Journal of Athletic Training 2023;58(4):338–344
doi: 10.4085/1062-6050-0703.21

Kinetic and Spatiotemporal Characteristics of Running During Regular Training Sessions for Collegiate Male Distance Runners Using Shoe-Based Wearable Sensors

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Context: Assessment of running mechanics has traditionally been conducted in laboratory settings; the advancement of wearable technology permits data collection during outdoor training sessions. Exploring changes in running mechanics across training-session types may assist runners, coaches, and sports medicine clinicians in improving performance and managing the injury risk.

Objective: To examine changes in running mechanics on the basis of routine training-session types.

Design: Descriptive observational study.

Setting: Field based, university.

Methods: Running mechanics data (ie, impact *g*, stride length, braking *g*, total shock *g*, cadence, and ground contact time) for National Collegiate Athletic Association Division I distance runners (n = 20 men) were collected using RunScribe sensors mounted to the laces during training sessions (long run [LR], interval run [IR], or recovery run [RR]) during a 1-week period.

Results: Repeated-measures analysis of covariance with Greenhouse–Geisser correction and training-session pace as a covariate indicated no statistically significant differences in spatiotemporal or kinetic measures across the 3 training-session types. Cadence and stride length were inversely related in all training sessions (LR: $r = -0.673$, $P = .004$; IR: $r = -0.893$, $P < .001$; RR: $r = -0.549$, $P = .023$). Strong positive correlations were seen between impact *g* and total shock in all training sessions (LR: $r = 0.894$, $P < .001$; IR: $r = 0.782$, $P = < .001$; RR: $r = 0.922$, $P < .001$). Ground contact time increased with stride length during LR training sessions ($r = 0.551$, $P = .027$) and decreased with braking *g* in IR training sessions ($r = -0.574$, $P = .016$) and cadence in RR training sessions ($r = -0.487$, $P = .048$).

Conclusions: Running mechanics in collegiate distance runners were not statistically different among training-session types when training-session pace was controlled. The use of wearable technology provides a tool for obtaining necessary data during overland training to inform training and program design.

Key Words: wearable technology, running mechanics, injury prevention

Key Points

- Kinetic and spatiotemporal variables were not statistically different across routine training-session types; however, the magnitude of the effect sizes suggested clinically meaningful differences may exist.
- Wearable sensors may allow clinicians to record running mechanical data for use in improving performance and patient care decision-making.

Running-related injuries (RRIs) are common among distance runners, with up to 90% of competitive runners sustaining an injury at some point in their training.[1] The cause of RRIs is multifactorial, with kinetic (forces) and kinematic (movement patterns) variables and training variables contributing to mechanical tissue damage (ie, mileage, intensity, duration, and step rate or cadence) and corresponding physiological responses (ie, inflammatory response or cascade), which may result in further tissue damage.[2,3] The development of RRIs is complex; no single running-related variable links all RRIs. Individual anatomy, excessive forces, and altered kinematics due to differences in surface, running speed, and terrain, combined with training errors, present greater opportunities for injuries.[4,5] Collecting data and information related to individual anatomy, running biomechanical variables, and training variables is a pertinent component of a comprehensive sport performance and injury-prevention program.

Running biomechanics have traditionally been assessed in controlled laboratory settings with specialized equipment, not with runners in their natural environment.[6] Whereas laboratory-based assessments are the criterion standard for biomechanical evaluation, running mechanics are known to differ in the natural environment because terrain, speed, and other variables are not constant.[4] Heart rate monitors, global positioning systems, and other accelerometer-based technologies are often used to collect training-related variables in the field.[7] The ability to collect both running-related biomechanical data and training-related variable data in a single application remains a challenge. Recent advances in technology have increased the use of wearable sensors for collecting kinetic (ie, impact force, braking force) and spatiotemporal data (ie, stride length [SL], cadence, ground contact time [GCT]) in clinical and research settings, offering additional opportunities to investigate competitive runners and running mechanics.[8–11] Within the National Collegiate Athletic Association (NCAA) alone, 30 000 student-athlete distance runners compete at more than 1000 institutions, providing a relatively large population of interest.

