Research load, expectation, goals

As per my candidate's statement, I devote approximately 65% of my time towards research endeavors. This research **load** is consistent with expectations within the School of Health and Rehabilitation Sciences for research focused faculty, with the **expectation** being that faculty pursue and secure external research funding and disseminate scholarly products (ideally peer-reviewed research publications) in their area of inquiry. Part of my research load is accounted for by my role as the Associate Dean for Research within the school.

My overarching research **goal** is to investigate the normal and abnormal functioning and treatment of the musculoskeletal system, with the overall intent of advancing human health and performance. This area of inquiry is clinically relevant as musculoskeletal disorders are the 2nd most common cause of disability worldwide (measured by years lived with disability). My current research goals in studying the musculoskeletal system are to:

1. Demonstrate the lifelong skeletal benefits of exercise
2. Establish the mechanism for the skeletal effects of selective serotonin reuptake inhibitors, and;
3. Explore musculoskeletal conditions in sports medicine

To reach my research goals, I founded while in rank the Indiana Center for Translational Musculoskeletal Research (ICTMR)—a center I continue to direct. The mission of the ICTMR is to advance health by performing studies into the normal and abnormal form and functioning of the musculoskeletal system. The center is particularly interested in bridging the gap between basic science and clinical research by translating findings from preclinical studies to clinical populations, and vice versa. The center also aims to be a resource for investigators with like interests, contribute to the training of students interested in musculoskeletal research, and disseminate the findings of musculoskeletal research.

As director of the ICTMR I have established a resource on campus that has capabilities in assessing body composition, muscle and bone health, and functional performance of research participants. As a result of these capabilities and skills, I am increasingly being called upon to contribute to pharmaceutical industry and academia-led clinical trials.

Five most significant publications

The following five publications were chosen as representative publications in my 4 main areas of research: 1) lifelong skeletal benefits of exercise; 2) skeletal consequences of selective serotonin reuptake inhibitors; 3) musculoskeletal conditions in sports medicine, and; 4) clinical trials in musculoskeletal health. Justification for their selection and evidence for their significance is provided.

NOTE: The full-text versions of the manuscripts are uploaded under the 'Appendix: Research or creative publications/works' link. The appendices referred to below are located under the 'Appendix: additional evidence' link.

1. WARDEN SJ, Mantila Roosa SM, Kersh ME, Hurd AL, Fleisig GS, Pandy MG, Fuchs RK. Physical activity when young provides lifelong benefits to cortical bone size and strength in men. *Proceedings of the National Academy of Sciences USA* 2014;111:5337-42

- This was a large (n=197 subjects) National Institutes of Health funded study (R01 AR057740) that recruited and tested subjects from the 48 contiguous states
- Subjects were current and former professional baseball players aged 25-94 years or controls who were transported to Indianapolis for testing
- Study translated observations I obtained in animal models to a human model to show for the first time that physical activity completed when had lifelong benefits on bone size and strength, but not mass
- This paradigm changing finding indicates the old adage of "use it or lose it" is not entirely applicable to the skeleton and that physical activity during youth should be encouraged for lifelong bone health, with the focus being optimization of bone size and strength rather than increasing mass
- In addition to the above finding, the study also: 1) used a musculoskeletal model to demonstrate the extreme loading and adaptation of the humerus to overhand throwing, and; 2) demonstrated that physical activity continued during aging helps maintain some of the bone mass and more of the bone strength benefits of activity completed when young
- Paper was published as first and corresponding author in the leading peer-reviewed journal *Proceedings of the National Academy of Sciences USA (PNAS)*
- The impact factor of *PNAS* (9.4; 2015 edition of the ISI Journal Citation Reports) places it within the top 2.5% of all journals (190-out-of-8778 journals) and fourth (out-of-63 journals) in the category of multidisciplinary sciences (after *Nature*, *Science* and *Nature Communications*) (Appendix R1)
- PNAS is the second most cited journal out of all journals after *Nature* (Appendix R2)
- Article was one of 5 articles featured on the cover and one of 6 papers editorially summarized in the 'In this issue' section of its respective journal issue (out of 85 papers in the issue) (Appendix R3)
- Article was the feature of independent editorials in two other journals—*Journal of Experimental Biology* (Appendix R4) and *IBMS BoneKEy* (Appendix R5)
- Article has generated an Almetrics score of 169 which places it in the: 1) top 5% of all research outputs scored by Almetrics; 2) 99th percentile of outputs of the same age, and; 3) 94th percentile of outputs of the same age and source (Appendix R6)
- Paper has been cited 32 times (16 times per year) in the 2 years since publication (according to ISI Web of Knowledge), which means it has performed above average for articles within the journal (i.e. according to the journal's impact factor, the average article in the journal receives 9.4 citations each year in the first two years following publication) (Appendix R7)
- Paper was co-authored by international (M.G.P. and M.E.K.) and nationally (G.S.F.) based collaborators, and two post-doctoral students (S.M.M.R. and M.E.K.)
- Primary post-doctoral student associated with the study (S.M.M.R.) was awarded a FASEB Minority Access to Research Careers (MARC) Program Award, ASBMR Young Investigator Travel Grant, ASBMR Young Investigator Award at the 2011 Forum on Aging and Skeletal Health, and Charles H. Turner Young Investigator Bone Research Award for work completed on the study
- Findings were subject of local, national and international media attention, including on the *Science/AAAS* (Appendix R8) and *NIH Research Matters* (Appendix R9) websites, in *Science News* (Appendix R10) and *Parents* (Appendix R11) magazines, in the *LA Times* (Appendix R12) and *U.S. News & World Report* newspapers, and featured on *ABC Radio (Australia)* (Appendix R13) and *Fox2Now (St. Louis)*, to name a few coverage lcoations
- Findings formed the basis of a National Institutes of Health R01 grant application as principal investigator that has been scored in the 30th percentile (Appendix R14)

