale scores, range of motion, movement speed, and agility after MT for the upper limb. In a novel study, Sütbeyaz et al.[8] used MT for the lower limbs and reported that it was effective for motor recovery and motor function improvement. A study by Ji and Kim[12] also reported a significant improvement in spatio-temporal gait variables after MT for the lower limbs of stroke survivors.

More recently, however, researchers are testing therapies that combine MT with other interventions. Moving away from existing interventions, Yun et al,[13] for the first time, combined MT as a cognitive intervention with neuromuscular electrical stimulation. Kim et al.[14] reported in their study that motor recovery and motor function of the upper limbs of stroke survivors improved by simultaneously applying both MT and functional electrical stimulation. Lin et al.[15] also reported that simultaneously applying MT and afferent electrical stimulation (AES) to the upper limbs of stroke survivors resulted in improvements in motor recovery, motor function, and gait. In addition, Xu et al.[16] reported that the application of MT and neuromuscular electrical stimulation on the lower extremity of patients with acute stroke was shown to improve muscle tone of lower extremity and gait velocity. Lee et al.[17] suggested that the application of MT and neuromuscular electrical stimulation on the lower extremity of chronic stroke survivors had been shown to improve balance and muscle strength in the lower extremity. Recent studies have reported that interventions combining MT with electrical stimulation are more effective than MT alone for improving function in stroke survivors.[13-17] However, previous studies for MT combined with electrical stimulation mostly focused on the upper extremity of stroke survivors. In addition, a few studies that evaluated lower extremity motor function only used clinical tools as outcome measures.

It has been reported that MT can be a simple and low-cost therapy alternative for chronic stroke survivors.[18,19] Yun et al.,[13] however, pointed out that applying MT alone can cause problems with attention to space and that combining electrical stimulation with MT is effective to overcome this drawback. Therefore, the aim of this study was to use AES combined with MT for the lower limbs of chronic stroke survivors to investigate the effects on motor function and balance and gait abilities of chronic stroke survivors.

Methods

Design

This study was designed as a pretest-posttest randomized controlled trial. The participants were randomly allocated into an experimental group (n=15) or a control group (n=15) using random allocation software.[20] All outcome measures before and after intervention were performed by a research assistant who was blinded to the allotment.

Participants and setting

This study was conducted with stroke survivors admitted to a rehabilitation hospital. Chronic stroke survivors were recruited by posting advertisements in the hospital, and the volunteers were screened according to the following criteria: 1) those who were diagnosed with cerebral hemorrhage and cerebral infarction based on computed tomography or magnetic resonance imaging, 2) those with disease duration of 6 months or more from stroke occurrence, 3) those who scored 24 or higher on the Mini Mental State Examination (MMSE),[21] 4) with no cognitive disorder that interfered with the purpose of the study, 5) those capable of independent walking with or without assistance for 10 meters or more, and 6) who could passively conduct 10° or greater ankle joint dorsiflexion. The following were the exclusion criteria: 1) those with a congenital deformity and orthopedic disorder of the lower limbs, 2) those with visual and perception disorders such as unilateral neglect or hemianopsia, 3) those with apraxia, and 4) those with a pacemaker. A total of 41 survivors were recruited. Of these, 30 survivors were selected as the subjects of this study, excluding 5 survivors with MMSE scores below the criterion, 4 survivors who were unable to walk independently for more than 10 meters, and 2 survivors with dorsiflexion contractures.

Ethical Considerations

After the study received approval from the institutional review board of Kyungnam University (1040460-A-2014-018), the purpose and procedures of the study were explained to all survivors before they voluntarily signed the consent form.

Sample size calculation

Using the G Power 3.1 statistical tool to achieve a statistical power of 80% with statistical significance at $p<0.05$ (two-tailed test) and an effect size of r=0.5, a total sample size of 28 participants was required for present trial.

