Trunk muscle activity in patients with multiple sclerosis: the influence of body weight support

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Background: Multiple sclerosis (MS) often lead to gait problems. The available literature does not present evidence that body weight supported treadmill training (BWSTT) is more effective than other methods of gait rehabilitation (1, 2). BWSTT (with minimum 30% BWS) reveals a gait pattern with only the lower limbs participate actively. The active dynamic trunk stability - important for the retention of the posture and balance during normal gait - is consequently less well involved in the gait training session. Only limited evidences have been published concerning the influence of BWS on the trunk muscle activity (3, 4). In this study, walking with different BWS levels were compared to a reference walking without BWS. We hypothesized that with increasing BWS levels the muscle activity would decrease due to passive suspension of the trunk in the harness. **Methods:** 14 patients with MS (EDSS-score: 2.5 to 6) and 14 healthy persons walked on a treadmill on different BWS levels (0%, 10%, 20%, 30%, 50% and 70%). After an acclimatization period, EMG measurements with surface electrodes bilaterally placed on the trunk muscles at the level of the m. rectus abdominis, m. obliquusexternus, m. erector spinae and m. multifidus were performed. To synchronize with the gait cycle, an electromagnetic sensor was placed on the left calcaneus. The muscle activation was presented as a percentage of a performance related reference contraction. A repeated measures ANOVA with simple contrasts was used. **Results:** The use of BWS system has an influence on the trunk muscle activity. Comparison of the different BWS levels with the condition of walking without BWS revealed the following general results: in healthy persons, no significant differences in rectus abdominis muscle activity, an increase in obliquusexternus muscle activity (on the left side) and a decrease in back muscle activity was measured with increasing BWS levels. In patients with MS, an increase in abdominal muscle activity and a decrease in back muscle activity was measured with increasing BWS levels.Most of the differences as compared to walking without BWS were found during high percentages (30% to 70%) of BWS. The conditions with 10% and 20%BWS are for trunk muscle activity closer to normal walking. **Conclusion:** Because of this reason we suggest to decrease the percentage BWS as fast as possible beneath the 30% BWS.

Keywords: trunk muscles, body weight support, electromyography, gait, multiple sclerosis.

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Uporaba vidne povratne informacije na sistemu Lokomat pri pacientih z nepopolno okvaro hrbtenjače – pregled literature

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Uvod: Vadba hoje na tekočem traku z delno razbremenitvijo telesne teže je v rehabilitaciji pacientov z nepopolno okvaro hrbtenjače stalna praksa. Pri hoji pacientu pomagata dva, včasih trije fizioterapevti, ki morajo opravljati ergonomsko zahtevno delo. Fizioterapevt pomaga pacientu pri izvedbi korakov, hkrati pa z rokami zaznava njegovo aktivno sodelovanje in mu lahko zaradi tega posreduje primerne napotke za dosego učinkovite vadbe. Napredek tehnologije je v zadnjih desetih letih omogočil razvoj robotskih sistemov za vadbo hoje. Eden takih je Lokomat. Prednosti vadbe hoje z njim so dolgotrajnejša obdobja vadbe, pravilen vzorec hoje in zmanjšanje števila potrebnih fizioterapevtov. Ena izmed slabosti je odsotnost fizioterapevtovega vodenja z dotikom. Lokomat ima v pogone za kolka in koleni vgrajene senzorje sil, ki ves čas med hojo zaznavajo pacientovo aktivno sodelovanje ali njegovo odsotnost. Pacient na zaslonu pred seboj dobiva povratne informacije o izvedbi korakov v smeri fleksije in ekstenzije kolkov in kolen v različnih oblikah, ki jih izbere s fizioterapevtom. **Metode:** Pregledali smo literaturo s področja uporabe Lokomata v kombinaciji z vidno povratno informacijo pri pacientih z nepopolno okvaro hrbtenjače. Iskali smo jo s podatkovno bazo PubMed. **Rezultati:** Ugotovili smo, da je literature z omenjenega področja malo. Splošno sprejeto je, da povratna informacija učinkovito pospeši motorično učenje, naj jo zagotovi strokovnjak ali naprava (1). Mišična aktivnost, opazovana z elektromiografijo, se poveča z upoštevanjem povratnih informacij o izvedbi korakov, ki jih pacienti dobijo na zaslonu, pri uporabi ogledala, pri hoji v navideznem okolju ali z verbalnimi spodbudami (2). Raziskovalci ugotavljajo, da je učinkovitost vadbe hoje z vidno povratno informacijo v obliki grafov enakovredna verbalnim spodbudam (3). Vendarle pa z vrednostmi, ki jih pacienti dosežejo na zaslonu, ni mogoče zaznavati napredka pri hoji (4). **Zaključki:** Koncept k nalogi usmerjene ponavljajoče se vadbe predlaga, da bi bile povratne informacije podajane med funkcijskimi aktivnostmi (5), kar nam Lokomat omogoča. Potrebne so nadaljnje raziskave, ki bi potrdile ali ovrgle hipotezo, da je sistem za podajanje vidnih povratnih informacij, ki je dodan k Lokomatu, učinkovit pripomoček za izboljšanje različnih vidikov hoje.

