

BIOMECHANICS STUDENTS' ACADEMIC PERFORMANCE BEFORE AND DURING THE COVID-19 PANDEMIC

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This study examines students' academic performance before and after the outbreak of the COVID-19 pandemic and associations with performance in introductory biomechanics. Two intact undergraduate biomechanics classes were retrospectively examined: One with in-person instruction (IPI) two semesters before the outbreak of the pandemic and one with online instruction (OI) two semesters after the outbreak of the pandemic. Class performance measures were not significantly different between instruction formats. The students' GPA was significantly higher after abruptly transferring from face-to-face to online instruction. GPA for three semesters during the pandemic had no association with the biomechanics class performance ($r = 0.29$, $p = 0.19$). Therefore, GPA during the pandemic years should be used with caution or in combination with other assessments.

KEYWORDS: instruction, learning, online, virtual learning

INTRODUCTION: Due to the outbreak of COVID-19 in early 2020, almost all institutions abruptly transferred from primarily in-person instruction (IPI) to online instruction (OI). This forced instructors and students to adopt a new way of teaching and learning quickly in an already traumatic time. The emergency transition to online instruction was found to be stressful for both students and instructors, especially toward students (Abdulghani et al., 2020). In the 2021 mid-year ISBS Symposium, an unofficial anonymous survey during a presentation indicated that teaching biomechanics online was considered a challenging task by 52 instructors worldwide from 141 registered participants. Through this transition, instructors were expected to modify their teaching and assessment approaches to meet the requirements of the online environment. It is unclear how this stressful transition has affected the learning of biomechanical concepts because of limited research.

There are inconsistent results in the few studies that could be implemented during the quick change of instruction format with COVID-19. Research in physics reported both performance increases (4-6%) with OI and with in-person labs (Fouad et al. 2022) compared to past IPI classes and a decrease of course grades between 15% with asynchronous OI and a 4% decline for students who voluntarily attended synchronous OI sessions (Guo, 2020). One study in biomechanics was able to document student perceptions of engagement and learning across a semester immediately transitioned from IPI to OI (Knudson, 2020). This study reported while a majority of students preferred IPI, there was similar or improved learning with OI. This potential improvement over past IPI data was questionable given academic integrity and the difficulty of supervision and proctoring online testing (Knudson, 2020; Knudson & Bopp, 2021). However, it is important to understand how the rapid transition to OI influenced overall academic performance and in introductory biomechanics courses.

Given the inconsistent data on student learning in biomechanics resulting from the COVID-19 pandemic, perhaps an examination of a surrogate measure of academic performance might be useful. Grade Average Point (GPA) has been used as an indicator for students' overall academic achievement and is sometimes a sole admission criterion for admission to post-baccalaureate degrees when standardized tests are not required. GPA has also been reported to be positively associated ($r = 0.24$ to 0.43) with learning biomechanical concepts in kinesiology majors (Hsieh & Knudson, 2008; Hsieh et al., 2012).

The purposes of this study were to retrospectively examine three questions in biomechanics students' performance across the change in instruction format due to the COVID-19 pandemic: 1) Is class performance different between OI and IPI instructional format? 2) Does overall GPA change with forced OI?, and 3) Is there a similar association between biomechanics class performance and pre-course GPA across instructional format? The study will provide additional data on the effect of the pandemic and instruction format on student performance and if GPA is still related to success in biomechanics.

METHODS: Performance of students in introductory biomechanics classes at one comprehensive university were examined at two time points relative to the COVID-19 pandemic. A Spring 2019 pre-pandemic class (N = 45) had in-person instruction (Class IPI) and served as the control group. This class used multiple active learning strategies implemented through a real-time response system (*Socrative*) such as think-pair-share, one-minute reflection, and guided problem-based learning. The Spring 2021 class (N = 40) during the pandemic had online instruction (Class OI). The OI class was offered fully online with both synchronous and asynchronous components. These were both a 4-credit course with a lab portion. The OI lab was offered in synchronous format online by using guided problem-based learning approach with simple physics simulator and Tracker for simple 2D motion analysis. The IPI lab was offered in-person with guided problem-based learning strategy while using lab equipment such as force plate and motion analysis software. Students were required to read the textbook, watch short lecture videos, and complete pre-work assignments prior to the synchronous learning. During the synchronous time of the class, students were engaged with active learning strategies such as think-pair-share and problem-based learning.

Student performances in both groups were retrospectively collected for overall GPA prior to the semester taking the biomechanics class, as well as two course performance measures (i.e., quizzes and exams). Identical 35 multiple-choice questions from the class quizzes and exams were combined to compare biomechanics performance between the two classes. These questions were administered fully online for Class OI but on paper in-person for Class IPI. All questions had the same weight and percentage correction was calculated. These questions covered linear and angular kinematics and kinetics. Only students with five consecutive semesters for pre-course GPA were included in the study (Class IPI: n = 23 & Class OI: n = 21). All these semesters were coded as semester 1 through 6. Both OI and IPI classes were offered in the 6th semester. The students in OI class experienced the pandemic transition of the instruction mode in the 4th, 5th, and 6th semester. One independent t-test compared the course performance measures between Class IPI and OI. A paired t-test was performed to compare the three-semester average GPA before (semester 1-3) and after (semester 4-6) the outbreak of the pandemic in Class OI. Two-tailed test was used for the test above to answer the research questions designed. A repeated measures ANOVA was used to compare the difference among the term GPA for the IPI class to examine the consistency of the academic performance. Greenhouse-Geisser adjustment was used to avoid the violation of the sphericity assumption. Correlations documented associations between the class performance, pre-term GPA, and pandemic term GPA in each class. Statistical analysis assumptions such as skewness, kurtosis, equal variance, and normality of the data set were examined with descriptive statistics and effect sizes calculated. The data normality was examined with the Shapiro-Wilk test. If any of the assumptions for the statistical analysis was not met, an appropriate corresponding nonparametric statistical analysis would be used. A Holm (1979) correction was used to progressively adjust critical test values to maintain the overall Type I error at $p \leq 0.05$.