Procedure

A total of 30 subjects were randomly assigned to either the experimental group (n = 15 persons) or the control group (n = 15 persons). In the experimental group, AES combined with MT (designed to reflect the healthy side) was performed for 30 minutes, followed by AES combined with gait training for 30 minutes. This 60-minute session was repeated 5 times a week for 4 weeks, for a total of 20 sessions. In the control group, sham AES combined with sham MT (with no reflection on the mirror) was performed for 30 minutes, followed by sham AES combined with gait training for 30 minutes. This 60-minute session was applied 5 times a week for 4 weeks, for a total of 20 sessions. The intervention was performed by physical therapists with more than 10 years' experience in treating stroke survivors in both groups. Muscle strength, muscle tone, balance, and spatio-temporal gait variables were assessed in the experimental and control group before and after the experimental intervention (Figure 1).

Afferent electrical stimulation therapy with mirror therapy

For the MT, a 50 cm × 70 cm mirror box designed for therapy was placed in front of the subject such that the subject's hemiplegic lower limb was inside the mirror box, while the non-hemiparetic side lower limb was in front of the mirror box. The height of the chair was adjusted so that the angles of the knee and hip joints were 90°, and the mirror box was positioned so that the subject could see the mirror without leaning the upper limbs towards the non-hemiparetic side. For the AES, a sock-shaped electric stimulator was placed on the subject's hemiplegic leg, and electrical stimulation began just before the start of the experiment. The subject was instructed to dorsiflex the ankle joints on the hemiplegic side and on the non-hemiparetic side at the same time while looking at the movement of the non-hemiparetic side reflected in the mirror.[8] As the patient repeatedly tried to synchronize the dorsiflexion on both ankle joints while looking at the mirror, the AES device was activated continuously to provide electrical stimulation to the hemiplegic side.

The AES device used in this study was the Mesh Sock (Prizm Medical Inc., Oakwood, GA, USA) programmed with specific frequency, rest time, and energization time. In this study, the P1 program was used, which comprises 15 minutes of electric stimulation frequency at 100 Hz and pulse width at 300 μs, and 15 minutes of electric stimulation frequency at 15 Hz and pulse width at 300 μs. The strength of electric stimulation was adjusted to within the range that the patient could sense (Figure 2).[15]

Sham afferent electrical stimulation therapy with mirror therapy

In the control group, a sham mirror box without a reflective mirror was used so that the subjects could place one leg inside and the other outside the box. The subjects were instructed to dorsiflex their ankle joints in the same manner as the experimental group were, while the sham AES device was set not to operate.

Outcome Measurements

Primary outcomes

For motor function, a handheld dynamometer (Power Track II, Jtech Medical Inc., Utah, USA) was used to measure muscle strength and the Modified Ashworth Scale (MAS) was used to measure muscle tone.

A handheld dynamometer was used to measure muscle strength. This device measures muscle strength in pounds (lb) by providing a counter-resistance to the subject's maximum movement. In this study, strength of the dorsiflexors was measured. To test for isometric contraction under the same conditions, the subjects were asked to sit on a chair so that the angles of the hip, knee, and ankle joints were maintained at 90°.[22] The subjects dorsiflexed their ankles as much as possible to measure the counter-resistance on the dynamometer. The strength of the dorsiflexors was calculated using the average from three measurements taken during three-second-long maximal muscle contractions. One inspector examined all the subjects before and after the intervention.

Muscle tone was measured using MAS for the plantarflexor in a sitting position with the knee flexed to approximately 90°. Three quick stretches were provided to the plantarflexor to determine an overall resistance. It has inter-rater reliability (K=0.84) for measuring spasticity in adults with stroke.[23]

Secondary outcomes

The Berg Balance Scale (BBS) was used to measure balance and GAITRite (GAITRite, CIR system Inc., New Jersey, USA) was used to assess gait.

