Personal Statement

In both my graduate work and subsequent faculty positions, I have developed service centers based out of my laboratory which provide applied sports medicine analyses to the campus and surrounding communities. These centers have allowed me to directly translating my research into clinical application. One thing I have learned from these experiences is that developing successful, sustainable translational research programs required networks of supporting partners. Otherwise any research findings cannot be easily and quickly translated into clinical application. One of the main attractions of the ITHS Translational Scholars program for me is that it would provide the opportunity to interact with other scholars from diverse fields and hear their strategies for developing clinical networks. The ITHS program also interests me because I have found that while my research is strongly translational in nature, to date I have not been successful in obtaining NIH funding. As such, this is one area I have specifically targeted for career development. I have already taken steps down this path completing a general grant writing workshop offered here at Montana State, as well as attending follow up seminars specific to NIH proposals. The didactic course work, weekly assignments, and peer-to-peer feedback, and advice from successful investigators have been incredibly valuable. I see the Translational Research Scholars program as the next logical step where I can gain similar insights, but from a group all focused on translational, health related research. Even if the actual topics are different, the common theme of human health makes the perspectives and feedback that much more valuable. When combined with the targeted mentoring and monthly assignments I am confident that this program would provide me the skills needed to successfully compete for R series grants.

The study I am proposing is a first step towards submission of a NIH R03 proposal. The goal of the currently proposed project is to examine how an intrinsic foot strengthening program improves foot function and dynamic balance control during walking in a healthy population. As described in the research proposal, foot muscle weakness is common in many foot pathologies, is related to the development of common overuse injuries, and could be a strategy for improving balance and preventing falls in older adults. Thus, while this first study will be done in a healthy population to demonstrate “proof of concept”, I plan for the R03 project to evaluate whether the same benefits are observed in a clinical population. The specific R03 I am targeting is an early career research award from the National Center for Medical Rehabilitation Research. I believe this would be a good fit given that the RFA specifically requests proposals evaluating novel rehabilitation strategies involving exercise and motor training. Combined, data from the current proposal and the R03 would provide compelling evidence that foot muscle strengthening can improve function, in both healthy and clinical populations. As a result, I believe this would be a strong foundation for a larger R01 to perform a clinical trial evaluating the efficacy of a foot muscle strengthening compared to current standard of care guidelines. Ultimately, this is what would be required to generate evidence based recommendations regarding including foot strengthening in the treatment of common foot pathologies and lower extremity injuries.

Over the next five years my translational research goals include the progression detailed above (current proposal to R03 to R01). However, in this time I also plan to continue performing basic science studies. For example, data from the pilot testing and development of the protocols to be used in the current proposal, are already being used to address basic questions regarding relationships between foot structure and function. I will also actively continue to develop the community networks and infrastructure for providing analyses to both physically active individuals and clinical practioners in the community. Not only will this serve to provide a constant stream of clinical participants, but will also ensure that my research findings can be quickly and easily translated to the community.

SPECIFIC AIMS

Weakness of the intrinsic foot muscles (IFM) contributes to the development of common foot pathologies and overuse injuries which, combined, affect up to 35% of the population (1–3). As such, strengthening the IFM could be an effective intervention capable of improving outcomes for these conditions. However, before any such interventions can be recommended there must be evidence that IFM strengthening improves the aspects of foot function which are impaired in these conditions. Thus, the goal of this project is to demonstrate the effects of IFM strengthening on foot function and dynamic balance during walking in a healthy population. Specifically we will evaluate the hypotheses that a progressive, eight week IFM strengthening program will:

- Minimize medial longitudinal arch collapse and midfoot movement during stance phase of walking.
- Reduce peak pressures under the metatarsal heads during stance phase of walking.
- Improve dynamic balance control during walking.

The results will provide the first evidence that IFM strengthening improves foot function and balance control during dynamic tasks, and will serve as a foundation for future studies comparing the relative efficacy of IFM strengthening versus current standard of care for various foot pathologies.

SIGNIFICANCE

The thirteen IFM have small cross sectional areas and small lever arms, suggesting their primary role is for stabilizing and supporting the foot arches (4–6). As such, maintaining strength and function of the IFM is critical for proper foot function. Given this importance, it is surprising that IFM strengthening programs are not included in clinical guidelines for treating common foot pathologies or lower extremity injuries. For example, recent clinical guidelines for evidence based treatment of plantar fasciitis (7), chronic ankle instability (8), and forefoot disorders including claw and hammer toes (9) mention providing arch support via taping as a potential intervention, but not strengthening IFM. Similarly, clinical practice guidelines for managing the diabetic foot (10) emphasize the need for off-loading peak pressures to prevent ulcerations, yet make no mention of IFM strengthening as a possible means for doing so.

