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Stepping Up to Rethink the Future of Rehabilitation: IV STEP Considerations and Inspirations

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Abstract

Background and Purpose—The IV STEP conference challenged presenters and participants to consider the state of science in rehabilitation, highlighting key area of progress since the previous STEP conference related to prediction, prevention, plasticity, and participation in rehabilitation.

Key Points—Emerging from the thought-provoking discussions was recognition of the progress we have made as a profession and a call for future growth. In this summary article, we present a recap of the key points and call for action. We review the information presented and the field at large as it relates to the 4 Ps: prediction, prevention, plasticity, and participation.

Recommendations for Practice—Given that personalized medicine is an increasingly important approach that was clearly woven throughout the IV STEP presentations, we took the liberty of adding a fifth “P,” Personalized, in our discussion of the future direction of the profession.

Keywords

IV STEP; participation; personalized; plasticity; prediction; prevention

INTRODUCTION

Taking place roughly every 10 to 15 years, the STEP conferences are designed to disseminate best-available evidence and set future directions in physical therapy education,

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research, and practice as they relate to individuals with neurologic conditions across the life span. IV STEP took place in July 2016 at The Ohio State University in Columbus, Ohio, and certainly accomplished this goal with enthusiastic presentations and discussion (Table 1). The purpose of this article is to highlight the key messages and themes that emerged from IV STEP. As stated by Marylou Barnes after II STEP, "the enormity of what has taken place at this conference has not yet struck any of us full force."[1] Indeed, this STEP conference, consistent with its predecessors, served as an unrestrained environment where ideas and plans were not constrained by "real-world" issues. Accordingly, the attendees and this IV STEP summary article coauthor group were challenged to analyze the state of current evidence in physical therapy practice; to develop priorities for education, research, and practice for the coming decade; and to present ideas to spur change for the future.

The IV STEP conference planning committee, after much discussion and review of current trends in practice and research, identified 4 critical themes on which to focus the conference presentations: prediction, prevention, plasticity, and participation (ie, the 4 Ps). The committee strategically observed that the emerging evidence in these 4 thematic areas was escalating and would critically impact the next decade of physical therapy practice in the area of neurologic conditions. Each invited presenter was given a specific charge that included reviewing the current evidence of his or her topic related to one or more of the themes and highlighting future research priorities of the profession (see the Appendix for speakers and charges).

We recap the key findings of the IV STEP conference in a diagram, which has 3 stages: (1) personalization, (2) intervention, and (3) outcomes (Figure 1). Stage 1 involves intervention planning for "personalized" care. In this stage, the physical therapists must consider the "4Ps": Prediction, Prevention, Plasticity, and Participation. Intervention planning involves inviting the patient to set goals for the intervention; the physical therapist then considers the person's neuroimaging, genetic, and classification data to inform planning and predicting outcomes (left section). Stage 2 is delivering the intervention (center section). Key principles of intervention include teamwork and partnership with the patient and other providers in their team. Physical therapy intervention will likely include exercise; intense motor training; virtual reality; self-efficacy and self-management training; and health promotion activities. Stage 3 is the measurement of intervention outcomes (right section). The desired outcomes of physical therapy intervention include better motor skills; better health; prevention of impairments; and measuring whether or not the patient's goals are achieved.

PREDICTION

A key element that will advance physical therapy practice is the ability to predict outcomes. Prediction of outcomes will lead to clearer patient expectations and better selection of interventions to match the individual. Predicting outcomes and guiding treatment with classification systems, including movement system diagnosis, is an important area of research. Examples of classification systems used in life span neurologic physical therapy practice include the American Spinal Cord Injury Association (ASIA) Impairment Scale (AIS)[2] and the Gross Motor Function Classification Scale (GMFCS).[3] The GMFCS is widely used for children with cerebral palsy to guide treatment and predict outcomes. In adults, no single measure is used in such widespread fashion, perhaps because no single measure is yet this effective in predicting outcomes.

Notably, the American Physical Therapy Association recently published a white paper that defines the human movement system as a foundation for physical therapy practice.[4] Building on the concept that physical therapists are the experts in diagnosis and treatment of human movement, it is clear that a common language is needed that enables the diagnosis of movement dysfunction, development of appropriate treatment options, and prediction of outcomes for individuals with neurological disorders. Movement system diagnosis has been proposed as one means of achieving this across medical diagnoses with 9 movement deficit categories: (1) movement pattern coordination, (2) force production, (3) sensory detection, (4) sensory selection and weighting, (5) perception of vertical orientation, (6) fractionated movement, (7) hypermetria, (8) hypokinesia, and (9) cognitive.[5] Yet, little research to date has examined the practical use of movement system diagnosis, that is, is it effective in determining treatment measures or outcomes by diagnostic category? The thinking behind proposing a movement system diagnosis focus is to promote use of a common language across neurologic conditions that would guide treatment choice, potentially decreasing treatment variability while improving communication between practitioners, and facilitate research through better grouping of study participants.