2. WARDEN SJ, Galley MR, Hurd AL, Richard JS, George LA, Guildenbecher EA, Barker RG, Fuchs RK. Cortical and trabecular bone benefits of mechanical loading are maintained long-term in mice independent of ovariectomy. *Journal of Bone and Mineral Research* 2014;29:1131-40

- This was a large (n=225 animals) National Institutes of Health funded study (R15 AR056858) that provided the justification and foundation for the translational human study described above
- Study involved mechanically loading/exercising the skeleton of animals for 4 weeks when young using the new tibial axial compression loading model before performing surgery to induce an artificial menopause and following the animals for up to 12 months
- Data supported my hypothesis that the bone size and strength benefits of mechanical loading when young persist long-term, but the bone mass benefits do not
- The data also extended my previous work to demonstrate that loading when young had lasting benefits on trabecular bone morphology which were not influenced by a surgically induced menopause
- Paper published as first and corresponding author in the leading bone journal *Journal of Bone and Mineral Research (JBMR)*
- The impact factor of *JBMR* (5.6; 2015 edition of the ISI Journal Citation Reports) places it within the top quartile of journals in the competitive *Endocrinology & Metabolism* category and top 5% of all journals (422-out-of-8778 journals) (Appendix R15)
- Paper was co-authored by four Doctor of Physical Therapy students (J.S.R., L.A.G., E.A.G. and R.G.B.) whose participation in the study was extra-curricular to their professional studies

3. WARDEN SJ, Hassett SM, Bond JL, Rydberg J, Grogg JD, Hilles EL, Bogenschutz ED, Smith HD, Fuchs RK, Bliziotes MM, Turner CH. Psychotropic drugs have contrasting skeletal effects that are independent of their effects on physical activity levels. *Bone* 2010;46:985-92

- This National Institutes of Health funded study (R01 AR052018) furthered our work into the skeletal effects of the serotonin transporter by demonstrating that the lower bone mass, smaller bone size and weaker bones associated with selective serotonin reuptake inhibitor (SSRI) use in mice is not due to a hypoactive phenotype (i.e. physical inactivity)
- This was a time consuming study as it required singly housing 40 mice and maintaining them in a tail-suspended position (i.e. with hindlimb quarters non-weight bearing) for 6 weeks
- The data confirmed a negative skeletal effect of a SSRI (fluoxetine), but not a tricyclic antidepressant (desipramine), and a positive skeletal effect of glycogen synthase kinase-3β inhibition via lithium chloride
- Paper was published as first and corresponding author in the journal *Bone*
- The impact factor of *Bone* (3.7; 2015 edition of the ISI Journal Citation Reports) places it in the 2nd quartile of journals in the competitive *Endocrinology & Metabolism* category and top 13% of all journals (1145-out-of-8778 journals) (Appendix R16)
- Findings have been cited in the high impact journals *Nature* (IF=38.1) and *Nature Medicine* (IF=30.4) (Appendix R17)
- Paper was co-authored by seven Doctor of Physical Therapy students (S.M.H., J.L.B., J.R., J.D.G., E.L.H., E.D.B. and H.D.S.) whose participation in the study was extra-curricular to their professional studies
- Findings formed the basis of a National Institutes of Health R15 grant application as principal investigator that has been scored in the 11th percentile (Appendix R18)

4. WARDEN SJ, Davis IS, Fredericson M. Management and prevention of bone stress injuries in long-distance runners. *Journal of Orthopaedic and Sports Physical Therapy* 2014;44:749-765

