Curriculum Vitae

Musa L. Audu, Ph.D.

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EDUCATION

1981 - 1984 Case Western Reserve University, Cleveland, Ohio 44106. U.S.A.
Ph.D. in Mechanical Engineering. Awarded in January 1985.

1978 - 1980 Ahmadu Bello University (A.B.U.), Zaria - Nigeria.
M.S. in Mechanical Engineering. Awarded in August 1980.

1974 - 1977 Ahmadu Bello University, Zaria - Nigeria.
B.S. in Mechanical Engineering. First Class Honors. Awarded in June 1977.

AWARDS AND HONORS

1. Shell-BP Prize for "Best Final Year Mechanical Engineering Student". A.B.U. Zaria - Nigeria, 1977.
2. Mobil Oil Prize for "Best Final Year Mechanical Engineering Design Project". A. B. U. Zaria - Nigeria, 1977.
3. U. A. C. Prize for "Best All round Student in the Faculty of Engineering". A.B.U. Zaria - Nigeria, 1977.
4. Nigerian Breweries Limited Prize for "Best Final Year Mechanical Engineering Student's Overall Performance over Three Years". A.B.U. Zaria - Nigeria, 1977.
5. Ahmadu Bello University, Zaria - Nigeria, Study Fellowship (January, 1981 to December, 1984). To study for a Ph.D. degree in the United States.
6. Association of Commonwealth Universities Traveling Fellowship (October, 1989 - November, 1989). To understudy some Centers of excellence in engineering schools in the United Kingdom.
7. Commonwealth Association of Polytechnics in Africa, Senior Management Development Workshop (14th - 24th March, 1994). Accra - Ghana.
8. 2012-2013 Outstanding Undergraduate Teaching Award, made by the CWRU Biomedical Engineering Society.

EMPLOYMENT

November, 2018 to date

1. Research Professor, Department of Biomedical Engineering, Case Western Reserve University, Cleveland, OH, USA. Continuing the duties of Research and other duties of Associate Professor.
2. Principal Investigator and Research Scientist, Advanced Platform Technology Center, Louis Stokes Cleveland VA Medical Center, Cleveland, OH, USA.

March, 2012 to October, 2018

1. Research Associate Professor, Department of Biomedical Engineering, Case Western Reserve University, Cleveland, OH, USA. Continuing the duties of Principal Researcher.
2. Principal Investigator, Advanced Platform Technology Center, Louis Stokes Cleveland VA Medical Center, Cleveland, OH, USA.

May, 2000 to February, 2012

1. Principal Researcher, Department of Biomedical Engineering, Case Western Reserve University, Cleveland, OH, USA. Developing mathematical/computer models for simulation of human standing posture and balance; being research on NIH/VA-Funded projects on restoration of function to individuals with spinal cord injury through Functional Electrical Stimulation (FES).
2. Teaching assignments at CWRU: EBME/EMAE 402 - Muscles, Biomechanics and Control of Movement (dynamics portion), EBME 309 – Modeling of Biomedical Systems (biomechanical modeling aspect). Also taught EMAE 415 on 'as needed basis'.
3. Principal Investigator, Advanced Platform Technology Center, Louis Stokes Cleveland VA Medical Center, Cleveland, OH, USA.

April, 1992 – May, 2000

1. Rector (President), The Federal Polytechnic, Bauchi - Nigeria. Responsible for the day-to-day administration of the Polytechnic.
2. I also participate in supervision of Postgraduate students at the Abubakar Tafawa Balewa University (A.T.B.U.) Bauchi - Nigeria.

November 1988 to March, 1992

Associate Professor (Reader) and Director, Center for Industrial Studies, Abubakar Tafawa Balewa University, Bauchi - Nigeria.

1. Day-to-day administration of the Center.
2. Taught the following undergraduate courses: Control Theory, Machine Design, Engineering Mechanics.
   And the following postgraduate courses: Theory of Elasticity, Advanced Dynamics, Theory of Metal Forming, Computers, Optimization and Design, Advanced Engineering Mathematics, Advanced Instrumentation and Industrial Control, Design for Production

August 1978 to October 1988

Graduate Assistant to Senior Lecturer, Department of Mechanical Engineering, A.B.U. Zaria - Nigeria - Duties included:

1. Teaching the following undergraduate courses: Dynamics, Mechanics of Machines, Machine Design, Vibrations Theory, Control Theory.
2. And the following Postgraduate courses: Machine Tool Design, Systems Theory.

PROFESSIONAL AND COMMUNITY SERVICE

1. Member, Governing Council of Bauchi State Polytechnic, 1988-1991.
2. Director, Federal Superphosphate and Fertilizer Company, Kaduna, 1988 - 1992.
3. Chairman, Shongom Community Bank, Kaltungo, 1993 - 1998.
4. Standing Member, National Institutes of Health, Biomedical Computing and Health

Informatics (BCHI) Study Section, 2017 - 2022.

5. Ad-Hoc Member, Scientific Peer Advisory and Review Services (SPARS) Panel overseeing proposals submitted to Paralyzed Veterans of America (PVA) Research Foundation.
6. Ad-Hoc Member, Special Emphasis Panel of the National Institutes of Health reviewing specific U01 proposals.

REVIEWER/EDITOR

1. Member, Editorial Board, Nigerian Journal of Technical Education, 1998 - 2000.
2. Reviewer, Journal of Rehabilitation, Research and Development.
3. Reviewer, IEEE Transactions on Neural Systems & Rehabilitation Engineering.
4. Reviewer, 2005 IEEE International Conference on Robotics and Automation.
5. Reviewer, Journal of Biomechanics.
6. Reviewer, Neuromodulation.
7. Reviewer, Transactions of the ASME, Journal of Biomechanical Engineering.
8. Reviewer, Journal of Applied Biomechanics.
9. Reviewer, Medical Engineering & Physics journal.
10. Reviewer, Medical & Biological Engineering & Computing journal.
11. Academic Editor, Applied Bionics and Biomechanics.