Ključne besede: hoja, robotika, povratna informacija, poškodba hrbtenjače, rehabilitacija.

The use of visual feedback with the system Lokomat in patients with incomplete spinal cord injury – literature review

Background: Treadmill training with partial body weight support is a common practice in rehabilitation of patients with incomplete spinal cord injury. A patient needs assistance of two or three physiotherapists that need to do ergonomically demanding task. A physiotherapist helps the patient during walking and at the same time feels his participation. That is how adequate guidance can be provided to the patient to achieve effective training. Advances in technology in past ten years enabled development of robotic systems for gait training. Lokomat is one of them. Advantages of gait training with the Lokomat are longer training periods, regular gait pattern and fewer physiotherapists needed for training. One of the disadvantages is absence of physical contact between a patient and a physiotherapist. Lokomat has built-in force sensors that perceive active participation of the patient or absence of it. On the screen in front the patient receives feedback about active participation in hip and knee joints in flexion and extension. The feedback comes in different forms that are selected in cooperation with the patient. **Methods:** We reviewed literature about the use of Lokomat in combination with visual feedback in patients with incomplete spinal cord injury. We searched it with database PubMed. **Results:** We found out the lack of literature. It is generally accepted, that feedback effectively facilitates motor learning, if provided by an expert or a machine (1). Muscle activity observed with electromyography is increased with feedback about gait, no matter what the form of the feedback is; on the screen, with mirror, in virtual reality or with verbal stimulus (2). The effectiveness of gait training is the same comparing visual feedback in the form of graphs and verbal stimulus (3). However, the values reached by the patient on the screen cannot be a measure of progress in gait training (4). **Conclusions:** The concept of task-oriented training suggests that the feedback should be delivered to the patient during functional activities (5). This is what the Lokomat enables. There is the need for further research, which would confirm or deny the hypothesis, that the Lokomat with integrated feedback system is an efficient tool for improving different aspects of gait.

Keywords: gait, robotics, feedback, spinal cord injury, rehabilitation.

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Učinki vadbe hoje z različnimi fizioterapevtskimi postopki, vključno s sistemom Lokomat, pri pacientki z dedno spastično paraparezo – poročilo o primeru

