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Regenerative Rehabilitation and Genomics: Implications for Occupational Therapy

Abstract

The completion of the human genome project has paved the way for health care practitioners to use genetic and environmental information to tailor medical treatment. This innovative approach to health care is rapidly evolving, and occupational therapists need to be aware of the impact it will have on future practice. Regenerative rehabilitation is a product of knowledge and techniques from the fields of rehabilitation and regenerative medicine with the common goal to restore function. Occupational therapists have the potential to play a significant role in regenerative rehabilitation research and implementation. The purpose of this article is to (a) increase understanding of genomics, regenerative medicine, and regenerative rehabilitation as they pertain to occupational therapy practice; (b) provide examples of how occupational therapy can contribute to and use evidence in the field of regenerative rehabilitation; and (c) advocate for the integration of these emerging techniques and technologies in occupational therapy training.

Comments

The author reports no potential conflicts of interest.

Keywords

genetics, genomics, occupational therapy, precision medicine, regenerative rehabilitation

Cover Page Footnote

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Credentials Display

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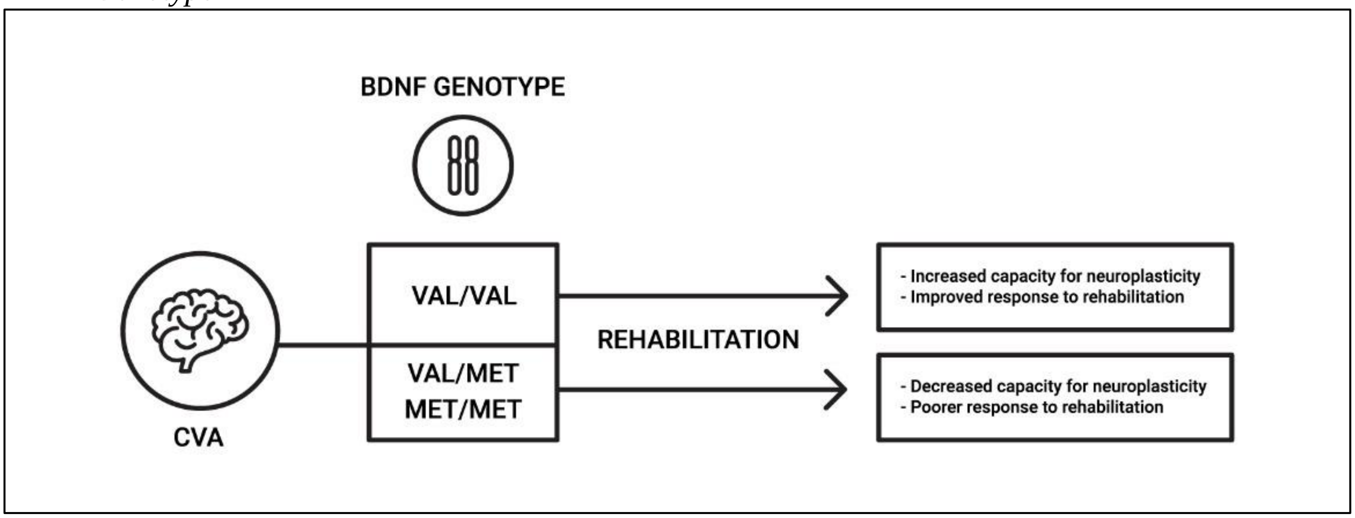
The last two decades have produced extensive developments in genomic technologies and regenerative medicine. These developments have ushered in a new era of prevention and treatment of acute and chronic conditions resulting from injury, disease, and aging. As an understanding of basic biological and genomic mechanisms underlying tissue regeneration and plasticity grows, rehabilitation specialists, such as occupational therapists, will benefit from incorporating these emerging principles into clinical practice guidelines and research collaboration efforts. The practice of occupational therapy will always be rooted in the use of occupations as an agent of change; however, evaluation and intervention methods may evolve as scientific and technological innovations provide further understanding of how the body may respond to intervention. Occupational therapy research offers insight into the human need for occupation; how health disorders impact occupation through client factors, performance patterns and skills, and the environment; and the power of occupational engagement in habilitation and rehabilitation (American Occupational Therapy Association [AOTA], 2020; Clark, 1997; Dickie et al., 2006; Nelson, 1996; Sutton et al., 2012; Wilcock, 1993; Wilcock, 2007). This insight will be crucial as health care teams use more genetic information to determine rehabilitation guidelines. Concepts from the emerging field of regenerative rehabilitation demonstrate the vital relationship between medical advances and rehabilitation techniques to improve functional outcomes. Occupational therapists need to understand how advances in these emerging sciences will impact future clinical practice.