PUBLICATIONS

Peer-Reviewed Published Journal Papers/Book Chapters

1. **Audu, M. L**. and Davy, D. T., "The Influence of Muscle Model Complexity in Musculoskeletal Motion Studies", Transactions of the ASME, Journal of Bioengineering Vol. 107, No. 2, pp 147 - 157, 1985 (PMID: 3999711).
2. Mansour, J. M. and **Audu, M. L.**, "The Passive Elastic Moment at the Knee and its Influence on Human Gait". Journal of Biomechanics, Vol. 19, No. 5, pp 369 - 373, 1986 (PMID: 3733762).
3. Davy, D. T. and **Audu, M. L.**, "A Dynamic Optimization Technique for Predicting Muscle Forces in the Swing Phase of Gait". Journal of Biomechanics, Vol. 20, No. 2 pp 187 - 201, 1987 (PMID: 3571299).
4. **Audu, M. L.** and Davy D. T. "A Comparison of Optimal Control Algorithms for Complex Bioengineering Problems" Optimal Control Applications and Methods, Vol. 9, No.1 pp 101 - 106. 1988.
5. **Audu, M. L.,** "Computer-Aided Kinematic Analysis of Mechanisms". Nigerian Journal of Engineering Vol. 5, No.2, pp 175 -185. 1988.
6. **Audu, M. L.**, "Computer-Aided Symbolic Derivation of Equations of Motion for Systems of Rigid Bodies", Journal of Engineering Research, Vol. JER-2, No.2, pp. 84 - 101, 1990.
7. Jolaiya, S.O., **Audu, M. L.** and Tuleun, L. T., "The Design of an Attachment for Longitudinal Turning on Single-Spindle Automatic Lathe", The Nigerian Engineer, Vol. 27, No. 3, pp. 75 - 83, 1992.
8. **Audu, M. L.**, "Automatic Simplification and Substitution in a Symbolic Manipulation

Program", Technical Transactions of the Nigerian Society of Engineers, Vol. 29, No. 2, 1994.

9. **Audu, M. L.** and Obi, A.I. "A Pulse Testing Technique for the Structural Identification of the Tool-Post Complex of a Lathe Machine". Spectrum Journal, Vol. 2, Nos. 1 and 2, pp. 25 - 36, 1995.
10. **Audu, M. L.**, "An Apparatus for the Study of the Efficiency of Screw Threads", Nigerian Journal of Technical Education, Vol. 13, No. 1 and 2, pp. 69 - 77, 1996.
11. **Audu, M. L.**, "Design, Construction and Testing of a Demonstration Twist Drill Dynamometer". Spectrum Journal, Vol. 3, Nos. 1 and 2, pp. 43 - 53, 1996.
12. **Audu, M. L.** and Ali, M.D., "Design and Production of Pistons for a Small Engine", Nigerian Journal of Technical Education, Vol. 14, No. 2, pp. 1 - 14, 1997.
13. **Audu, M. L.** "An AutoCAD-based program for the insertion of points in a planar domain with applications in the Finite Element Method". Spectrum Journal, Vol. 4, Nos. 1 and 2, pp. 45 - 59, 1998.
14. **Audu, M. L.** and Alhaji, A. U., "Design, Construction and Testing of a Manually-operated Pipe Chair Frame Bending Jig", Polymath Journal, Vol. 1, No. , pp. 16 - 22, 2000.
15. **Audu, M. L.**, "An Optimal Control Strategy for Determining the Lower Limb Joint Torques required to stand erect from the squatting position". Nigerian Journal of Technical Education, vol. 17, Nos. 1 and 2, pp. 10 - 26, 2000.
16. Adisa, A. B. and **Audu, M. L.** "Automatic Renumbering of Finite Element Nodes", Journal of Engineering Technology and Industrial Applications. Vol.1 No.1, pp24-39, 2000.
17. **Audu, M.L.**, Kirsch, R. F. and Triolo, R.J., "A Computational Technique for Determining the Ground Reaction Forces in Human Bipedal Stance". Journal of Applied Biomechanics, vol. 19, No. 4, pp. 361 – 371, November 2003.
18. Knutson, J, **Audu, M** and Triolo, R, "Interventions for Mobility and Manipulation after Spinal Cord Injury: A Review of Orthotic and Neuroprosthetic Options". In Topics in Spinal Cord Injury Rehabilitation, Thomas Land Publication, Birmingham, AL, USA, 2006.
19. Wilkenfeld, A., Triolo, R.J. and **Audu, M.L.**, "Feasibility of Functional Electrical Stimulation for Control of Seated Posture after Spinal Cord Injury: A Simulation Study", Journal of Rehabilitation, Research and Development, vol. 43, No. 2, pp. 139 – 152, 2006 (PMID: 16847781).
20. Heilman, B. P., **Audu, M. L.**, Kirsch, R. F. and Triolo, R.J., "Selection of an Optimal Muscle set for a 16-channel Standing Neuroprosthesis using a Human Musculoskeletal Model", Journal of Rehabilitation, Research and Development, vol. 43, No. 2, pp. 273 – 286, 2006 (PMID: 16847793).
21. Amankwah, K., Kirsch, R. F. and Triolo, R.J. and **Audu, M.L.**, "A model-based study of passive joint properties on muscle effort during static stance". Journal of Biomechanics, volume. 39, pp. 2253-2263, 2006 (PMID: 16157347).
22. **Audu, M.L.**, Kirsch, R. F. and Triolo, R.J., "Experimental Verification and Application of a Computational Technique for determining Ground Reactions in Human Bipedal Stance". Journal of Biomechanics, vol. 40, 1115 – 1124, 2007 (PMID: 16797023).
23. To, C. S., Kobetic, R., Schnellenberger, J. R., **Audu, M. L.** and Triolo, R. J., "Design of a variable constraint hip mechanism for a hybrid neuroprosthesis to restore gait after spinal

cord injury". IEEE/ASME Transactions on Mechatronics, vol. 13, No. 2, pp. 197-205, April 2008.