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Uvod: Poškodbe in obolenja živčnega sistema pogosto vplivajo na pacientovo sposobnost hoje. Eden glavnih ciljev rehabilitacije nevroloških pacientov je ponovno učenje hoje. Cilj fizioterapije je izboljšati funkcijo hoje z različnimi fizioterapevtskimi postopki (1). Vadba temelji na motoričnem učenju, učinki pa so odvisni od specifičnosti naloge, intenzivnosti vadbe in trajanja. V prispevku so predstavljeni učinki vadbe hoje z različnimi fizioterapevtskimi postopki, vključujoč vadbo hoje s sistemom Lokomat, na funkcijo hoje pri pacientki z dedno spastično paraparezo. **Metode dela:** 53-letna pacientka z diagnozo dedne spastične parapareze je bila sprejeta na programe rehabilitacije. Pred dvema letoma je prišlo pri pacientki do poslabšanja hoje v smislu vedno manj zanesljive hoje, zanašanja, težje je hodila po klancu in stopnicah navzdol. Brez dodatne opore je lahko hodila od 50 do 100 metrov. Namen fizioterapije je bil izboljšati funkcijo hoje (doseči varnejšo hojo in izboljšati vzorec hoje). Vadba hoje je obsegala 15 obravnav, in sicer po 30 minut z različnimi fizioterapevtskimi postopki, ki so vključevali hojo po različnih podlagah (mehke blazine, hrapava tla), v različnih smereh in z različno hitrostjo ter hojo po stopnicah in 30 minut vadbe hoje na sistemu Lokomat (2). Pred začetkom in po obravnavah je bila ocenjena z Bergovo lestvico za oceno ravnotežja, testom hitrosti hoje na 10 metrov, časovno merjenim testom vstani in pojdi in 6-minutnim testom hoje. Narejena je bila tudi kineziološka analiza hoje (3). **Rezultati:** Pri pacientki so se po obdobju vadbe izboljšali ravnotežje na Bergovi lestvici (s 53 na 56 točk), čas pri časovno merjenem testu vstani in pojdi (z 21 na 10 sekund), hitrost hoje (z 21 na 9 sekund) in vzdržljivost pri hoji (129 m več). Kineziološka analiza hoje je potrdila, da sta se po obdobju vadbe občutno povečala hitrost hoje (za 0,20 m/s) in dolžina koraka (z levo nogo je bil korak daljši za 0,11 m, z desno za 0,09 m). Povečalo se je tudi število korakov (s 86 korakov/min na 93 korakov/min). Dolžina dvojne opore se je zmanjšala za 0,22 sekunde, enojne opore pa povečala za 0,07 sekunde. Hoja je bila še vedno toga, z zmanjšanimi obsegi gibljivosti v vseh sklepih. **Zaključki:** Vadba hoje z različnimi fizioterapevtskimi postopki, vključno s sistemom Lokomat, je pri pacientki z dedno spastično paraparezo pripomogla k izboljšanju hitrosti in vzdržljivosti pri hoji ter k varnejšemu spreminjanju smeri hoje. V terapevtskem in bolnišničnem okolju je pacientka varneje hodila, sama pa ni opazila vidnejših sprememb v sposobnosti hoje.

Ključne besede: dedna spastična parapareza, hoja, nevrofizioterapija, Lokomat.

Effect of gait training with conventional physiotherapy and Lokomat system in a patient with hereditary spastic paraparesis – a case report

Background: Injuries and diseases of the nervous system often affect the patient's ability for walking. One of the main goals of rehabilitation in neurological patients is relearning of walking. The aim of physiotherapy is to improve walking with different physiotherapeutic interventions. A treatment is based on motor learning, task-oriented training, intensive and repetitive training (1). The article presents the effectiveness of robotic assisted gait training – Lokomat (2) with conventional physiotherapy on the gait function in a patient with hereditary spastic paraparesis. **Methods:** A 53-year-old patient with hereditary spastic paraparesis was included in the rehabilitation programs. Two years ago her walking worsened. She had difficulties with maintaining her balance, walking downhill and down the stairs. She was able to walk from 50 to 100 meters without support. The purpose of the gait training was to improve the gait function (walking pattern and to achieve safer walk). The patient was included in fifteen treatment sessions. Treatment session included 30 minutes of conventional physiotherapy (gait training on different surface, walking in different directions and velocity) and 30 minutes of robot-assisted gait training (Lokomat). The patient was evaluated before and after the fifteen treatment sessions. Primary outcomes were Berg balance scale, gait velocity with 10-meter walk test, timed up and go and 6-minute walk test. The kinesiologic gait analysis was also made. **Results:** The balance improved from 53 to 56 points measured with Berg balance scale. The 10- meter walk test improved from 21 seconds to 9 seconds. Up and go test improved from 21 seconds to 10 seconds and the patient was able to walk 129 meters farther than before the treatment. Kinesiologic gait analysis after the therapeutic treatment showed significant increase of walking speed by 0.20 m/s and the length of the step: left foot for 0.11 m, right foot for 0.09 m. The number of steps also increased after the therapeutic treatment: from 86 steps/min to 93 steps/min. The length of the double support was reduced by 0.22 seconds, single support increased by 0.07 seconds. The range of motion was still limited in all joints and the gait was still rigid. **Conclusions:** Five weeks of robot-assisted gait training with Lokomat and conventional physiotherapy improves gait speed, walking distance, the changing of walking direction is safer. The patient reported no visible changes in the gait function.