There is a growing focus in the profession on developing disease-specific classification systems, such as the AIS for spinal cord injury; however, there is considerable variability in the level of function of patients classified within a given category.[6] In response, the Neuromuscular Recovery Scale (NRS) was developed to differentiate function on 11 critical motor tasks for people classified as AIS C and D (motor incomplete), focusing on recovered movement patterns instead of compensatory movements.[7,8] More recently, a pediatric NRS has been developed.[9] The NRS has been shown to be responsive to change in function over time[8] and can be used as an outcome measure; however, it has not been evaluated as a predictive instrument. The GMFCS, a 5-level motor severity classification system. It is not an outcome measure but has a strong predictive relationship with a child's development of gross motor function measured on the Gross Motor Function Measure (GMFM-66 items).[10] Cerebral palsy gross motor curves have been generated that further predict gross motor function as a function of age and GMFCS level. These curves can (*a*) guide the timing of physical therapy intervention through identification of children who lag behind during early development or exhibit an unexpected loss of motor function during adolescence and (*b*) help predict realistic outcomes from treatment, for example, when to use active motor training versus when to use compensation (such as a powered wheelchair) to achieve independent mobility. Development of disease-specific measures, such as the GMFCS, GMFM, and NRS, is critical for the future of neurologic physical therapy, so that changes in function can be measured across the life span. Specifically, such measures could focus treatment and enable the accurate prediction of outcomes.

Effective prediction, however, may require more than just behavioral measures. For example, the PREP (Predicting Recovery Potential) algorithm that was developed to predict functional arm recovery poststroke uses (*a*) early motor function (manual muscle testing of Shoulder Abduction, Finger Extension = SAFE), (*b*) transcranial magnetic stimulation (TMS) (if the 2

SAFE scores sum to <8), and (*c*) diffusion imaging (if the TMS fails to elicit a motor-evoked potential in the finger extensors) to determine the degree of integrity within the corticospinal tract.[11] This work demonstrates that combining measures of motor function, neurophysiological analysis, and neuroimaging can predict long-term outcomes with 88% specificity and 73% sensitivity in people with mild to moderate stroke severity.[11] The PREP algorithm also illustrates the need for multimodal data to effectively predict outcomes in individuals with neurologic conditions.

Efforts to develop predictive algorithms are exciting; however, it is imperative for our profession to identify the factors that result in change in classification levels for individuals and to explain why, in some cases, there is a disparity in the predictive value of algorithms. Factors that may disrupt the predictive ability of algorithms include environmental, behavioral, motivational, and treatment variations. Furthermore, at this time, predictive algorithms have not accounted for what the individual considers to be meaningful outcomes; this is critical, as the capacity for recovery (the ability to perform a task as measured on objective assessments) does not always mirror performance (task completion within natural environments). Patient report must inform our assessments and classification methods to accurately plan treatments and predict long-term outcomes.

Relatedly, the development of clinical pathways (ie, decision trees/algorithms, and/or practice guidelines) is critical for evidence-based treatments and education of therapists. The utility of clinical pathways stems from their use of individual patient data that enables personalization of treatment, which can lead to prediction of recovery. Adoption of the template for intervention description and replication (TiDIER) guideline[12] for clear reporting of the key ingredients of rehabilitation interventions will help ensure that we are comparing “apples with apples” in the future. The use of electronic medical records and registries also makes treatment comparisons feasible. There is a need to evaluate trajectories of recovery and eventual outcomes based on well-defined treatment approaches; this will ultimately facilitate comparison of outcomes across individuals and settings.

PLASTICITY

It is clear that to move forward as a field, neurologic physical therapists must embrace technologies that facilitate positive plasticity. Technology can be used to enhance intensity, motivation, dosing, and consistency of practice as well as to quantify exercise parameters and outcomes. Technological innovations are progressing at a rapid rate, and a flood of new Food and Drug Association–approved robotics, devices, and so forth, is readying for market release. Yet, we must ensure that rehabilitation needs, not marketing, drive purchasing.[13] Optimal technological design should include all stakeholders including physical therapists, patients, and caregivers. Use of robotic gait orthothes as a component treadmill-based locomotor training has transitioned from research laboratories to common clinical use. Active participation appears to be a key ingredient, if improved overground walking is the goal.[14] Walk-assist exoskeletons, single and multiarticular, are now commercially available for community use. While promising, device limitations include a lack of balance reaction mechanisms to prevent falls, unnatural gait patterns, low battery life, skin integrity, and cumbersome donning and doffing.[13] Physical therapists must oversee training with these devices to ensure safety and provide feedback for refinement of this technology.