- This invited, but peer-reviewed review paper (Appendix R19) comprehensively (17 journal printed pages) reviewed the management and prevention of bone stress injuries in long-distance runners
- Paper was published as first and corresponding author, with nationally-based, internationally-known co-authors I invited to participate (I.S.D. and M.F.)
- Paper invitation resulted from symposium presentations on the topic I provided at: 1) the American Physical Therapy Association 2011 Combined Sections Meeting; 2) 2011 Annual Meeting of the

American College of Sports Medicine and World Congress on Exercise is Medicine, and 3) Spine and Sport Rehabilitation Running Symposium at the Rehabilitation Institute of Chicago

- Presentations and expertise in running and bone injuries have been recognized by interviews and quotes in the *New York Times* (Appendices R20 and 21)
- The impact factor of *Journal of Orthopaedic and Sports Physical Therapy* (2.6; 2015 edition of the ISI Journal Citation Reports) places it in the top quartile of journals in the categories of *Orthopedics*, *Rehabilitation* and *Sport Sciences* (Appendix R22)
- Paper was selected as the 'Read for Credit' paper out of the 18 articles in the respective journal issue (Appendix R23)
- Article has an Almetrics score of 60 which places it in the: 1) top 5% of all research outputs scored by Almetrics; 2) among the highest scoring outputs from the journal (38th out of 1046), and; 3) 97th percentile of outputs of the same age (Appendix R24)
- Independent tweets about the article used superlatives such "absolute cracker of an article", "great article", "fantastic paper", "must-read" and "WOW!" (Appendix R25)
- Paper has been cited 7 times (>3.5 times per year) in the <2 years since publication (according to ISI Web of Knowledge), which means it has performed above average for articles within the journal (i.e. according to the journal's impact factor, the average article in the journal receives 2.6 citations each year in the first two years following publication) (Appendix R26)
- Paper resulted in invitation to contribute to book chapters on acute and chronic injuries in the 5th edition of *Brukner and Khan's Clinical Sports Medicine*

5. Becker C, Lord SR, Studenski SA, WARDEN SJ, Fielding RA, Recknor CP, Hochberg MC, Ferrari SL, Blain H, Binder EF, Rolland Y, Poiraudeau S, Benson CT, Myers SL, Hu L, Ahmad QI, Pacuch KR, Gomez EV, Benichou O for the STEADY Group. Myostatin antibody (LY2495655) in older weak fallers: a proof-of-concept, randomised, phase 2 trial. *Lancet Diabetes and Endocrinology* 2015;3:948-57

- This was a pharmaceutical industry-led randomized, placebo-controlled, double-blind, parallel, multicenter, phase 2 study performed at 21 investigator sites across 6 countries (Argentina, Australia, France, Germany, Sweden and the USA)
- Study investigated the benefits and safety profile of LY2495655 (LY), a humanized monoclonal antibody that neutralizes the activity of the myostatin protein, in olders fallers with reduced muscle strength and power
- Study demonstrated for the first time that myostatin inhibition not only increases muscle mass, but also improves physical function
- My principal role on the project was to oversee the performance of physical function assessments, which included writing the operation manual, recording videos and training study site investigators for performance of physical function tests
- My significant contribution to the study is indicated by being listed as the fourth author on the paper associated with the study (out of 19 investigators and 56 STEADY Group collaborators)
- Study paper was published in the high-impact journal *Lancet Diabetes and Endocrinology*
- The impact factor of *Lancet Diabetes and Endocrinology* (16.3; 2015 edition of the ISI Journal Citation Reports) places it as the second ranked journal in the competitive *Endocrinology & Metabolism* category and in the top 1% of all journals (71-out-of-8778 journals) (Appendix R27)
- Manuscript was selected to be accompanied by an editorial in its respective journal issue (Appendix R28)
- Article has an Almetrics score of 139 which places it in the: 1) top 5% of all research outputs scored by Almetrics; 2) among the highest scoring outputs from the journal (32nd out of 607), and; 3) 98th percentile of outputs of the same age (Appendix R29)
- Findings were subject of an institutional press release (Appendix R30) that was covered by local, national and international media (Appendix 31)
- Paper co-authored by internationally-based collaborators from Germany (C.B.), Australia (S.R.L.), Switzerland (S.L.F.) and France (H.B., Y.R., S.P. and O.B.)

Significance of grant and awards

NOTE: The appendices referred to below are located under the 'Appendix: additional evidence' link.