Keywords: hereditary spastic paraparesis, walking, neurophysiotherapy, Lokomat.

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Ugotavljanje razumljivosti in ocena skladnosti med ocenjevalci za slovenski prevod lestvice za oceno funkcionalne hoje (FGA) pri pacientih po možganski kapi

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Uvod: Pri osebah po preboleli možganski kapi so zelo pogosto prisotne motnje ravnotežja, ki pomembno vplivajo tudi na sposobnost hoje in tveganje za padce (1). Ocena funkcionalne hoje (angl. Functional gait assessment – FGA) je ena redkih ocenjevalnih lestvic, ki omogoča ocenjevanje ravnotežja med hojo. Vsebuje deset nalog, ki vključujejo hojo po ravnem, spremembo hitrosti hoje, hojo z obračanjem glave horizontalno, hojo z nagibi glave vertikalno, hojo in obrat na mestu, prestopanje ovire, hojo na zmanjšani podporni ploskvi, hojo z zaprtimi očmi, hojo nazaj in hojo po stopnicah (5). Namen predstavljene študije je bilo ugotoviti skladnost med ocenjevalci, ki so uporabljali slovenski prevod FGA pri pacientih po možganski kapi. **Metode:** Pet ocenjevalcev (4 fizioterapevti z 10- do 20-letnimi delovnimi izkušnjami na področju rehabilitacije po možganski kapi ter 1 študentka fizioterapije) je pol ure pred predvidenim začetkom ocenjevanja dobilo ocenjevalne protokole z navodili za ocenjevanje. Sledilo je samostojno preučevanje testa brez možnosti diskusije. Nato so se ocenjevalci razporedili na statična mesta za opazovanje vzdolž poligona. Dva ocenjevalca in fizioterapevt, ki je preiskovancem demonstriral naloge, dajal ustna navodila in spremljal preiskovance med hojo, so imeli štoparice. Ocenjevalci so po lestvici FGA hkrati ocenili vsakega izmed desetih pacientov po možganski kapi, ki so bili sposobni brez pomoči in čezmernega utrujanja prehoditi vsaj 6 metrov. Demonstraciji posamezne naloge je sledil testni poizkus in nato poizkus, ki je bil vrednoten s točkami od 0 do 3 glede na hitrost in kakovost izvedbe ter obseg motenj ravnotežja. Dobljeni podatki so bili obdelani s programom SPSS, razlike med ocenjevalci glede povprečne ocene smo preizkusili z enosmerno analizo variance za ponovljene meritve. Skladnost med ocenjevalci smo ocenili z intraklasnim korelacijskim koeficientom (dvosmerni naključni model za posamezno meritev – ICC (2,1), oblika za absolutno skladnost (2) in prikazali s črtnim diagramom (3, 4). **Rezultati:** ICC je znašal 0,984. Med ocenjevalci ni bilo statistično značilne razlike v povprečni oceni (analiza variance za ponovljene meritve: $p = 0{,}190$). **Zaključki:** V primerjavi z drugimi podobnimi študijami (5, 6) smo pri slovenskem prevodu lestvice FGA ugotovili odlično skladnost ocenjevalcev, zato ga bomo na oddelku po možganski kapi uporabljali kot eno izmed metod ocenjevanja funkcionalnosti hoje in dinamičnega ravnotežja. Z nadaljnjim delom bomo poskušali natančneje opredeliti vrsto dejavnikov in stopnjo njihovega vpliva na nepravilnosti pri hoji.

