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Gait Analysis and Electrodynogram

Number: 0263

Policy

Please see amendment for Pennsylvania Medicaid at the end of this CPB.

Aetna considers gait analysis (also known as motion analysis studies), dynamic electromyography or the use of an electrodynogram experimental and investigational for conditions that result in gait deviations and for all other indications because there is insufficient peer-reviewed medical literature demonstrating the clinical value of these technologies.

See also CPB 0294 - Pedobarograpghy (0294.html) .

Background

Also known as motion analysis, gait analysis is a systematic evaluation of the dynamics of gait (walking and walking patterns). The standard method of gait analysis is by observational assessment (without the use of any computers or computer programs); focuses on motion of the hips, knees, ankles and feet throughout the gait.

Policy History

Last Review

06/11/2019

Effective: 06/18/1998

Next

Review: 02/27/2020

Review History

Definitions

Additional Information

Clinical Policy Bulletin

Notes

Several investigators have advocated the use of gait analysis for planning surgery and therapy treatments for children with cerebral palsy (CP). Although their rationale appears sound, it has not been supported by clinical outcome studies demonstrating its efficacy beyond visual analysis of gait abnormalities routinely performed by clinicians.

An assessment conducted by the BlueCross BlueShield Association Technology Evaluation Center (2002) concluded that "[t]he evidence does not permit conclusions on whether the use of gait analysis for evaluation of children with cerebral palsy improves health outcomes or is as beneficial as established alternatives." The assessment noted that several studies have reported that treatment decisions were affected by the results of gait analysis; these studies, however, do not demonstrate whether clinical outcomes were improved by basing treatment decisions on gait analysis. The assessment identified only 1 study that directly addressed the question of whether gait analysis improves patient outcomes, compared with standard clinical assessment. This retrospective study (Lee et al, 1992) reported on the outcomes of 23 children with CP, 15 of whom were treated according to the recommendation of gait analysis data plus clinical assessment, and 8 of whom were treated according to clinical assessment alone. Of the 7 children who were classified as not improved, 5 had been treated according to clinical assessment alone. The TEC assessment noted several problems with this study, including small numbers of study subjects, lack of consideration of confounding factors, and vague definition of outcomes. Most important, however, it was not reported whether children analyzed as treated according to gait analysis data underwent treatments discordant with the recommendations of clinical assessment alone or in agreement with clinical assessment alone (BCBSA, 2002). The TEC assessment notes that, if it is the latter, then the study is severely flawed and can not be used to compare clinical assessment and gait analysis. The TEC assessment concluded that, "[i]n the absence of any well-designed observational or randomized controlled trials, no conclusion can be drawn about whether gait analysis in the clinical evaluation and treatment of cerebral palsy has an effect upon health outcomes."

Gait analysis studies that have been published since the TEC assessment was released suffer from similar limitations as previous studies, in that they have not included outcomes of internal comparison groups of children with CP who were managed based on clinical assessment alone. Comparisons of outcomes between studies (i.e., comparisons of outcomes of studies where gait analysis was used with studies where gait analysis was not used) is problematic due to confounding factors that may account for differences in outcomes (such as differences in surgical technique and experience, characteristics of study subjects, methods of assessing outcomes, etc.).

Several studies have reported that treatment decisions are affected by the results of gait analysis (Lofterod et al, 2007; Kay et al, 2000; Molenaers et al, 2006; Wren et al, 2005); these studies, however, do not demonstrate whether clinical outcomes are improved by basing treatment decisions on gait analysis. Similarly, studies examining correlations (or the lack thereof) between clinical measurements and quantitative gait analysis (Desloovere et al, 2006; Kawamura et al, 2006) do not prove that the quantitative measurements provided by gait analysis alter the management of patients such that clinical outcomes are improved.

One small retrospective study evaluated the impact of computerized gait analysis on clinical outcomes (Chang et al, 2006). The study included 10 patients with CP and 10 age- and sex-matched controls. Children in the control group chose not to follow the gait analysis recommendation and chose a non-surgical treatment approach, whereas children in the gait analysis group followed a physician's recommendation for gait analysis. The results documented that 74 % of patients in the control group had no change or a negative outcome, 26 % in the control group had a positive outcome. Of the gait analysis group 61 % had no change or a negative outcome, while 44 % of this group had a positive outcome. While the results of this study suggest that gait analysis recommendations may improve clinical outcomes, the control group did not undergo surgery, whereas those in the gait analysis group did. Therefore, it is not possible to determine the relative contributions of gait analysis and surgery.