Preliminary work[6,12–14] has shown that wearable technology can be used to collect field-based data to assess running mechanics. RunScribe sensors (ScribeLabs Inc) are an example of such wearable technology. Each sensor contains a triaxial accelerometer and gyroscope with onboard memory and processing capabilities. When paired with the RunScribe mobile application, running mechanics data are available in real time and for later analysis. Good to excellent concurrent validity has been reported for the RunScribe sensors for a variety of kinetic and spatiotemporal measures, including SL (intraclass correlation coefficient [ICC] = 0.8), stride pace (ICC = 0.73), foot strike type (78% accuracy), cycle time (ICC = 0.91), and GCT (0.92), as well as face validity for identifying changes in outdoor running activities.[15]

Running mechanics change with the intensity, distance, and duration of the running event.[16–18] Whereas RunScribe sensors have been used to investigate changes in running biomechanics on the basis of speed and surface type,[15] we need to investigate mechanics of competitive distance runners during routine training by training-session type. It is common for competitive distance runners to manipulate training volume and loads by adjusting training variables (ie, intensity, distance, recovery) to maximize performance and reduce the injury risk.[19] Therefore, the overall purposes of our research were to (1) quantify the running biomechanical metrics for NCAA Division I distance runners training in their natural environment, (2) identify the relationships between and among training-related variables and running metrics in these runners, and (3) evaluate changes in running metrics on the basis of training-session types. We hypothesized that the SL, cadence, shock, and GCT would differ among training-session types. In addition, we hypothesized that increased cadence would result in lower impact *g* and decreased braking *g* during long runs.

METHODS

Participants

Participants were recruited from an NCAA Division I men's cross-country and track and field team at a single midsized, comprehensive liberal arts university. The track and field participants were screened to identify distance (ie, >1500-m) runners to ensure that distance running was a part of their training regimen. Runners were excluded if they reported any current RRI that caused them to miss practice or competition[20] or surgery within the past 6 months. Written consent was obtained from all participants, and the study was approved by the university's institutional review board. Because the data collected were part of a comprehensive sport performance program, an a priori sample size estimate was not performed.

Instruments

Upon completion of the informed consent procedures, the participants were given RunScribe sensors (RunScribe Plus) and lace cradles used to secure the sensors on the laces of the shoes used for training. The location was selected following the recommended practice from the manufacturer. Sensors placed on the laces had good to excellent validity, better than high-speed video analysis, for contact time, flight time, step length, and step frequency.[10,11] Each sensor contained a triaxial accelerometer (range = ±16*g*) and triaxial gyroscope (range = ±2000°/s), sampling at 200 Hz with onboard memory and processing capabilities.

Procedures

Each participant was required to download the RunScribe application on their mobile device to transmit running data via Bluetooth technology (Bluetooth SIG, Inc) and track the training-session data for later analysis. Each person was shown how to attach the sensors to his preferred training footwear and how to synchronize the sensors with the mobile device and RunScribe application. Once the individuals became familiar with the application, the sensors were calibrated during an outdoor run at a self-selected pace over a known distance to orient them to the participant's gait patterns and improve SL determination.[9,13,15,21] The participants were instructed to wear the sensors and track their training sessions via a written log for 7 days of typical training.[13] The sensors and log were returned at the end of the 7-day period. During the initial set-up, the sensors were set to auto-start and auto-stop recording data when the cadence reached 140 steps/min for 5 or 6 steps. All biomechanical run-session data were transferred via Bluetooth to the mobile application dashboard.

The 7-day-data collection periods were staggered through the competitive season for logistical purposes, with each participant recording 1 long run (LR) training session, 1 interval run (IR) training session, and 1 recovery run (RR) training session for data analysis. An *LR* was defined as the highest-volume (mileage) day of the week (length varied for each person on the basis of training). An *IR* was defined as a period of high-intensity (pace or speed) running (work) followed by low-intensity running (recovery). The distance and duration of the work portion of the intervals varied week by week according to the individual training goal, with typical sessions being 5 × 600 m. An *RR* was operationally defined as low-intensity (as identified by the participant) efforts generally lasting in the 30- to 50-minute range used as recovery sessions in the overall training program. The training-session type was identified in the written log. We reviewed training-session data in the RunScribe dashboard at the end of the 7-day period for analysis.

Data Analysis

All biomechanical outcome measures were derived from the proprietary algorithms of the manufacturer. Means and SDs for impact *g*, SL (m), braking *g*, shock *g*, cadence (steps/minute), and GCT (milliseconds) were determined for each training-session type. Impact and braking *g* represent the peak vertical and horizontal decelerations, respectively, after the initial footstrike. Shock represents a composite of impact and braking *g* multiplied by the number of steps per run.[21]

We manually reviewed each training session in the proprietary online dashboard. Warm-up and cool-down times were visually identified using pace and cadence, manually trimmed, and removed from the analysis. For the IR sessions, the data were inspected manually to determine the work and recovery components. Using pace and cadence, we visually inspected the work components of the interval sessions and used these values for analysis.