24. Gartman, S., **Audu, M. L.**, Kirsch, R. F. and Triolo, R. J., "Selection Of An Optimal Muscle Set For A 16-Channel Standing Functional Electrical Stimulation System", Journal of Rehabilitation, Research and Development, vol. 45, No. 7, pp. 1007–1018, 2008 (PMID: 19165690).
25. Kobetic, R., To, C.S., Schnellenberger, J.R., **Audu, M.L.**, Bulea, T.C., Gaudio, R., Pinault, G., Tashman, S. and Triolo, R.J., "Development of hybrid orthosis for standing, walking, and stair climbing after spinal cord injury", Journal of Rehabilitation Research & Development, Vol. 46, No. 3, Pages 447–462, 2009 (PMID: 19675995).
26. Lambrecht, J. M., **Audu, M. L.**, Triolo, R. J. and Kirsch, R. F. "Musculoskeletal model of trunk and hips for development of seated-posture-control neuroprosthesis", Journal of Rehabilitation, Research and Development, vo. 46, No. 4, Pages 515-528, 2009 (PMID: 19882486).
27. **Audu, M. L.**, To, C. S., Kobetic, R. and Triolo, R. J., "Gait evaluation of a novel hip constraint orthosis with implication for walking in paraplegia", IEEE Trans. on Neural Systems and Rehab Eng., vol. 18, No. 6, pp. 610-618, 2010 (PMID: 20378478).
28. Nataraj, R., **Audu, M. L.**, Kirsch, R. F. and Triolo, R. J., "Comprehensive Joint Feedback Control for Standing by Functional Neuromuscular Stimulation—A Simulation Study", IEEE Trans. on Neural Systems and Rehab Eng., vol. 18, No. 6, pp. 646 - 657, 2010 (PMID: 20923741).
29. **Audu, M. L.,** Nataraj R., Gartman S.J., and Triolo R.J., "Posture shifting after spinal cord injury using functional neuromuscular stimulation - a computer simulation study." Journal of Biomechanics, vol. 44, No. 9, pp. 1639-1645, 2011.
30. To, C.S., Kobetic, R., Bulea, T.C., **Audu, M.L.**, Schnellenberger, J.R., Pinault, G. and Triolo, R.J. "Stance control knee mechanism for lower-limb support in hybrid neuroprosthesis". Journal of Rehabilitation, Research and Development, vol. 48, No. 7, Pages 839-850, 2011.
31. Nataraj, R., **Audu, M. L.**, Kirsch, R. F. and Triolo, R. J., "Trunk Acceleration for Neuroprosthetic Control of Standing – a Pilot Study". Journal of Applied Biomechanics, vol. 28, No. 1., pp 85 – 92, 2012.
32. To, C. S., Kobetic, R., Bulea, T. C., **Audu, M. L.**, Schnellenberger, J. R., Pinault, G., Triolo, R. J. "Sensor-Based Stance Control With Orthosis and Functional Neuromuscular Stimulation for Walking After Spinal Cord Injury", Journal of Prosthetics & Orthotics, vol. 24, Issue 3, p 124–132, 2012.
33. Bulea T.C., Kobetic R., To C.S., **Audu M.L.**, Schnellenberger J., Triolo R.J. "A Variable Impedance Knee Mechanism for Controlled Stance Flexion During Pathological Gait", IEEE Transactions on Mechatronics, vol. 17, no. 5, pp. 822-832, 2012.
34. Nataraj, R., **Audu, M. L.**, Kirsch, R. F. and Triolo, R. J., "Center of mass acceleration feedback control for standing by functional neuromuscular stimulation: A simulation study", Journal of Rehabilitation, Research and Development, vol. 49, No. 2, Pages 279-296, 2012.
35. Nataraj, R., **Audu, M. L.** and Triolo, R. J., "Center of mass acceleration feedback control of functional neuromuscular stimulation for standing in presence of internal postural perturbations", Journal of Rehabilitation, Research and Development, vol. 49, No. 6, Pages 889-912, 2012.
36. Nataraj, R., **Audu, M. L.** and Triolo, R. J., "Comparing joint kinematics and center of

mass acceleration as feedback for control of standing balance by functional neuromuscular stimulation", Journal of NeuroEngineering and Rehabilitation, vol. 9:25, Pages 1-11, 2012 (PMID: 22559852).

37. Bulea, T.C., Kobetic, R., **Audu, M.L.**, Schnellenberger, J.R. and Triolo, R.J., "Finite State Control of a Variable Impedance Hybrid Neuroprosthesis for Locomotion After Paralysis", IEEE Trans. on Neural Systems and Rehab Eng., vol. 21, No. 1, pp. 141 - 151, 2013.
38. Nataraj, R., **Audu, M.L.** and Triolo, R.J., "Center of Mass Acceleration Feedback Control of Standing Balance by Functional Neuromuscular Stimulation Against External Postural Perturbations", IEEE Transactions on Biomedical Engineering, vol. 60, No. 1, pp. 10-19, 2013.
39. Triolo, R.J., Bailey, S.N., Miller, M.E., Lombardo, L.M. and **Audu, M.L.**, "Effects of Stimulating Hip and Trunk Muscles on Seated Stability, Posture, and Reach After Spinal Cord Injury", Archives of Physical Medicine and Rehabilitation, vol. 94, pp:1766-1775, 2013.
40. Triolo, R.J., Bailey, S.N., Lombardo, L.M., Miller, M.E., Foglyano, K. and **Audu, M.L.**, "Effects of Intramuscular Trunk Stimulation on Manual Wheelchair Propulsion Mechanics in 6 Subjects With Spinal Cord Injury", Archives of Physical Medicine and Rehabilitation, vol. 94, pp. 1997-2005, 2013.
41. Bulea,T.C., Kobetic,R., **Audu**,M.L. and Triolo,R.J., "Stance controlled knee flexion improves stimulation driven walking after spinal cord injury.", Journal of NeuroEngineering and Rehabilitation, vol. 10:68, pp:1-11, 2013.
42. To, C.S., Kobetic, R., Bulea, T.C., **Audu**, M.L., Schnellenberger, J.R., Pinault, G., Triolo, R.J., "Sensor-based hip control with hybrid neuroprosthesis for walking in paraplegia", Journal of Rehabilitation, Research and Development, vol. 51, No. 2, Pages 229-244, 2014.
43. **Audu, M.L.**, Gartman, S.J., Nataraj, R. and Triolo, R.J, "Posture dependent control of stimulation in a standing neuroprosthesis: a simulation feasibility study", Journal of Rehabilitation Research and Development, vol. 51, No. 3, pp:481-496, 2014.
44. Ho, C.H., et al, "Functional Electrical Stimulation and Spinal Cord Injury", Physical Medicine and Rehabilitation Clinics of North America, vol. 25, No. 3 , Pages 631-654, 2014.
45. Murphy, J.O., **Audu, M.L.**, Lombardo, L.M., Foglyano, K.M., Triolo, R.J. "Feasibility of closed-loop controller for righting seated posture after spinal cord injury", Journal of Rehabilitation, Research and Development, vol. 51, No. 5, Pages 747–760, 2014.
46. Bulea, T.C., Kobetic, R., **Audu, M.L.**, Schnellenberger, J.R., Pinault, G. and Triolo, R.J., "Forward stair descent with hybrid neuroprosthesis after paralysis: Single case study demonstrating feasibility", Journal of Rehabilitation, Research and Development, vol. 51, No. 7, Pages 1077-1094, 2014.
47. Nataraj, R., **Audu, M.L.** and Triolo, R.J. "Modified Newton-Raphson method to tune feedback gains of control system for standing by functional neuromuscular stimulation following spinal cord injury", Applied Bionics and Biomechanics, vol. 11, pp:169–174, 2014.
48. **Audu, M.L.**, Lombardo, L.M., Schnellenberger, J.R., Foglyano, K.M., Miller, M.E. and Triolo1, R.J., "A neuroprosthesis for control of seated balance after spinal cord injury". Journal of NeuroEngineering and Rehabilitation, vol. 12:8, pp:1-12, 2015.
49. Nataraj, R., **Audu, M.L.** and Li, Z., "Digit mechanics in relation to endpoint compliance