Grant funding and applications are listed on CV pages 13-17. I have consistently sought funding during my time in rank, despite the current economic environment which has made funding increasingly competitive and difficult to obtain. I have been associated with 17 funded grants totaling $9.3M while in rank and >$30M of grant submissions (**Table**). Eight funded grants were as principal investigator (PI) totaling $4.6M and generated $0.5M of indirect cost recovery. The largest grant was a $1.1M R01 grant (AR057740) from the National Institute of Arthritis and Musculoskeletal and Skin Disorders (NIAMS) which was funded from 2010-2015. The award was to investigate the lifelong skeletal benefits of exercise during growth and remains only the 2nd NIH R01 award given in our school's history. I am currently working on acquiring funding for the follow-up NIH R01 award, with the competing renewal application receiving a score placing it in the 30th percentile (Appendix R14).

Table. Funded grants while in rank

Funded grants while in rank	N=17	$9,286,868
• Funded grants as PI/Co-PI	8	$2,466,845
• Indirect cost recovery	—	$544,274
• Currently active grants	7	$4,609,351
• Currently active grants as PI/Co-PI	2	$447,220

Another line of active research is the investigation of the skeletal effects of the serotonin transporter, which is the target of selective serotonin reuptake inhibitors (SSRIs). I received $104K of funds from internal sources while in rank to explore serotonin transporter skeletal effects and currently have an NIH R15 application under consideration. The latest submission received a score placing it in the 11th percentile (Appendix R18).

Of currently active grants, I am Co-PI (with Dr. Todd McKinley) on a subcontract from John Hopkins University for $412K. The overall project is a multicenter, randomized, controlled clinical trial entitled the Rehabilitation Enhanced by Partial Arterial Inflow Restriction (REPAIR) study, which is funded by the Department of Defense. Dr. McKinley and I are the co-PI's of the subcontract at the IU/Methodist Hospital study site. The project is investigating the benefit of blood flow restriction during strengthening exercise on recovery following femur diaphyseal fracture.

Significance and impact of research publications and presentations

NOTE: The appendices referred to below are located under the 'Appendix: additional evidence' link.

PUBLICATION PRODUCTIVITY

I have been a prolific scholarly writer during my time in rank with a total of 50 full-length research publications (including 'in press' publications) (**Table 1**). This number does not include published abstracts. Two-thirds (66%) of the publications were primary research articles containing original data and one-fifth (20%) were invited review articles. The former primary data articles indicate my dedication to performing original research and advancing the body of knowledge, while the latter invited articles provide evidence of external recognition of my work and contributions. Of the 50 articles published while in rank, two-thirds were published as senior/corresponding author reflecting my leadership on the associated projects. The articles published while in rank represent half of my total career publications, despite time in rank accounting for only one-third of my total career duration. Thus, I was able to continue and increase my relative productivity while in rank.

Table 1. Research publication productivity

Publication type	In rank (as corresponding author)	Total career (as corresponding author)
Primary research articles	33 (18)	65 (32)
Systematic reviews	2 (0)	3 (1)
Unsolicited reviews	0 (0)	6 (6)
Invited reviews	10 (8)	22 (17)
Editorials	1 (1)	5 (5)
Published letters	0 (0)	2 (2)
Book chapters	4 (4)	6 (5)
Total publications	**50 (31)**	**109 (68)**

PUBLICATION IMPACT

In addition to a high productivity, my work has been impactful. Determining impact is somewhat ambiguous; however, two commonly used methods are to assess the: 1) impact of the journal in which the work was published and; 2) citation counts for the individual contribution. Based on journal impact factors and citation counts, my work is of quantifiably high impact.

The impact factor (IF) for a journal provides a measure reflecting the yearly average number of citations to recent articles published in the journal. It is frequently used as a proxy for the relative importance of a journal within its field, with journals with higher IFs deemed to be more important than those with lower ones. I published primary research data articles in journals with an average IF of 3.6 while in rank, according to the 2015 edition of ISI Journal Citation Reports (**Table 2**). This is a high relative IF. For instance, it is close to the average IF for journals in the competitive category of *Endocrinology & Metabolism* (average IF = 4.0), and higher than the average IF for journals in the categories of *Sport Sciences* (average IF = 2.3) and *Rehabilitation* (average IF = 1.8) (Appendix 32). These categories list journals in which my work is most frequently published. The competitiveness of the *Endocrinology & Metabolism* category is reflected by the average IF for this category being in the top 12.5% of all categories (22-out-of-177 categories).

