

DOI: https://doi.org/10.48009/4_iis_2026_152

Force plate analysis of collegiate athletes: sport, class year, and weekly trends in neuromuscular performance

Taylor M. Pickering, *Nichols College*, Taylor.Pickering@nichols.edu

Kaelyn R. Casper, *Nichols College*, Kaelyn.Casper@nichols.edu

David P. Hodge, *Nichols College*, David.Hodge@nichols.edu

TJ Cahill, *Nichols College*, TJ.Cahill@nichols.edu

Kevin Mentzer, *Nichols College*, Kevin.Mentzer@nichols.edu

Abstract

Force plate testing is increasingly used in collegiate athletics to monitor neuromuscular performance, yet it remains unclear which outcomes are most sensitive to longitudinal change and how those outcomes vary across athlete groups. The purpose of this study was to examine differences in force plate outcomes across class year, sport, and week of testing in collegiate athletes using a repeated-measures design. The dataset included 2,478 athlete-week observations from 250 athletes representing multiple sports. Separate linear mixed-effects models were estimated for jump height, RSI-modified, peak power relative to body mass, concentric peak force, eccentric braking rate of force development, peak landing force, and landing rate of force development. Fixed effects included centered week, class year, sport, and week-by-year interactions, while athlete was included as a random effect. Results indicated that sport was the most consistent predictor across models, with significant between-sport differences observed for nearly all outcomes. Class year main effects were generally limited, though several force-based outcomes showed significant week-by-year interactions. Jump height, RSI-modified, and peak power relative to body mass did not show meaningful linear change across weeks, whereas concentric peak force, eccentric braking rate of force development, peak landing force, and landing rate of force development demonstrated significant weekly trends. These findings suggest that force-based and landing-related variables may be more sensitive indicators of longitudinal change than jump-height-based outcomes alone. Overall, the results support the use of force plate testing as a sport-sensitive athlete monitoring tool and highlight the importance of interpreting weekly trends within both sport and developmental context.

Keywords: force plates; collegiate athletes; neuromuscular performance; mixed-effects models; athlete monitoring; sport performance

Introduction

Force plate testing is increasingly used in collegiate athletics to evaluate neuromuscular performance during jump and landing tasks. By capturing ground reaction forces and the force-time characteristics of movement, force plates provide practitioners with more detailed information than traditional performance outcomes such as jump height alone. In strength and conditioning settings, these data are commonly used to monitor athlete performance, evaluate longitudinal trends, and support decision-making related to training and athlete management.

Force plate assessments are especially valuable because different variables may reflect different components of performance. Measures such as jump height and RSI-modified summarize broad aspects of explosive ability, while variables such as concentric peak force, eccentric braking rate of force development, peak landing force, and landing rate of force development provide more detailed information about how athletes produce and absorb force. As a result, force plate testing may offer a more complete view of athlete performance than single-outcome jump assessments.

Despite the growing use of force plate testing in applied settings, less is known about how force plate outcomes vary across sports, class years, and repeated weekly testing periods in collegiate populations. Sport-specific demands, differences in athlete development, and longitudinal changes across a training period may all influence force plate performance. Understanding these relationships may help coaches and sport scientists interpret force plate data more effectively and identify which variables are most useful for athlete monitoring.

The purpose of this study was to examine how force plate outcomes varied across class year, sport, and week of testing in collegiate athletes using a repeated-measures design. In addition, the study sought to determine which force plate variables were most sensitive to weekly change over time.

Significance of Study

In addition to its value in sport science, this study is also situated within the broader field of sports analytics, where performance technologies generate repeated data that must be collected, modeled, interpreted, and translated into action. From an information systems perspective, force plate testing is not only a measurement practice but also a data-driven decision-support process. This framing is especially relevant given growing student interest in sports analytics and recent work showing that force-plate and wearable data can serve as analytically rich inputs for learning, engagement, and interpretation in sports analytics education (Mentzer et al., 2025; Reece & Hong, 2021). The present study emerged from that same applied context, extending student-centered sports analytics work into a formal analysis of repeated athlete performance data.

Given the need to better understand how force plate outcomes vary across athlete groups and over time, the study addressed the following research questions:

Research Questions

1. To what extent do force plate outcomes differ across class years in collegiate athletes?
2. To what extent do force plate outcomes differ across sports?
3. Which force plate outcomes appear most sensitive to weekly change over time?
4. Do weekly trajectories differ across class years for selected force plate outcomes?