Video gaming technology is another area that shows great promise, but future versions must increase the challenge and reward scheme to optimize and maintain patient engagement and effect. Gaming especially motivates pediatric patients. Children may not fully appreciate the benefit of exercise but must engage fully for optimal motor learning. They can also easily "become bored" by the same game; accordingly, there is a need to find ways to match the speed of technology development with their appetite for novel challenges.[15]

Neural imaging technology techniques are advancing our research and practice. Functional and structural neuroimaging, electrodiagnostic, and electrical stimulation technologies, touched upon during plenary sessions, were a focus of many IV STEP poster presentations. Physical therapy intervention can be targeted for specific brain structures and can evaluate the effect of our treatments. Transcranial magnetic stimulation is an exciting and promising area of research that can be used to evaluate neuronal circuitry, promote neural plasticity, and inhibit maladaptive plasticity. Although many repetitive TMS trials to date have been disappointing,[16] this area of research has taught us that priming the brain for motor learning and recovery is possible.[17] Further work may elucidate the key parameters of stimulation, which, when combined with practice, are optimal for promoting neural reorganization in the developing child.[18,19] Other forms of cortical priming are rapidly gaining attention, including transcranial direct current stimulation,[18,20] and acute bouts of exercise.[21,22] Evidence suggests that epidural stimulation may also provide a level of excitatory priming in the cord that allows those with incomplete spinal cord injuries to activate local circuitry for muscle activation.[23] Furthermore, it appears that the use of repetitive TMS, in at least recovery from stroke, may be influenced by genetic factors.[24] Data such as these simply reinforce the need for predictive algorithms that account for numerous individual factors in decision making regarding optimal interventions.

PREVENTION

The goals of physical therapy must extend beyond function to include health promotion. "Physical activity," an essential component of health, refers to body movement during playing, working, active transportation, house chores, and recreational activities.[25] Exercise, a subcategory of physical activity, refers to purposeful movement designed to meet a fitness goal (eg, resistive exercise, aerobic training, flexibility).[25] It is critical for physical therapists to recognize the need for physical activity for people with neurologic conditions across the life span. While some exercise is better than none, there is a positive relationship between exercise intensity and enhanced physical function.[26] Even those with chronic disability and very limited mobility may benefit from low levels of exercise to optimize emotional and physical health.[27] While the evidence is limited, there is growing evidence that we can prevent secondary conditions associated with chronic health conditions if we intervene early in the disease or injury process and incorporate personalized strategies to prevent reoccurrence or reinjury.

Exercise interventions can also enhance neural reserve and capacity[28]; interestingly, the type of exercise influences the area of brain affected.[29] With exercise, it is possible to change the trajectory of a progressive disease and delay onset of motor symptoms in others. Physical fitness is positively associated with brain volume, and both aerobic and nonaerobic exercise can improve cognition in people with dementia.[30,31] High levels of physical activity are associated with delayed symptom progression in individuals with the Huntington disease gene.[32] A similar delay in onset of Parkinson disease symptoms has been found.[33]

For childhood-onset disability, physical activity and exercise are essential for optimal development of body systems, and there may be critical time periods for intervention.[34,35] In addition to the promotion of skilled movement, physical activity and exercise interventions are beneficial for premature infants. Exercise that benefits bone health can begin in the neonatal intensive care unit within days after birth.[36] Children with cerebral palsy are more sedentary and their physical activity levels are approximately 30% lower than recommended guidelines.[37,38] Less is known about other childhood-onset disabilities.

Children with disability, who are unable to run and play at sufficient intensities to optimize health, must be provided with alternative exercise programs to develop strong musculoskeletal and cardiorespiratory systems. There is evidence that exercise can improve academic performance in adolescents without disability[39] and psychosocial health in children with cerebral palsy.[40] It is hoped that promotion of physical activity in childhood can set the course for a healthy lifestyle that prevents or minimizes fatigue, pain, and depression experienced by adults with cerebral palsy and other childhood-onset disabilities.[41]

Physical therapists need to be involved early to intervene on behalf of individuals with all types of neurologic conditions, incorporating physical activity and exercise into treatment protocols that consider personal preferences. We are the movement experts best able to design safe and effective ways to develop, improve, and maintain physical health for people with or at risk for neurological conditions. However, we must network with our health promotion colleagues in schools and the community to ensure success in this endeavor.

