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Can biomechanics turn youth sports into a venue for informal STEM engagement?

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ABSTRACT

A common pitfall of existing Science, Technology, Engineering, and Math (STEM) outreach programs is that they preferentially engage youth with a preexisting interest in STEM. Biomechanics has the unique potential to broaden access to STEM enrichment due to its direct applicability to sports and human performance. In this study we examine whether biomechanics within youth sports can be used as a venue for STEM outreach, and whether recruiting participants through youth sports programs could broaden access to the STEM pipeline. We created a four-hour sports science clinic that was performed as part of National Biomechanics Day and invited two groups of student participants: youth recruited through local high school sports programs ("Sports Cohort", N = 80) and youth recruited through existing STEM enrichment programs ("STEM Cohort", N = 31). We evaluated interest in STEM, Sports Science, and Sports using a pre-post survey. Somewhat expectedly, youth recruited through sports programs (Sports Cohort) had a lower baseline interest in STEM and a higher baseline interest in sports, compared to those recruited through STEM programs (STEM Cohort). The Sports Cohort exhibited a statistically significant increase in STEM interest following participation in the clinic, while youth in the STEM Cohort maintained their high baseline of STEM interest. These findings provide evidence that youth sports programs can serve as an attractive partner for biomechanists engaged in STEM outreach, and that situating STEM within sports through biomechanical analysis has potential to introduce STEM interest to a wider audience and to broaden access to the STEM fields among diverse youth.

1. Introduction

Biomechanics concepts and research, and their direct applicability to youth sports, provide biomechanists with the opportunity to engage new, non-self-selected populations of Underrepresented Minority (URM) youth who are presently inaccessible to traditional STEM outreach programs (Drazan, 2020). Using youth sports as a framework for STEM engagement has a number of strengths. First, the number of youth playing sports in their free time is much larger than those who participate in academic enrichment (Larson et al., 2006). Youth sports also have a massive, existing network of community-based programs that serve highly diverse populations of youth from across the country (Simon and Uddin, 2018; Turner et al., 2015; Yu et al., 2015). Furthermore, youth athletes enjoy their sports and recognize that athletic success requires hard work and perseverance (Akiva et al., 2013; McCarthy et al., 2008; Shernoff and Vandell, 2007). Taken together, situating STEM outreach within sports has potential to not only broaden access to STEM careers among diverse youth but also transfer the growth mindset that these athletes have for sports to STEM activities.

The purpose of this study was to evaluate sports as a venue for STEM engagement through biomechanics among new populations of youth. We approached our analysis in three ways. First, we evaluated the effect of recruitment method on the starting interests of the student participants in a sport science outreach program. We hypothesized that students recruited through high school STEM programs (STEM Cohort) would have higher levels of starting STEM interest relative to student

Abbreviations: STEM, Science, Technology, Engineering, Mathematics; URM, Underrepresented Minority; NBD, National Biomechanics Day.

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athletes who were recruited through athletic departments (Sport Cohort). Similarly, we hypothesized that those in the Sport Cohort would have a higher starting sport interest than the STEM Cohort students. Second, we evaluated the effect of participation in the sports-science clinic on both cohorts. We hypothesized that the Sport Cohort would exhibit a larger increase in STEM interest relative to the STEM Cohort. Third, to understand whether the STEM interest change was driven by the sport-specific application of STEM, we also hypothesized that, among the Sport Cohort, an increase in STEM interest would be associated with an increase in sport science interest.

2. Methods

2.1. Study overview

We hosted a four-hour sport science clinic at Rensselaer Polytechnic Institute (RPI) as part of National Biomechanics Day. Following IRB approval (#1772), we recruited subjects by inviting high school students from a STEM enrichment program with a preexisting relationship with RPI (STEM Cohort, N = 31, 61 % female) and from the soccer and basketball teams of two local urban high schools who had never been invited to campus previously (Sport Cohort, N = 80, 31 % female). We measured the athletic performance of each high school participant within various soccer- or basketball-related skills or athletic activities using low-cost, "do-it-yourself" (DIY) sport-science equipment (Drazan et al., 2017, 2016; Marshall et al., 2020).