Literature Review

Force plate testing has become an increasingly important tool in sport science because it enables researchers and practitioners to quantify the force-time characteristics of athletic movement with a level of precision that is not possible through observational assessment alone. In collegiate athletics, force plates are commonly used during countermovement jumps and related tasks to evaluate neuromuscular performance, identify asymmetries, and monitor changes in force production and landing mechanics over time (Berberet, 2022; Berberet, 2024; Weldon et al., 2022). Rather than reducing performance to a single outcome such as jump height, force plate technology captures multiple phases of movement and provides a more detailed

representation of how athletes generate, absorb, and redirect force (Beckham et al., 2014; Merrigan et al., 2021).

This distinction is important because force plate variables are not interchangeable. Measures such as jump height and RSI-modified provide useful summaries of explosive performance, but they may overlook meaningful changes in the underlying mechanics of movement. By contrast, variables such as concentric peak force, eccentric braking rate of force development, peak landing force, and landing rate of force development provide more refined information about an athlete's neuromuscular strategy and mechanical output. Prior work has argued that force plate assessment is most valuable when interpreted through the broader force-time profile rather than through a single performance metric alone (Beckham et al., 2014; Merrigan et al., 2021). From this perspective, force plates offer a multidimensional view of movement that may be especially useful for athlete monitoring across time.

A second major theme in the literature is the role of force plate testing within athlete monitoring systems (Berberet et al., 2024). In applied settings, practitioners are often interested in whether changes in neuromuscular performance reflect adaptation, readiness, fatigue, or accumulated training stress. The broader fatigue literature suggests that performance decline is multifactorial and should be understood as involving both perceived and performance fatigability (Behrens et al., 2022). Related sport science research has linked training load and fatigue markers to injury and illness risk, reinforcing the value of regular objective monitoring in athletic populations (Halson, 2014; Jones et al., 2017; Malone et al., 2017). Research using biomechanical and movement data has also shown that fatigue-related states can be inferred from performance signals, suggesting that force plate-derived variables may capture meaningful changes in physical function across repeated testing periods (Jiang et al., 2021). Although force plate outcomes should not be treated as direct measures of recovery in isolation, the literature supports their use as objective indicators within a broader athlete-monitoring framework (Heishman et al., 2020; Murr et al., 2023; Philipp et al., 2023b).

Literature also suggests that force plate performance must be interpreted within athlete-specific and sport-specific contexts. Sports differ substantially in movement demands, loading profiles, force-production requirements, and training emphasis, all of which are likely to influence jump and landing characteristics. Recent normative work in NCAA Division I men's basketball, for example, has shown that countermovement jump force plate variables vary meaningfully across athletes and can be used to establish sport-specific benchmarks (Berberet et al., 2024). Several other studies have also described position and sport-specific differences found through force plate testing (Heishman et al., 2020; Philipp et al., 2023a). This is important because a value that appears high or low in one sport may be typical in another. Accordingly, force plate data are most useful when interpreted relative to a sport environment rather than against a single universal standard.

Athlete development is another relevant consideration. Although class year is an imperfect proxy for training age, maturity, and accumulated collegiate experience, it may still capture meaningful differences in strength and conditioning exposure. Research on related force plate metrics suggests that athletes with greater training history may display different force-time characteristics and different movement efficiencies than less experienced athletes. Thomas et al. (2015), for example, demonstrated the reliability of the Dynamic Strength Index in collegiate athletes, supporting the use of force plate-derived measures for comparing strength-expression profiles across athlete groups. Morrison et al. (2020) also reported preseason-to-postseason changes in force plate balance metrics among college athletes, suggesting that neuromuscular characteristics can shift across time in trained collegiate populations. These findings imply that developmental differences may not always appear as simple static group differences, but may also emerge in longitudinal patterns of change.

Force plate systems can also be understood through an information systems and analytics lens. In addition to functioning as biomechanical measurement tools, they collect, structure, visualize, and support interpretation of repeated performance data. That framing aligns well with Mentzer et al. (2025), who examined how student-generated data from wearables, force plates, and performance-visualization tools influenced engagement and motivation in a Division III sports analytics course. Their study positions force-plate data not only as performance information, but also as an analytically rich input for decision-making, interpretation, and learning. In that sense, force plate monitoring can be viewed as a domain-specific analytics system that transforms repeated observations into usable information for coaches, students, and sport-performance professionals (Mentzer et al., 2025).