A study by Wren et al (2009) is a retrospective analysis of numbers of procedures and costs in children whose surgery was planned by gait analysis and those whose surgery was performed without gait analysis. The investigators found no significant differences overall in total numbers of procedures and costs between the 2 groups. Limitations of the study include its retrospective nature and lack of randomized assignment. Since the study was retrospective, the authors were unable to assess other outcomes such as function, participation, and quality of life, which are important outcomes that need to be examined in future prospective studies.

Dobson and colleagues (2007) evaluated the validity of existing classifications of gait deviations in children with CP. The authors noted that numerous efforts have been made to develop classification systems for gait in CP to assist in diagnosis, clinical decision-making and communication. The authors examined the internal and external validity of gait classifications in 18 studies, including their sampling methods, content validity, construct validity, reliability and clinical utility. The authors found that half of the studies used qualitative pattern recognition to construct the gait classification and the remainder used statistical techniques such as cluster analysis. Few adequately defined their samples or sampling methods. The authors found that most classifications were constructed using only sagittal plane gait data, and that many did not provide adequate guidelines or evidence of reliability and validity of the classification system. No single classification addressed the full magnitude or range of gait deviations in children with CP. The authors concluded that, although gait classification in CP can be useful in clinical and research settings, the methodological limitations of many classifications restrict their clinical and research applicability.

Lofterod and Terjesen (2008) evaluated the outcome of orthopedic surgery in ambulant children with CP, when the orthopedic surgeons followed the recommendations from pre-operative 3-dimensional gait analysis. A total of 55 children (mean age of 10 years and 11 months) were clinically evaluated by orthopedic surgeons who proposed a surgical treatment plan. After gait analysis and subsequent surgery, 3 groups were defined. In group A, there was agreement between clinical proposals, gait analysis recommendations, and subsequent surgery in 128 specific surgical procedures. In group B, 54 procedures were performed based on gait analysis, although these procedures had not been proposed at the clinical examination. In group C, 55 surgical procedures that had been proposed after clinical evaluation were not performed because of the gait analysis recommendations. The children underwent follow-up gait analysis 1 to 2 years after the initial analysis. The kinematic results were satisfactory, with improvement in most of the gait parameters in children who had undergone surgery and no significant deterioration in those who were not operated. In group A, there were significant improvements in maximum hip extension in stance, minimum knee flexion in stance, timing of maximum knee flexion in swing and knee range of motion (ROM), maximum ankle dorsiflexion in stance, and mean femur rotation in stance. In group B, there were significant improvements in maximum hip extension in stance, minimum knee flexion in stance, and knee ROM. The authors concluded that gait analysis was useful in confirming clinical indications for surgery, in defining indications for surgery that had not been clinically proposed, and for excluding or delaying surgery that was clinically proposed. The findings of this study need to be validated by well-designed studies.

An additional important factor that limits the ability to interpret the evidence on gait analysis is the fact that the technical parameters, diagnostic variables, and outcome measures vary among studies. Some of the differences included the number and placement of video cameras, reflective markers, and force plates; number and type of gait parameters that are measured; and variations in the use of electromyography (EMG) data. Study participants are heterogenous with regard to the type of gait disorder and clinical history. Studies of the impact of computerized gait analysis on patient management evaluated different types of surgical procedures, and varied in the number and type of muscles that were operated on. In addition, few studies include follow-up data.

Narayanan (2007) reviewed the scientific literature to describe the role of gait analysis in the orthopedic management of ambulatory children with CP and examined the current best evidence to support these roles. The author stated that although gait analysis has been shown to alter decision making, there is little evidence that the decisions based on gait analysis lead to better outcomes. Consequently, clinical gait analysis remains controversial, with wide variation in the rates of utilization of gait analysis in the management of children with ambulatory CP. The author stated that the time is ripe for clinical trials and cohort studies to provide the evidence to establish the appropriate utilization of this technology.

Randomized controlled clinical trials to compare outcomes of surgery planned with and without gait analysis are currently ongoing. One of these studies, sponsored by the Federal Agency for Healthcare Research and Quality (AHRQ) and conducted at 2 children's hospitals in Los Angeles, has been completed, and its results (Wren, et al., 2012) are reported below. The AHRQ explained why this study is needed: "Gait analysis testing has been used to assist orthopedic surgeons in developing treatment plans for children with gait abnormalities, particularly children with cerebral palsy. Previous studies have shown that gait analysis testing significantly impacts surgical decision-making for these patients. However, no controlled studies have been done to determine whether gait analysis and the subsequent changes in surgical decision-making affect clinical outcomes. Consequently, the use of gait analysis in clinical practice remains controversial. The purpose of this study is to conduct a randomized controlled trial to assess the effects of preoperative gait analysis on surgical outcomes in ambulatory children with cerebral palsy" (AHRQ, 2005).