2.2. Overview of sport science clinic development

The activities within the clinic were developed by the study authors in partnership with collegiate student-athletes from the RPI men's and women's basketball and soccer teams. For both sports, the clinic consisted of four stations, each designed to measure an aspect of sport-specific performance. The collegiate student-athletes participated in a voluntary, eight-week program where they identified the skills for their sport and applied existing technology to measure this skill or used the engineering design process to build their own measurement tools. For example, to measure explosiveness, the basketball athletes used a DIY low-cost flight-time measurement system to measure vertical jump (Drazan et al., 2016). To quantify foot speed and agility, the soccer athletes designed and built a custom "toe-tapper" device using the engineering design process (Fig. 1). Although there are more accurate ways to measure athletic performance using commercial equipment, we used DIY tools built by our collegiate student-athletes to better demonstrate the direct applicability of STEM to sports performance measurement. Once each of the stations was developed, the collegiate athletes from their respective sport were assessed using these devices, prior to the clinic, to provide an "elite" benchmark for the clinic participants. These team-wise measurements were provided to the high school participants following their own testing in the clinic to provide a goal for our participants' performance.

2.3. Overview of program and evaluation

On the day of the clinic, high school participants completed the pre-survey upon arrival. The Sport Cohort was divided into basketball or soccer groups by sport participation, and the STEM Cohort was divided by reported sport interest. Every participant completed each of the athletic testing stations, and their results were recorded and summarized into a personalized, sport-specific sports-science report. Following completion of all testing stations within a sport, the data from all participants was pooled and analyzed during a lunch break. When each group reconvened, the study authors and college athletes presented the de-identified pooled performance data, leading a discussion on interpreting sports-science data and using these data to improve training. At the conclusion of the clinic, all participants completed the post-survey.

Before and after the clinic, we evaluated participant interest from the Sport and STEM cohorts in three interest domains (STEM, sports, and sports science) using a 15-question, Likert-type survey. Participants reported age, demographics, sports participation, and STEM activity participation. Question-by-question differences between groups were assessed using the Wilcoxon rank-sum test. Paired differences between pre- and post-intervention surveys within groups were assessed using the Wilcoxon sign-rank test. Questions related to each of the three interest domains were averaged to create true Likert items representing each of these concepts. To assess whether an increased interest in STEM was associated with an increased interest in sports-science, we used Spearman's rank correlation coefficient (ρ) to evaluate this shift in both the Sport and STEM Cohorts.

3. Results

Recruiting from existing sports or STEM programs yielded distinct initial interest profiles among youth participants for STEM enrichment. There was a statistically significant difference in both collegiate sports interest ($p < 0.01$) and collegiate STEM interest ($p < 0.01$) between the two cohorts at the start of the clinic. 83 % of the Sport Cohort reported they were "interested" or "extremely interested" in playing college sports, while only 41 % reported interest in studying STEM in college. This trend was reversed in the STEM Cohort, where 26 % reported an interest in playing college sports, and 94 % reported an interest in studying STEM in college (Fig. 2). STEM career interest among the STEM