One likely reason why IFM strengthening has not been included in clinical guidelines is that there is minimal evidence that IFM strengthening improves the aspects of foot function which are impaired in these pathologies, especially during dynamic activities. Thus far, studies on IFM strengthening have either examined only static measures of foot function (4,11,12), or have used only static or quasi-dynamic measures of balance control (11–14). While the results of these studies generally show that IFM strengthening raises arch height and improves balance, it is unclear whether similar improvements would be observed in more dynamic activities such as walking.

INNOVATION

Over the last year my laboratory has refined techniques to thoroughly quantify foot biomechanics using a multi-segmented kinematic foot model coupled with simultaneous measures of plantar pressures and muscle activity for selected IFM(15–17). Together these techniques allow a comprehensive evaluation of changes in foot function and dynamic balance control following IFM strengthening. This research will not only bridge gaps in the existing literature, but will also provide strong foundational evidence for future studies on the clinical effectiveness of IFM strengthening for treating various foot pathologies.

APPROACH

Based on effect sizes reported in previous IFM strengthening studies (11–13), it is estimated that 30 participants will be required. Exclusion criteria include individuals with current or chronic foot pathologies or individuals who are already performing some type of foot strengthening exercises. During baseline testing a motion capture system will be used to evaluate multi-segment foot kinematics (18) and dynamic balance control during walking and obstacle crossing (19,20). Peak pressures under the metatarsal heads and load distribution among the metatarsals will be simultaneously evaluated using a plantar pressure mat. Following baseline testing participants will commence an eight week progressive IFM strengthening program. The program will consist of two exercises using progressions documented in previous IFM strengthening studies (11,12). During the initial two weeks participants will perform their training in the laboratory while using EMG bio-feedback to ensure proper technique. For the final six weeks participants will perform the exercises at home. Compliance with the protocol will be monitored using daily online exercise logs, with follow up phone calls as needed. The effects of the strengthening program will be evaluated at four and eight weeks using the baseline assessment protocol.

This one year project will start in March, 2018. IRB approval has already been obtained and two pilot participants have begun the protocol. Based on ongoing community collaborations, a pool of potential participants has already been developed, thus recruitment should not be a problem. One foreseeable issue is participant dropout over the 8 week period. To minimize this problem, small financial compensation will be provided after each visit and weekly phone checkups will be used to help keep participants invested. We anticipate evaluating 2 participants per week during the academic year, and 4 per week during the summer months, meaning 30 participants could complete the protocol by mid-August, 2018. This allows sufficient time to recruit additional participants in the event some do not complete the study. Data from this project will be used to support an application to the NCMRR Early Career R03 Research Award in March, 2019. The R03 proposal will focus on implementing the IFM strengthening protocol in a clinical population.

TRANSLATIONAL IMPACT

Weakness of the IFM plays a role in the development of common foot pathologies including claw and hammer toe deformities (21,22) and hallux valgus (21,23), and common overuse injuries such as plantar fasciitis (24,25) and chronic ankle instability (26). IFM weakness also facilitates the development of flat foot deformities and excessive plantar pressures commonly observed in diabetic feet (27,28). Finally, since the IFM are strongly activated during balance tasks (29), improving IFM strength may be an as yet unexplored method for improving stability and reducing fall risk in older adult populations. The exercises used in our IFM strengthening protocol can be performed without specialized equipment, making it ideal for outpatient or home care settings. If IFM strengthening improves foot function and dynamic balance, as proposed in the current project, then our strengthening protocol could be translated for use in treating common foot pathologies, injuries, or balance issues in both young and older populations. Ultimately, incorporating IFM strengthening into clinical guidelines and rehabilitation programs could prove to be a highly cost effective, simple intervention capable of improving outcomes for a large numbers of patients across many common conditions.

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Becker, James Nicholas

ITHS Institute of Translational Health Sciences — Accelerating Research. Improving Health.