Another randomized controlled clinical study of gait analysis, funded by the Canadian government, is being conducted at 2 children's hospitals in Toronto. The study description explains the need for this trial: "Pre-operative planning is based on the physical examination and visual (observational) analysis of the child's gait. In some centres, patients undergo additional gait analysis in a motion laboratory. While gait laboratory analysis is accepted as an important research tool, there is controversy about its clinical utility in decision making for the surgical management of this population. To date, no clinical trials have been undertaken to answer this question, and the appropriate clinical utilization of this technology is yet to be established. The consequence of this uncertainty is that ambulatory children with cerebral palsy are either being deprived of a useful assessment tool in some centres, or alternatively they are being subjected to an unnecessary evaluation that is both expensive and time consuming in other centres" (Hospital for Sick Children, 2007). Both of these randomized controlled clinical trials will examine the impact of gait analysis on a number of parameters, the most important of which relate to clinical outcomes (i.e., improvements in function and quality of life), as opposed to intermediate outcomes.

Maquet and colleagues (2010) evaluated gait characteristics during simple and dual task in patients with mild cognitive impairment (MCI) and compared them with those of healthy elderly subjects and mild Alzheimer's disease (AD) patients. These researchers proposed a gait analysis to appreciate walking (simple task and dual task) in 14 MCI, 14 controls and 6 AD subjects who walked at their preferred speed. A 20-second period of stabilized walking was used to calculated stride frequency, stride length, symmetry and regularity. Speed walking was measured by electrical photocells. Variables measured during simple and dual tasks showed an alteration of motor function as well in mild AD patients as in MCI patients. The authors concluded that at the end of this preliminary study, they defined a specific gait pattern for each cognitive profile. They stated that further researches appear necessary to enlarge the study cohort. Furthermore, in a review on clinical gait analysis, Chapin (2010) stated that additional research documenting the value of incorporating clinical gait analysis in the treatment planning process may ultimately change the payment patterns of insurers.

Ornetti and colleagues (2010) stated that kinematic gait analysis consisting of measuring gait parameters (e.g., dynamic joint angles, gait speed, and stride length) is a potential outcome measure in osteoarthritis (OA). These investigators evaluated the psychometric properties of gait analysis. A systematic literature search was performed in PubMed and the Cochrane database until January 2008 by selecting manuscripts assessing any psychometric property of gait analysis in knee or hip OA. These researchers assessed feasibility (access, cost, and time); reliability; discriminant capacity by differences between OA and non-OA patients; construct validity by correlation between gait analysis and OA symptoms: pain or functional disability (Lequesne/WOMAC); and responsiveness by improvement of gait analysis after treatment of OA using effect size. Among the 252 articles identified, the final analysis included 30 reports (i.e., 781 knee OA patients and 343 hip OA patients). Gait analysis presents various feasibility issues and there was limited evidence regarding reliability (3 studies; 67 patients). Discriminant capacity showed significant reduction of gait speed, stride length and knee flexion in OA patients compared to healthy subjects. Few data were available concerning construct validity (3 studies; 79 patients). Responsiveness of gait speed was moderate to large with effect size ranging respectively from 0.33 to 0.89 for total knee replacement, and from 0.50 to 1.41 for total hip replacement. The authors concluded that available data concerning validity and reliability of kinematic gait analysis are insufficient to date to consider kinematic parameters as valuable outcome measures in OA. They stated that further studies evaluating a large number of patients are needed.

Calhoun et al (2011) compared kinematic and kinetic gait patterns in children with autism versus age-matched controls. A total of 12 children with autism and 22 age-matched controls participated in the study. An 8-camera motion capture system and 4 force plates were used to compute joint angles and joint kinetics during walking. Parametric analyses and principal component analyses were applied to kinematic and kinetic waveform variables from the autism and control groups. Group differences in parameterization values and principal component scores were tested using 1-way ANOVAs and Kruskal-Wallis tests. Significant differences between the autism and control group were found for cadence, and peak hip and ankle kinematics and kinetics. Significant differences were found for 3 of the principal component scores: (i) sagittal ankle moment principal component one, (ii) sagittal ankle angle principal component one, and (iii) sagittal hip moment principal component two. Results suggest that children with autism demonstrate reduced plantar-flexor moments and increased dorsiflexion angles, which may be associated with hypotonia. Decreased hip extensor moments were found for the autism group compared to the control group, however, the clinical significance of this result is unclear. This study has identified several gait variables that were significantly different between autism and control group walkers. This is the first study to provide a comprehensive analysis of gait patterns in children with autism. The role of gait analysis, if any, in the managment of children with autism has yet to be established.