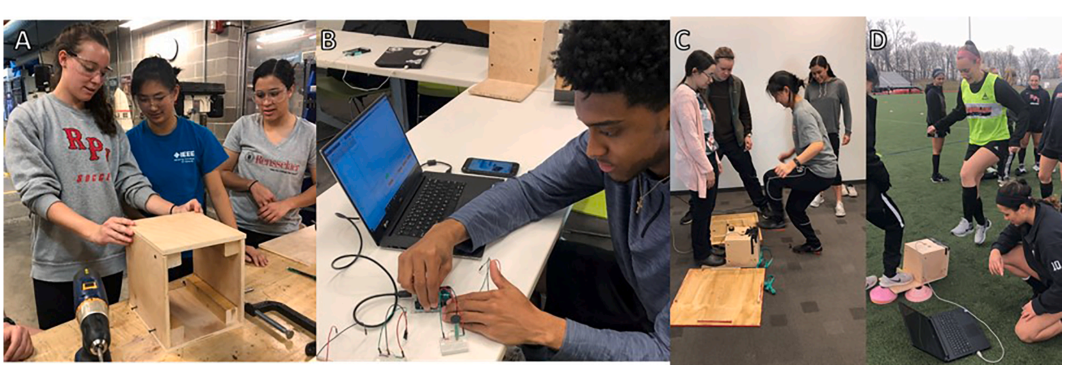

Fig. 1. Collegiate student-athletes used the engineering design process to design, test, and deploy custom sport science testing equipment. A) RPI student-athletes from the Men's and Women's soccer team designed and fabricated a "toe-tapper" device to measure soccer agility. B) Undergraduate and graduate student volunteers designed and tested a simple force-resistive circuit to measure when the foot was in contact with the top of the box and count the number of touches performed in a certain time frame. C) Following initial design, collegiate student athletes and volunteers tested the device to identify issues and inform redesign. D) Members of the women's soccer team assessed themselves and compared their results to on-field agility measurements prior to the clinic.

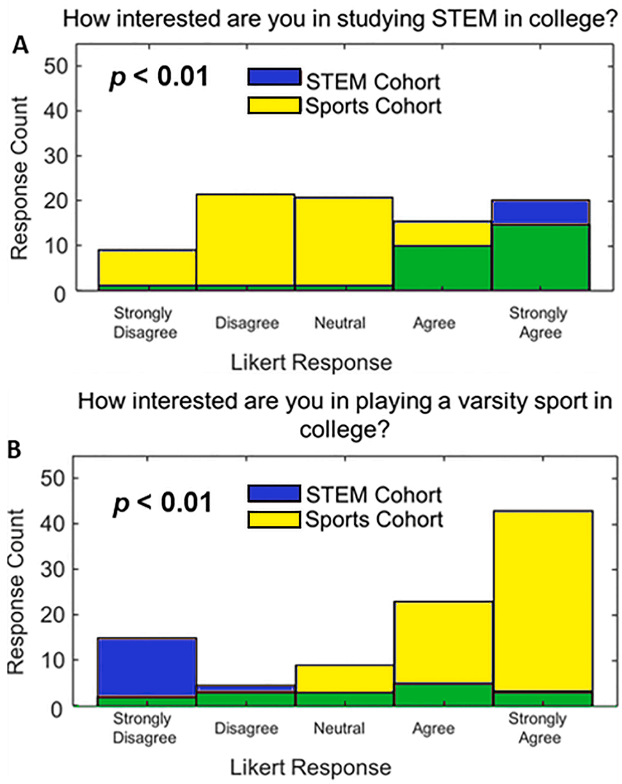

Fig. 2. N = 111. Differences in starting STEM interest and sports interest among the STEM and Sports Cohort that demonstrate different motivations for participating in the clinic. A) There was a significant difference in starting STEM interest between the Sports Cohort (yellow) and STEM Cohort (blue). Overlaps in the histogram between the two groups are shown in green. The mode response of the Sports Cohort being "Disagree" while the STEM Cohort's mode response was "Strongly Agree." B) In contrast the Sports Cohort mode response regarding interest in playing a college sport was "Strongly Agree" while the STEM Cohort's mode response was "Strongly Disagree.".