Data were downloaded from the RunScribe mobile application and transferred to SPSS (version 27.0; IBM Corp) for analysis. We performed repeated-measures analysis of covariance using pace as a covariate, with the Greenhouse–Geisser correction, for each dependent variable (impact *g*, SL, braking *g*, shock, cadence, and GCT) to compare the effects of training-session type (LR, IR, RR).[15] When interpreting significant interactions, we examined post hoc tests for relevant comparisons. When no significant interaction was identified but a main effect for training-session type existed, we assessed pairwise comparisons. Significance was established a priori at $P < .05$ for all analyses. Effect sizes were calculated by converting partial $\acute{\eta}^2$ to the Cohen *d* for consistency in reporting and were defined as ≤ 0.2 = *small* effect, 0.21 to 0.49 = *moderate* effect, 0.5 to 0.79 = *medium* effect, and ≥ 0.8 = *large* effect.[22]

We used partial correlations with training-session pace as a covariate to evaluate relationships between kinetic and spatiotemporal variables within the training-session types. Correlation coefficients were interpreted as 0.00 to 0.39 = *weak*, 0.40 to 0.59 = *moderate*, and 0.60 to 1.0 = *strong*.[23] Negative correlations were labeled using the same ranges.

RESULTS

A total of 20 men participated in the investigation (19.45 ± 1.69 years old; Table 1). Training-session demographics (pace, duration, and distance) are also shown in Table 1. The IR pace (work portion) was faster than the LR pace and RR pace (IR: 03:45.0 ± 0:38.1; LR: 4:18.8 ± 1:16.1; $P = .001$; RR: 4:06.9 ± 0:18.3; $P = .003$). The RR duration (0:39:17 ± 0:09:48) was shorter than the LR duration (1:01:12 ± 0:10:54; $P < .001$) and total IR duration (work + recovery; 0:57:08 ± 00:26:25; $P = .03$). The LR distance (13.67 ± 1.89 km) was greater than the RR distance (10.03 ± 3.38 km; $P < .001$) and total IR distance (work + recovery; 9.82 ± 3.40 km; $P < .001$).

Only runners who supplied complete data from all training-session types (n = 17) were analyzed. Means and SDs for all running metrics for all training-session types for male runners are shown in Table 2. Including pace as a covariate revealed significant interactions between pace and SL during the IR sessions ($P < .001$). No significant interactions existed between pace and peak impact (LR: $P = .26$; IR: $P = .38$; RR: $P = .34$), pace and braking force (LR: $P = .49$; IR: $P = .49$; RR: $P = .23$), pace and shock (LR: $P = .17$; IR: $P = .90$; RR: $P = .86$), pace and cadence (LR: $P = .26$; IR: $P = .38$; RR: $P = .34$), or pace and GCT (LR: $P = .76$; IR: $P = .86$; RR: $P = .56$).

Repeated-measures analysis of covariance with training-session pace as a covariate and the Greenhouse–Geisser correction demonstrated no statistically significant differences in impact *g* (LR: 10.63 ± 3.64*g*; IR: 15.07 ± 2.89*g*; RR: 11.29 ± 3.66*g*; $P = .53$, Cohen *d*: 0.42), SL (LR: 2.84 ± 0.25 m; IR: 3.04 ± 0.51 m; RR: 2.60 ± 0.38 m; $P = .36$, Cohen *d*: 0.54), braking *g* (LR: 9.29 ± 1.99 g; IR: 9.70 ± 1.81*g*; RR: 9.24 ± 1.79*g*; $P = .54$, Cohen *d*: 0.41), shock (LR: 14.67 ± 2.95; IR: 10.91 ± 3.57; RR: 15.07 ± 3.00; $P = .08$, Cohen *d*: 0.99), cadence (LR: 172.17 ± 9.85 steps/min; IR: 179.83 ± 10.2 steps/min; RR: 170.41 ± 8.66 steps/min; $P = .08$, Cohen *d*: 0.94), or GCT (LR: 259.71 ± 27.96 milliseconds; IR: 228.48 ± 32.15 milliseconds; RR: 263.00 ± 22.94 milliseconds; $P = .49$, Cohen *d*: 0.46) across the 3 training-session types.