DETAILED BUDGET

FROM	THROUGH
03/01/18	02/28/19

List PERSONNEL *(Applicant Organization Only)*
Enter Dollar Amounts Requested (omit cents) for Salary Requested and Fringe Benefits

Use Cal, Acad, or Summer to Enter Months Devoted to Project

NAME	ROLE ON PROJECT	Cal. Mnths	Acad. Mnths	Summer Mnths	INST.BASE SALARY	SALARY REQUESTED	FRINGE BENEFITS	TOTAL
James Becker	PI	0.50			60,000	3,334	1,167	4,501
Graduate Assistant						2,250	45	2,295
SUBTOTALS →						5,584	1,212	6,796

CONSULTANT COSTS		
EQUIPMENT *(Itemize)*		
SUPPLIES *(Itemize by category)*		
Motion capture reflective markers	200	200
Marker adhesives	725	725
Tape	150	150
TRAVEL		
OTHER EXPENSES (Itemize by category)		
2 conference posters	120 each	240
Participant support	1,800	1,800

CONSORTIUM/CONTRACTUAL COSTS	DIRECT COSTS	
SUBTOTAL DIRECT COSTS FOR BUDGET PERIOD		**$** 9,911
CONSORTIUM/CONTRACTUAL COSTS	FACILITIES AND ADMINISTRATION COSTS	
TOTAL DIRECT COSTS FOR BUDGET PERIOD		$ 9,911
TOTAL INDIRECT COSTS FOR BUDGET PERIOD		$
TOTAL COSTS FOR BUDGET PERIOD		**$ 9,911**

BUDGET JUSTIFICATION

Summer Salary for PI

Based on annual salary, $3,334 represents 0.5 months of work for the PI, with an additional 35% budgeted for fringe benefits. During the academic year the PI has 40% of their time dedicated to research. This compensation will cover the time during the summer months where the PI is organizing the project, recruiting and following up with participants, and training research assistants.

Graduate Research Assistant

This project will support one graduate research assistant working 10 hours per week for 15 weeks at a salary of $15 per hour. Fringe benefits at 10% are also included. 10 hours per week should be enough time to collect data from four participants as well as process and analyze that data.

Supplies

The motion capture supplies are standard disposable supplies needed for performing motion capture. The lab currently has all these supplies in stock and could perform the project immediately. The supplies line item allows replacement of these disposable items.

Conference Poster Presentations

It is anticipated that this project would result in at least two conference presentations (likely more). A budget of $120 per poster has been included to cover the costs of printing the posters.

Participant Compensation

Participants will be compensated $20 per visit for their participation in the study. This is enough to compensate them for their time, but not an amount that would overly incentivize participation for monetary reasons.

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Becker, James Nicholas

eRA COMMONS USER NAME (credential, e.g., agency login):

POSITION TITLE: Assistant Professor of Biomechanics

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Middlebury College, Middlebury, VT, USA	B.A.	02/2002	Geography
University of Oregon, Eugene, OR, USA	M.S.	06/2010	Human Physiology
University of Oregon, Eugene, OR, USA	Ph.D.	06/2013	Human Physiology

A. Personal Statement

I have a broad background in lower extremity biomechanics, with specific expertise in assessing foot function as it relates to overuse injuries. My discipline specific training includes expertise in motion capture, kinetic analysis, plantar pressure measurement, and musculoskeletal modeling. With this training I am also have extensive experience bridging the gap between the research laboratory and clinical practice, providing detailed assessments and evaluations for orthopedic patients. Since 2008 I have conducted over three hundred biomechanical assessments almost all of which included detailed orthopedic evaluations, as well as using the tools described in this proposal. Since 2009 I have been an active member of both the American and International Societies of Biomechanics where I have attended and presented my work at their annual conferences. Additionally I am a frequent ad-hoc reviewer for numerous biomechanics or interdisciplinary journals including *Journal of Applied Biomechanics, Sports Biomechanics,* and *Medicine and Science in Sport and Exercise.*

After completing my doctoral study, took a faculty position where the duties were primarily teaching. While there was not a heavy emphasis on publishing research during this time, this experience provided me with managerial skills which I would not have obtained otherwise. Through grant writing, I raised over $800,000 in internal funds to build and equip a state of the art biomechanics laboratory. As the director, I was responsible for all equipment purchase, installation, development, and maintenance. In this role, I was also in charge of outreach and promoting interdisciplinary collaboration with faculty members from Engineering, Physical Therapy, and Education. Collaborating with these colleagues, we successfully obtained a NSF Major Research Equipment grant which brought a $400,000 virtual reality system to campus. Emphasizing translational research, I developed an interdisciplinary sports performance and medicine center which provided community service in the form of biomechanical assessments for injury prevention or rehabilitation. Finally, I gained extensive experience mentoring graduate students and involving them in the research process. In three years, I served as the primary mentor for 6 graduate students who, among them, produced over 40 student authored research presentations at regional, national, and international biomechanics conferences. All six of these students are now pursuing doctoral degrees in biomechanics.