RESULTS: All assumptions were met for parametric statistical analysis. Biomechanics class performance measures was not different ($p = 0.16$) between Class IPI ($77.9\% \pm 7.5\%$) and OI ($72.7\% \pm 15.6\%$). There was a significant ($p < 0.018$, $d = 0.38$) increase in $M \pm SD$ GPA from 2.8 ± 0.6 pre-pandemic (semester 1-3) to 3.0 ± 0.5 in the pandemic terms (semester 4-6) for the OI class (Table 1). A repeated measures ANOVA with Greenhouse-Geisser adjustment

showed that the students' term GPAs from Class IPI before taking biomechanics had no significant ($p = 0.27$) difference (Table 2) across terms prior to the pandemic. The students' three semesters average GPA before taking biomechanics had a significant positive association with the biomechanics performance in the Class IPI ($r = 0.48$, $p < 0.05$) but not for the Class OI ($r = 0.24$, $p = 0.3$).

Table 1. Term GPA before and after the outbreak of the pandemic for the Class OI ($n = 21$)

Terms	1 st (F18)	2 nd (S19)	3 rd (F19)	4 th (S20)	5 th (F20)	6 th (S21)
GPA	2.8 ± 0.86	2.7 ± 0.69	2.7 ± 0.89	3.2 ± 0.4	2.9 ± 0.75	2.67 ± 0.75

Note: Mean GPA in semesters 1-3 using primarily IPI was significantly lower (2.8) than mean GPA in semesters 4-6 with OI (3.0). The courses were offered fully online in semesters 4-6 (coded red).

Table 2. Term GPA before the outbreak of the pandemic for the Class IPI ($n = 23$)

Terms	1 st (F16)	2 nd (S17)	3 rd (F17)	4 th (S18)	5 th (F18)	6 th (S19)
GPA	3.09 ± 0.5	3.0 ± 0.61	3.19 ± 0.63	3.08 ± 0.67	3.26 ± 0.51	3.08 ± 0.63

Note: Mean GPA had no significant difference across semesters pre-pandemic.

DISCUSSION: The present study supported preliminary research reporting inconsistent effects of emergency online instruction related to the COVID-19 pandemic in biomechanics and physics (Fouad et al. 2022; Gou, 2020; Knudson, 2020). Both the IPI and OI classes had similar performance on quiz and exam questions, however overall academic performance (GPA) in the OI class moderately ($d = 0.38$) increased from pre-pandemic (IPI) to post-pandemic (OI). This increase in overall academic performance is not logical given the additional stress of the pandemic (e.g., Aucejo et al., 2020), isolation, no change in the biomechanics course performance, and the less-than-ideal time to prepare engaging OI lessons in a difficult subject like biomechanics. This increased GPA from the pre-pandemic semester to the pandemic semester across the disciplines has also been observed across multiple institutions (Fass-Holmes, 2021; Karadag, 2021; Troher, 2021; Walker & Grimm, 2021).

Overall academic performance of the IPI class did not change over semesters and remained correlated ($r = 0.48$) with biomechanics performance, while GPA did not significantly correlate with biomechanics performance for OI class. This evidence taken together indicates that the increase in GPA post-pandemic in these students could be multifactorial. One of them could be the difficulty to cover all the course materials that resulted in easier classes for students to complete. It could also be due to the instructors who were unfamiliar with online instruction to implement the same standard and expectation of the class as pre-pandemic time. One other possibility could also be related to lower academic integrity of poorly proctored online assessments of performance (Knudson, 2020; Knudson & Bopp, 2021) than actual improvement. Substantial improvements in semester GPA for primarily OI format during the pandemic should be interpreted with caution. This may represent that students receive higher grades without necessarily demonstrating a higher level of mastery in the subject matter, which threatens the integrity of college grades as indicators of academic achievement (Chowdhury, 2018). Instructors teaching biomechanics may need to be aware that students are even more underprepared for your biomechanics class than before the pandemics. Future studies are needed to resolve the inconsistent results on the effects of the pandemic and OI on academic performance. This is important given greater emphasis on GPA with graduate program admissions (Verostek et al., 2021) over standardized tests like the Graduate Record Examination, GRE (Liu et al., 2021).

Limitations of this study include the retrospective design and a small, systematic sample of kinesiology majors from one comprehensive university. Based on the program curriculum, the courses taken by students before the semester when taking biomechanics class should be similar. However, there were a few electives that were not the same among the students between the semesters that might influence GPA. The two class groups also appeared to be slightly different in ability given the IPI class initially had nominally higher (0.2) GPAs than the OI class. These data, therefore, provide weak confirmatory evidence of previous research and primarily relate to the specific classes studied.

CONCLUSION: Performances in biomechanics classes at a university were not different between traditional IPI and OI after the COVID-19 pandemic. The outbreak of the pandemic in early 2020 and subsequent OI contributed to increased overall GPA. This GPA inflation decreased the association between the biomechanics class performance and pre-course GPA. Therefore, when using GPA during the COVID-19 pandemic years as an indicator for student academic success or admissions, it should be used with caution or in combination with other assessments such as standardised examinations or writing samples. More research is needed on how the pandemic and OI are affecting student performance in biomechanics and overall.

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