The COVID-19 pandemic has affected scientists around the world since March 2020. While the direct safety measures to protect people from COVID-19 are winding down at some campuses across the United States and the world, the pandemic continues to have many significant impacts on the productivity of scientists. Scholarly articles and perspectives attempting to describe and quantify these effects have been published beginning in April 2020 and continuing to the present. Some of these impacts have been felt similarly across all workers and all scientists, and broad-based investigations by the National Academies, National Science Foundation, and National Institutes of Health have and will continue to describe these impacts.

However, most biomechanists work in an interdisciplinary environment, i.e., their academic or employment "home" may be in an organization where many, if not most, of their colleagues have not experienced the same pandemic-related impacts affecting biomechanists. In keeping with the American Society of Biomechanics' mission to "facilitate the development of biomechanics as a basic and applied science"[1], we believe it is important to provide perspective on the unique challenges biomechanists have faced. Our hope is that biomechanists can leverage and cite this statement in their own work, and that leaders review this statement to better understand and address the specific challenges that biomechanists face. This statement is informed by several workshops and meetings at the American Society of Biomechanics (ASB) virtual annual meetings in August 2020 and August 2021 and a survey of the society's membership conducted by the ASB Executive Board in November 2021.

What is biomechanics, and who are biomechanists?

Biomechanics occurs at the intersection of biology and physics. Biomechanists typically apply the lens of viewing a biological system as a mechanical system for unique insights into development, health, disease, and performance of living organisms. With this lens, biomechanists can better understand the interactions between mechanical forces on the one hand and movement, development, and adaptation of the organism on the other.

Biomechanists perform studies at all length scales and with all living organisms. The scales include molecular, cell, tissue, cadaver, and *in vivo*; and the organisms include single-celled organisms, plants, animals, and humans. Types of research span the entire range from basic science to translational science to clinical application, and both experimental and computational work.

Biomechanists live and work in many different sectors of research and development. The five broad scientific fields where biomechanists usually work include biological sciences, exercise and sport sciences, health sciences, engineering and applied sciences, and ergonomics and human factors. One can also find biomechanists working in many corporate settings including product research and development, failure and injury analysis, regulatory agencies, and sport performance. Biomechanists exist at all career stages – from students to advanced-career faculty, administrators, executives and everything in between.

General Effects of COVID-19 Pandemic

Many general effects of the COVID-19 pandemic have been experienced by biomechanists, as well as the larger scientific community, and have been well-documented in recent publications[2–9]. Short-term general effects have included:

- Having to interrupt regular work to contribute to efforts that combat the spread of disease
- Accommodating other needs of the institution such as changing teaching delivery from in-person to online
- Lack of childcare, which disproportionately affects early career scientists, women, and people living with family members at high risk of severe illness from COVID-19 infection
- Delays in peer review and publishing
- Mental health challenges due to anxiety and isolation
- Staffing shortages due to hiring freezes or lack of funding
- Supply chain delays for supplies and equipment
- Student access to hands-on and in-person learning opportunities
- Financial difficulties affecting the ability to stay in school, which has a disparate effect on historically excluded groups
- Furloughs, especially on contingent faculty and staff
- Emotional taxation in connection with disparate rates of infection and anti-Asian sentiment
- Increased meetings to plan COVID responses
- Difficulties in communicating with students, collaborators, mentors, and advisors

Specific Impacts to Biomechanists

In addition to these general impacts, many biomechanists have experienced significant challenges specific to the work they do. In November 2021, the ASB sent out a survey to its members requesting comments on how the COVID-19 pandemic had affected them specifically. Respondents included biomechanists in all stages of their careers from students to advanced-career professionals, with the largest group responding being early-career professionals.

Across the world, research laboratories were closed for many months in an effort to avoid any unnecessary in-person interactions. Even when they re-opened, these laboratories experienced

capacity restrictions that continued to limit productivity. Survey respondents estimated that they have experienced and will continue to experience delays that last anywhere from less than 6 months to more than 3 years, with 74% expecting the delay to be more than one year. 88% of respondents expect that the pandemic will create its largest impact on their work in 2022 or later, i.e., after the direct restrictions have been lifted. It is also worth noting that biomechanists earlier in their career are reporting longer expected delays than those later in their career.