The American Association of Electrodiagnostic Medicine/American Academy of Physical Medicine and Rehabilitation's technology review on "Dynamic electromyography in gait and motion analysis" (1999) concluded that "its utility in pre-operative planning has not been proven in well-designed, large, multi-center studies. There remains many legitimate differences of opinion as to the relative benefits of surface versus fine-wire techniques that future studies will need to resolve. Also in doubt is the best way of determining onset of electrical activity and other technical variables. Dynamic EMG, as part of comprehensive motion analysis, has found applications in the optimization of athletic performance. The subjects in these studies are not patients in the classic sense and did not necessarily carry any type of medical diagnosis".

A randomized controlled clinical trial (Wren et al, 2013) found no significant difference in primary outcome measures and most secondary outcome measures with use of gait analysis in cerebral palsy surgery. This study examined the impact of gait analysis on surgical outcomes in 156 ambulatory children with CP through a randomized controlled trial. Patients underwent gait analysis and were randomized to 2 groups: (i) Gait Report group (n = 83), where the referring surgeon received the patient's gait analysis report, and (ii) Control group (n = 73), where the surgeon did not receive the gait report. Outcomes were assessed pre- and 1.3 + 0.5 years post-operatively. An intent-to-treat analysis compared outcomes between the 2 groups. The primary outcome measures were the walking scale of the Gillette Functional Assessment Questionnaire (FAQ), the Gait Deviation Index (GDI), and the oxygen cost of walking (O2 cost). Secondary outcome measures included the gross motor function measure (GMFM-66) and health-related quality of life questionnaires (Child

Health Questionnaire (CHQ), Pediatric Outcomes Data Collection Instrument (PODCI), and Pediatric Evaluation and Disability Inventory (PEDI). The outcomes that differed significantly between groups were change in health component of the CHQ, which was rated as much better for 56 % (46/82) of children in the Gait Report group compared with 38 % (28/73) in the Control group ($p = 0.04$), and the upper extremity physical function component of the PODCI. There were no significant differences in outcomes between the Gait Report group and the Control group in the primary outcome measures: the FAQ, the GDI, and O2 cost. There were also no significant differences in most secondary outcomes, including the GMFM-66, all four components of the PEDI, and components of the CHQ other than change in health (i.e., global health, physical functioning, role/social limitations - physical, pain/discomfort, self esteem, general health perception, parental impact - emotional, and parental impact - time), and components of the PODCI other than upper extremity physical function (i.e., sports/physical function, transfer/basic mobility, pain/comfort, and global functioning). The authors posited that one potential reason for the lack of difference between the Gait Report group and the Control group for most measures was because surgeons who received gait reports followed the report recommendations less than half (42 %) of the time.

In a cohort study, Chow and colleagues (2012) examined the velocity-dependent change in medial gastrocnemius (MG) activity during the stance phase of gait in patients with moderate-to-severe resting hypertonia after stroke or traumatic brain injury (TBI). Convenience sample of patients with chronic TBI and stroke ($n = 11$ each), and age- and sex-matched healthy controls ($n = 22$). Main outcome measures included frequency and gain (steepness) of positive (greater than 0) and significant positive (greater than 0 and goodness of fit $p \leq 0.05$) electromyogram-lengthening velocity (EMG-LV) linear regression slope in MG during the stance phase of gait. Positive and significant positive slopes were found significantly more often on the more affected (MA) than less affected (LA) side in patients with TBI but not stroke. Both the frequencies of positive and significant positive slopes on the MA side in patients with TBI were also significantly higher than in controls. However, neither the gain of positive nor significant positive EMG-LV slope was different between the MA and LA sides or in comparison with controls. Positive slope parameters were not related to Ashworth score on the MA side. The authors concluded that the frequency and gain of positive EMG-lengthening slope did not effectively differentiate patients from controls, nor were they related to the resting muscle hypertonia. Motor output during MG lengthening in the stance phase of gait is apparently not exaggerated or related to resting hypertonia in patients with chronic TBI and stroke. Thus, changes in gait during stance cannot be ascribed to increased stretch reflex activity in MG muscle after acquired brain injury.