Table 3 provides a list of some of the individual journals in which my work has been published during my career. Journals published while in rank are shown in **blue** under the 'CV publication' column. To highlight some of the journals I have published in, they include:

1. Top 3 journals and 9 of the top 15 journals in the category of *Sport Sciences* (Appendix R33)
2. Three of the top 7 journals in the category of *Rehabilitation* (Appendix R34)
3. Second ranked journal in the category of *Endocrinology & Metabolism* (Appendix R27)
4. Four journals in the top quartile in *Endocrinology & Metabolism*
5. Fourth ranked journal in *Multidisciplinary Sciences* (Appendix R1)
6. Second most cited journal out of all journals (Appendix R2)

Table 2. Average impact factors for the journals in which my work was published*

Publication type	In rank average (range)	Career average (range)
Primary research articles	3.6 (1.4 to 16.3)	3.7 (0.8 to 16.3)
Systematic reviews	4.1 (1.5 to 6.7)	4.1 (1.5 to 6.7)
Unsolicited reviews	—	4.2 (0.9 to 5.6)
Invited reviews	2.7 (1.1 to 3.7)	3.1 (1.1 to 7.4)
Editorials	1.6 (1.6 to 1.6)	4.9 (1.6 to 6.7)
Published letters	—	2.8 (2.8 to 2.8)
Book chapters	—	—
Total publications	**3.4 (1.1 to 16.3)**	**3.7 (0.8 to 16.3)**

*Impact factors from 2015 edition of ISI Journal Citation Reports

Table 3. Impact of individual journals in which may work has been published*

Title	Impact factor	CV publication†	Journal standing
Lancet Diabetes & Endocrinology	16.3	**#8**	2nd ranked journal in *Endocrinology & Metabolism* (out of 131) Ranked in top 1% of all journals (71-out-of-8778)
Proceedings of the National Academy of Sciences USA	9.4	**#14**	4th ranked journal in *Multidisciplinary Sciences* (out of 63) 2nd most cited journal out of all journals (out of 8778) Ranked in top 2.5% of all journals (190 out of 8778)
Biomaterials	8.4	#40	Top ranked and most cited journal in *Materials Science*, *Biomaterials* (out of 33) 2nd ranked and most cited journal in *Engineering, Biomedical* (out of 76) Ranked in top 3% of all journals (246 out of 8778)
Science Signaling	7.4	#85	Ranked in top quartile in both *Biochemistry & Molecular Biology* (28 out of 289) and *Cell Biology* (29 out of 187) Ranked in top 3.5% of all journals (314 out of 8778)
British Journal of Sports Medicine	6.7	**#66**, 90, 98, 99, 100	Top ranked journal in *Sport Sciences* (out of 82) Ranked in top 4% of all journals (354 out of 8778)
Journal of Bone and Mineral Research	5.6	**#12**, 43, 44, 52, 53	Ranked in top quartile in *Endocrinology & Metabolism* (15 out of 131) Ranked in top 6% of all journals (494 out of 8778)
Sports Medicine	5.6	#69, 70, 71	2nd ranked journal in *Sport Sciences* (out of 82) Ranked in top 6% of all journals (506 out of 8778)
Journal of Clinical Endocrinology and Metabolism	5.5	**#4, 13, 15**	Ranked in top quartile in *Endocrinology & Metabolism* (16 out of 131) Top cited journal in *Endocrinology & Metabolism* (out of 131) Ranked in top 6.0% of all journals (518 out of 8778)
American Journal of Sports Medicine	4.5	#39, 45	3rd ranked journal in *Sport Sciences* (out of 82) and *Orthopedics* (out of 74)
Rheumatology	4.5	#37	6th ranked journal in *Rheumatology* (out of 32) 4th most cited journal in *Rheumatology* (out of 32)
Endocrinology	4.2	**#17**, 55	Ranked in top quartile and 4th most cited journal in *Endocrinology & Metabolism* (30 out of 131)
Medicine and Science in Sport and Exercise	4.0	**#25,** 57, 65	6th ranked journal in *Sport Sciences* (out of 82) 2nd most cited journal in *Sports Sciences* (out of 82)
Physical Therapy	2.8	**#24**, 49, **76**	2nd most cited journal in *Rehabilitation* (out of 65) 5th ranked journal in *Rehabilitation* (out of 65)

*Impact factors from 2015 edition of ISI Journal Citation Reports
†CV publications in **blue** were published while in rank

In addition to publishing my work in impactful journals, the articles have been individually impactful. This is evident by my *h*-index of 28 to 42. ISI Web of Knowledge indicates I have 28 papers that have been cited at least 28 times (Appendix R35). This is likely an underestimate as ISI is notoriously slow at updating its database and only reports on citations in ISI database journals, which does not include non-English journals. In contrast, Google Scholar has my *h*-index at 42 (Appendix R36). Metrics by Google Scholar are becoming more accepted as their database has a much broader coverage, including non-English journals. However, Google Scholar's limitation is the inclusion of citations in some non-scholarly sources. Given the respective limited and liberal citation counts provided by ISI Web of Knowledge and Google scholar, my true *h*-index is likely somewhere in between 28 and 42, with Elsevier's Scopus database providing an *h*-index of 33 (Appendix R37) and ResearchGate providing an *h*-index of 37 (Appendix R38). Essentially, a *h*-index of 30+ indicates that I have 30+ publications that have been cited 30+ times. This is a high score considering the next best ISI Web of Knowledge *h*-index for a faculty member within the school is 17. ResearchGate also indicates I have an RG Score of 38.99 which is higher than 95% of all ResearchGate members' (Appendix R38) and I am frequently one of the most popular IUPUI members on ResearchGate in terms of publication downloads (out of 3,549 IUPUI members) (Appendix R39).