Table 1. Participant and Workout Session Descriptive Data

Variable	Men (n = 20)
Age, y	19.45 ± 1.69
Height, m	1.79 ± 0.09
Weight, kg	63.51 ± 14.34
Body mass index, kg/m^2	20.53 ± 1.37
Run pace, min/km, mm:ss.ms	
Long	4:18.8 ± 1:16.1
Interval	3:45.0 ± 0:38.1[a]
Recovery	4:06.9 ± 0:18.3
Run duration, hh:mm:ss	
Long	1:01:12 ± 0:10:54[b]
Interval run duration, total time	0:57:08 ± 00:26:25[b]
Recovery	0:39:17 ± 0:09:48
Distance, km	
Long	13.67 ± 1.89[c]
Interval	9.82 ± 3.40
Recovery	10.03 ± 3.38

[a] Different from the long run and recovery run ($P < .05$).
[b] Different from the recovery run ($P < .05$).
[c] Different from the interval and recovery run distance ($P < .001$).

Partial correlations by training session (Tables 3–5), when we controlled for training-session pace, revealed strong negative correlations between cadence and SL in LR training sessions ($r = -0.673$, $P = .004$), IR training sessions ($r = -0.893$, $P < .001$), and RR training sessions ($r = -0.549$, $P = .023$). Strong positive correlations were also seen between peak impact and shock in LR training sessions ($r = 0.894$, $P < .001$), IR training sessions ($r = 0.782$, $P < .001$), and RR training sessions ($r = 0.922$, $P < .001$). Braking *g* and shock were strongly correlated in LR training sessions ($r = 0.513$, $P = .042$) and RR training sessions ($r = 0.552$, $P = .022$) but not in IR training sessions ($r = 0.095$, $P = .717$). The GCT was positively correlated with SL during LR training sessions ($r = 0.551$, $P = .027$) and negatively correlated with braking *g* in IR training sessions ($r = -0.574$, $P = .016$) and cadence in RR training sessions ($r = -0.487$, $P = .048$).

DISCUSSION

The purposes of our investigation were to describe the running mechanics (kinetic and spatiotemporal variables) and training-related variables of NCAA male distance runners and to identify the relationships between training variables and running mechanics in these individuals using RunScribe sensors. We hypothesized that changes would occur in biomechanical variables among training-session types, but the results indicated no statistically significant differences in kinetic or spatiotemporal variables across training sessions when training-session pace was controlled. Although statistical significance was not reached, training-session type had the largest estimated effects on

Table 2. Running Metrics for Male Distance Runners (n = 17) by Training-Session Type

Variable	Run (Mean ± SD) Long	Interval	Recovery	Training Session Effect (*P* Value)	Effect Size (Cohen *d*)
Impact *g*	10.63 ± 3.64	15.07 ± 2.89	11.29 ± 3.66	.53	0.42
Stride length, m	2.84 ± 0.25	3.04 ± 0.51	2.60 ± 0.38	.36	0.54
Braking *g*	9.29 ± 1.99	9.70 ± 1.81	9.24 ± 1.79	.54	0.41
Shock *g*	14.67 ± 2.95	10.91 ± 3.57	15.07 ± 3.00	.54	0.99
Cadence, steps/min	172.18 ± 9.85	179.83 ± 10.21	170.41 ± 8.66	.08	0.94
Ground contact time, ms	259.71 ± 27.96	228.48 ± 32.15	263.00 ± 22.94	.49	0.46

the spatiotemporal variables of cadence (0.94), SL (0.55), and GCT (0.46), with moderate estimated effects on the kinetic variables of impact *g* (0.41), braking *g* (0.41), and shock (0.41) when session pace was included as a covariate.

Assessment of running mechanics has traditionally been conducted in controlled laboratory settings. Running in the natural environment produces different profiles than laboratory-based running due to environmental and surface variations that are difficult to recreate in the lab setting.[4] RunScribe sensors have been used to identify changes in running biomechanics in natural running environments in order to examine changes based on injury status, running speed, and running surface.[9,13,15] Our research extends the body of knowledge by exploring the biomechanical data of competitive collegiate distance runners engaged in routine training sessions. Similar to DeJong and Hertel,[13] we found that IR training sessions had the longest SL, highest cadence, and shortest GCT and that RR training sessions (slowest training session pace) had the shortest SL, lowest cadence, and highest GCT. These findings are consistent with those reported by Hollis et al,[15] who observed reduced contact time during faster runs over both surfaces. Whereas we noted no statistically significant differences in spatiotemporal measures among training-session types, large to medium estimated effects of training session on SL, cadence, and GCT were present.