Despite growing interest in force plate applications, several gaps remain in the literature. Much of the published work emphasizes a single sport, a narrow time window, or a limited set of outcomes. Fewer studies examine repeated force plate observations across multiple collegiate sports while simultaneously accounting for athlete development and the nested structure of repeated observations within athletes. This is an important limitation, because weekly monitoring data are inherently longitudinal, and repeated observations from the same athlete should not be treated as statistically independent. Moreover, if force plate variables differ in their sensitivity to change, analyses that collapse them into a single generalized notion of “performance” may obscure practically meaningful patterns. The present study addresses these gaps by examining repeated force plate outcomes across multiple sports, class years, and weeks of testing in a collegiate athlete sample, with attention to both sport-specific differences and longitudinal trends.

Methodology

Research Design

This study employed a quantitative repeated-measures design to examine force plate outcomes in collegiate athletes. A quantitative approach was appropriate because the study focused on numerical performance variables collected across repeated testing sessions. The repeated-measures design allowed for the analysis of both between-athlete differences and within-athlete changes over time.

Participants and Data Structure

The dataset included 2,478 athlete-week observations from 250 collegiate athletes representing multiple sports. Sports included football (n=68), field hockey (n=21), men’s basketball (n=20), men’s ice hockey (n=31), men’s lacrosse (n=35), men’s soccer (n=1), softball (n=20), women’s basketball (n=15), women’s ice hockey (n=5), women’s lacrosse (n=13), and women’s soccer (n=21).

Because athletes were tested repeatedly across weeks, the data had a nested structure in which multiple observations belonged to the same athlete. This repeated structure was important analytically because observations from the same athlete could not be assumed to be independent.

Variables

The primary outcome variables in this study are summarized in Table 1. Each outcome represents a distinct component of countermovement jump performance, including broad jump outcomes, force-production characteristics, and landing mechanics. Separate mixed-effects models were estimated for each of these seven outcomes.

Table 1. Force Plate Outcome Variables Included in the Analysis

Outcome Variable	Description
Jump Height	Vertical jump height in inches
RSI-modified	Reactive Strength Index-modified
Peak power / BM	Peak power relative to body-mass
Concentric peak force	Maximum force produced during the concentric phase
Eccentric Braking RFD	Rate of force development during the eccentric braking phase
Peak landing force	Maximum force recorded during landing
Landing RFD	Rate of force development during landing

The principal predictor variables were week of testing, class year, and sport. Week was derived from the testing date, with Week 1 beginning on August 25, 2025. For analysis, week was centered so that Week 2 served as the reference point. Centering improved the interpretability of model intercepts by making them correspond to an observed early-semester time point.

Data Preparation

Data were cleaned and prepared in Python. Raw column names were standardized, dates were converted into week numbers, and sport and class year were coded as categorical variables. Repeated observations within the same athlete-week combination were aggregated into weekly summary rows using mean values for the primary force plate metrics. This process produced one summarized observation per athlete per week for analysis. Overall, approximately 85% of student-athletes performed testing more than once in any given week. No missing data existed; all jump test data was automatically gathered for each student-athlete each time they performed a jump.

Analysis

Data preparation and management were performed in Python using pandas (McKinney, 2010), and statistical models were estimated using statsmodels (Seabold & Perktold, 2010). Because the dataset contained repeated observations nested within athletes, linear mixed-effects models were used.

Separate mixed-effects models were estimated for each of the seven force plate outcomes listed in Table 1. Athlete was included as a random intercept to account for repeated observations within individuals. Fixed effects included centered week, class year, sport, and the interaction between centered week and class year. This modeling approach allowed the study to evaluate whether outcomes differed across sports and class years and whether weekly trajectories varied across class years.

The general form of the final model was: $Outcome \sim week_c * year + sport$

Football served as the reference sport category, and first-year athletes served as the reference class-year group. Statistical significance was evaluated at the .05 level.

Results

Linear mixed-effects models were estimated for the seven force plate outcomes listed in Table 1 using 2,478 athlete-week observations from 250 collegiate athletes. Athlete was included as a random intercept in each model to account for repeated observations within individuals. Fixed effects included centered week, class year, sport, and the interaction between centered week and class year. To aid interpretation, Table 2 summarizes the overall pattern of findings across all seven outcome models. Because presenting complete coefficient tables for all seven models would exceed the manuscript's space limitations, Table 3 provides the full fixed-effect estimates for the jump height model as an illustrative example. The same model specification and reporting procedures were applied to each of the remaining six outcomes, and their statistically significant effects are described in the accompanying text.