PARTICIPATION

The ultimate goal of rehabilitation throughout the life span ought to be that people with neurological disabilities are fully included and participating in life activities that matter to them. Participation in a full life is the human right of every person with a disability and a core tenet of the International Classification of Functioning and Disability and is endorsed by the United Nations and the World Health Organization.[42] While much of this work has been done in pediatric populations, the concepts apply to adults as well.[43] There are varying definitions of participation that include "involvement in life situations"[43] and a "set of activities that are completed in order to achieve a setting-specific personally or socially meaningful goal."[44] Full participation in childhood has been characterized by doing immensely engaging activities that are meaningful to the child, belonging and being accepted socially, and being with a sense of self-purpose and identity.[45]

People with disabilities and their families identify societal attitudes, the built environment, lack of support, low personal confidence, and pain and fatigue as barriers to participation. It is the therapist's role to optimize home and community participation.[45] A person's participation will be influenced by his or her preferences, his or her locality and the opportunities it affords, his or her family's context and routines, and the person's physical abilities.[45] Evidence indicates that framing intervention by a person's preferences and priorities increases participation.[45,46] To develop an optimal intervention plan for a child, both the child and the family should be assessed to identify strengths, interests, desires, and concerns that are specific to the participation goal. In addition, the environment should be evaluated for safety, accessibility, physical/social/emotional supports, and community resources.[47] When planning and carrying out treatment and research, physical therapists must, therefore, remain cognizant that improving a person's physical performance at the body' structures function level of the International Classification of Functioning and Disability does not automatically transfer to improved participation. Intervention aiming to improve participation will need first to look at the barriers to participation and address these; some of these may be the person's physical abilities but others may not (eg, community access, societal attitudes).

Remote capture of physical activity and exercise at home and in the community, using wearable technologies, may inform our treatment plans because it can provide quantitative outcome measures of spontaneous self-selected physical activity, and GPS locaters might provide participation profiles, for example, how often does the person leave his or her home?. Yet, to date, our attempts at monitoring physical activity remotely (patient compliance logs, accelerometers) have been limited and have provided incomplete information. While lower extremity activity monitors are an effective means of capturing community walking,[48] upper extremity activity monitoring is more complex. Reports have found improved motor function on behavioral measures (eg, Action Research Arm Test[49]) with and without increased activity measures from accelerometry[50]; conversely, study participants with stroke have reported improved arm use without a concomitant improvement in measured arm function.[51] Attention needs to be paid, and new methods conceived, for integrating self-report with technological measurement of activity. Advances in complex monitoring may allow us to provide therapies that increase Participation, and allow us to accurately measure Participation as an outcome.

Telemedicine is just being established for physical therapy practice and the rules and guidelines are still being developed, but it shows great potential, especially for outreach to rural communities. Telemedicine technology enables people to receive intervention within their own environment, and this is important because ecologically bound intervention is more likely to accurately reflect a person's real-life participation barriers, needs, levels, and opportunities.

PERSONALIZED

Personalized medicine is an increasingly important approach that was clearly woven throughout the IV STEP presentations, so we have taken the liberty of adding a fifth "P" to the 4P model for setting the future direction of the profession.

It is becoming clear that there is no "one size fits all" rehabilitation intervention for individuals with neurological disorders. This is true for both adult and pediatric clients. Thus, the future of our profession is to incorporate individualized health care to create personalized rehabilitation interventions that are informed by (1) capacity—brain and muscle structure or function; genetics, epigenetics, metabolic influences; and (2) client and family goals that define the right treatment at the right time for the right person. Recently, there have been a number of large randomized controlled trials (RCTs) considering novel rehabilitation interventions,[52] the dosing of practice within and across session,[8] the timing of rehabilitation onset,[53] and the numbers of rehabilitation sessions in a week.[54] When considering the "average" individual, each of these trials reported no advantage for their specified intervention over that found for the control intervention, which was described as "standard care" (or in the case of a recent trial on dose response, a lower amount of practice per rehabilitation session[51]). In particular, at IV STEP, the results of this dose-response trial by Lang et al were presented; the finding that there was no additional benefit to larger numbers of practice trials per session was met with much dismay by the attendees. Taken together, the results of these large, well-run, randomized trials may indicate that high-quality "standard care" (ie, that employs intensive practice at the peak of the patient's increasing abilities) is adequate for recovery after stroke. However, earlier trials[55] found intensive therapy more effective than standard care, which may indicate that standard care has improved over the last decade, but it may also mean that more is not always better. It is unknown, however, how much variability exists in "standard care" throughout the country.