Genomics, Regenerative Medicine, and Regenerative Rehabilitation

The completion of the Human Genome Project in 2003 heralded in a new era of medicine (Roberts & Middleton, 2017). Scientists gained a greater understanding of the importance of genetics in predicting, diagnosing, and even treating individual health conditions (Ambrosio & Kleim, 2016). With this new understanding, personalized medicine became a reality. Better known as precision medicine today, this model of practice assesses an individual's risk for diseases or conditions and estimates the effectiveness of various treatments based on their unique genetic and environmental risk factors (Jameson & Longo, 2015). With the assistance of researchers, physicians can now use genetic information to predict risk factors better, select the most appropriate diagnostic tests, and then prescribe the optimal therapeutic regimen (Jameson & Longo, 2015; Perkins et al., 2018). While this process creates new avenues for understanding disease progression and developing novel treatment approaches, unprecedented ethical dilemmas may accompany the increased use and availability of genetic information (de Paor & Blanck, 2016; Roberts & Middleton, 2017). One concern that may impact rehabilitation services is that the holistic and client-centered approach to evaluating and treating individuals may shift toward a reductionistic view of genetic and environmental factors. Occupational therapists can add value to this model of prediction and prescription by emphasizing the relationship between occupation and health, helping other disciplines view people as occupational beings, and ensuring rehabilitation evaluation and prescription avoid reductionistic approaches (Wilcock, 2007).

A favorable clinical implication of precision medicine is improving the ability of rehabilitation specialists, such as occupational therapists, to individualize treatment strategies and provide more realistic prognoses based on the addition of knowledge from genetic makeup. Genomic research has shown that genotypes (i.e., genetic makeup) not only alter the response to pharmacological treatment, but also influence response to motor rehabilitation after brain injury or disease by affecting the capacity for neuroplasticity (Goldberg et al., 2015). For example, polymorphisms, or genetic variations, in the brain-derived neurotrophic factor (BDNF) and apolipoprotein E genes have shown to significantly alter the capacity for neural plasticity and recovery after cerebrovascular accidents and traumatic brain injuries (Goldberg et al., 2015). Knowing how genetic makeup may affect the severity and progression of neurological diseases and response to rehabilitation provides valuable information to occupational therapists (see Figure 1) (Hofker et al., 2014). This new information allows occupational therapists to identify clients that may need more intensive rehabilitation or, based on a poorer prognosis, may need to shift from remediation or restoration to an adaptive or compensatory approach (see Figure 2). Knowing this information earlier in the rehabilitation process may allow occupational therapists to better advocate for clients (e.g., increased intensity of rehabilitation services, expedited approval for adapted equipment, or home modifications when appropriate). In addition, occupational therapists can help identify ways to use genetic information while maintaining a client-centered and top-down approach to rehabilitation.