Table 2. Summary of Mixed-Effects Model Results by Outcome

Outcome	Week effect	Class Year main effect	Sport effect	Week x Year interaction	Key Finding
Jump Height	No	No	Yes	No	Stable across weeks; differs by sport
RSI-modified	No	No	Yes	No	Stable across weeks; differs by sport
Peak power / BM	No	No	Yes	No	Stable across weeks; differs by sport
Concentric peak force	Yes	No	Yes	Yes	Weekly change differs by class year
Eccentric Braking RFD	Yes	No	Yes	Yes	Weekly change differs by class year
Peak landing force	Yes	No	Yes	Yes	Sport and weekly change both important
Landing RFD	Yes	No	Yes	Yes	Weekly change differs for seniors

Table 3. Fixed Effects from the Mixed-Effects Model Predicting Jump Height

Predictor	B	SE	z-score	p-value	95% CI
Intercept	14.338***	0.395	36.311	< .001	[13.564, 15.112]
Year: SO	-0.010	0.489	-0.020	.984	[-0.967, 0.948]
Year: JR	-0.924	0.560	-1.651	.099	[-2.020, 0.173]
Year: SR	-0.366	0.509	-0.719	.472	[-1.364, 0.632]
Sport: MBB	2.851***	0.658	4.330	< .001	[1.560, 4.141]
Sport: MICE	1.866***	0.521	3.580	< .001	[0.845, 2.888]
Sport: MLAX	1.289*	0.518	2.487	.013	[0.273, 2.305]
Sport: MSOC	-0.233	3.231	-0.072	.943	[-6.565, 6.099]
Sport: WBB	-2.333**	0.693	-3.369	.001	[-3.691, -0.976]
Sport: WFH	-3.845***	0.604	-6.367	< .001	[-5.029, -2.662]
Sport: WICE	-3.385*	1.533	-2.208	.027	[-6.388, -0.381]
Sport: WLAX	-3.441**	1.104	-3.116	.002	[-5.605, -1.277]
Sport: WSB	-3.588***	0.623	-5.764	< .001	[-4.809, -2.368]
Sport: WSOC	-3.955***	0.608	-6.501	< .001	[-5.148, -2.763]
Week c	-0.011	0.014	-0.781	.435	[-0.039, 0.017]
Week c × JR	0.024	0.025	0.954	.340	[-0.025, 0.072]
Week c × SO	-0.015	0.022	-0.708	.479	[-0.058, 0.027]
Week c × SR	-0.014	0.028	-0.498	.618	[-0.070, 0.041]

Random intercept variance (athlete)	4.596	0.169	—	—	—
--	-------	-------	---	---	---

Note. Football served as the reference sport category, and first-year athletes served as the reference class-year group. Week was centered such that Week 2 = 0. $p < .05$ (), $p < .01$ (**), $p < .001$ (***)*

As shown in Table 2, sport emerged as the most consistent predictor across the models, whereas class-year main effects were generally limited. In addition, the outcomes did not all display the same longitudinal pattern. Jump height, RSI-modified, and peak power relative to body mass showed little evidence of meaningful linear change across weeks, whereas concentric peak force, eccentric braking rate of force development, peak landing force, and landing rate of force development demonstrated significant weekly trends.

Jump Height

The mixed-effects model for jump height showed no significant linear effect of week and no significant main effects of class year (see Table 3). As the representative example in Table 3 illustrates, sport was the most meaningful predictor in the model. Relative to football, several sports demonstrated significantly lower jump height values, whereas men's basketball, men's ice hockey, and men's lacrosse demonstrated significantly higher values. Consistent with the pattern summarized in Table 2, jump height appeared more strongly differentiated by sport than by class year or week of testing.

RSI-Modified

A similar pattern was observed for RSI-modified. Week was not a significant predictor, and class-year main effects were not statistically significant. Sport again emerged as an important predictor, with several sports demonstrating significantly lower RSI-modified values than football and men's basketball demonstrating significantly higher values. As summarized in Table 2, RSI-modified appeared relatively stable across weeks but varied across sports.

Peak Power Relative to Body Mass

The model for peak power relative to body mass also showed no significant linear effect of week and no significant main effects of class year. Sport remained the strongest predictor, with several sports demonstrating significantly lower values than football and men's basketball demonstrating significantly higher values. As shown in Table 2, peak power relative to body mass differed more by sport than by class year or weekly trend.

Concentric Peak Force

The model for concentric peak force showed a significant positive weekly effect for the reference year group, indicating that concentric peak force increased over time in that group. Sport differences were also substantial, with many sports demonstrating significantly lower values than football. Although class-year main effects were not statistically significant, the interaction terms between week and class year were significant for sophomores and seniors, indicating that weekly trajectories differed across class years. This pattern aligns with the summary presented in Table 2.