Studies that emerged out of III STEP suggest that the dosing and type of exercises performed in neurologic rehabilitation were below that which is used in "standard care" control interventions.[56–58] Relatedly, experience suggests that the "standard care" delivered in many clinics may not be at the same level as that tested in the study settings. These data may also be signaling that effective rehabilitation interventions require personalization of their content. Personalized interventions would be designed to address the specific needs of each client and modified to suit the precise capacity of each biological system.

Research disseminated at IV STEP illustrates both the challenge and the promise of moving toward personalized rehabilitation interventions for individuals with neurological disorders. The importance of genetics in numerous aspects of neuroplasticity was articulated. It is clear that different genetic markers have a profound influence on motor learning.[59] As an example, the expression of dopamine genes has a large influence on both motor learning and neuroplastic change in the motor cortex; critically, it was a combination of genes not a single factor that revealed these relationships.[59] At this time, however, the consideration of genetics in responses to rehabilitation is in its infancy. Little work has considered specific neurological populations. Furthermore, the role of epigenetics has yet to be revealed. Epigenetics encompasses the study of modifications to DNA and DNA packaging, which can potentially affect gene expression, without changing the nucleotide sequence.[60] Differential DNA methylation patterns in the *BDNF*[61] and *DRD2*[62] genes impact gene expression and have been associated with psychiatric disorders.[63,64] Yet at this time, no data exist to explain whether variation in DNA methylation patterns contributes to interindividual variability in individuals with neurological disorders. Given that epigenetics are affected by our environment and behavior throughout the life span,[65] it is likely that their influence on recovery trajectories and treatment responses will be profound.

Although not explicitly considered at IV STEP, other candidate biomarkers that may enable the development of personalized interventions include brain structure and function. Brain imaging is noninvasive and easily accessible, enabling the categorization of brain anatomy, function, chemistry, and connectivity.[66,67] Another potential recovery biomarker is neurophysiological status as mapped using noninvasive brain stimulation (ie, TMS).[11] Transcranial magnetic stimulation– based neurophysiological measures of the electrophysiological relationship(s) between the 2 cortical hemispheres and the integrity of the corticospinal tract via the generation of motor-evoked potentials relate to motor outcome in chronic[66] and acute adult stroke.[11] However, their value in predicting the best type of rehabilitation intervention is not well understood. In addition, work in this area has focused on adults with stroke; a rich opportunity exists to broaden these questions to include other types of neurological disorders[68] as well as ask questions across the life span. Children appear to respond differently since their motor skills and repertoire are still being established, and, therefore, treatment plasticity and reorganization are different to adults with well-defined motor maps and pathways.

Finally, it is crucial that the perspective, goals, and needs of the client be incorporated into personalized rehabilitation interventions. Through focus groups and surveys of individuals with stroke, it has become clear that what is meaningful to this group is the use of their arm in their real-world environments.[69] Research in pediatric populations confirms this finding as well that goal-directed, salient practice of real-life tasks in real-world environments leads to the greatest functional improvements. These data are not surprising as they match the optimal conditions for inducing plasticity. For our rehabilitation interventions to be truly effective for each person, we must identify what is meaningful recovery to the individual and index changes in quality of life. Only when these goals are met will we have created truly effective interventions. Relatedly, future STEP conferences should consider increasing participation from other stakeholders groups, such as patients and families, to further ground our discussion in this important issue.

PLANNING FOR THE FUTURE

Research and the critical discussion of findings will continue to fuel the advancement of neurologic physical therapy practice. Critical to this advancement must be a paradigm shift in terms of how we approach rehabilitation research in terms of both design and interpretation. We have known for some time that patients have different outcomes from treatment, some respond, while others do not (ie, nonresponders). More precise data delineating the responder/nonresponder phenomenon would enable more accurate prediction of prognosis. The innovative movement of “individualized (or personalized) medicine” addresses the responder/nonresponder phenomenon by tailoring clinical care to counter an individual’s (epi)genetic makeup, environment, and goals. Individualized medicine also necessitates an expansion of the way in which the field needs to think about designing, analyzing and appraising clinical rehabilitation research. Although RCTs are the current gold standard methodology for evaluating treatment efficacy, they are limited by their analysis at group mean level. Individual responder results can be obscured and washed out by nonresponders in group mean reporting.