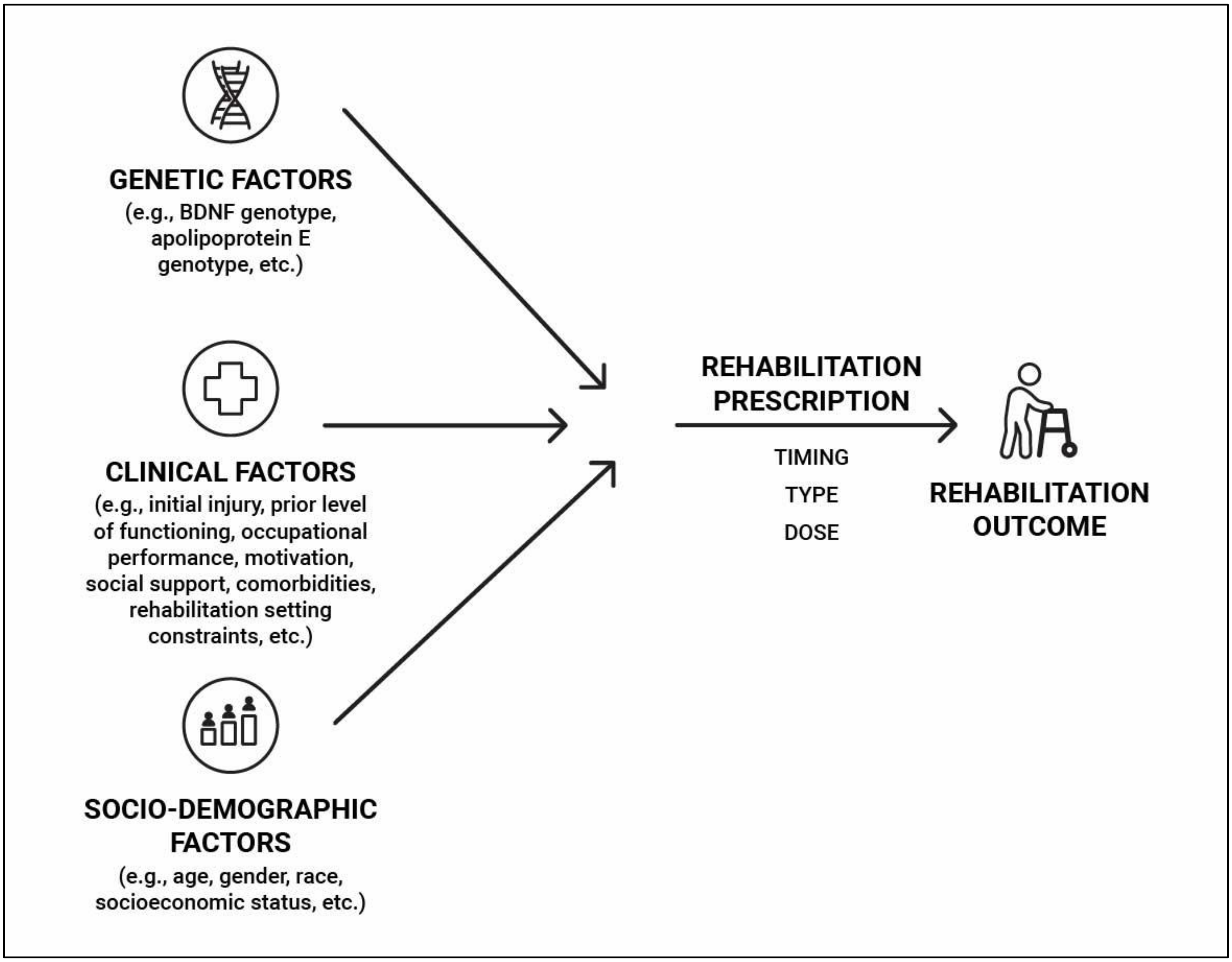
Figure 1
BDNF Genotype



Note. Genetic factors, such as BDNF genotype, have been associated with neurological recovery. This figure illustrates the theoretical implications of BDNF genotypes on recovery after stroke. Individuals with the Met allele, or a variant form of the gene, have been shown to have decreased capacity for neuroplasticity, poorer outcomes in response to motor rehabilitation, and a poorer overall prognosis (Goldberg et al., 2015; Kleim et al., 2006). Occupational therapists may use this information to recommend more intense rehabilitation for individuals with the Met allele (a genetic variant) when recovering from a stroke.

Figure 2

Factors Influencing Rehabilitation Prescription



Note. Many factors influence rehabilitation prescription and outcome and must be considered when designing a client-centered and evidence-based rehabilitation plan of care. Knowing the genetic makeup of a client, among other clinical factors, which are too numerous to illustrate in this figure, has the potential to add value and impact rehabilitation prescription (e.g., the type, timing, and dose of therapy) because of increased understanding of disease severity, progression, and potential response to rehabilitation. Occupational therapists may use this information to better advocate for appropriate rehabilitation prescriptions.