These lingering and large delays are likely associated with the specific and sensitive subjects biomechanists need to perform their research activities. A large fraction of biomechanists perform research with human and/or animal subjects. Access to these populations was cut-off for many months in 2020. This eliminated biomechanists' ability to collect experimental data for existing protocols, pilot new experiments, and train students on experimental procedures for this period. All of this delayed any following research that was previously scheduled. Further, for scientists performing longitudinal studies of cell lines, animals, or human participants, even a brief closure can lead to the loss of many years of prior work if a follow-up time point is missed. This can even lead to the need to start again from scratch with new cells, new animals, or new human participants. For biomechanists performing research with cadaveric specimens, the supply of these specimens also was greatly reduced for months due to fears of COVID-19 transmission in the absence of adequate testing capabilities.

One survey respondent commented, *"My organization has prioritized safety. I appreciate this and think it is the correct thing to do, but it has been devastating for productivity."* Another commented, *"The administration was driven by fear and ignorance to create a 'safe' environment. They stopped caring about education and the student experience."*

A large portion of the ASB community resides in academia, but biomechanists also work in clinical settings, sports performance and analytics settings (i.e., professional sports teams), industrial settings, and in technology companies, some of which support the research being performed at the academic institutions. The impacts on these biomechanists both mirror and vary from those seen in academia. Unique challenges include pivoting from in-person development of client relationships, to relying on equipment availability remotely, and/or virtual simulation of applications and capabilities. Without "hands-on" research, development, and exposure to technology, progress, sales, and performance has lagged.

In response to the challenges that their employees have faced, some employers have taken pro-active steps to ease burdens and accommodate needs, while others *"only pursued negative initiatives to 'keep the lights on.'"* One very common response by universities has been to extend tenure clocks by one year for early career faculty.[2] This response is problematic on its own because it delays career advancement. Beyond this, extension of the tenure clock does not acknowledge the multi-year ripple effects that research delays can, and will, have on scientists' ability to collect the preliminary data and publish manuscripts that are needed for competitive grant submissions. Given the disparate impact of the COVID-19 pandemic on women and other historically-excluded groups due to non-work caregiving responsibilities, disparate rates of

infection, and emotional taxation, inadequate responses by employers threaten to exacerbate pre-existing inequities.[2,10]

Specific insights from our members include:

- *"My institute extended the tenure clock and concurrently increased expectations (grant funding) for tenure."*
- *"Being in a mechanical engineering department that does not fully understand the challenges of human subjects research, I feel that the impact of COVID on my research is not recognized sufficiently."*
- *"The pandemic is still not over and the continuing anxiety, depression, and burn out builds on all of us. While universities demand that we get back to our previous levels of productivity (or be more productive to make up for the lost time), we cannot ignore the fact that we are still not performing at our full capacity. Nor are our students and colleagues."*
- *"Another challenge was the stance taken by the NIH and my institution to continue to support folks from grant funding so that we didn't have to reduce FTE or lay people off—but this meant we spent our grant funds without meeting the expected project goals and deliverables...so we are here years in, the budget is spent, and the project is not finished. Beyond this project, it may negatively affect our competitiveness for the next NIH proposals we submit."*

Recommendations

As employers consider how best to support the biomechanists who work for them, the ASB strongly recommends an emphasis on acknowledging the new reality that biomechanists face in doing science.[2] A recalibration of what represents success is needed – the usual metrics that existed pre-pandemic may not be appropriate today. Moreover, employers should consider the previously unimaginable creativity, flexibility, and resilience that biomechanists have demonstrated over the past two years. Obvious examples include the instructional design work to pivot from in-person teaching to online teaching; the learning pivot by trainees to online; the development of new ways to collaborate efficiently with peers, mentors, and mentees; pivots in research to COVID-19, telehealth, computational work, and secondary data analyses; anti-racism work; and collaborations in COVID-19 response task forces broadly.

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