during precision pinch". Journal of Biomechanics, v.48, pp:672-680, 2015.

50. Foglyano, K.M., Kobetic, R., To, C.S., Bulea, T.C., Schnellenberger, J.R., **Audu, M.L.**, Nandor, M.J., Quinn, R.D. and Triolo, R.J., "Feasibility of a Hydraulic Power Assist System for Use in Hybrid Neuroprostheses". Applied Bionics and Biomechanics, vol. 2015, Article ID 205104, 8 pages, 2015.
51. **Audu, M.L.** and Triolo, R.J., "Intrinsic and Extrinsic Contributions to Seated Balance in the Sagittal and Coronal Planes: Implications for trunk control after Spinal Cord Injury". Journal of Applied Biomechanics, vol. 31, No. 4, pp: 221-228, 2015.
52. Chang, S.R., Kobetic, R., **Audu, M.L.**, Quinn, R.D. and Triolo, R.J., "Powered Lower-Limb Exoskeletons to Restore Gait for Individuals with Paraplegia – a Review", Case Orthopedic Journal, vol. 12, No.1, pp:75-80, 2015.
53. Nataraj R., **Audu M.L.** and Triolo R.J. "Simulating the restoration of standing balance at leaning postures with functional neuromuscular stimulation following spinal cord injury". Med Biol Eng Comput., vol. 54(1), pp:163-76, 2016. PubMed PMID: 26324246.
54. Crawford, A., Armstrong, K., Loparo, K., **Audu, M.L.** and Triolo, R.J., "Detecting destabilizing wheelchair conditions for maintaining seated posture", Disability and Rehabilitation: Assistive Technology, DOI: 10.1080/17483107.2017.1300347, 2017.
55. Chang, S.R., Nandor, M.J., Li, L., Kobetic, R., Foglyano, K.M., Schnellenberger, J.R., **Audu, M.L.**, Pinault, G., Quinn, R.D. and Triolo, R.J. "A muscle-driven approach to restore stepping with an exoskeleton for individuals with paraplegia", Journal of NeuroEngineering and Rehabilitation, 2017, 14:48.
56. Hunt, A.J., Odle, B.M., Lombardo, L.M., **Audu, M.L.** and Triolo, R.J. "Reactive stepping with functional neuromuscular stimulation in response to forward-directed perturbations", Journal of NeuroEngineering and Rehabilitation (2017) 14:54.
57. Nataraj, R., **Audu, M.L.** and Triolo, R.J. "Restoring standing capabilities with feedback control of functional neuromuscular stimulation following spinal cord injury", Medical Engineering & Physics, vol. 42, 2017, Pages 13-25.
58. **Audu, M.L.**, Odle, B.M. and Triolo, R.J., "Control of standing balance at leaning postures with functional neuromuscular stimulation following spinal cord injury", Medical & Biological Engineering & Computing, vol. 56, pp 317–330, 2018.
59. **Audu, M.L.**, Kobetic, R., Selkirk, S. and Triolo, R.J. "Lower Extremity Motor System Neuroprostheses", NeuroModulation (2nd Ed.), Krames, E.S., Peckham, P. H. and Rezai, A. R. (Editors), Volume 3, Chapter 97, pp.1171-1182, 2018.
60. Armstrong, K.L., Lombardo, L.M., Foglyano, K.M., **Audu, M.L**. and Triolo, R.J., "Automatic application of neural stimulation during wheelchair propulsion after SCI enhances recovery of upright sitting from destabilizing events", Journal of NeuroEngineering and Rehabilitation, 2018, 15:17.
61. Odle, B.M., Lombardo, L.M., **Audu, M.L.** and Triolo, R.J. "Experimental Implementation of Automatic Control of Posture-Dependent Stimulation in an Implanted Standing Neuroprosthesis", Applied Bionics and Biomechanics, vol. 2019, Article ID 2639271. https://doi.org/10.1155/2019/2639271.
62. Liu C., Lonsberry A. G., Nandor M.J., **Audu M.L.**, Lonsberry, A.J. and Quinn, R.D. "Implementation of Deep Deterministic Policy Gradients for Controlling Dynamic Bipedal Walking", Biomimetics 2019, 4, 28; doi:10.3390/biomimetics4010028.
63. Bheemreddy A, Friederich A, Lombardo L, Triolo R.J, **Audu M.L**. Estimating total maximum isometric force output of trunk and hip muscles after spinal cord injury. Med Biol Eng Comput. Vol. 58, pp:739–751, 2020.