Ključne besede: ocenjevanje hoje, ravnotežje, rehabilitacija, veljavnost in zanesljivost, možganska kap.

Evaluation of comprehensibility of Slovenian translation of Functional Gait Assessment (FGA) and conformity among raters in patients after stroke

Background: Balance impairments are a frequent consequence of cerebral stroke which can impair the patient's walking abilities and increase the risk of falls (1). The Functional gait assessment (FGA) scale is one of the few measuring scales that enable the assessment of balance during gait. It consists of 10 tasks including gait on level surface, change in gait speed, gait with horizontal head turns, gait with vertical head turns, gait and pivot turn, stepping over obstacle, gait with narrow base of support, gait with eyes closed, ambulating backwards and gait on steps (5). The aim of the study was to determine internal consistency among raters using Slovenian translation of FGA in patients after stroke. **Methods**: Five raters (4 licensed physical therapists with 10-20 years of experience in rehabilitation of patients after stroke, and 1 physiotherapy student), received instructions for the assessment half an hour before the testing and studied the instructions independently without questions or discussion. Then they positioned themselves at equal interval along both sides of the walkway and simultaneously used the FGA to evaluate each of the ten persons after stroke that were able to walk at least 6 m without assistance or fatigue. Individual tasks were demonstrated and then performed by the subjects firstly as a test trial and secondly as a trial evaluated on a scale from 0 to 3 in relation to the speed and quality of activity and the severity of balance deficit. The collected data were analyzed with SPSS, the differences among the raters in relation to the average score were tested with one-way analysis of variance for repeated measures. The conformity among the evaluators was assessed with intraclass correlation coefficient - Two-way random single measure ICC (2, 1) – Consistency/Absolute Agreement (2) and illustrated on a line diagram (3, 4). **Results**: Similarly to other comparable studies (5, 6) the consistency among raters using the Slovenian translation of FGA was found to be excellent. **Conclusions:** The Slovenian translation of FGA will therefore be used at the department for rehabilitation after stroke as one of the methods for assessment of gait functionality and dynamic balance. In our further activities we intend to define the type of factors and the level of their effect on gait anomalies.

Keywords: gait assessment, balance, rehabilitation, validity and reliability, stroke.

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Ocena skladnosti med ocenjevalci za slovenski prevod krajše različice testa za oceno sistemov ravnotežja (mini-BESTest) pri pacientih po možganski kapi