The BBS is a 14-item scale that quantitatively assesses both static and dynamic aspects of balance. The items are scored from 0 to 4, with a score of 0 representing an inability to complete the task and a score of 4 representing independent item completion. A global score is alculated out of 56 possible points. Internal consistency was excellent (Cronbach alpha=.92–.98) as was interrater reliability (intraclass correlation coefficients [ICCs]=.95–.98), intrarater reliability (ICC=.97), and test-retest reliability (ICC=.98).[24]

The subjects' gait was measured using GAITRite, which is a device mainly used to measure spatio-temporal gait variables. After having the subject stand facing the GAITRite placed on the floor, a verbal cue was given by the inspector for the subject to walk through the 461 × 88 cm GAITRite at a comfortable walking speed while looking ahead. Walking velocity, cadence, step length of the less affected side and more affected side, stride length of less affected side and more affected side, single support time of less affected side and more affected side, and double support time were collected as spatiotemporal gait parameters. This test was performed three times and the average of the three measurements was used as the data for this study.

Statistical analysis

The statistical analysis in the present study involved the use of SPSS version 18.0 (IBM Corporation, NY, USA). All data underwent a test of normality using the Shapiro Wilk method. A paired sample t-test or a Wilcoxon signed-rank test was used to compare the dependent variables in accordance with respective interventions within the groups. An independent sample t-test or a Mann-Whitney U test was conducted to compare the differences between dependent variables in accordance with the interventions between groups. All statistical significance levels (α) were set to 0.05.

Results

There were no significant differences between the experimental group and the control group in terms of gender, age, height, weight, paralysis site, disease duration, etiology, and MMSE score (Table 1).

Motor function

Muscle strength in both the experimental and control groups increased. However, in the pre-post comparison, significant differences were only observed in the experimental group. Additionally, there were significant differences in muscle strength between the two groups after the experiment ($p < 0.05$). The muscle tone decreased in the experimental group and control group. In the pre-post comparison, significant differences were found only in the experimental group ($p < 0.05$) (Table 2).

Balance

The BBS scores increased in the experimental group and the control group. In the pre-post comparison, significant differences were found only in the experimental group. Significant differences were also found for balance between the groups after the experiment ($p < 0.05$) (Table 2).

Gait

The spatio-temporal gait variables showed significant differences in several variables. In the pre-post comparisons by group, there were significant differences in gait velocity, cadence, step length, and stride length in the experimental group ($p < 0.05$). Comparison between the two groups after the intervention showed significant differences only in gait velocity, step length, and stride length ($p < 0.05$) (Table 3).

Discussion

This study investigated whether AES combined with MT affects lower extremity motor function, balance, and gait in chronic stroke survivors. The results of this study confirmed a potential that AES combined with MT has positive effects on the improvement of muscle strength, balance, and gait in stroke survivors.

Previous studies on MT have suggested that MT can be a promising tool to promote post-stroke motor recovery, movement, muscle strength, agility, and motor function.[10,11] In addition, since the application of MT in stroke survivors, recent studies are investigating the combined use of electrical stimulation with MT. Previous studies have reported that MT training can increase a patient's attention to the limb that is not visible (that is, hemiplegic limbs).[25] Similar to the rationale for constraint-induced movement therapy, it has been reported that the motor network can be activated with the application of MT as the attention to the hemiplegic side limb is increased and the reflected image gives the illusion of the hemiplegic side being "treated".[9] To further maximize this attention to the hemiplegic limbs, Yun et al.[13] stated that combining MT, which is a cognitive intervention, with neuromuscular electrical stimulation, is more effective than applying neuromuscular electrical stimulation alone. The study by Yun et al.[13] suggested that while motor function is improved by neuromuscular electrical stimulation, it is particularly more effective when the stimulation is combined with the cognitive intervention MT. Various other studies have found similar results of improved motor function when combining electrical stimulation with MT.[14,15] The current study examined the effects of AES training combined with MT on the lower limbs, rarely examined in previous studies, by having the subjects perform voluntary ankle joint dorsiflexion of the non-hemiparetic limb during the combined intervention. Ankle joint dorsiflexion was chosen because it is a selective motor control in the lower limb typically affected by stroke.[8] Ankle joint movement training is also known to contribute to brain reorganization.[8]