64. Bheemreddy A., Lombardo L.M., Miller, M.E., Foglyano, K.M., Nogan-Bailey, S., Triolo R.J. and **Audu M.L.** "A closed-loop self-righting controller for seated balance in the coronal and diagonal planes following spinal cord injury". Medical Engineering & Physics, vol. 86, 2020, Pages 47-56.
65. Reyes, R., Kobetic, R., Nandor, M., Makowski, N., **Audu, M.**, Quinn, R. and Triolo, R. "Effect of Joint Friction Compensation on a "Muscle-First" Motor-Assisted Hybrid Neuroprosthesis", Frontiers of Neurorobotics, 11 December 2020, https://doi.org/10.3389/fnbot.2020.588950.
66. Friederich, A. R. W., **Audu, M. L.** and Triolo, R. J. "Characterization of the Force Production Capabilities of Paralyzed Trunk Muscles Activated with Functional Neuromuscular Stimulation in Individuals with Spinal Cord Injury,". *IEEE Transactions on Biomedical Engineering*, vol. 68(8), pp. 2389-2399, Aug. 2021.
67. Nandor, M., Kobetic, R., **Audu, M.L.**, Triolo, R.J. and Quinn, R. "A Muscle-First, Electromechanical Hybrid Gait Restoration System in People with Spinal Cord Injury", *Frontiers in Robotics and AI*, 27 April 2021 | https://doi.org/10.3389/frobt.2021.645588.
68. Liu, C., **Audu, M.L.**, Triolo, R.J. and Quinn, R.D., "Neural Networks Trained via Reinforcement Learning Stabilize Walking of a Three-Dimensional Biped Model with Exoskeleton Applications", Front. Robot. AI, 06 August 2021 | https://doi.org/10.3389/frobt.2021.710999.
69. Hnat, S.K., **Audu, M.L.**, Triolo, R.J. and Quinn, R.D. "Estimating Center of Mass Kinematics During Perturbed Human Standing Using Accelerometers", Journal of Applied Biomechanics, https://doi.org/10.1123/jab.2020-0222. First Published Online: 27 Aug 2021, In Print: Vol. 37, Issue 5, pp: 415-424, 2021.
70. Koelewijn, A.D., **Audu, M.L.**, et al. "Adaptation Strategies for Personalized Gait Neuroprosthetics", Front. Neurorobot. 15:750519. doi: 10.3389/fnbot.2021.750519. https://www.frontiersin.org/article/10.3389/fnbot.2021.750519.
71. Makowski, N.S., Fitzpatrick, M.N., Triolo, R.J., Reyes, R.D., Quinn, R.D. and **Audu, M.L.** "Biologically Inspired Optimal Terminal Iterative Learning Control for the Swing Phase of Gait in a Hybrid Neuroprosthesis: A Modeling Study, Bioengineering 2022, 9 (2), 71. https://doi.org/10.3390/bioengineering9020071.
72. Bao, X., **Audu, M.L.**, Friederich, A.R. and Triolo, R.J. "Robust Control of the Human Trunk Posture Using Functional Neuromuscular Stimulation- A Simulation Study", Trans ASME, Journal of Biomechanical Engineering, September 2022, Vol. 144 / 091002-1-11.
73. Bean, N.F., Lombardo, L. M., Triolo1, R. J. and **Audu, M. L.** "Facilitation of dependent transfers with functional neuromuscular stimulation: a computer simulation study", Medical & Biological Engineering & Computing, https://doi.org/10.1007/s11517-022-02672-3, 2022.
74. Friederich, A. R. W., **Audu, M. L.** and Triolo, R.J. "Trunk Posture from Randomly Oriented Accelerometers", Sensors 2022, 22, 7690. https://doi.org/10.3390/s22197690.

Conference/Seminar Papers/Poster Presentations

1. Mansour, J. M. and Audu, M. L., "Influence of Passive Elastic Joint Moments on Human Gait". Seventh Annual Conference of the American Society of Biomechanics, Mayo Clinic, Rochester, Minnesota. Sept. 28 - 30, 1983.
2. Audu, M. L. and Davy, D. T., "A Comparison of Different Muscle Models in Human Motion Studies". 1984 Advances in Bioengineering, ed. R. L. Spilker, pp 135 - 136.

3. Audu, M. L., "Optimization Problems in Human Locomotion Studies", Presented at the National Mathematical Centre, Abuja, Nigeria, Saturday, 13th March, 1999.
4. Audu, M.L., Kirsch, R. F. and Triolo, R.J., "Development of an Artificial Vestibular System for Unassisted Standing in FES", Poster Presented at the Thirty Second Neural Prosthesis Workshop of the National Institutes of Health (NIH), Bethesda, Maryland, October, 2001.
5. Audu, M.L., Kirsch, R. F. and Triolo, R.J., "Estimating the Ground Reaction Forces in Three-Dimensional Simulation of Standing Posture", Presented at the 6th Annual Conference of the International FES Society, Cleveland, OH, June, 2001.
6. Audu, M.L., Kirsch, R. F. and Triolo, R.J., "Estimating the Magnitude and Location of the Ground Reaction Forces with Application to three Dimensional Studies of Standing Postures", Poster Presented at the Thirty Third Neural Prosthesis Workshop of the National Institutes of Health (NIH), Bethesda, Maryland, October, 2002.
7. Audu, M.L., Kirsch, R. F. and Triolo, R.J., "Three Dimensional Modeling Of The Lower Extremity For The Study Of Static Standing Postures In Functional Electrical Stimulation (FES)", Presented at the Second Joint meeting of the IEEE EMBS-BMES Conference, Houston, Texas, October, 2002.
8. Triolo, R.J., Davis, J.A., Audu, M.L., Bogie, K., Kirsch, R. F. and Wilkenfeld, A., "Neuroprosthesis for Standing, Walking and Control of Seated Posture", Poster Presented at the Thirty Fourth Neural Prosthesis Workshop of the National Institutes of Health (NIH), Bethesda, Maryland, October, 2003.
9. Hincapie, J.G., Audu, M.L. and Kirsch, R.F., "Adaptive Control Techniques for Upper Extremity Neuroprosthesis", Poster Presented at the Thirty Fourth Neural Prosthesis Workshop of the National Institutes of Health (NIH), Bethesda, Maryland, October, 2003.
10. Heilman, B., Kirsch, R.F., Triolo, R.J., Audu, M.L., and Amankwah, K., "Selection of an Optimal Muscle set for a Standing Neuroprosthesis using Human Musculoskeletal Model", Poster Presented at the Thirty Fourth Neural Prosthesis Workshop of the National Institutes of Health (NIH), Bethesda, Maryland, October, 2003.
11. International Symposium on Technology Education and Training organized by the World Federation of Technology Organizations (27th June to 1st July, 1998). Cape Town - South Africa.
12. Internet Technology and Education Workshop organized by the Faculty Center for excellence in Teaching, California State University, Hayward, California, U.S.A. (13th to 16th August, 1998).
13. First World Congress of Colleges and Polytechnics organized by the Association of Canadian Community Colleges, Quebec, Canada (29th May to June 1st, 1999).
14. Audu, M.L., Kirsch, R. F. and Triolo, R.J., "Controller design for hands-free standing of SCI subjects with FES", Poster Presented at the *Neural Interfaces Workshop* of the National Institutes of Health (NIH), Bethesda, Maryland, November, 2004.
15. Audu, M.L., Kirsch, R. F. and Triolo, R.J., "Design of Controllers for Restoration of Balance in Bipedal Human Standing", *Proceedings of the International Symposium on computer Simulation in Biomechanics*, Cleveland, Ohio, July, 2005, pp. 7-8.
16. Nataraj, R., Triolo, R.J., Kirsch, R.F., and Audu, M.L., "Controller development for Automatic Standing Balance using Functional Neuromuscular Stimulation following Spinal Cord Injury", *Proceedings of the International Symposium on computer Simulation in Biomechanics*, Cleveland, Ohio, July, 2005, pp. 9-10.
17. Nataraj RN, Audu ML, Kirsch RF, Triolo RJ. "Control System Development for