An evidence review of management of children with cerebral palsy (Narayanan, 2012) stated that there is good evidence that gait analysis does alter surgical decision-making at least some of the time. However, "there remain concerns about the reliability (reproducibility) of these decisions or whether implementing these recommendations would result in different, let alone better outcomes" (Narayanan, 2012). The review reported on one study of gait analysis that found that, when the same gait analysis data were examined by gait analysis experts from 6 different institutions, there was only slight to moderate agreement in the list of problems generated by the experts (citing Skaggs, et al., 2000). Agreement about specific surgical recommendations was similarly poor. The review explained that, although gait analysis data are themselves objective, there is subjectivity in interpretation even among experts, with diagnoses and treatment recommendations varying significantly by surgeon or institution. The evidence review stated that, in another study (citing Noonan, et al., 2003), there was variability in the kinematic data generated in 4 different motion laboratories that tested the same 11 patients. Although the clinical significance of some of this variability has been challenged, the treatment recommendations generated from these data were different across the 4 centers for 9 of the 11 patients. The author of the review stated: "Variability in the interpretation of gait data reflects the prevailing uncertainty (or controversies) about the causes and/or significance of specific findings and will only be resolved with ongoing clinical research and experience using gait analysis. Similarly, variability in treatment recommendations based on the same gait data also reflects differences of opinion about best strategies to deal with specific problems, which in turn can only be definitively resolved with comparative clinical trials or observational studies" (Narayanan, 2012). The review author concluded that "as long as such significant variability exists, the recommendation that gait analysis is essential for all preoperative decision-making before multilevel orthopaedic surgery in clinical (as opposed to research) practice is currently not supported by the literature" (Narayanan, 2012).

An UpToDate review on “Gait disorders of elderly patients” (Ronthal, 2013) states that “It becomes evident that the control of walking is a highly complex and integrated activity. With multiple control points, multiple areas of vulnerability to disruption of normal gait are present. Knowledge of the basic physiology is a good starting point in gait disorder analysis. More sophisticated analysis of gait by posturography and studies of gait variability are largely research tools, but can help with rehabilitation”.

Zugner and associates (2017) simultaneously examined 14 patients with optical tracking system (OTS) and dynamic radio-stereometric analysis (RSA) to evaluate the accuracy of both skin- and a cluster-marker models. The mean differences between the OTS and RSA system in hip flexion, abduction, and rotation varied up to 9.5° for the skin-marker and up to 11.3° for the cluster-marker models, respectively. Both models tended to under-estimate the amount of flexion and abduction, but a significant systematic difference between the marker and RSA evaluations could only be established for recordings of hip abduction using cluster markers ($p = 0.04$). The intra-class correlation coefficient (ICC) was 0.7 or higher during flexion for both models and during abduction using skin markers, but decreased to 0.5 to 0.6 when abduction motion was studied with cluster markers. During active hip rotation, the 2 marker models tended to deviate from the RSA recordings in different ways with poor correlations at the end of the motion (ICC less than or equal to 0.4). During active hip motions soft tissue displacements occasionally induced considerable differences when compared to skeletal motions. The best correlation between RSA recordings and the skin- and cluster-marker model was found for studies of hip flexion and abduction with the skin-marker model. The authors concluded that studies of hip abduction with use of cluster markers were associated with a constant under-estimation of the motion; and recordings of skeletal motions with use of skin or cluster markers during hip rotation were associated with high mean errors amounting up to about 10˚at certain positions.

Rogan and colleagues (2017) evaluated the concurrent validity of the RehaWatch system using the GAITRite system as a criterion reference for gait assessment in the long-term care (LTC) elderly. In this study, a total of 23 elderly participants (mean age of 90.9 ± 8.4 years) performed 4 walking trials at normal and fast walking speed during single-task and dual-task walking. Data for both systems were collected simultaneously for each trial. Concurrent validity was assessed through limits of agreement (LoA) methodology using Bland-Altman plots. No systematic bias could be determined. Mean biases for step duration, velocity and cadence were above the pre-specified ±7 % value from zero lines for normal walking during single-task and dual-task walking. The LoA had a wide range between -21 % and 25 %. Only cadence showed small LoA for normal walking speed during single- (-8.4 % to 7.7 %) and dual-tasking (-4.1 % to 3 %). Heterogeneous bias was determined for step duration during fast walking during dual-task and for velocity during fast walking during single-task and dual-task. Heteroscedasticity was shown for step length during normal walking under the dual-task condition and fast walking during single-task and dual task activities. The authors concluded that no gait parameters were interchangeably usable between the 2 systems for normal walking during single-task and dual-task activities.