Eccentric Braking Rate of Force Development

Eccentric braking rate of force development also demonstrated a significant positive weekly effect for the reference year group. Sport remained a strong predictor, and several sports differed significantly from football. Significant week-by-year interactions for sophomores and seniors indicated that the weekly pattern of change differed across class years, with those groups demonstrating flatter or more negative trajectories than the reference year group. Table 2 summarizes this result as evidence that weekly change differed by class year for this force-based outcome.

Peak Landing Force

Peak landing force demonstrated a significant positive weekly effect for the reference year group, along with strong sport effects. Class-year main effects were not significant, but the interaction between week and senior status was significant, indicating that senior athletes followed a different longitudinal pattern from the reference year group. As shown in Table 2, both sport and weekly change were important for this outcome.

Landing Rate of Force Development

Landing rate of force development also showed a significant positive weekly effect in the reference year group and meaningful sport differences. The interaction between week and senior status was significant, again suggesting that weekly trajectories differed across class years for this landing-related outcome. This pattern is summarized in Table 2.

Summary of Findings

Taken together, the results presented in Tables 2 and 3 suggest three broad patterns. First, sport was the most consistent predictor across the models. Second, class-year main effects were generally limited, suggesting that baseline differences between class years were relatively small once sport was accounted for. Third, not all force plate variables demonstrated the same longitudinal pattern. Jump height, RSI-modified, and peak power relative to body mass were relatively stable across weeks, whereas concentric peak force, eccentric braking rate of force development, peak landing force, and landing rate of force development were more sensitive to weekly change. For several of these force-based outcomes, weekly trajectories differed across class years.

Discussion

The purpose of this study was to examine how force plate outcomes varied across class year, sport, and week of testing in collegiate athletes using a repeated-measures design. The results indicate that sport was the most consistent predictor across the models, whereas class-year main effects were generally limited. In addition, the findings suggest that not all force plate variables are equally sensitive to longitudinal change. As summarized across all seven models in Table 2 and illustrated using the complete jump height model in Table 3, outcomes such as jump height, RSI-modified, and peak power relative to body mass were relatively stable across weeks, whereas several force- and landing-based outcomes demonstrated significant weekly trends. Jump height was selected for detailed presentation because it is the most widely recognized force plate outcome and provides a clear illustration of the model structure and coefficient interpretation.

One of the clearest findings was the consistency of sport effects across nearly all outcomes. Even after accounting for class year and week of testing, athletes from different sports differed meaningfully on jump height, RSI-modified, force-production variables, and landing variables. This pattern reinforces the importance of interpreting force plate data within sport-specific contexts rather than against a single universal benchmark. Sports differ substantially in movement demands, loading profiles, training emphasis, and physical characteristics, and those differences appear to be reflected in force plate performance. This finding is consistent with prior literature emphasizing the value of sport-specific interpretation of countermovement jump and force plate variables (Berberet et al., 2024; Merrigan et al., 2021).

A second important finding was that class-year main effects were generally weak. After controlling for sport and week, athletes in different class years did not consistently differ at the reference week on most outcomes. This suggests that class-year alone may be a relatively limited explanatory variable when compared with sport context. Although class year may capture some aspects of athlete development, it is

likely only a rough proxy for more direct influences such as training age, accumulated strength and conditioning exposure, body composition, or competitive role. In practical terms, this means that practitioners should be cautious about assuming that older athletes will necessarily demonstrate superior force plate profiles simply because of class standing.

At the same time, class year was not irrelevant. For several force-based outcomes, week-by-year interactions were significant, indicating that weekly trajectories differed across class years even when baseline class-year differences were small. In particular, concentric peak force, eccentric braking rate of force development, peak landing force, and landing rate of force development showed evidence that longitudinal patterns were not uniform across athlete groups. This is an important distinction, because it suggests that developmental differences may be expressed more clearly in how athletes change over time than in simple cross-sectional comparisons at a single point in the semester.

Another major takeaway is that force plate variables should not be treated as interchangeable. Jump height, RSI-modified, and peak power relative to body mass showed little evidence of meaningful linear change across weeks, whereas concentric peak force, eccentric braking RFD, peak landing force, and landing RFD were more responsive to weekly variation. This supports the idea that broad summary outcomes may not always capture the same information as more specific force- and landing-based variables. Prior work has argued that force plate interpretation is most informative when the entire force-time profile is considered rather than relying solely on jump height (Beckham et al., 2014; Merrigan et al., 2021), and the present findings align with that perspective. In applied settings, monitoring only jump height may overlook meaningful changes that are detectable in more specific mechanical variables.