Automatic Standing Balance using Functional Neuromuscular Stimulation (FNS) Following Spinal Cord Injury (SCI)". *American Society of Biomechanics*, August 2007, Stanford University, Palo Alto, CA.

18. Nataraj RN, Audu ML, Kirsch RF, Triolo RJ. "Automatic Control of Standing Balance Using Functional Electrical Stimulation following Spinal Cord Injury", *12th Annual Conference of the International FES Society*, November 2007, Philadelphia, PA.
19. Audu, M. L., Nataraj, R., Kirsch, R.F., and Triolo, R.J., "Dynamic Computer Optimization for Standing Balance and Control of Postural Sway after Spinal Cord Injury", *12th Annual Conference of the International FES Society*, November 2007, Philadelphia, PA.
20. Audu, M. L. and Triolo, R.J., "Dynamic trunk control for adjustment of seated posture – a computer simulation study", Poster presented at the *First Neural Interfaces Conference*, Cleveland, Ohio, USA. 2008.
21. Nataraj R.N., Audu M.L., Kirsch R.F. and Triolo R.J., "Development of Sensor-Feedback Control System for Automatic Standing Maintenance Using Functional Electrical Stimulation following Spinal Cord Injury", Poster presented at the *First Neural Interfaces Conference*, Cleveland, Ohio, USA. 2008.
22. Audu, M.L., Murphy, J.O. and Triolo, R.J., "Design of Controllers for Seated Balance After Spinal Cord Injury", Military Health System Research Symposium (MHSRS), August, 2012, Ft Lauderdale, FL.
23. Audu, M.L., Murphy, J.O and Triolo, R.J., "Trunk Stability after Spinal Cord Injury", *17th Annual Meeting of the International Functional Electrical Stimulation Society (IFESS)*, September 9-12, 2012, Banff, Alberta, Canada.
24. Murphy, J.O., Audu, M.L., Triolo, R.J., "Control of Seated Balance after Spinal Cord Injury using Functional Electrical Stimulation", *Biomedical Engineering Society (BMES) Annual Meeting*, October 24-27, 2012, Atlanta, Georgia, USA.
25. Audu, M. L., "Neuroprosthetic and Advanced Orthotic Applications for Lower Limb Weakness", Invited Speech to: *Regional Lower Limb Prosthetics &Orthotics Rehabilitation Course* – May 11, 2013.
26. Audu, M.L and Triolo, R.J., "Are Paralyzed Muscle strengths underestimated?", *Midwest ASB Regional Meeting, The University of Akron*, March 4-5th 2014.
27. Audu, M.L., Marinis, L. and Triolo, R.J., "Seated balance perturbation rejection control after spinal cord injury", Poster presented at *Case ShowCase*, April, 18, 2014.
28. Murphy, J.O., Audu, M.L. and Triolo, R.J., "Comparison between Direct Neuromuscular and Reflex Activation of Hip Flexors: Implications for Maintaining Balance via Protective Stepping". Poster Presented at *Case ShowCase*, April, 18 2014.
29. Nataraj, R., Audu, M.L. and Triolo, R.J., "Feedback Control to Restore Forward Standing Balance Using Functional Neuromuscular Stimulation Following Spinal Cord Injury", *Midwest ASB Regional Meeting, The University of Akron*, March 4-5th 2014.
30. Tepe, K., Nogan-Bailey, S., Audu, M.L., and Triolo, R.J., "Selecting Upper Extremity Muscle Signals to Modulate Electrical Stimulation of Trunk Muscles during Manual Wheelchair Propulsion". Poster Presented at *Case ShowCase*, April, 18 2014.
31. Audu, M.L., Marinis, L. and Triolo, R.J., "A perturbation rejection controller for seated balance after spinal cord injury", Poster presented at the *World Congress of Biomechanics, Boston, MA*, July, 6-11, 2014.
32. Nataraj, R., Audu, M.L. and Li, Z., "Precision pinch joint mechanics in relation to digit endpoint compliance". Poster presented at the *World Congress of Biomechanics, Boston,*

MA, July, 6-11, 2014.