PRESENTATIONS

As a result of my publications and expertise in the musculoskeletal system, I am frequently invited to speak at conferences and meetings (CV p.19). Meetings I have presented at while in rank include the Annual Meeting of the American College of Sports Medicine and Combined Sections Meeting of the American Physical Therapy Association. These meetings each attract over 7,000 attendees annually. Most recently I was invited and participated in the Bone Health and Osteoporosis in Duchenne Muscular Dystrophy meeting (Appendix R40). This meeting was attended by a select group of 32 scientists and clinicians, and by program officers and representatives from 4 separate institutes within the National Institutes of Health. Later this year (Oct 2016), I will present at the 5th Annual Symposium on Regenerative Rehabilitation. I was invited to present a primer on mechanotherapy and mechanobiology based on a perspective and review article I was senior/corresponding author on published in *Physical Therapy* (Appendix 41).

MEDIA COVERAGE

Media coverage further reflects the impact and reputation of my work. My work has been widely disseminated to the lay population, receiving national and international coverage in radio, television, print and electronic media. I have given at least 20 interviews with media outlets while in rank (CV p.24), including in person, email, phone and on camera interviews. In addition to the coverage of my work concerning the lifelong skeletal benefits of exercise completed when young that has already been discussed (see 'Discussion of 3-5 most significant publications/exhibitions' and Appendices R7-13), I am frequently interviewed and quoted on the potential hazards and lack of efficacy of prophylactic use of non-steroidal anti-inflammatory drugs (NSAIDs) (Appendix R42). My expertise on the latter topic has resulted in quotes and exposure while in rank in numerous media venues, including: 1) *Vogue* magazine (Appendix R43); 2) The *New York Times* newspaper (Appendix R44); 3) *Outside* magazine (Appendix R45); 4) *BBC News* (Appendix R46); 5) *CBC News* (Appendix R47), and; 6) *Men's Health* magazine (Appendix R48).

Individual contributions to collaborative/interdisciplinary work

The following table details prominent collaborations I have participated in while in rank. Collaborators are listed alphabetically and respective contributions to the collaborative work are provided.

Collaborator	Contribution to collaborative work
Olivier Benichou, MD, PhD, MBA International Early Phase Clinical Research, Rheumatology & Diabetology, Eli Lilly and Co.	Dr. Benichou led two international, multicenter, placebo-controlled, phase 2 studies into the benefits of LY2495655 (myostatin antibody) for the intervention of elderly fallers and patients following total hip replacement. I participated in both trials as a consultant for the performance of physical function tests. My involvement including writing the operations manual, recording videos and training study site investigators in the performance of physical function tests. Our collaboration yielded two published research papers on which I am co-author (CV publications #5 and 8).
Kay M. Crossley, PT, PhD Professor, School of Allied Health, College of Science, Health and Engineering, La Trobe University (Australia)	Dr. Crossley is an internationally-recognized physical therapist and researcher in the area of sports medicine and is currently Director of the La Trobe Sport and Exercise Medicine Research Center. We collaborate on a range of sports medicine related projects, and co-supervise students. Dr. Crossley directly supervises the students, while I provide remote supervision, problem-solving, data processing and interpretation, and manuscript preparation and submission. Our collaboration has yielded three research data papers on which I am first and corresponding author (CV publications #37, 39 and 56), one research data paper on which I am senior/last and corresponding author (CV publication #41), one systematic review paper (CV publication #68) and two other review articles (CV publications #70 and 90) on which I am first and corresponding author, two systematic review papers on which I am a co-author (CV publications #66 and 67), and three published research data papers on which I am a co-author (CV publications #9, 41 and 57).
Robyn K. Fuchs, PhD Associate Professor, Department of Physical Therapy, Indiana University	Dr. Fuchs works within the same department and has very similar research interests into the study of bone health and the skeletal effects of exercise. We regularly meet to discuss research ideas and directions, and work together to complete translational animal-based studies. Our collaboration has yielded 7 published research data papers on which I am first and corresponding author (CV publications #12, 14, 20, 29, 38, 44 and 49), 3 invited review papers on which I am first and corresponding author (CV publication #75, 93 and 95), one invited review paper on which I am senior/last and corresponding author (CV publication #79), one invited review paper on which I am co-author (CV publication #89), two editorials on which I am first and corresponding author (CV publications #98 and 100), one book chapter on which I am first and corresponding author (CV publication #106), and one book chapter on which I am co-author (CV publication #108).
Richard D. Lewis, RD, PHD, FACSM UGA Professor, Department of Family and Consumer Sciences, University of Georgia	Dr. Lewis is the Director of the Bone & Body Composition Laboratory at the the University of Georgia and the overall PI of the multicenter NIH-funded GeorgiA-Purdue-Indiana (GAPI) Trial. The GAPI Trial was a placebo controlled trial investigating the influence of supplemental vitamin D on functional outcomes in early adolescence. My role on the project was as a study site investigator, where I performed anthropometric measures of growth, and DXA and pQCT assessments