In the study by Shamay et al.,[26] task-oriented training combined with transcutaneous electrical nerve stimulation (TENS) was applied to ankle joints. A 60-minute session of task-oriented training combined with TENS was implemented 5 times per week for 4 weeks. According to the results, the task-oriented training combined with TENS group and the group that only underwent TENS showed significant improvement on ankle dorsiflexor strength and gait velocity compared to the control group which did not receive any intervention.[26] In the present study, when applying intervention, during the first 30 minutes, the participants performed MT with the ankle dorsiflexion movement using AES, and then during the last 30 minutes, the participants received gait training with AES. These interventions can be considered as task-oriented training. In addition, in the previous study,[26] they reported that the application of TENS for 60 minutes elicited a significant effect on muscle strength. Similar to the previous study, in the present study, the application of AES for 60 minutes had a positive effect on the muscle strength of ankle dorsiflexion. Levin et al.[27] reported that electrical stimulation contributes to muscle strength improvement since the electrical stimulation automatically disinhibits the stretch reflex of spastic muscles and reduces co-contraction. Therefore, it appears that the 60 minutes of AES with the MT implemented in this study had a positive effect on improving muscle strength associated with ankle dorsiflexion.

The present study did not find any changes in muscle tone, a finding similar to that of the study by Sütbeyz et al.[8] As noted by Sütbeyz et al.[8] it is likely that the visual feedback was not sufficient to control or affect muscle spasticity and more complex pathophysiological problems are involved in muscle tone. However, Xu Q et al.[16] reported that MT with neuromuscular electrical stimulation was effective in improving muscle tone in stroke survivors. There was no significant difference on muscle tone in the groups with mirror therapy alone, and there was a significant difference in the group with mirror therapy combined with neuromuscular electrical stimulation. However, in the study by Lee et al.,[17] they used MT with neuromuscular electrical stimulation as an intervention, and there was no significant difference in muscle tone as in the present study. In the study by Xu Q et al.[16], the participants included acute stroke patients with less than 50 days since onset; however, in the study by Lee et al.[17] and the present study, the participants were chronic stroke survivors. This difference seems to have made a difference in the results. Thus, MT with electrical stimulation may not be effective for muscle tension in chronic stroke survivors. However, the participants in the present study had been chronic stroke patients for more than 40 months, and additional studies were needed for subacute stroke patients between 3 months and 6 months.