The RCT model, which emerged from pharmaceutical trials, appears to be ill suited for rehabilitation interventions. A key limitation of this model in rehabilitation is the identification of the control condition: how do you provide sham physical therapy? A good control must provide similar nonessential experience and test the essential ingredients to the treatment. In the case of a drug, that is a relatively easy pharmacological achievement (eg, a placebo sugar pill). But, what is the “essential ingredient” to physical therapy? Is it salience, dose, intensity, timing, or attention froma caring provider? We have not yet parsed these elements out; thus, the hypothesis-driven questions must continue to attempt to elucidate what is the critical component to be included in our therapies.

Within rehabilitation in the past several years, there has been reference to “failed trials” of rehabilitation. In the reconsideration of rehabilitation research, the term “failed trial” needs to be clarified. This term comes from drug trials where a drug has failed to produce a prespecified effect or the negative effects outweigh the positive. A failed trial means that the drug will not go to market for use. However, in PT, due to the complex and multifaceted aspects of an intervention that cannot necessarily be controlled, an RCT may fail to support a primary hypothesis but often illuminates other critical aspects of an intervention. Potentially important findings could include rate of recovery, treatment effectiveness in the nonprimary outcome measures, predictors of responsiveness, and so forth. Use of the term “failed trial” suggests that the intervention is not effective; when often a more accurate assessment may be that, on average, it is not better than a different PT intervention but for certain individuals it may be. A better term may be “equally effective” or “no difference,” which accurately describes the failed primary hypothesis but may allow appropriate appreciation and discussion of the findings to continue to build the science of rehabilitation. As mentioned previously, important consideration also needs to be made for what the control intervention is and how that relates to true “standard care” being delivered in clinics throughout the country.

Other trial designs, including comparative effectiveness studies, single-subject designs, and pragmatic designs, should be embraced to overcome these aforementioned methodological problems in rehabilitation research. Single case design, comparative effectiveness research, and population registries are 3 alternative research methodologies that enable analysis at the individual level. These designs overcome the problem of average performance not reflecting population variability. The principle benefit of the single case design is that it charts and reports individual results and, therefore, allows the opportunity to provided detail descriptions of responders.[70] Single case design is useful and often necessary in low-incidence disorders in which adequate statistical power cannot be achieved using traditional empirical designs.[70–72] The added benefit of comparative effectiveness research and population registries is that big data enable comparison of an individual’s performance to the population of interest.[73] Indeed, the RCT should not be abandoned and will likely continue to be the favored design of funding agencies, but other pragmatic designs[74] are emerging as valid methodologies for high levels of evidence and should be considered.

Comparative effectiveness research allows for the evaluation of treatment outcomes to improve health care quality by providing patients, health care providers, and other stakeholders with better information about the risks and benefits of different treatment options. APTA Connect (http://www.apta.org/CONNECT/) and the Patient-Centered Outcomes Research Institute (http://www.pcori.org/research-results/patient-centered-outcomes-research) are good resources on this topic. However, this type of research requires a set of common data elements that encompass valid, reliable measures. Recent work demonstrates both the promise and the challenges of this type of approach to research.[75] To date, few of us report a common set of data elements; this significantly hampers the combination of small studies into what might be considered "big data." These challenges stem from the plethora of measures that exist. Fortunately, online resources are being developed that can facilitate measurement selection. For example, the National Institute of Neurological Disorders and Stroke has created an open resource Common Data Elements Web site (https://www.commondataelements.ninds.nih.gov) that is disease specific with common measures across multiple diseases. Cerebral palsy common data elements, to be completed in 2016, will include physical therapy classifications and measures. Going forward, the physical therapy profession must embrace single case design research and big data methodologies to stay on the forefront of individualized medicine. Big data methodologies will require us to foster collaborative partnerships between clinicians, providers, insurers, and government. Future work may harness information from a vast network of providers, taking inspiration from crowd source science practices.

As knowledge rapidly advances in the field of physical therapy, an imperative exists to embrace effective knowledge translation strategies. First, ensure that patients receive evidence-based leading-edge therapy. Second, ensure that the policy governing the funding and reimbursement of care matches best-available evidence. Knowledge translation to the policy level must seek to ensure that policy evolves to include billing codes and/or funding for new and proven treatments and at the same time, discontinues reimbursement for ineffective treatments. Numerous systematic reviews exist to guide clinicians, educators, researchers, and policy makers about how best to translate leading-edge research knowledge into routine patient care. Known effective knowledge translation strategies supported by high-quality evidence include audit and feedback; clinical practice guidelines; continuous quality improvement; financial incentives; mass media; opinion leaders; outreach visits; peer comparison feedback; reminders including computerized decision supports; research-active staff in the workplace; tailored interventions; and combinations of these approaches known as multifaceted interventions.[43,76] Knowledge translation requires clinicians, researchers, and academics to "stretch" their role to include advocacy for evidence-based practice at policy, insurance, and systems levels.