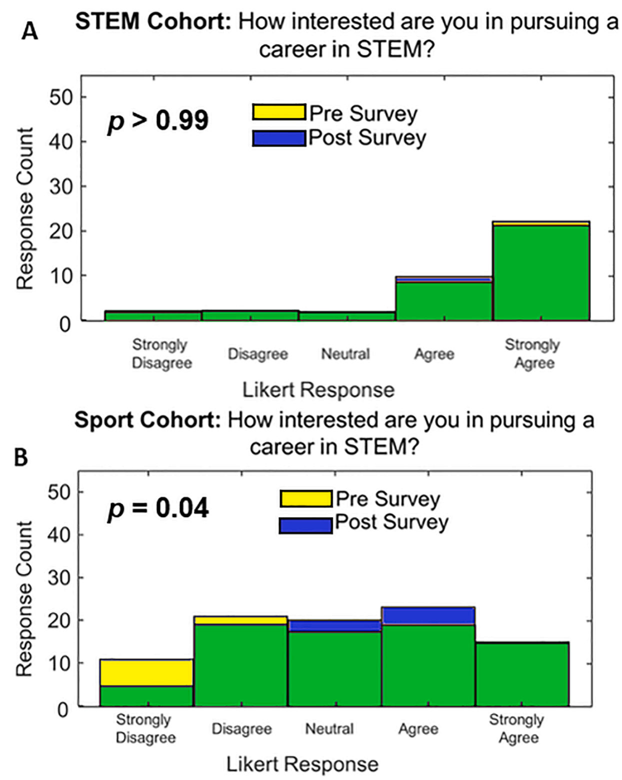

Fig. 3. N = 111. Participation in the clinic impacted the career in STEM interest of the two cohorts of participants differently, based on pre-post survey comparisons. A) The STEM cohort's interest in pursuing a career in STEM did not significantly change after the clinic. B) The Sports Cohort exhibited a statistically significant shift, from starting interest in STEM (yellow) with a mode response of "Disagree", to an ending interest in STEM (blue) with a mode response of "Agree." Areas of overlap are shown in green.

Cohort did not significantly increase ($p = 0.99$) after the clinic, although this group was already highly interested prior to participation. In contrast, STEM career interest was significantly increased ($p = 0.043$) among student-athletes following the sport-science clinic with the mode response shifting from "disagree" to "agree" (Fig. 3).

Other significant findings from the survey among the Sport Cohort include a statistically significant increase in: the belief that applying math and science to sport can make them a better player ($p < 0.01$), familiarity with sports analytics ($p < 0.01$), interest in doing science or math activities during free time ($p < 0.01$), the belief that participation in sports can help with math and science classes ($p < 0.01$), the belief that content learned in math and science classes can help with sports ($p < 0.01$), enjoyment of using math and science outside of class ($p < 0.02$), and familiarity with sports science ($p < 0.01$). The only two statistically significant shifts among the STEM cohort were familiarity with sports science ($p < 0.01$) and familiarity with sports analytics ($p < 0.01$). Among the Sport Cohort, increased STEM interest was moderately and significantly correlated (Spearman's rho = 0.25, $p = 0.02$) with an increased interest in sports science (Fig. 4). There was no statistically significant relationship between changes in STEM interest and changes in sports-science interest among the STEM cohort (Fig. 4). The Sport Cohort (51 % URM) was significantly more racially diverse than the STEM Cohort (3 % URM).

4. Discussion

In this study, we evaluated whether situating STEM outreach within sports enables recruitment of participants based on an interest in sports rather than STEM, within the context of a sports-science outreach event for National Biomechanics Day. We recruited participants from two student pools: high school athletic programs and pre-existing STEM enrichment programs. We found that the Sport Cohort exhibited an interest in sports, rather than STEM, at the start of the clinic and that these student athletes' interest in STEM increased following participation. Although it is difficult to attribute direct causality, we believe that this increased interest was due, in part, to the application of STEM within a sports context (Fig. 4). In contrast, the STEM cohort was already very interested in STEM careers, and outside of an increased awareness of the applicability of STEM to sports, their high levels of baseline STEM interest were maintained. These findings highlight the significant potential for using biomechanical analysis within youth sports programs to increase accessibility to informal STEM education for youth who are not presently involved with informal STEM activities. Furthermore, these findings demonstrate that situating STEM within non-STEM activities can broaden access to STEM enrichment into new populations of underserved youth.

The success of this approach is consistent with current educational literature and our previous findings. Prior studies have demonstrated that sports can serve as a venue for STEM engagement for URM students (Drazan et al., 2017; Marshall et al., 2020; Valerdi et al., 2013). Our sports-science clinic met several criteria that have been previously identified as effective for generating interest in new topics among youth (Harackiewicz et al., 2016). Framing STEM within sports enhances the student athletes' perceived utility of STEM within sports, an activity within which they are intrinsically motivated to improve, as demonstrated by their high level of interest in playing a college sport. Similar to other recent studies, we showed that using sports as a venue for STEM