These findings also have practical implications for athlete monitoring. If practitioners are using force plate testing to support longitudinal evaluation of athlete performance, the results suggest that force- and landing-based metrics may provide greater sensitivity to change than jump height alone. This does not mean that jump height lacks value; rather, it suggests that jump height may function better as a broad descriptive measure than as the most responsive indicator of week-to-week change. From an information systems perspective, this also reinforces the importance of collecting, organizing, and interpreting multiple related performance variables rather than relying on a single metric. Force plate systems are most useful when they support richer decision-making through multidimensional performance data, a view that aligns with recent IIS work emphasizing the value of performance data as analytically meaningful information rather than as isolated measurements (Mentzer et al., 2025).

The findings should also be interpreted with appropriate caution. Although several outcomes demonstrated significant week effects or week-by-year interactions, the present models captured linear change only. Athlete performance may shift nonlinearly across a semester due to competition schedules, academic demands, training cycles, or injury-related factors. In addition, the study did not include contextual variables such as workload, sleep, wellness, playing position, or injury status. As a result, the models identify patterns in force plate outcomes but do not fully explain why those patterns occurred.

Overall, the present study contributes to the literature in two important ways. First, it extends force plate research beyond narrow single-sport or single-outcome analyses by examining repeated observations across multiple sports and seven distinct performance variables. Second, it demonstrates that sport context and variable selection both matter when interpreting force plate data longitudinally. For collegiate practitioners, the results suggest that force plate monitoring may be most informative when interpreted within sport-specific contexts and when emphasis is placed on force- and landing-related variables in addition to jump height.

Taken together, the findings provide clear responses to the study's research questions. First, force plate outcomes did not differ strongly across class years at baseline once sport was taken into account, although class year moderated weekly trajectories for several force-based measures. Second, force plate outcomes differed meaningfully across sports, with sport emerging as the most consistent predictor across the models. Third, concentric peak force, eccentric braking rate of force development, peak landing force, and landing rate of force development appeared more sensitive to weekly change than jump height, RSI-modified, and peak power relative to body mass. Finally, weekly trajectories did differ across class years for selected force-based outcomes, indicating that developmental differences were more apparent in longitudinal patterns than in static group comparisons.

These findings also matter beyond sport-performance interpretation alone. In sports analytics, the challenge is not simply collecting performance data, but determining which variables are most informative, how they change across time, and how they should be communicated for decision-making. Viewed this way, the study contributes to an information systems conversation about how repeated performance data are transformed into usable knowledge. This perspective is particularly relevant in educational settings, where student interest in sports analytics continues to grow and where force-plate data can function as analytically rich, decision-oriented data sources (Mentzer et al., 2025).

Limitations and Future Research

This study has several limitations that should be considered when interpreting the findings. First, the data were drawn from a single NCAA Division III institution, which limits the generalizability of the results to other collegiate settings, competitive levels, and training environments. Force plate outcomes may differ across institutions due to differences in athlete populations, coaching practices, sport culture, and performance infrastructure.

Second, the distribution of athletes across sports and class years was uneven. Although the overall number of athlete-week observations was substantial, some sport groups likely contained fewer athletes than others. As a result, certain sport-specific estimates may be less stable or less precise than others. This is especially important when interpreting coefficients relative to football, which served as the reference sport category.

Third, the analyses modeled week as a linear predictor. This approach provided a useful starting point for evaluating longitudinal change, but athlete performance may not change in a strictly linear fashion across a semester. Weekly force plate outcomes may be influenced by nonlinear factors such as competition schedules, training cycles, tapering periods, injury, or academic stress. Future work could address this by treating week as a categorical variable or by fitting nonlinear trends.

Fourth, the models did not include several contextual variables that may influence neuromuscular performance. Factors such as training load, practice intensity, injury status, playing position, sleep, wellness, nutrition, and time of day were not included in the final analyses. These omitted variables may account for some of the within-athlete and between-athlete variation observed across the models.

Finally, the study focused on force plate-derived performance outcomes only. Although these measures may be related to readiness, fatigue, or recovery, they should be interpreted as indicators of neuromuscular performance rather than as direct measures of broader physiological or psychological states. Force plate data can provide valuable insight into athlete performance trends, but they do not fully explain the mechanisms underlying those trends without additional contextual or physiological information.