SUMMARY: FROM CHAOS TOWARD CLARITY

In Mary Lou Barnes' summary article of II STEP in 1990,[1] she spoke of a "breaking down of ideas" and a "sense of chaos" in the profession, where dearly held beliefs were being dismantled. The gurus of the profession and distinct "sects" were finally being harmonized as physical therapists were performing research that was not only informing practice but also advancing understanding of neurophysiologic mechanisms. Rereading of her philosophical epitaph is a worthy reminder of the value of historical reflection. At each of these seminal conferences, we may experience a feeling of chaos or discomfort where current understanding and beliefs are challenged or destroyed; we must face the idea that we were wrong. As Dr Barnes stated, the primary charge for the profession was to embrace the chaos, merging old and new ideas, because from that we advance toward truth. In the poetic manner of history repeating itself, we can draw comfort and inspiration from our predecessors at the conclusion of IV STEP. We advocate for embracing the discomfort of challenging ideas and harnessing it to leverage forward movement. We may need to drastically reconsider our dearly held ideas and be willing to be uncomfortable to continue our forward momentum with novel research designs of hypothesis-driven questions. We will not be in the same place as a profession at V STEP, and someday the future may look back at the highly novel and disrupting findings presented at this conference and characterize them as quaint realizations. That is worthy of celebration, indeed.

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Appendix

Speakers and the Charge From the Planning Committee

Speaker(s)	**Charge**
Carolee Winstein, Susan Harris	Summarize the history of the STEP conferences, your thoughts/*reflections* on current PT practice and introduce the 4 Ps and their interdependences.
Ann VanSant	Explain the development of movement system diagnoses and how these will assist with prediction of optimal response to intervention choice, as well as strategies to link classification with accurate predicted outcomes.
Andrea Behrman, Susan Harkema, Elizabeth Ardolino	Provide current knowledge of how movement system diagnoses and/or classifications can predict and direct treatment for neuromuscular recovery in adults and children.
Steve Cramer, Jill Stewart	Provide current knowledge of and future direction for genetics and epigenetics related to prediction and plasticity to achieve the most effective and efficient physical therapy interventions.
Chet Moritz, Faby Ambrosio	Provide current knowledge of and future direction for regenerative rehabilitation in the context of physical therapy practice for prevention, plasticity, and participation, related to the future of how to provide effective and efficient physical therapy.
Jane Burridge, Alan Chon Lee	Discuss current telehealth physical therapy practice and how these services may assist with improving prevention, participation, and perhaps assist with plasticity.
Ellen McGough	Discuss how physical therapists should be involved in primary health promotion practices to prevent or delay the development of neurological disorders.
Edgar van Mil	Discuss how pediatric physical therapists should be involved in primary health promotion practices to prevent or delay obesity and/or neurological disorders.
Don Morgan, Lori Quinn	Discuss how physical therapy promotes health and contributes to further motor disorders in adult (Quinn) and pediatric (Morgan) neurologic populations.
Catherine Lang, Michele Basso	Discuss the most effective rehabilitation program from the perspective of amount and timing of services to maximize plasticity and participation in adult neurological populations and whether this is the same when the objective is plasticity or participation or both.
Mary Gannotti	Summarize the research that indicates what the most effective rehabilitation program is from the perspective of amount and timing of services to maximize plasticity, participation, or both in pediatric neurological populations.

Speaker(s)	Charge
Judy Deutsch, Sally McCoy	Review the types of technology, which have been shown to effectively induce neuroplasticity, are, therefore, likely to improve participation, and discuss how physical therapists could utilize technology presently and in the future.
Arum Jayaraman	Review the kinds of robotic technology that have presently been shown to be effective from a plasticity perspective, the types of robotics that improve participation, and how PTs could employ robotic technology now and in the future.
Lisa Chiarello	Discuss how we can measure participation and design effective interventions to improve participation? What research needs to be done in the future to improve rehabilitation services that are focused on assisting our clients to participate in family, recreation, and daily activities?
Sarah Kagan, Michele Lobo	Present the key points of research designs other than the randomized controlled trials (qualitative, single subject, big data/epidemiology) that may assist researchers in answering important scientific questions about rehabilitation focused on any of the 4Ps, but especially participation.
Deborah Backus, Jennifer Moore, Keiko Shakako-Thomas	Enlighten the audience about key points of promoting evidence-based practice, how to best achieve knowledge translation, and how service providers can change their behaviors and adopt alternate practice, based on scientific evidence.