Mutoh and colleagues (2018) obtained data of gait parameters on predicting long-term outcome of hippotherapy. In 20 participants (4 to 19 years; GMFCS levels I to III) with cerebral palsy (CP), gait and balance abilities were examined after 10-m walking test using a portable motion recorder. Hippotherapy was associated with increased Gross Motor Function Measure (GMFM)-66 at 1 year from the baseline ($p < 0.001$). Hippotherapy increased stride length, walking speed, and mean acceleration and decreased horizontal/vertical displacement ratio over time ($p < 0.05$). Stride length and mean acceleration at 6 weeks predicted the elevation of GMFM-66 score. The authors concluded that these data suggested that 1-year outcome of hippotherapy on motor and balance functions can be assessed from the early phase by serial monitoring of the gait parameters The drawbacks of this study included its single-arm design with relatively small number of subjects (n = 20), which meant that the results may not be extrapolated to all types and severity levels of CP. In this study, no matched-control or other training modalities (e.g., horseback riding simulator and whole-body vibration) was provided because parents of all potential participants were adamant that they wanted their sons/daughters to undergo the actual intervention as a result of the likely benefit of hippotherapy. These issues need to be overcome in future studies.

Petis and associates (2018) examined the impact of surgical approach for total hip arthroplasty (THA) on quantitative gait analysis. Patients undergoing THA for primary osteoarthritis of the hip were assigned to 1 of 3 surgical approaches: anterior, posterior and lateral. Standardized implants were used at the time of surgery. Three-dimensional gait analysis was performed pre-operatively and at 6 and 12 weeks post-operatively. At each time-point, these researchers compared temporal parameters, kinematics and kinetics. They included 30 patients in their analysis (10 anterior, 10 posterior, and 10 lateral). The groups were similar with respect to age ($p = 0.27$), body mass index (BMI; $p = 0.16$), and Charlson Comorbidity Index score ($p = 0.66$). Temporal parameters were similar among the groups at all time-points. The lateral cohort had higher pelvic tilt during stance on the affected leg than the anterior cohort at 6 weeks ($p = 0.041$). Affected leg ipsilateral trunk lean during stance was higher in the lateral group than in the other cohorts at 6 weeks ($p = 0.008$) and 12 weeks ($p = 0.040$). The anterior and posterior groups showed increased external rotation at 6 weeks ($p = 0.003$) and 12 weeks ($p = 0.012$) compared with the lateral group. The authors concluded that temporal gait parameters were similar following THA for all approaches. Moreover, they stated that the impact of gait anomalies on the long-term mechanical durability of implant fixation remains unknown; future studies, such as corroborating biomechanical changes with soft tissue changes seen on cross-sectional imaging with long-term follow-up, would provide insight into how healed or unhealed tissue may explain gait aberrancies.

This study had several drawbacks. The lack of true randomization may have introduced selection bias on behalf of the surgeon and expectation bias on behalf of the patient. Studies have shown that patients believe minimizing muscle damage is important after major reconstructive surgery, such as THA. Thus, knowing that an approach potentially is “muscle-sparing” may psychologically prime an individual to be more motivated to achieve earlier mobilization and hasten progress with rehabilitation. It is important to consider this confounding factor across all comparative studies that examine minimally invasive or muscle-sparing, techniques.

The addition of an age-, sex- and BMI-matched control group would provide useful information to understanding how well each surgical approach restores gait mechanics. In addition, randomization may have reduced pre-operative kinematic and kinetic differences between the cohorts, although these variables were likely more a function of individual differences than sample selection. These investigators did not report changes in leg length and femoral offset following THA, which could affect gait mechanics by changing the length of the muscles around the hip joint. These findings were limited to a short-term follow-up of 12 weeks, which may be too short to observe optimal restoration of gait mechanics in all groups. Finally, the single-center study design limited the generalizability of the data, as only 3 surgeons performed the procedures.

Scheidt and colleagues (2018) noted that the rise in the number of patients with lumbar back pain has led to an increase in the number of spinal surgeries. To avoid unfavorable outcomes, high accuracy and reliability of indication for surgery are essential. This requires critical evaluation of post-operative outcomes with its 2 key dimensions pain and function. While imaging findings give details about the technical dimension of the intervention, they are prone to high inter-/intra-observer variability, with limited relation to functional outcomes. Pain improvement can be directly asked from patients or documented by questionnaires. There is abundant literature on post-operative function based on questionnaires, but quantifiable data such as gait or posture analysis are scarce. High precision measurement tools are available and easy to implement in a clinician's work routine. These researchers examined if lumbar fusion surgery changes gait and postural variables and how these changes are related to patients' descriptions of alterations in their levels of pain. Back profiles and gait analyses were measured by treadmill gait analysis and video rasterstereography. Measurements were recorded before surgery, at discharge, after 3 months in a longitudinal (n = 30), and after 12 months in a cross-sectional group (n = 29). A reference group was formed (n = 28). The improvement on the Numeric Pain Rating Scale was documented and compared with changes in gait and posture. A significant reduction in kyphotic (52 to 43°, $p = 0.014$) and lordotic (28 to 11°, $p < 0.001$) angles was observed. The values again increased after 3 months, with a significant reduction in cadence (98 to 91 steps/min, $p = 0.006$). While improvements in pain were also obtained by surgery ($p < 0.001$), no clear correlation could be detected between 3-month alleviation in pain and changes in kyphotic/lordotic angle or cadence. The authors concluded that although both methods offered high-precision measurement, changes in gait and posture were not related with the patients' reported pain relief after lumbar fusion surgery.