33. Audu, M.L., Lombardo, L. and Triolo, R.J., "A neuroprosthesis for maintaining seated balance after spinal cord injury", *Military Health System Research Symposium (MHSRS)*, August, 2014, Ft Lauderdale, FL.
34. Nataraj, R, Audu, M.L. and Triolo, R.J., "Estimating Center of Mass Kinematics with a Networked Neuroprosthesis for Standing", Presented at the 36th *Annual International IEEE EMBS Conference*, Chicago, Ill., August, 26-30, 2014.
35. Nataraj, R., Audu, M.L. and Triolo, R.J. "Simulation of Leaning Standing after Spinal Cord Injury", *Dynamic Walking Conference 2015*, The Ohio State University, July 21-24, 2015, Columbus Ohio.
36. Audu, M.L., Odle, B., Nataraj, R. and Triolo, R.J. "Effects of Stimulation on Non-Erect Postures with a Standing Neuroprosthesis," *World Congress on Medical Physics & Biomedical Engineering*, June 7-12, 2015, Toronto CA.
37. Crawford, A., Audu, M.L. and Triolo, R.J. "Automatic Detection of Destabilizing Wheelchair Conditions for Modulating Actions of Neuroprostheses to Maintain Seated Posture," *World Congress on Medical Physics & Biomedical Engineering*, June 7-12, 2015, Toronto CA.
38. Tepe, K., Nogan-Bailey, S., Audu, M.L. and Triolo, R.J. "Selecting Upper Extremity Command Signals to Modulate Electrical Stimulation of Trunk Muscles During Manual Wheelchair Propulsion," *World Congress on Medical Physics & Biomedical Engineering*, June 7-12, 2015, Toronto CA.
39. Audu, M.L. and Triolo, R.J. "A Neuroprosthesis for Coronal Plane Trunk Control,", *World Congress for Neurorehabilitation*, WCNR, Philadelphia PA, May 11-13, 2016.
40. Odle. B., Hunt, A., Audu, M., L., Lombardo, L. and Triolo, R.J., "Center of pressure feedback control on task-dependent postures in a user with a standing neuroprosthesis", *Proceedings of the North American Neuromodulation Society-Neural Interfaces Conference*, Baltimore, MD (June 25-29, 2016).
41. Odle. B., Hunt, A., Audu, M., L., Lombardo, L. and Triolo, R.J., "Center of pressure feedback control of posture in an implanted standing neuroprosthesis", *38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Orlando, FL (August 16-20, 2016).
42. Hunt, A., Odle. B., Audu, M., L., Lombardo, L. and Triolo, R.J., " Reactive Stepping with Functional Neuromuscular Stimulation in Response to Forward Directed Perturbations Reactive Stepping with Functional Neuromuscular Stimulation in Response to Forward Directed Perturbations", *38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Orlando, FL (August 16-20, 2016).
43. Audu, M.L., Lombardo, L. M. and Triolo, R.J. "Sagittal plane control of trunk posture after spinal cord injury," *41st Annual Meeting of the American Society of Biomechanics*, Boulder, CO, USA, August 8th – 11th, 2017.
44. Odle, B.M., Audu, M.L., Lombardo, L.M. and Triolo, R.J., "Experimental evaluation of a feedback control system to adopt task-dependent postures in an implanted standing neuroprosthesis", *41st Annual Meeting of the American Society of Biomechanics*, Boulder, CO, USA, August 8th – 11th, 2017.
45. Armstrong, K.L., Audu, M.L., and Triolo, R.J. "Automatic Application of Neural Stimulation during Wheelchair Propulsion after SCI Enhances Recovery of Upright Sitting from Destabilizing Events," *41st Annual Meeting of the American Society of Biomechanics*, Boulder CO, USA, August 8th- 11th, 2017.

46. Armstrong, K.L., Audu, M.L., and Triolo, R.J. “Automatic Detection of Destabilizing Wheelchair Conditions for Modulating Actions of Neuroprostheses to Maintain Seated Posture,” *Academy of Spinal Cord Injury Professionals Educational Conference*, Denver, CO, USA, September 3rd – 6th, 2017.
47. Armstrong, K.L., Audu, M.L., and Triolo, R.J. “Automatically Detecting Destabilizing Wheelchair Conditions and Applying Electrical Stimulation to Maintain Seated Posture,” *Biomedical Engineering Society Conference*, Phoenix, AZ, USA, October 11th – 14th, 2017.
48. Audu, M.L., Alibeji, N. A., Odle, B.M., and Triolo, R.J. “A Sensor Fusion Algorithm for Estimating Center of Mass Kinematics in Human Walking,” *42nd Annual Meeting of the American Society of Biomechanics*, Rochester, MN, USA, August 8th – 13th, 2018.
49. Odle, B.M., Alibeji, N. A., Audu, M.L. and Triolo, R.J., “Predicting Interaction Forces Between Upper Extremities and Support Devices”, *42nd Annual Meeting of the American Society of Biomechanics*, Rochester, MN, USA, August 8th – 13th, 2018.
50. Alibeji, N. A., Odle, B.M., Audu, M. L. and Triolo, R.J. “Gait Restoration After a Spinal Cord Injury: A Simulation and Experimental Study of the Double Support Phase,” *42nd Annual Meeting of the American Society of Biomechanics*, Rochester, MN, USA, August 8th – 13th, 2018.
51. Bheemreddy, A., Alibeji, N., Triolo, R.J. and Audu, M.L., “Estimating Coronal Plane Trunk Muscle Maximum Isometric Force after Spinal Cord Injury”, *Biomedical Engineering Society Conference*, Atlanta, GA, USA, October 17th – 20th, 2018.
52. Bean, N., Odle, B.M., Lombardo, L.M., Audu, M.L. and Triolo, R.J. “Augmentation of caregiver dependent transfers with functional neuromuscular stimulation (FNS)”. *Midwest Regional Meeting of the American Society of Biomechanics (ASB)*, Dayton OH, February 2019.
53. Bean, N., Odle, B.M., Lombardo, L.M., Audu, M.L. and Triolo, R.J. “Functional neuromuscular stimulation to facilitate assisted transfers: a pilot study”. *Rehabilitation Engineering Society of North America (RESNA) Meeting*, Toronto CA, June 2019. Honorable Mention, Student Scientific Paper Competition
54. Odle, B. M., Bean, N., Lombardo, L.M., Audu, M.L. and Triolo, R.J. “Feasibility of Neural Stimulation to Facilitate Assisted Transfers after Paralysis”, *Academy of Spinal Cord Injury Professionals (ASCIP) Educational Conference and Expo.*, Nashville, TN, September 2 - 4, 2019.
55. Hnat, S.K., Audu, M.L., and Triolo, R.J. “Estimating Center of Mass Kinematics using Inertial Measurement Units,” *Biomedical Engineering Society Conference*, Philadelphia, PA, USA, October 16th – 19th, 2019.
56. Friederich, A.R.W., Alibeji, N.A., Audu, M.L. and Triolo, R.J. "Accurate Characterization of Nonlinear Recruitment Properties of Trunk Musculature", *Biomedical Engineering Society Conference*, Philadelphia, PA, USA, October 16th – 19th, 2019.
57. Bao, X., Friederich, A. R., Audu, M. L. and Triolo, R. J. "An Integrated Control System for Optimal Human Trunk Motion", *8th IEEE RAS/EMBS International Conference for Biomedical Robotics and Biomechatronics (BioRob)*, New York, NY, November 29 - December 1, 2020 (Virtual Conference).
58. Odle, B.M., Rosenbrook, P., Lombardo, L.M., Audu, M.L. and Triolo, R.J., “User perceptions of neural stimulation-facilitated transfers across surfaces of different heights”, RESNA Annual Conference, September 23 - 24, 2020.
59. Audu, M.L., Labrozzi, G., Warner, H., Makowski, N. and Triolo, R.J. “Musculoskeletal