The studies by Sütbeyz et al.[8] and Lee et al.[17] reported that there was no improvement on gait ability. However, the present study found that AES combined with the MT was effective in improving spatio-temporal gait variables such as gait velocity, step length, and stride length. Normal walking involves complex performance and other factors such as endurance, balance, coordination, and muscle strength. Accordingly, it has been stated that for successful motor learning and to achieve normal gait survivors, interventions should be applied as often as possible.[28,29] Sütbeyz et al.[8] and Lee et al.[17] did not provide gait training to the subjects after MT. However, in the present study, an additional 30 minutes of gait training with AES was provided. This was included because a previous study has suggested that repeated task-specific protocols could induce reorganization.[30] In addition, it has been discussed in a previous study that the lack of effective improvement in gait after MT may be attributed to the MT application duration, and that, for such a complex activity as MT, a 4-week (20 sessions, 10 hours in total) intervention may be too short for significant outcomes. Kwakkel[31] reported that interventions should be applied at least for 16 hours in total and that the amount of exercise affecting the motor function should be considered when determining the intervention application time. Therefore, in the present study, the improvement in gait is attributed to the addition of gait training, which took into account the necessity for sufficient amount of exercise after the AES combined with MT. Moreover, the improvement in step length, stride length, and gait velocity observed in this study may be attributed to the enhanced ankle dorsiflexion muscle strength. In the study by Xu Q et al.,[16] the experimental group that received MT for 30 min for 4 weeks compared to the control group showed a significant improvement in gait velocity. The study by Ji and Kim[12] conducted on stroke survivors also showed improvements in spatio-temporal gait variables, such as single stance, step length, and stride length, after an additional MT of 15 minutes per session for 4 weeks. These findings are similar to the present study results, and furthermore, Ji and Kim explained that the survivors' ability to control motor function of their lower limbs improved after MT.[12] In the study by Xu Q et al., [16] motor function recovery of the lower extremities would have had a positive effect on gait ability. Since there was a significant improvement in gait even when MT was applied for a shorter duration, the study by Ji and Kim further supports the validity of the current study results. However, in both studies that reported a significant improvement of gait ability, the participants were patients with acute stroke of less than 50 days and subacute stroke of less than 6 months.[12,16] These points were different from the present study in that the participants were chronic stroke survivors. Additionally, considering the lack of study on the application of MT to the lower extremity of stroke survivors, it is necessary for future studies to determine the application protocols of MT in terms of its duration and time for effective therapy outcomes.[8]

Regarding balance, a significant difference was found between the experimental group and the control group in the BBS scores after the intervention. It has been reported that MT training can facilitate the mobilization of ipsilateral motor pathways.[32] A normal body moving in front of a mirror transmits information of the moving side to the contralateral brain. However, it has been reported that in MT, information is transmitted to the ipsilateral brain, which is on the hemiplegic side, to vitalize the hemiplegic side. This is a significant rationale to explain motor function recovery in hemiplegic survivors.[33,34] Therefore, although the BBS evaluates dynamic balance, improvements in muscle strength, step length, and stride length, motor function may have positively influenced the change in the BBS scores.

This study is limited in that the intervention period of 4 weeks was relatively short and that the study involved a small number of subjects. Although the sample size was calculated, the statistical power and effect size was not set relatively high. Hence, this point will be considered in the future study. Given these limitations, it is difficult to generalize the study results to all stroke survivors with hemiplegic lower limbs. In addition, change of sensation was not confirmed in this study. As the intervention combining portable MESH Sock and MT, which could be easily used at home, was performed in in-survivors, further research is needed before using the combined intervention as a home-based program. In particular, there is a need to provide a guideline through studies investigating appropriate intervention times. Moreover, the present study did not investigate how the combined intervention influences daily life activities. Nevertheless, the positive effects of AES combined with MT on the improvement of motor function, dynamic balance, and gait in chronic stroke survivors suggested the possibility of the combined intervention as a home-based therapy program. Therefore, it is expected that this combined intervention will be further examined in relevant studies and developed as an intervention for stroke survivors.

Conclusion

The purpose of this study was to investigate the effects of AES combined with MT on lower extremity motor function, balance, and gait in chronic stroke survivors. Through the results of this study, it was confirmed that AES combined with MT improves muscle strength, balance, and gait in stroke survivors. These findings make MT with AES particularly useful as complementary therapy to a home-based rehabilitation program for subjects with chronic stroke. Such a program has the added benefits of being cost-effective and convenient to patients with motor function, balance, and gait impairment.