Differential Diagnosis of Progressive Supranuclear Palsy and Idiopathic Normal-Pressure Hydrocephalus

In a cross-sectional study, Selge and colleagues (2018) examined if quantitative gait analysis of gait under single- and dual-task conditions can be used for a differential diagnosis of progressive supranuclear palsy (PSP) and idiopathic normal-pressure hydrocephalus (iNPH). Temporal and spatial gait parameters were analyzed in 38 patients with PSP (Neurological Disorders and Stroke and Society for Progressive Supranuclear Palsy diagnostic criteria), 27 patients with iNPH (International iNPH guidelines), and 38 healthy controls. A pressure-sensitive carpet was used to examine gait under 5 conditions: single task (preferred, slow, and maximal speed), cognitive dual task (walking with serial 7 subtractions), and motor dual task (walking while carrying a tray). The main results were as follows. First, both patients with PSP and those with iNPH exhibited significant gait dysfunction, which was worse in patients with iNPH with a more broad-based gait ($p < 0.001$). Second, stride time variability was increased in both patient groups, more pronounced in PSP ($p = 0.009$). Third, cognitive dual task led to a greater reduction of gait velocity in PSP (PSP 34.4 % versus iNPH 16.9 %, p = 0.002). Motor dual task revealed a dissociation of gait performance: patients with PSP considerably worsened, but patients with iNPH tended to improve. The authors concluded that patients with PSP appeared to be more sensitive to dual-task perturbations than patients with iNPH. They stated that an increased step width and anisotropy of the effect of dual-task conditions (cognitive versus motor) appeared to be good diagnostic tools for iNPH.

The authors stated that this study had several drawbacks. The most important one was the absence of a histopathologic diagnosis. This was a drawback of every study that relied on a clinical diagnosis. Because these researchers were aware of this problem, they included only typical clinical cases that were examined and characterized in detail. A second unavoidable drawback of studies that compared different diseases was the definition of symptom load. These investigators tried to solve this problem by determining the Functional Gait Assessment. They did not address whether the participants prioritized one task (calculation task versus walking task) over the other under the dual-task conditions because the authors did not examine the single-task calculation while the patient was seated. Furthermore, this study exclusively examined patients with typical cases; thus limiting its generalizability to atypical cases.

Evaluation of Children with Idiopathic Toe Walking

O'Sullivan and associates (2018) stated that toe-walking is a normal variant in children up to 3 years of age but beyond this a diagnosis of idiopathic toe-walking (ITW) must be considered. Idiopathic toe-walking is an umbrella term that covers all cases of toe-walking without any diagnosed underlying medical condition and before assigning these diagnosis potential differential diagnoses such as CP, peripheral neuropathy, spinal dysraphism and myopathy must be ruled out. Gait laboratory assessment (GLA) is thought to be useful in the evaluation of ITW, and kinematic, kinetic and

EMG features associated with ITW have been described. However, the longer term robustness of a diagnosis based on GLA has not been investigated. These researchers examined if a diagnosis of ITW based on GLA features persisted. All patients referred to a national gait laboratory service over a 10-year period with queried ITW were sent a postal survey to establish if a diagnosis of ITW that had been offered following GLA persisted over time. The gait and clinical parameters differentiating those reported as typical ITW and not-typical-ITW following GLA were examined in the survey respondents. Of 102 referrals to the laboratory with queried ITW, a response rate of 40.2 % (n = 41) was achieved. Of the respondents, 78 % (n = 32) were found to be typical of ITW following GLA and this diagnosis persisted in the entire group at an average of 7 years post-GLA. The remaining 9 subjects were reported as not typical of ITW following GLA and 44.4 % (n = 4) received a subsequent differential diagnosis. The clinical examination and gait analysis features differentiating these groups were consistent with previous literature. The authors concluded that GLA appeared to be an useful objective tool in the assessment of ITW and a diagnosis based on described features persisted in the long-term. The main drawback of this study was the low response rate (40.2 %) of the survey.