	of body composition and bone and muscle mass and size. Our collaboration has yielded a published research paper on which I am first and corresponding author (CV publication #21), three other co-authored papers (CV publications #4, 13 and 15) and two submitted manuscripts (CV publications #111 and 115).
Todd McKinley, MD Professor, Department of Orthopedic Surgery, Indiana University	Dr. McKinley is nationally-recognized orthopedic surgeon who has particular expertise and interests in the management of trauma patients. We currently collaborate on a multicenter, randomized, controlled clinical trial entitled the Rehabilitation Enhanced by Partial Arterial Inflow Restriction (REPAIR) study. Dr. McKinley and I are the co-PI's of the subcontract at the IU/Methodist Hospital study site. The project is investigating the benefit of blood flow restriction during strengthening exercise on recovery following femur diaphyseal fracture.
Munro Peacock, MD Professor, Department of Medicine, Indiana University	Dr. Peacock is an internationally-recognized leader in endocrinology, particularly related to bone health. He was: 1) study site PI on a multi-site, National Dairy Council funded randomized controlled study investigating the impact of three serves of dairy on bone health and body composition in normal and overweight adolescents and 2) study site PI on the GAPI Trial (see *Richard D. Lewis* above). My role on the projects were to provide bone health, body composition and anthropometric measures on the subjects recruited to the Indiana University site, and provide expertise and oversight in terms of the execution of these measures at all sites. In addition, Dr. Peacock is the study site PI on three phase 2 clinical trials into an anti-fibroblast growth factor 23 antibody that I am currently contributing to as the study site physical therapist. My role is to perform anthropometric and physical performance assessments in study participants. Our collaboration has yielded a research data paper on which I am first and corresponding author (CV publication #21), three other co-authored papers (CV publications #4, 13 and 15) and three submitted manuscripts (CV publications #111, 113 and 115).
Connie M. Weaver, PhD Distinguished Professor and Head, Department of Food and Nutrition, Purdue University	Dr. Weaver is an internationally-recognized leader in bone health and the role of nutrition. She was PI on a multi-site, National Dairy Council funded randomized controlled study investigating the impact of three serves of dairy on bone health and body composition in normal and overweight adolescents. My role on the project was to provide bone health, body composition and anthropometric measures on the subjects recruited to the Indiana University site, and provide expertise and oversight in terms of the execution of these measures at both sites. Our collaboration has yielded a submitted manuscript for the study detailed above (CV publication #113). In addition, we collaborated together on the GAPI Trial (see *Richard D. Lewis* above) with Dr. Weaver being the study site PI at Purdue University. Our collaboration on the GAPI Trial has yielded a published research paper on which I am first and corresponding author (CV publication #21), three other co-authored papers (CV publications #4, 13 and 15) and two submitted manuscripts (CV publications #111 and 115).

Future plans for ongoing research program

NOTE: The appendices referred to below are located under the 'Appendix: additional evidence' link.

As described in my candidate statement, I have strong plans to further my research endeavors. The immediate plan is to secure funding in my two most prominent lines of inquiry—1) long-term skeletal benefits of exercise and 2) skeletal consequences of selective serotonin reuptake inhibitors.

In terms of the long-term skeletal benefits of exercise, unresolved, clinically important questions include whether exercise completed when young has lasting benefits in: 1) corticocancellous sites prone to osteoporotic fracture; 2) specific regions within the bones to resist injurious loads (e.g. sideways fall onto the greater trochanter), and; 3) in women. To this end, I have recently established throwing athletes (i.e. baseball and softball pitchers) as a model that unilaterally exposes not only their upper extremity to elevated loading, but also their lower extremity. Pitchers take a large stride to generate forces within their plant leg (i.e. leg opposite their throwing arm) that are >2X bodyweight and twice those in their push-off leg. Using a combination of quantitative computed tomography, computational anatomy approaches (voxel- and tensor-based morphometry) and subject-specific finite element modeling (FEM), I have observed the proximal femur within the plant leg of throwing athletes have: 1) 5% greater volumetric bone mineral density; 2) adaptation principally within the primary compressive trabeculae, inferior femoral neck cortex and throughout the greater trochanter region, and; 3) 4% greater estimated fracture load to single-leg stance forces than in the contralateral push-off leg. These data are currently in preparation for publication and the plan now is to explore how long the benefits persist following exercise cessation (i.e. by assessing bilateral asymmetry in former throwing athletes). To facilitate the later work, I recently submitted a renewal of an NIH R01 award. The application was viewed favorably receiving an impact score in the 30th percentile (Appendix 14) and is scheduled to be resubmitted in the coming months.