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Uvod: Ravnotežje je ključno za delovanje gibalnega sistema in izvajanje večine dejavnosti vsakdanjega življenja (1). Če opredelimo vzrok motnje ravnotežja pri posameznem pacientu, lahko izboljšamo učinkovitost vadbe ravnotežja. Ena izmed pomembnejših ocenjevalnih lestvic za sistemsko klinično ocenjevanje ravnotežja je test za oceno sistemov ravnotežja (angl. Balance Evaluation Systems Test – BESTest) (2). Ocenjuje 36 nalog, ki so razdeljene v šest kategorij, kar nam pomaga pri določanju vzrokov motnje ravnotežja. Glavna omejitev te ocenjevalne lestvice je poraba časa, ocenjevanje traja od 30 do 45 min. Zaradi tega so razvili krajšo različico, tako imenovani mini-BESTest (3). Vključuje le 14 nalog (ocene od 0 do 2) in se lahko izvede v približno 15 minutah. Je zanesljiv, veljaven in ponovljiv (3). Namen: Oceniti skladnost med ocenjevalci pri uporabi mini-BESTest v slovenskem prevodu pri pacientih po možganski kapi. **Metode:** Pet ocenjevalcev je hkrati ocenjevalo istega pacienta, skupaj so ocenili 10 pacientov z motnjami ravnotežja po možganski kapi. Ocenjevalci so bili diplomirani fizioterapevti z 10- do 20-letnimi delovnimi izkušnjami na področju rehabilitacije pacientov po možganski kapi. Nobeden izmed njih še ni izvajal testa. Navodila so dobili uro pred začetkom ocenjevanja. Pri vsakem preiskovancu so ocenili vseh 14 nalog. Skladnost med ocenjevalci smo ocenili z intraklasnim korelacijskim koeficientom (dvosmerni naključni model za posamezno meritev – ICC (2, 1), oblika za absolutno skladnost (4); in prikazali s črtnim diagramom (5, 6). Razlike med ocenjevalci glede povprečne ocene smo preizkusili z enosmerno analizo variance za ponovljene meritve. **Rezultati:** Povprečna ocena posameznega ocenjevalca se je gibala med 18,6 (standardni odklon: 14,2) in 19,7 (standardni odklon: 14,5). ICC je znašal 0,96. Med ocenjevalci ni bilo statistično značilne razlike v povprečni oceni (analiza variance za ponovljene meritve: $p = 0,190$). **Zaključki:** Slovenski prevod mini-BESTest je razumljiv, po izsledkih naše študije je skladnost med ocenjevalci odlična. Na oddelku za rehabilitacijo bolnikov po možganski kapi URI – Soča smo ga začeli uporabljati poleg drugih kliničnih testov za ocenjevanje ravnotežja, da bi izboljšali učinkovitost terapevtskih ukrepov.

Ključne besede: slovenski prevod, Mini BESTest, ravnotežje, možganska kap.

Assessment of conformity among raters using Slovenian translation of the short version of Balance evaluation systems test (mini-BESTest) in patients after stroke

Background: Balance is essential for functioning of the motor system and performance of most daily activities (1). With identifying the cause of balance deficit in individual patients, the efficiency of balance training can be improved. One of the most important evaluation scales for systemic clinical balance assessment is Balance evaluation systems test (BESTest) (2). The test evaluates 36 different tasks divided into six different categories and is aimed at identifying the causes of balance disorder. The main shortcoming of the test is its length – the evaluation takes from 30 to 45 minutes. For that reason, a shorter version has been developed, the so called mini-BESTest (3). The later includes only 14 tasks and can be done in about 15 minutes. Aim: To assess conformity among raters when using the Slovenian translation of mini-BESTest. **Methods**: Five raters simultaneously assessed the same patient; a total of 10 patients with balance disorder after stroke were assessed. The raters were certified physical therapists with 10 to 20 years of work experience in the field of rehabilitation of patients after stroke. None of the raters had used the test before. The instructions were given one hour before the assessment. In each subject, 14 tasks were evaluated on a scale from 0 to 3. The conformity among the raters was assessed with intraclass correlation coefficient - Two-way random single measure ICC (2, 1) – Consistency/Absolute Agreement (4); and then illustrated on a line diagram (5, 6). The difference among the raters in relation to the average score was tested with one-way analysis of variance for repeated measures. **Results:** The ICC was 0.962. The difference among the raters in relation to the average score was not statistically significant (repeated measures ANOVA: p=0.190). The average score of individual raters ranged from 18.6 (st. deviation 14.2) to 19.7 (st. deviation 14.5). **Conclusions:** Different authors found mini-BESTest reliable, valid and repeatable (3). The Slovenian translation of mini-BESTest is comprehensible, and the present study has shown excellent conformity among the raters. It is used beside other clinical tests for balance assessment at University Rehabilitation Institute, Republic of Slovenia department for rehabilitation of patients after stroke with the purpose of improving the efficiency of therapeutic interventions.

Keywords: Slovenian translation, mini-BESTest, balance, stroke.

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