Eventually I recognized that the high teaching load and lack of research support would not facilitate my career goals. As such, I recently moved to a high research institution. In the year since taking this position I have worked to build the infrastructure needed for a successful research program including a fully equipped laboratory, time and funding for pursuing research, and support for graduate students. In addition to building new infrastructure I have endeavored to be highly productive, having written and submitted ten papers in this last year. Many of these papers have direct topical or methodological links to the proposed study including:

1. Nakajima, M., Burns, K., Vargas, T., Wu, W., and Becker, J. An Augmented Pre-Participation Examination for Predicting Injury Among Collegiate Athletes. *Currently in review at Journal of Athletic Training.*
2. Borgia, B., and Becker, J. Lower Extremity Joint Stiffness While Running in Minimalist, Traditional, and Ultra-Cushioning Shoes*. Currently in review at Footwear Science.*
3. Nakajima, M., Wu., W., and Becker, J. Biomechanical Factors Associated with Medial Tibial Stress Syndrome in Runners: A Prospective Study. *Currently in review at Medicine and Science in Sport and Exercise.*
4. Becker, J., James, S., Osternig, L., and Chou, LS. Altered Foot Kinematics in Runners with a History of Navicular Stress Fracture. *Currently in review at The American Journal of Sports Medicine.*

B. Positions and Honors

Positions and Employment

2016-present	Assistant Professor, Department of Health and Human Development, Montana State University, Bozeman, MT
2013-2016	Assistant Professor, Department of Kinesiology, California State University Long Beach, Long Beach, CA

Other Experience and Professional Memberships

2009-present	Member, American Society of Biomechanics
2011-present	Member, International Society of Biomechanics
2012-present	Consultant, Sport Biomechanist, USA Track & Field, Indianapolis, IN

Honors

2011	Outstanding Poster Presentation Award – Northwest Biomechanics Symposium
2012	Outstanding Podium Presentation Award – Northwest Biomechanics Symposium

C. Contribution to Science

1. My initial research focus examined the role that foot pronation plays in overuse injuries. Historically, despite conflicting support in the literature, excessive amounts or velocities of pronation have been often cited as contributing factors to common overuse injuries. I have explored an alternative hypothesis that it is not the amount or velocity which is critical for injury, rather it is the duration the foot remains in a pronated position across stance phase. During late stance phase the foot must be a rigid lever in order to generate an effective push off. If this has not happened then, since one is lacking bony support, there must be extra effort from the intrinsic and extrinsic foot muscles to stabilize the foot. Repeated over time this extra effort may be responsible for many common overuse injuries. To date, I have examined this hypothesis by identifying biomechanical markers of prolonged pronation, showing in both retrospective and prospective studies that runners with common overuse injuries demonstrate prolonged but not excessive pronation, and used musculoskeletal modeling software to estimate musculotendon kinematics with prolonged pronation. The composite results from these studies suggest prolonged pronation may be an issue which needs to be considered in clinical care for common overuse injuries. Publications from this contribution area include:

    a. Nakajima, M., Wu., W., and Becker, J. Biomechanical Factors Associated with Medial Tibial Stress Syndrome: A Prospective Study. *Currently in review at Medicine and Science in Sport and Exercise.*

b. Becker, J., James, S., Wayner, R., Osternig, L., Chou, LS. (2017) Biomechanical Factors Associated with Achilles Tendinopathy and Medial Tibial Stress Syndrome in Runners. The American Journal of Sports Medicine. Vol. 45(11), pp. 2614-2621.

c. Becker, J. (2013). Towards an Understanding of Prolonged Pronation: Implications for Medial Tibial Stress Syndrome and Achilles Tendinopathy. *Doctoral Dissertation*.

2. A second area where I have made significant contribution is in the use of plantar pressure measurements for assessing foot function and overuse injury risk. In this area, I have performed studies examining how the center of pressure trajectory differs between barefoot and shod running, examined how peak regional plantar pressures and forces differ between rearfoot and forefoot striking runners, developed novel methods for analyzing plantar pressure which examine how load is distributed across the metatarsals and applied this methods to show that individuals with a history of metatarsal stress fractures demonstrate altered loading, examined how plantar pressures change when using novel rehabilitation devices such as anti-gravity treadmills, and demonstrated that plantar pressure mapping can be used as a quick and easy clinical screening tool. Specific publications relevant to this area include:

   a. Nakajima, M., and Wu., W., Becker, J. Plantar Pressure Measurements for Predicting Common Overuse Injuries. *In review at Gait & Posture.*

   b. Borgia, B. and Becker, J. Influence of an Anti-Gravity Treadmill on Foot Contact Mechanics. *In review at Journal of Applied Biomechanics.*

   c. Becker, J., Pisciotta, E., James, S., Osternig, L., and Chou, LS (2014). Center of Pressure Trajectory Differences Between Shod and Barefoot Running. *Gait & Posture*, 40, pp. 504 – 509.

   d. Becker, J., Howey R.J., Osternig, L., James, S., and Chou, LS. (2012) Vertical Load Distribution in the Metatarsals During Shod Running. Presented at the 2012 Annual Meeting of the American Society of Biomechanics.