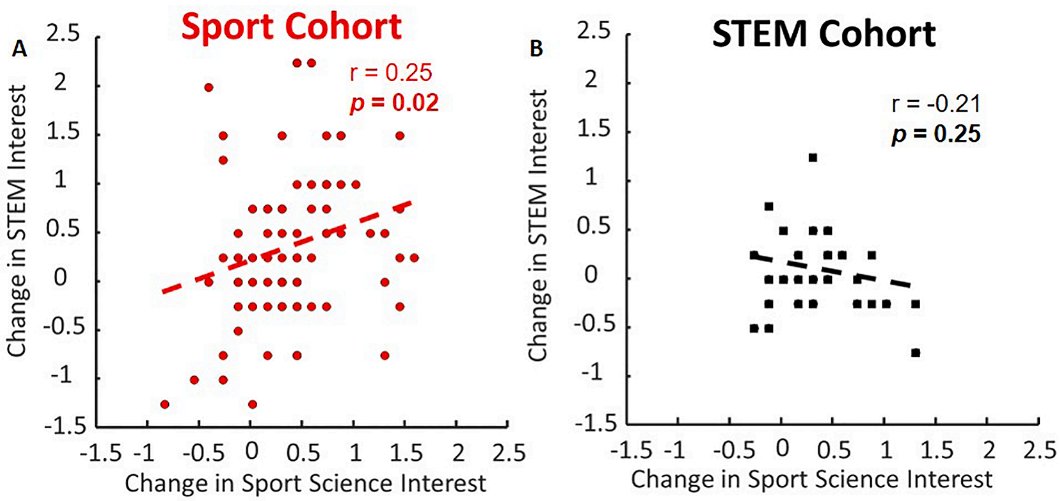

Fig. 4. Our analysis provides evidence that situating STEM within sports-science increased STEM interest among youth athletes, without negatively affecting the STEM interest of STEM-recruited participants. A) N = 80. The Sport Cohort exhibited a statistically-significant correlation between increased interest in STEM and increase interest in Sport-Science. B) N = 31 There was no observed correlation between change in STEM interest and Sport Science interest among the STEM Cohort.

engagement benefits sport-inclined youth without decreasing interest in non-sport students (Jones et al., 2020). Our findings are also broadly consistent with other culturally-situated STEM educational research outside of sports, such as hip hop (Emdin et al., 2016), Indigenous design (Eglash et al., 2013, 2006), and video games (Mayo, 2009).

There are several limitations to this study. First, we evaluated interest directly prior to and immediately following participation in the clinic using a self-reported survey. As this is a preliminary study to identify whether youth athletes have a different interest profile than students already in STEM programs, we believe that this shorter time frame is sufficient to demonstrate that sports has potential to serve as an important venue for STEM engagement to reach new populations of youth. However, further study is warranted to evaluate how long these interests persist. Second, although the correlation between sport science-interest and STEM-interest among the student athletes lends support to the importance of the applicability of STEM within the sport context, our study would have been strengthened by including an additional day in which athletes participated in a STEM-intensive activity to serve as a control. Third, the Sports Cohort had a higher percentage of males than female participants. This was due to our recruitment method. Unbeknownst to us at the time, one of the high schools we partnered with did not have a Girl's Junior Varsity soccer team. As a result, this school sent more than twice the number of males (JV and Varsity) as females (Varsity) from the soccer program. Therefore, this imbalance is due to administrative oversight rather than a feature of sports as a venue for STEM outreach. Indeed, by recruiting from an equal number of boy's and girl's (JV/Varsity) teams, a greater male/female parity can be easily achieved within the Sports Cohort.

Although we performed this study within the context of two sports, soccer and basketball, we believe our findings highlight a broader opportunity for biomechanists to engage with the community through youth programs on National Biomechanics Day and beyond (DeVita, 2018). Movement is a component of many youth activities, ranging from marching bands to interpretive dance. Therefore, while a specific sport may not be inclusive of all interests of the entire youth population, as a field, we can achieve wider inclusion by providing diverse multitude of youth-program-situated offerings based on the passions on individual biomechanists.

CRediT authorship contribution statement

Amy K. Loya: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Phillip E. Smith:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization. **Deva D. Chan:** Writing – review & editing, Writing – original draft, Funding acquisition, Formal analysis, Data curation, Conceptualization. **David T. Corr:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation. **John F. Drazan:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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