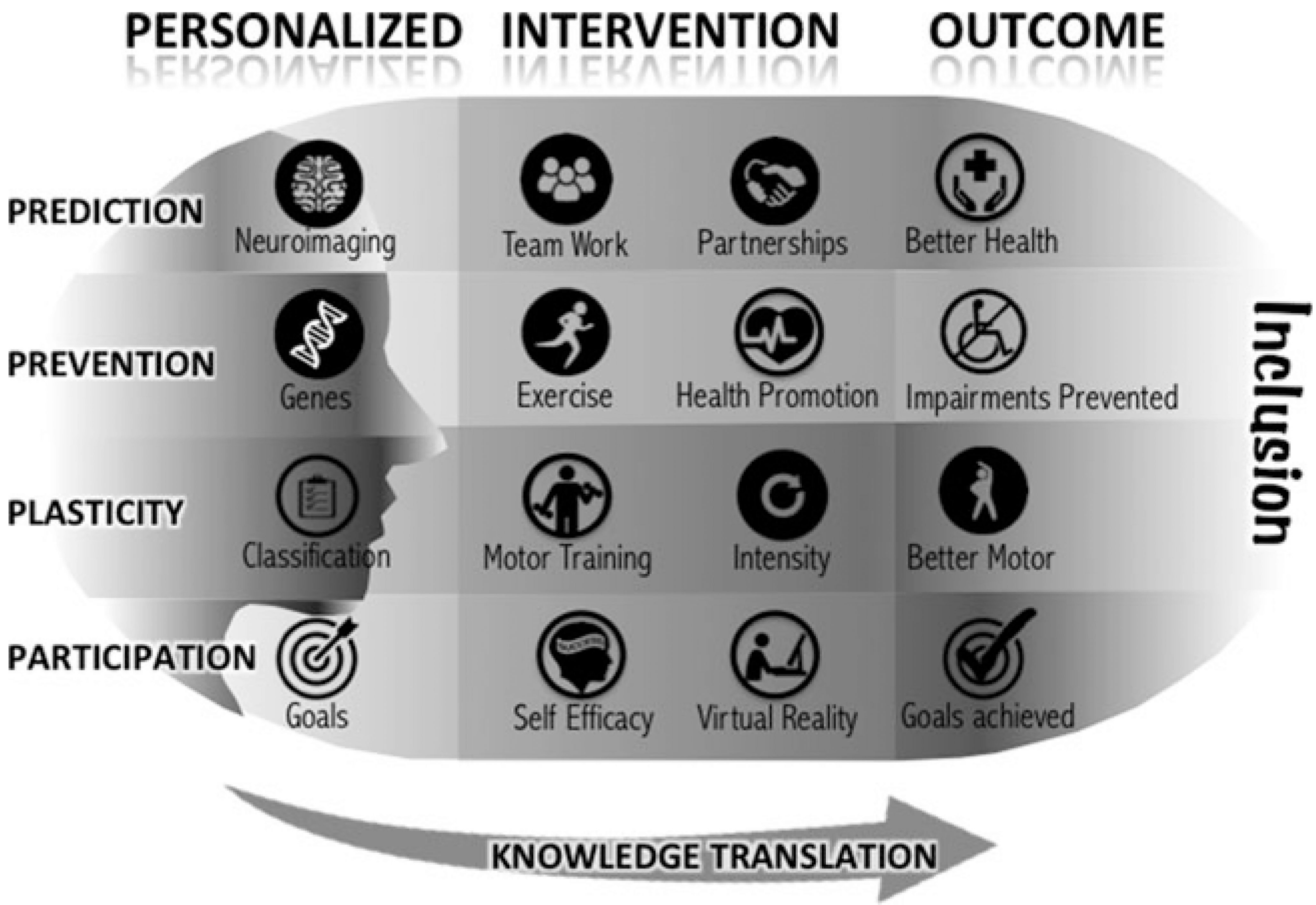

Fig. 1.
Summary of the IV STEP conference key messages.

TABLE 1

IV STEP Demographic Information

Attendees
701 (413 >40 y, 218 <40 y) (M: 67; F: 567; unreported 67)
Speakers
34
Section affiliation
387 neurology
124 pediatric
91 dual membership
99 nonmembers
Primary setting
331 clinicians
295 academicians
Geographic representation
44 US states as well as people from Australia, Canada, Chile, Denmark, Iceland, India, South Korea, Kosovo, Malaysia, Netherlands, South Africa, United Kingdom