In the current study, impact *g* and braking *g* were greatest during the speed and work portions of an IR training session. These findings are consistent with those of Hollis et al,[15] who identified increased impact *g* and braking *g* when running speed increased, regardless of the running surface, and of Tessutti et al,[24] who determined that running on harder surfaces (ie, asphalt and concrete) produced higher loads. Additional support is seen in the moderate correlation between impact *g* and braking *g* during IR training sessions (as impact *g* increased, braking *g* increased). However, these findings should be interpreted with caution because of the significant interaction between IR training-session pace and IR training-session variables, suggesting that pace should be considered carefully when analyzing a runner's biomechanics in a natural setting.

It is common for competitive runners to vary their training, including running on different surfaces (ie, grass, gravel, wooded trails, roads, track) and terrain (ie, bank, flat, sloped) within the same training session.[20] In the current study, LR and RR training sessions were typically completed on a variety of surfaces in a single run session (cinder trail, sidewalk, grass, or dirt) with varying terrain (flat, elevation), whereas IR training sessions were typically conducted on either a track or road (asphalt) surface. Runners automatically adjust their mechanics on the basis of the running surface.[25,26] The run sessions conducted by Hollis et al[15] and Tessutti et al[24] were completed on a single surface during a single session. Given the changes in SL, cadence, and kinetics between different surfaces in separate sessions reported by Hollis et al,[15] it is possible that changing surfaces during a single training session affected our overall results. Also, because 1 of our goals was to investigate running mechanics during routine training and the participants were collegiate student-athletes training during a competitive season, we did not exert experimental control over such factors as terrain and surface. Despite the lack of significant findings, the magnitude of estimated effect sizes suggests clinically meaningful differences may exist among training-session types; further investigation limiting the type of surface during a single training session will advance our work.

Increasing cadence has been suggested as an optimal approach to reduce RRIs and improve performance.[12,27,28] The strong negative correlations between cadence and SL across all training sessions are consistent with previous results. Heiderscheit et al[27] described that increasing cadence 5% over preferred cadence led to a decrease in SL, demonstrating the negative relationship between cadence and SL when speed was controlled. Whereas higher cadence has been

Table 3. Summary of Correlations Between Running Metrics in Long Run Training Sessions (Pace as Covariate, n = 17)

Variable	Impact *g* *r*	r^2	*P*	Stride Length *r*	r^2	*P*	Braking *g* *r*	r^2	*P*	Shock *g* *r*	r^2	*P*	Ground Contact Time, ms *r*	r^2	*P*
Impact *g*							0.087	0.008	.749	0.894	0.799	<.001[b]	0.127	0.016	.638
Stride length	0.025	0.006	.927				−0.015	0.000	.957	0.019	0.000	.945	0.551	0.304	.027[a]
Braking *g*										0.513	0.263	.042[a]	−0.415	0.172	.110
Shock *g*													−0.117	0.013	.666
Cadence	−0.039	0.002	.887	−0.673	0.452	.004[b]	0.017	0.000	.951	−0.035	0.001	.896	−0.451	0.203	.080

[a] $P \leq .05$.
[b] $P \leq .01$.

Table 4. Summary of Correlations Between Running Metrics in Interval Run Training Sessions (Pace as Covariate, n = 17)

Variable	Impact *g*			Stride Length, m			Braking *g*			Shock *g*			Ground Contact Time, ms		
	r	r^2	*P*	*r*	r^2	*P*	*r*	r^2	*P*	*r*	r^2	*P*	*r*	r^2	*P*
Impact *g*							0.562	0.315	.019[a]	0.782	0.611	<.001[b]	−0.188	0.035	.470
Stride length	0.206	0.042	.428				0.103	0.010	.695	0.027	0.001	.919	0.419	0.176	.094
Braking *g*										0.095	0.009	.717	−0.574	0.329	.016[a]
Shock *g*													0.152	0.023	.559
Cadence	−0.266	0.071	.303	−0.893	0.797	<.001[b]	−0.134	0.018	.609	−0.177	0.031	.498	−0.411	0.169	.101

[a] $P \leq .05$.
[b] $P \leq .01$.

suggested as an optimal approach to reduce impact forces on the lower extremities,[12,14,27–29] the lack of a relationship between cadence and impact *g* in our study, in conjunction with the lack of a relationship between cadence and loading rates noted by Futrell et al[30] and Tenforde et al,[31] provides contrasting evidence. The negative correlations between cadence and GCT (as cadence increased, GCT decreased), combined with the absence of a relationship between cadence and impact *g*, support more recent evidence suggesting that GCT may be an important clinical consideration for runners experiencing pain or returning from injury.[9,32] DeJong Lempke et al[9] revealed that runners with exercise-related lower leg pain had higher GCT than their healthy counterparts. Reducing contact time by up to 5% (approximately 8 milliseconds) has been proposed to modify gait to make it more similar to that of healthy runners.[9] The optimal intervention needed to produce sustainable reductions in GCT (ie, increasing cadence,[27] increased pace or speed, or a combination) has not yet been fully elucidated and warrants further investigation.