While the concept of genetics is generally understood, genetics and genomics are often incorrectly used interchangeably. Genetics refers to principles of heredity through the study of genes and their roles in inheritance (i.e., how certain traits or conditions are passed down from one generation to another) (National Human Genome Research Institute [NHGRI], 2018). In contrast, genomics refers to studying the entirety of a person's genes, called the genome, and includes how genes interact with each other and the environment (NHGRI, 2018). While both play a role in health and disease, genomics is critical to understanding complex diseases caused by multiple genes and environmental factors, and why some people respond to certain medications or rehabilitation differently than others (Hofker et al., 2014; NHGRI, 2018). Advances in genomics have further supported another innovative field, regenerative medicine (Chen & Liu, 2016; Mao & Mooney, 2015).

Regenerative medicine is an interdisciplinary field that applies engineering and life science principles to promote regeneration by restoring the structure and function of damaged or diseased tissues and whole organs (Mao & Mooney, 2015). This remarkable field rests on the goal of regenerating tissues and organs damaged by age, disease, or trauma (Mao & Mooney, 2015). Regeneration is accomplished by replacing the damaged tissue using cell-based therapies, tissue engineering, or promoting the body's repair mechanisms (Perez-Terzic & Childers, 2014). While regenerative medicine may seem beyond the field of occupational therapy, individuals who receive regenerative therapies will require rehabilitation to make full use of their restored anatomy and newly regained abilities (Thompson et al., 2016). Occupational therapists can collaborate with scientists, physicians, and surgeons to maximize the benefit of regenerative medicine interventions and ensure structural restoration leads to functional restoration. In addition, the emerging field of regenerative rehabilitation, which unites regenerative medicine with rehabilitation techniques to restore normal function, provides another unique role and opportunity for occupational therapy.

Perez-Terzic and Childers (2014) proposed the following working definition of regenerative rehabilitation: "Regenerative rehabilitation integrates regenerative technologies with rehabilitation clinical practices to restitute function and quality of life in individuals with disabilities due to otherwise irreparable tissues or organs damaged by disease or trauma" (p. 4). Regenerative rehabilitation demonstrates the effectiveness of combining emerging technologies and new knowledge from regenerative medicine and rehabilitation science. Regenerative rehabilitation aims to improve rehabilitation outcomes for disorders and injuries previously difficult to treat or even considered untreatable (Perez-Terzic & Childers, 2014). Regenerative rehabilitation techniques may include, but are not limited to, using emerging technologies, such as stem cell transplantation, the integration of knowledge gained about physiological processes induced by manual therapy techniques, or rehabilitation techniques to enhance neural recruitment (Perez-Terzic & Childers, 2014). The overarching goal of regenerative rehabilitation is to develop novel and effective methods to promote restoration of function through tissue regeneration and repair; these examples provided above are just a part of a continuum of innovation in this field. Additional areas of concentration exist in regenerative rehabilitation that can impact occupational therapy and provide future research opportunities. For example, the creation of new medical devices and artificial organs, tissue engineering and biomaterials (substances engineered to interact with biological systems for a therapeutic or diagnostic effect), cellular therapies (injecting, grafting, or implanting cells into a person as a form of medical treatment), and clinical translation of these regenerative therapies.

Regenerative rehabilitation will inevitably impact all practice areas in rehabilitation (Ambrosio & Kleim, 2016; Hofker et al., 2014). Occupational therapists need to recognize the impact genomics and regenerative rehabilitation have on the profession, become competent consumers of the evidence, and integrate the principles into clinical practice. In addition to recognizing the impact of regenerative rehabilitation, occupational therapists can contribute to interdisciplinary teams dealing with genomic findings, including physicians, geneticists, bioinformaticians, and genetic counselors. Moreover, occupational therapists can also contribute to regenerative rehabilitation research and provide a unique perspective of how these advances will impact health, well-being, participation, and occupational engagement.