Caserta and colleagues (2019) noted that ITW is a diagnosis of exclusion for children walking on their toes with no medical cause. In a systematic review, these investigators evaluated the clinical utility, validity and reliability of the outcome measures and tools used to quantify lower limb changes within studies that included children with ITW. The following databases were searched from inception until March 2018: Ovid Medline, Ebsco, Embase, CINAHL Plus, PubMed. Inclusion criteria were studies including children with ITW diagnosis, reporting use of measurement tools or methods describing lower limb characteristics, published in peer-reviewed journals, and in English. The relevant psychometric properties of measurement tools were extracted, and assessed for reported reliability and validity. Included articles were assessed for risk of bias using McMaster quality assessment tool. Results were descriptively synthesized and logistic regression used to determine associations between common assessments. From 3,164 retrieved studies, 37 full texts were screened and 27 full texts included. There were 27 different measurement tools described across joint ROM measurement, gait analysis, EMG, accelerometer, strength, neurological or radiology assessment. Interventional studies were more likely to report ROM and gait analysis outcomes, than observational studies. Alvarez classification tool in conjunction with Vicon motion system appeared the contemporary choice for describing ITW gait. There was no significant association between the use of ROM and gait analysis outcomes and any other outcome tool or assessment in all studies ($p > 0.05$). There was limited reliability and validity reporting for many outcome measures. The authors concluded that this review highlighted that a consensus statement should be considered to guide clinicians and researchers in the choice of the most important outcome measures for this population. They stated that having a standard set of measures would enable future treatment trials to collect similar measures; thus allowing future systematic reviews to compare results.

Spatio-Temporal Gait Analysis in Foot Dystonia

Datta and co-workers (2018) stated that foot dystonia (FD) is a disabling condition causing pain, spasm and difficulty in walking. These investigators treated 14 adult patients experiencing FD with onabotulinum toxin A injection into the dystonic foot muscles. They analyzed the spatio-temporal gait utilizing the GaitRite system pre- and 3 weeks post-botulinum toxin injection along with measuring dystonia by the Fahn-Marsden Dystonia Scale (FMDS), pain by the visual analog scale (VAS) and other lower limb functional outcomes such as gait velocity, the Berg Balance Scale (BBS), the Unified Parkinson's Disease Rating Scale-Lower Limb Score (UPDRS-LL), the Timed Up and Go (TUG) test and the Goal

Attainment Scale (GAS). These researchers found that stride length increased significantly in both the affected ($p = 0.02$) and unaffected leg ($p = 0.01$) after treatment, and the improvement in stride length was roughly the same in each leg. Similar results were found for step length ($p = 0.02$) with improvement in the step length differential ($p = 0.01$). The improvements in the lower limb functional outcomes were also significant -- FMDS, VAS, TUG, and UPDRS-LL decreased significantly after treatment (all $p < 0.001$), and BBS ($p = 0.001$), GAS ($p < 0.001$) except cadence ($p = 0.37$). The authors concluded that botulinum toxin injection improved walking in FD as evidenced through gait analysis, pain and lower limb functional outcomes. The main drawbacks of this study were small sample size (n = 14) and the lack of a control group.

Code	**Code Description**
CPT codes not covered for indications listed in the CPB:	
96000	Comprehensive computer-based motion analysis by video-taping and 3-D kinematics
96001	with dynamic plantar pressure measurements during walking
96002	Dynamic surface electromyography, during walking or other functional activities, 1 - 12 muscles
96003	Dynamic fine wire electromyography, during walking or other functional activities, 1 muscle

Code	Code Description
96004	Review and interpretation by physician or other qualified health care professional of comprehensive computer-based motion analysis, dynamic plantar pressure measurements, dynamic surface electromyography during walking or other functional activities, and dynamic fine wire electromyography, with written report
ICD-10 codes not covered for indications listed in the CPB (not all-inclusive):	
G80.0 - G80.9	Cerebral palsy
G82.20 - G83.9	Paraplegia, quadriplegia and other specified paralytic syndromes
R26.0 - R26.9	Abnormality of gait and mobility
R27.0 - R27.9	Other lack of coordination

The above policy is based on the following references:

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Amendment to Aetna Clinical Policy Bulletin Number: 0263 Gait Analysis and Electrodynogram

Gait analysis for planning surgery and therapy treatments for children with cerebral palsy will be considered on a case by case basis for the Pennsylvania Medical Assistance plan.