The use of RunScribe sensors allowed for weekly field-based data collection of running biomechanical variables associated with routine training-session types in competitive collegiate runners. In addition, RunScribe sensors are useful for real-time monitoring of variables associated with training and exercise program design and may have use in injury risk mitigation and return-to-activity planning and programming.[9,13] Prospective tracking of running mechanics over the course of an entire competitive season may provide additional insights to monitor athlete training (ie, cumulative stress and load monitoring). Although not assessed in our research, measures of internal training load (eg, the session rating of perceived exertion) combined with external loads (ie, duration, total distance, cumulative shock[21]) should be considered as other indicators of training stress and potential mechanical changes.

Taking into account the ease of use of mobile monitoring and wearable technology, value exists in monitoring other activities or sports in which running is required for training and performance. Future authors should explore changes in running biomechanical variables while in the natural environment among various populations (eg, military and law enforcement training, long-course triathletes). This application of technology in nontraditional athlete models is likely to offer useful data to inform treatment and performance programming.

LIMITATIONS

Our results must be considered while acknowledging certain methodologic limitations. Data collection for each person was limited to a single week, which may not represent the complete training load over the course of the training season. The type of athletic season (championship versus nonchampionship) differed among athletes, with some data collected during cross-country season and other data during track season. This is important as individual differences may be present in training sessions assigned during these times based on competition schedules and periodization, even if the training-session type remains the same. Given that the participants were members of an NCAA Division I athletic program, we neither standardized nor controlled several factors (ie, training session, intensity, length, duration, footwear). Because our main purpose was to collect running-related biomechanical data in the natural running environment, the running surface (eg, grass, gravel) and terrain varied among participants and likely varied within individual training sessions, as discussed earlier. Future researchers should investigate differences in running metrics with standardization of the training surface (eg, grass, track, gravel), footwear, and training-session variables. The participants were all male competitive distance runners from a single NCAA Division I program. This sample may limit the generalizability of the results obtained here to other runners,

Table 5. Summary of Correlations Between Running Metrics in Recovery Run Training Sessions (Pace as Covariate, n = 17)

Variable	Impact *g*			Stride Length			Braking *g*			Shock *g*			Ground Contact Time, ms		
	r	r^2	*P*	*r*	r^2	*P*	*r*	r^2	*P*	*r*	r^2	*P*	*r*	r^2	*P*
Impact *g*							0.194	0.038	.456	0.922	0.850	<.001[b]	0.278	0.077	.279
Stride length	0.119	0.014	.648				0.524	0.275	.031[a]	0.307	0.094	.231	−0.063	0.004	.811
Braking *g*										0.552	0.305	.022[a]	−0.306	0.094	.232
Shock *g*													0.085	0.007	.746
Cadence	0.168	0.028	.519	−0.549	0.301	.023[a]	0.060	0.004	.820	0.179	0.032	.492	−0.487	0.237	.048[a]

[a] $P \leq .05$.
[b] $P \leq .01$.

notably women and runners of different experience levels (eg, recreational or novice). We also recognize that the study may have lacked the statistical power to detect differences with the repeated-measures design. However, given the magnitude of the estimated effect sizes for certain variables, clinically meaningful differences among training sessions may exist. Finally, whereas the RunScribe sensors have shown good to excellent validity for a variety of the measures they record,[10,11] the data we obtained should be interpreted with caution because the accuracy of the RunScribe sensors is not identical to criterion-standard motion capture. Future authors should continue to assess the validity and reliability of these devices in a variety of laboratory and field-based settings.

CONCLUSIONS

Kinetic and spatiotemporal running metrics were not statistically different across training-session type for male competitive distance runners. The relationships between variables across training sessions support previous associations between kinetic and spatiotemporal variables. RunScribe sensors provide another tool clinicians, researchers, and performance staff may be able to use to make data-informed decisions about training.

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