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Table legend

Table 1. General information of the participants

Table 2. Comparison of motor functions and balance

Table 3. Comparison of gait variables

Figure legend

Figure 1. Flow chart

Figure 2. Afferent electrical stimulation with mirror therapy

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Table 1. General information of the participants

Variables	Experiment group (n=15)	Control group (n=15)	*χ2/t*
Gender (male/female)	11/4	10/5	0.159
Age mean (year)	50.80 (9.00)	50.13 (6.53)	0.232
Height (cm)	168.60 (6.11)	167.13 (7.30)	0.597
Weight (kg)	65.73 (9.12)	67.87 (11.70)	0.557
Paralysis location (Lt./Rt.)	5/10	8/7	0.000
Etiology (hemorrhage/infarction)	10/5	10/5	1.222
Disease duration (month)	41.33 (30.61)	44.87 (31.32)	0.312
MMSE (score)	27.37 (2.09)	27.2 (2.18)	0.598

NOTE. The values are presented as mean (SD)

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Table 2. Comparison of motor functions and balance

Variables	Experiment group (n=15)			Control group (n=15)			*p*
	Pre-	Post-	Variation	Pre-	Post-	Variation	
Muscle strength (lb)	4.17 (1.98)	7.13 (2.80)	2.95 (1.74)[a]	3.41 (2.66)	4.51 (3.89)	1.10 (2.30)	0.043*
Modified Ashworth Scale (Score)	1.53 (0.88)	1.17 (0.78)	-0.37 (0.40)[a]	1.67 (1.14)	1.20 (0.70)	-0.47 (0.88)	0.461
Berg Balance Scale (Score)	46.00 (6.01)	48.13 (5.17)	2.13 (3.48)[a]	38.60 (9.64)	40.27 (9.48)	1.67 (4.01)	0.01*

NOTE. The values are presented as mean (SD).
[a] p<0.05, between pre-test and post-test, *p<0.05, between Experiment group and Control group.

Table 3. Comparison of gait variables

Variables	Experiment group (n=15)			Control group (n=15)			*p*
	Pre-	Post-	Variation	Pre-	Post-	Variation	
Velocity (m/s)	50.16 (26.49)	64.67 (28.45)	14.50 (13.96)[a]	41.26 (24.48)	41.15 (23.30)	-0.10 (7.23)	0.020*
Cadence (step/min)	73.37 (23.21)	85.47 (22.32)	12.09 (8.87)[a]	73.45 (25.37)	73.20 (26.02)	-0.25 (4.31)	0.177
Step length (cm)	39.19 (10.63)	45.17 (11.62)	5.98 (7.51)[a]	35.69 (9.24)	36.47 (7.19)	0.78 (4.60)	0.021*
Stride length (cm)	77.89 (22.37)	86.95 (21.26)	9.06 (12.69)[a]	65.58 (22.98)	66.35 (21.95)	0.76 (8.20)	0.014*
Single support time (sec)	0.37 (0.08)	0.35 (0.06)	-0.01 (0.05)	0.46 (0.43)	0.37 (0.09)	-0.09 (0.44)	0.492
Double support time (sec)	0.95 (0.64)	0.64 (0.36)	-0.31 (0.34)[a]	1.03 (0.84)	1.06 (1.07)	0.03 (0.32)	0.106

NOTE. The values are presented as mean (SD).
[a]p<0.05, between pre-test and post-test, *p<0.05, between Experiment group and Control group.

Appendix. Afferent electrical stimulation with mirror therapy program

Program	Composition	Duration
AES with MT	AES with MT, 30 min AES : 15 minutes, electric stimulation frequency 100 Hz, pulse width at 300 μs, and 15 minutes, electric stimulation frequency 15 Hz, pulse width 300 μs MT : The participants was performed to dorsiflex the ankle joints on the hemiplegic side and on the non-hemiparetic side at the same time while looking at the movement of the non-hemiparetic side reflected in the mirror for 30 minutes while the AES was applied to the hemiplegic side. AES with Gait training, 30 min AES : 15 minutes, electric stimulation frequency 100 Hz, pulse width at 300 μs, and 15 minutes, electric stimulation frequency 15 Hz, pulse width 300 μs Gait training : The participants was performed to walk on a treadmill for 30 minutes while the AES was applied to the hemiplegic side.	1 session 60min / 5 days per week for 4 weeks

AES: Afferent electrical stimulation therapy; MT: mirror therapy

Figure 1. Flow chart