3. A third area where I have made substantial contributions is by bridging the gap between motor skill acquisition and biomechanics. Working with colleagues from both motor control and sports medicine, I have investigated how manipulating an individual's focus of attention alters their movement and examined the underlying neural components responsible for these changes. I anticipate this line of research will have substantial crossover to clinical and translational areas such as identifying best practices for gait retraining or teaching individuals to move differently to avoid injury. Recent publications in this area include:

   a. Vidal, A., Wu, W., Nakajima, M., and Becker, J. (2017). Investigating the Constrained Action Hypothesis: A Dynamical Systems Approach. Journal of Motor Behavior. Epub ahead of print. DOI: 10.1080/00222895.2017.1371111.

   b. Schutts, K., Wu, W., Vidal, A., Heigel, J., and Becker, J. (2017). Does Focus of Attention Improve Snatch Lift Kinematics? Journal of Strength and Conditioning Research. Vol. 31(10), pp. 2758-2764.

   c. Becker, J. and Wu, W. (2015). Integrating Biomechanics and Motor Control Principles in Elite High Jumpers: A Transdisciplinary Approach to Enhancing Sport Performance. Journal of Sport and Health Science. Vol. 4(4), pp. 341-346.

D. Research Support

<u>Ongoing Research Support</u>
<u>ITHS Translational Research Scholars Program – current proposal</u> 03/01/2018 – 2/28/2019
Can Foot Strengthening Be Medicine?
The goal of this study is to evaluate how strengthening the intrinsic foot musculature impacts foot function and dynamic balance control during walking.
Role: PI

College of Education, Health, and Human Development 10/09/2017 – 05/30/2019
Research Integration and Translation Seed Grant.
This is a joint project with the College of Engineering to develop the biomechanics laboratory into a productive research laboratory and resource center capable of performing gait or other movement analyses for patients referred from the community.
Role: PI

NSF Major Research Instrumentation Program 09/01/2016 – 08/31/2018
MRI: Acquisition of Dynamic Immersive Virtual Environment for Research in Human-Machine Interaction
This project supported the obtainment of a virtual reality cave system to be used in interdisciplinary studies on rehabilitation, sports training, advanced manufacturing, and design of human-machine interfaces.
Role: Supporting Investigator

Completed Research Support

College of Education, Health, and Human Development Research Seed Grant 11/01/2016 – 05/30/2017
Relationship Between Foot Structure, Mobility, and Plantar Load Distribution
This study developed tools to synchronized motion capture, force plates, and plantar pressure mapping to examine how load distribution under the metatarsals changes based on foot structure and mobility
Role: PI

CSU Program for Education and Research in Biotechnology 06/01/2016 – 08/16/2016
Pilates as an Osteogenic Exercises
This project designed and built an instrumented Pilates reformer which was used to quantify joint loading during various Pilates activities.
Role: PI

USA Track & Field Sport Science Grant 01/01/2016 – 12/31/2016
Biomechanics Support Services for Elite High Jumpers
This project provides biomechanical analysis and feedback for elite high jumpers through USA Track & Field's sport science services.
Role: PI

Internal Equipment Grant, California State University, Long Beach 08/16/2015 – 08/15/2016
Equipment for Supporting Rehabilitative and Movement Science Research
This grant funded equipment purchases for the development of an interdisciplinary biomechanics facility which provided biomechanical assessments to the Long Beach community.
Role: PI

USA Track & Field Sport Science Grant 01/01/2015 – 12/31/2015
Biomechanics Support Services for Elite High Jumpers
This project provides biomechanical analysis and feedback for elite high jumpers through USA Track & Field's sport science services.
Role: PI

Internal Equipment Grant, California State University, Long Beach 08/16/2014 – 08/15/2015
Tools For Teaching Motion Analysis
This grant funded equipment purchases for the development of an interdisciplinary biomechanics laboratory at California State University, Long Beach.
Role: PI