Future research should extend this work by incorporating additional contextual variables that may help explain changes in force plate outcomes across time. Variables such as training load, injury status, playing position, wellness, sleep, competition schedule, and time of testing could provide a more complete picture of why athlete performance changes from week to week. Including these factors would strengthen the interpretation of longitudinal trends and improve the practical usefulness of force plate monitoring.

Future studies should also examine longitudinal change using more flexible modeling strategies. In the present study, week was treated as a linear predictor, which provided a clear starting point for evaluating repeated performance trends. However, athlete performance may change in nonlinear ways across a semester due to variation in training cycles, tapering, competition demands, and recovery periods. Modeling week as a categorical variable or testing nonlinear time effects may reveal patterns that are not captured by a linear approach.

A third direction for future research is to expand the study across institutions, divisions, and athlete populations. Multi-site studies would improve generalizability and allow researchers to examine whether the patterns observed here are consistent across different competitive levels and training environments. Broader samples would also support more detailed subgroup analyses by sport, position, or athlete experience.

Future work should additionally examine whether force- and landing-based variables consistently provide greater longitudinal sensitivity than jump height and other broad performance outcomes. The present findings suggest that several force-based variables may be more responsive to weekly change than jump height, RSI-modified, or peak power relative to body mass. Replicating this pattern in other samples and contexts would help determine which outcomes are most useful for athlete monitoring in applied settings.

Finally, future research could continue to explore force plate systems from an analytics and information systems perspective. As sport programs increasingly rely on performance technologies to collect repeated athlete data, there is growing value in understanding how these systems support interpretation, communication, and decision-making. Research that connects biomechanical measurement with analytics workflows and practitioner use may help bridge sport science and information systems in a way that is especially relevant for applied and interdisciplinary audiences.

Conclusion

This study examined repeated force plate outcomes in collegiate athletes to determine how performance varied across class year, sport, and week of testing. Using linear mixed-effects models, the analysis showed that sport was the most consistent predictor across the seven outcomes, indicating that force plate performance should be interpreted within sport-specific contexts. In contrast, class-year main effects were generally limited, suggesting that baseline differences by academic standing were smaller than expected once sport was taken into account.

The study also showed that not all force plate variables behaved similarly across time. Jump height, RSI-modified, and peak power relative to body mass were relatively stable across weeks, whereas concentric peak force, eccentric braking rate of force development, peak landing force, and landing rate of force development demonstrated stronger evidence of weekly change. In several cases, those weekly trends also differed across class years, indicating that developmental differences may be more evident in longitudinal performance patterns than in baseline comparisons alone.

Taken together, these findings suggest that force plate testing can provide meaningful value for longitudinal athlete monitoring when interpreted through multiple outcomes rather than through jump height alone. More broadly, the results highlight the importance of viewing force plate data not only as biomechanical measurements, but also as analytically useful performance information that can support decision-making in collegiate athletics.

Acknowledgements

Generative AI was used to assist with language refinement and readability improvement during preparation of the final manuscript draft. The authors reviewed and revised all content and take full responsibility for the originality, accuracy, and integrity of the submission.

References

- Beckham, G., Suchomel, T., & Mizuguchi, S. (2014). Force plate use in performance monitoring and sport science testing. *New Studies in Athletics*, 29(3), 25-37.
- Behrens, M., Gube, M., Chaabene, H., Prieske, O., Zenon, A., Broscheid, K. C., Schega, L., Husmann, F., & Weippert, M. (2022). Fatigue and human performance: An updated framework. *Sports Medicine*, 53, 7-31. <https://doi.org/10.1007/s40279-022-01748-2>.
- Bereberet, D. (2022, January 3). 2021 Year in review: By the numbers. Hawkin Dynamics Blog. Retrieved from: <https://www.hawkindynamics.com/blog/2021-year-in-review-by-the-numbers>
- Bereberet, D. (2024, January 17). 2023 Year in review: By the numbers. Hawkin Dynamics Blog. Retrieved from: <https://www.hawkindynamics.com/blog/2023-wrapped-end-of-year-stats>
- Bereberet, D., Petway, A., Bell, K., Gillen, Z., Mundy, P., Barrera, H., Kabo, J., Walker, D., Meded, G., Welsh, B., & McMahon, J. (2024). Unlocking basketball athletic performance: Force plate-derived countermovement jump normative reference values from seven NCAA Division-I Power Five men's college basketball teams. *International Journal of Strength and Conditioning*, 4(1). <https://doi.org/10.47206/ijsc.v4i1.354>.
- Halson, S. L. (2014). Monitoring training load to understand fatigue in athletes. *Sports Medicine*, 44(Suppl 2), 139-147. <https://doi.org/10.1007/s40279-014-0253-z>.
- Heishman, A. D., Daub, B. D., Miller, R. M., Freitas, E. D. S., & Bembien, M. G. (2020). Monitoring external training loads and neuromuscular performance for division I basketball players over the preseason. *Journal of Sports Science and Medicine*, 19, 204-212. PMID: PMC7039036.
- Jiang, Y., Hernandez, V., Venture, G., Kulić, D., & Chen, B. K. (2021). A data-driven approach to predict fatigue in exercise based on motion data from wearable sensors or force plate. *Sensors*, 21(4), 1499. <https://doi.org/10.3390/s21041499>.
- Jones, C. M., Griffiths, P. C., & Mellalieu, S. D. (2017). Training load and fatigue marker associations with injury and illness: A Systematic Review of Longitudinal Studies. *Sports Medicine*, 47(5), 943-974. <https://doi.org/10.1007/s40279-016-0619-5>.