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Occupational Therapy and Regenerative Rehabilitation

Occupational therapists are already using regenerative rehabilitation principles in clinical practice. For example, occupational therapists seek to identify what client factors, performance skills and patterns, and environments impact occupational performance (AOTA, 2020). Many client factors, such as denervation, muscle atrophy, soft tissue shortening, scar tissue deposition, and bone mass and density loss, negatively impact occupational performance. Although regenerative medicine or regenerative rehabilitation is rarely mentioned in occupational therapy literature, occupational therapists working in physical dysfunction (e.g., orthopedic and neurological rehabilitation) have incorporated early regenerative medicine evidence as preparatory methods for participation in occupations. For example, therapists use mechanical stimulation through manual therapy techniques to support occupational performance. Mechanical stimulation affects the underlying molecular and cellular mechanisms guiding the regenerative tissue responses from the added physical forces (Ambrosio & Kleim, 2016). The evidence supporting the use of manual therapy techniques falls in the field of regenerative rehabilitation. Occupational therapists can play a crucial role in advancing regenerative medicine knowledge by integrating and expanding the understanding of regenerative medicine and rehabilitation techniques to improve client outcomes and achieve health, well-being, and participation in life.

Although genetic and genomic testing for common diseases is not widely available yet, technology is improving, costs are decreasing, and genomic information is becoming more readily available in health care (Roberts & Middleton, 2017). Consideration of genetic and genomic factors can help occupational therapists better understand individual differences in clinical disease presentation, the pain experience, and response to intervention (Curtis et al., 2016). Curtis et al. (2016) highlight the recent discoveries demonstrating that many chronic diseases associated with lifestyle choices, such as cardiovascular disease and osteoarthritis, are influenced by various common genetic variants. Occupational therapy approaches aimed at preventing and managing chronic conditions can use this knowledge to design better lifestyle modification programs and offer insight into future interventions targeting these conditions among individuals with genetic variants.

Pairing stem cell therapy with supportive rehabilitation therapy offers a tremendous opportunity for patients with neurological disorders (Kamelska-Sadowska et al., 2019). Promising future rehabilitation efforts will reactivate, modify, and stimulate residual nerve fibers using regenerative rehabilitation technologies, such as stem cell transplantation (Kamelska-Sadowska et al., 2019). Occupational therapy will be necessary to prevent muscle atrophy and joint stiffness while the stem cells work to repair damaged nerve function and ensure functional outcomes (Kamelska-Sadowska et al., 2019). Occupational therapists are poised to contribute to interventions to reduce the risk of secondary health problems through health promotion and disability prevention while patients undergo cellular-based therapies. Increasing the amount of physical activity and engagement in daily activities has been shown to reduce the risk of secondary health conditions, such as cardiovascular disease and pressure sores, and improve quality of life for individuals with spinal cord injuries (Nooijen et al., 2011). Increasing physical activity for people with spinal cord injuries, cerebrovascular accidents, traumatic brain injuries, and other neurological diseases requires occupational therapists' skill to provide graded and modified activities to ensure safety and optimal functional recovery.

Further research will be needed to identify optimal rehabilitation dosage, effective preventative strategies, and appropriate service delivery models as cellular-based therapy use increases.

Rehabilitation plays a critical role before, during, and after the regenerative process. Further research is needed to identify the added benefit occupational therapy provides and to explore the potential advances in tissue regeneration through novel technologies and therapeutic interventions. Genomic and regenerative rehabilitation research efforts are needed to bridge expertise across these diverse fields with occupational therapy.

This paper has highlighted several unique areas, but there are numerous other topics and areas of potential research and collaboration in these fields that directly apply to clinical practice and highlight occupational therapy's unique expertise:

- Genomic influences on types and intensities of rehabilitation across diagnoses seen by occupational therapists.
- The regenerative responses of genetic influence coupled with occupational therapy interventions.
- Increasing the usability of brain-computer interfaces for independent living.
- Identifying the most effective coping techniques for depression and anxiety in various genotypes.
- Cognitive and behavioral therapies to increase attrition, engagement, and functional recovery for cognitive rehabilitation research.
- Designing enriched environments to slow the progression of neurodegenerative diseases.
- Evaluating genomic influences on modifiable lifestyle factors and identifying effective treatment approaches.
- Determining the impact occupation-based interventions have on enhancing neurogenesis and circuitry reconstitution in people with cognitive impairment.