Models for Human Stepping after Spinal Cord Injury," *North American Conference on Biomechanics (NACOB)*, Ottawa, ON, Canada, August 21st – 25th, 2022.

60. Labrozzi, G., Audu, M.L., Warner, H., Makowski, N. and Triolo, R.J. "Center of Mass Estimation for Gait Control in Spinal Cord Injury," *North American Conference on Biomechanics (NACOB)*, Ottawa, ON, Canada, August 21st – 25th, 2022.
61. Friederich, A.R.W., Audu, M.L. and Triolo, R.J. "A comparison of FeedForward methods for Control of the Trunk after SCI", *North American Conference on Biomechanics (NACOB)*, Ottawa, ON, Canada, August 21st – 25th, 2022.
62. Warner, H., Audu, M.L., Labrozzi, G., Makowski, N. and Triolo, R.J. "Musculoskeletal Modelling for Gait Control Studies in Spinal Cord Injury with OpenSim Moco", Biomedical Engineering Society Conference, San Antonio, TX, USA, October 12th – 15th, 2022.
63. Labrozzi, G., Kumar, H., Warner, H., Makowski, N., Audu, M.L. and Triolo1, R.J. "Gait Variability and Symmetry After Spinal Cord Injury", Biomedical Engineering Society Conference, San Antonio, TX, USA, October 12th – 15th, 2022.

RESEARCH FUNDING HISTORY

CO-PI/PRINCIPAL INVESTIGATOR:

Title	Agency	Grant Number	Dates	Direct Costs	Indirect Costs	Total
Automatic Control of Standing Balance and Gait with Implanted Neuroprostheses	Funding: NIH (NINDS) Support: LSCVAMC	R01 NS040547	10/18 – 09/23	$2,293,477	$1,105,635	$3,399,112
Enhancing Seated Stability & Reaching After Spinal Cord Injury	Funding: NIH (NINDS) Support: LSCVAMC	R01 NS101043	04/18 – 04/23	$1,540,224	$ 187,640	$ 1,727,864
Enhancing Seated Stability and Reaching after Spinal Cord Injury	Funding: DoD SCIRP Support: LSCVAMC	SC160104	10/17 – 09/21	$499,875	$ 173,468	$ 673,343
Control of Seated Balance with Functional Neuromuscular Stimulation	Funding: DoD SCIRP Support: LSCVAMC	SC090230	10/10 – 09/13	$722,115	$ 187,750	$ 909,865
Automatic Control of Standing Balance with FES	Funding: NIH (NINDS) Support: LSCVAMC	R01 NS40547	04/06 – 03/10	$900,000	$ 483,143	$ 1,383,143
Trunk stability and seated reaching after spinal cord injury.	Funding: DoD SCIRP Support: LSCVAMC	SC210292	09/22 – 08/25	$1,128,928	$ 176,463	$ 1,305,391
Total				$ 7,084,619	$ 2,314,099	$ 9,398,718

LSCVAMC - Louis Stokes Cleveland VA Medical Center.

CO-INVESTIGATOR:

Title	Agency	Grant Number	Dates	Direct Costs	Indirect Costs	Total
A Neuroprosthesis for Seated Posture and Balance	VA (RR&D)	1I01RX001204	7/13-6/17	$1,078,144	0	$1,078,144
Automatic Control of Standing Balance with Functional Neuromuscular Stimulation	Funding: NIH (NINDS) Support: LSCVAMC	R01 NS40547	7/11-6/18	$1,632,284	$734,406	$2,366,690
A Hybrid Neuromechanical Ambulatory Assist System	DoD CDMRP	W81XWH-13-1-0099	5/13-4/15	$398,982	$103,736	$502,718
A Neuroprosthesis for Seated Posture and Balance	VA (RR&D)	B6406R	1/10-12/12	$738,100	0	$738,100
A Hybrid Neuroprosthesis for Mobility after Paralysis from Spinal Cord Injuries	Funding: DoD PRMRP Support: LSCVAMC	PR043047	4/05 - 3/09	$1,270,062	$475,471	$1,745,533
Hybrid Neuroprosthesis with Power Assist for Walking after SCI	VA (RR&D)	1I01RX002275 -01	7/16-6/20	$1,087,516	0	$1,087,516
Hybrid Neuroprosthesis with Variable Knee Control for Walking in SCI	VA (RR&D)	B0608R	1/13 – 12/15	$797,328	0	$797,328
Control of a Hybrid Neuroprosthesis for Walking in SCI	VA (RR&D)	B6026R	7/08-9/11	$572,300	0	$572,300
Design of Controllable Hip Joints for Hybrid Walking Orthoses	VA (RR&D)	B3463R	7/04 – 6/07	$647,000	0	$647,000
Customizable cooperative multi-joint control to enhance walking mobility after stroke	NIH NICHD	1 R01 HD105008-01	09/22 – 06/27	$ 3,084,815	0	$ 3,084,815
Total:				$11,306,531	$1,313,613	$12,620,144

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