- Malone, S., Owen, A., Newton, M., Mendes, B., Collins, K. D., & Gabbett, T. J. (2017). The acute:chronic workload ratio in relation to injury risk in professional soccer. *Journal of Science and Medicine in Sport*, 20(6), 561–565. <https://doi.org/10.1016/j.jsams.2016.10.014>.
- McKinney, W. (2010). Data structures for statistical computing in Python. In S. van der Walt & J. Millman (Eds.), *Proceedings of the 9th Python in Science Conference* (pp. 56–61). <https://doi.org/10.25080/Majora-92bf1922-00a>
- Mentzer, K., Ruff, J., Wendry, B., Price, J., & Gouws, B. (2025). From the weight room to the classroom: student-generated data as a catalyst for engagement. *Issues in Information Systems*, 26(1). https://doi.org/10.48009/1_iis_127.
- Merrigan, J. J., Stone, J. D., Martin, J. R., Hornsby, W. G., Galster, S. M., & Hagen, J. A. (2021). Applying force plate technology to inform human performance programming in tactical populations. *Applied Sciences*, 11(14), 6538. <https://doi.org/10.3390/app11146538>.
- Morrison, R., Petit, K. M., Kuenze, C., Moran, R. N., & Covassin, T. (2020). Preseason to Postseason changes on the BTrackS Force Plate in a Sample of College Athletes. *Journal of Sport Rehabilitation*, 29(1), 134–136. <https://doi.org/10.1123/jsr.2018-0304>.
- Murr, S., Aldred, M., & Games, J. (2023). Monitoring countermovement jump performance for Division I basketball players over the competitive season. *American Journal of Sports Science*, 11(1), 33-40. <https://doi.org/10.11648/j.ajss.20231101.14>.
- Philipp, N. M., Cabarkapa, D., Nijem, R. M., Blackburn, S. D., & Fry, A. C. (2023a). Vertical jump neuromuscular performance characteristics determining on-court contribution in male and female NCAA Division 1 basketball players. *Sports*, 11(12), 239. <https://doi.org/10.3390/sports11120239>.
- Philipp, N. M., Cabarkapa, D., Nijem, R. M., and Fry, A. C. (2023b). Changes in countermovement jump force-time characteristic in elite male basketball players: A season-long analyses. *PLoS ONE*, 18(9). <https://doi.org/10.1371/journal.pone.0286581>.
- Reece, J., & Hong, S. (2021). Big data analytics for smart sports using apache spark. *Issues in Information Systems*, 22(3). https://doi.org/10.48009/3_iis_2021_1-15
- Seabold, S., & Perktold, J. (2010). statsmodels: Econometric and statistical modeling with Python. In *Proceedings of the 9th Python in Science Conference* (pp. 92–96). <https://doi.org/10.25080/Majora-92bf1922-011>
- Thomas, C., Jones, P. A., & Comfort, P. (2015). Reliability of the dynamic strength index in college athletes. *International Journal of Sports Physiology and Performance*, 10(5), 542-545. <https://doi.org/10.1123/ijspp.2014-0255>.
- Weldon, A., Duncan, M. J., Turner, A., LaPlaca, D., Sampaio, J., and Christie, C. J. (2022). Practices of strength and conditioning coaches: A snapshot from different sports, countries, and expertise levels. *Journal of Strength and Conditioning Research*, 36(5), 1335-1344. <https://doi.org/10.1519/JSC.0000000000003773>.