In terms of the skeletal consequences of selective serotonin reuptake inhibitors (SSRIs), I am currently vigorously studying the underlying pathways linking serotonin transporter (SERT) inhibition and bone changes in order to provide biological plausibility for a relationship and identify modifiable pathways that may modulate the off-target skeletal effects of SSRIs. To this end, I am currently using genetic approaches involving constitutive and conditional null mutation of single and multiple genes to localize the skeletal effects of SERT inhibition and identify contributing pathways. To permit this approach, I have developed and preliminary investigated a unique animal model that carries floxed alleles of the gene encoding the SERT. This model did not previously exist and enables me to localize the origin of the skeletal effects of SERT inactivation by inactivating the transporter in isolated cells and tissues. Through preliminary crosses I have:

1. Confirmed germline transmission of the modified SERT allele & generated homozygous mice;
2. Backcrossed for 10 generations with C57BL/6 wildtype mice to generate mice with a more homozygous (99.9% C57BL/6) genetic background;
3. Crossed my mouse with EIIa-cre mice to confirm recombination and demonstrate the existence of a skeletal phenotype with ubiquitous inactivation of the *SERT* gene;
4. Treated mice with ubiquitous disruption of the SERT gene with an SSRI (fluoxetine hydrochloride [Prozac]) to demonstrate the negative skeletal effects of the SSRI are due to SERT inhibition;
5. Crossed my mouse with mice expressing Cre under the control of cathepsin-K to demonstrate SERT inactivation in mature osteoclasts does not produce a skeletal phenotype, and;
6. Crossed my mouse with mice expressing Cre under the control of 2.3 kb fragment of the rat Col1a1 promoter to demonstrate *Sert* inactivation in osteoblasts does not produce a skeletal phenotype.

To facilitate work in this area, I was awarded $104,000 of internal grant funds while in rank and I have an NIH R15 award submitted as PI that was recently reviewed and scored in the 11th percentile (Appendix 18).

In addition to the above work, I am continuing and expanding my contribution to the design and execution of clinical trials. Currently, I am contributing to the performance of physical function assessments for 3 phase II pharmaceutical-led trials of a fibroblast growth factor 23 (FGF-23) antibody for the management of hypophosphatemic osteomalacia. In addition, I am study site co-PI for a multisite clinical trial exploring

the benefit of blood flow restricted strength training on recovery following femoral shaft fracture. I am a member of the protocol committee for the latter study which is being administered by the Major Extremity Trauma Research Consortium (METRC) of which I am a member.

In the coming years, I look to integrate my skills and the resources of the Indiana Center for Translational Musculoskeletal Research which I direct with the newly formed Indiana Center for Musculoskeletal Health (Executive Director: Dr. Lynda Bonewald) to expand my contributions to the study of musculoskeletal health.

Research recognition

Beyond external media recognition of my work, which demonstrates translatability to the general public (see *Significance and impact of research* section), I received school- and campus-level awards for my research while in rank. The awards were given during the early stages as a newly tenured faculty member (2010-2011).

I was awarded the *Excellence in Research Award* from the School of Health and Rehabilitation Sciences in both 2010 and 2011. This award is given annually to a school faculty member who excelled in research over the past calendar year, with nominations being submitted by faculty. With my move into the role of Associate Dean for Research within the school, I have not applied for this award in recent years in order to avoid the appearance of potential bias.

I was awarded a *Research Frontiers Trailblazer Award* in 2011 from the Office of the Vice Chancellor for Research. The award recognizes outstanding IUPUI researchers who are showing great promise in becoming nationally and internationally known for their accomplishments in advancing the frontiers of knowledge. It is awarded annually to up to three faculty who are in the first three years of promotion to associate professor.

The above awards are in addition to the numerous young and new investigator awards I received as an assistant professor from organizations including the American Society of Bone and Mineral Research, American College of Sports Medicine, Orthopedic Research Society and Australian Sports Medicine Federation (see CV p.3). The above personal awards are also in addition to numerous awards given while in rank to mentees for work completed in my lab (see CV p.5 [these latter mentee awards are discussed further in the teaching section of my dossier]).