These are just a few examples of topics using regenerative rehabilitation principles that need further exploration. Examples provided in this paper are not intended to be exhaustive; instead, they are meant to stimulate discussion about the growing field of genomics and regenerative rehabilitation and how occupational therapy can contribute. This research field is quickly expanding, and researchers will need innovative thinkers, creative solutions, and clinician-patient perspectives to further develop and integrate regenerative rehabilitation into research and practice. Willett et al. (2020) highlighted the necessity of interdisciplinary approaches to regenerative rehabilitation research. These authors have identified occupational therapy as a specialized field in which regenerative concepts will have an important role (Willett et al., 2020). As a profession, occupational therapy would be well served by joining other disciplines to develop regenerative rehabilitation programs and research outcomes.

Potential Integration into Occupational Therapy Training

The difficulty associated with the inclusion of these topics into occupational therapy education standards must be acknowledged. However, selected topics on genomics, precision medicine, regenerative medicine, and regenerative rehabilitation must be integrated into occupational therapy education if occupational therapy, as a profession, aims to contribute to these fields of study effectively. Occupational therapy students and practicing clinicians must be exposed to these fields of study to speak to and understand the mutual language of health care professionals working in this arena. This critical content can be incorporated naturally into existing courses, such as emerging practice or research courses, without additional educational standards. These topics can also logically be integrated into foundational courses, such as anatomy, kinesiology, neuroscience, analysis of movement, or any course reviewing body systems. Regenerative rehabilitation is an emerging practice area that provides an additional perspective on occupational therapists' evaluation and intervention approaches to address

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client factors. It does not take away from occupational therapy's core belief in the positive relationship between occupation and health; instead, it highlights the impact on performance skills and client factors underlying the ability to participate in desired occupations (AOTA, 2020). Regenerative rehabilitation complements courses discussing the occupational therapy practice framework, rehabilitation theories, models of practice, and frames of reference. Regenerative rehabilitation topics can provide novel ideas for doctoral capstone projects and interdisciplinary collaboration. In addition, occupational therapists have a responsibility to stay current with scientific advances that impact service provision. Post professional education and training should include opportunities for practicing clinicians to learn more about regenerative rehabilitation and how to apply knowledge gained from this field into evaluations, interventions, and novel service delivery models.

Future Implications

The future of rehabilitation will be heavily impacted by genomics and regenerative medicine. Precision medicine is affecting virtually all health care areas, including the world of occupational therapy (Chang et al., 2015; Hofker et al., 2014; Kostek, 2019). The genomic era is upon us, and we must be prepared to contribute to the emerging evidence of regenerative rehabilitation. Regenerative rehabilitation represents a collaborative approach whereby rehabilitation specialists, such as occupational therapists, research scientists, and physicians, can enhance tissue and functional restoration by creating tailored rehabilitation treatments incorporating the highest levels of evidence from each discipline. Ambrosio and Kleim (2016) report that one of the greatest challenges for any therapist is deciding which intervention is optimal. Soon, therapists will be able to use advances in genetic variations as an additional factor in understanding the individual differences contributing to impairment manifestation, treatment response, and overall patient wellness (Ambrosio & Klein, 2016; Goldberg et al., 2015; Jameson & Longo, 2015; Perkins et al., 2018). Genomics is simply another tool to enhance the impact and outcome of occupational therapy. Occupational therapists can play an integral role in dealing with the opportunities and challenges that genomic medicine brings to health care.

It is hoped that this article will inspire clinicians and students to recognize the future of occupational therapists leading and practicing with expertise in precision and regenerative medicine. Occupational therapists have the power to learn from these fields of study and contribute as valuable members of the team in both practice and research. Occupational therapy programs can teach about these emerging fields by providing students with a framework to incorporate innovative technologies into evaluations and novel interventions based on genomic information (Curtis et al., 2016; Goldberg et al., 2016; Perez-Terzic & Childers, 2014). The future of regenerative rehabilitation is the future of rehabilitation, and occupational therapy can contribute to this exciting field of study.

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