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THE RELATIONSHIP OF ISOKINETIC AND FIELD TEST MEASURES IN COLLEGIATE SPRINTERS: AN EXPLORATORY STUDY

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ABSTRACT
Practitioners often utilize test batteries to assess elements of sport performance using field-based test measures. This study assessed both field test outcomes and isokinetic data from 10 NCAA Division I sprinters to determine the relationship between the isokinetic measures of peak torque and hamstrings to quadricep ratios and the field-based assessments of vertical jump (VJ), standing broad jump (SBJ), and sprint times (5m, 10m, 20m, and 40m intervals). There were no significant correlations between hamstring and quadricep (H:Q) and vertical or standing broad jump (VJ and SBJ) measures. The r values for H:Q and the two jump measures were low (<0.3) to moderate (0.3 – 0.5), but none were statistically significant. Peak Torque (PT) was highly correlated with both VJ and SBJ with r values exceeding 0.5 across all variables. Statistically significant correlations were calculated for all PT and jump variables with the exception of PT at 60º/sec on the left side. Generally, there were significant negative correlations with sprint intervals at 5, 10, 20, and 40 meters and isokinetic measures of PT. Isokinetic PT at 60º/sec for left extension did not yield significant correlations with speed at 5m but did yield a moderate r value of -0.45. Additionally, the 5m sprint time with isokinetic parameters set to 180º/sec for left flexion did not yield a significant correlation, but the r value of -0.63 indicates a large correlation between the variables. H:Q and sprint times were not significantly correlated, and R values were generally low (< 0.3). Findings from this study indicate that practitioners may benefit from isokinetic testing; however, utilization of PT is likely more beneficial than calculating the H:Q for sprint performance.

Keywords: Isokinetic, Field Test, Vertical Jump, Standing Broad Jump, Sprint, H:Q Ratio, Peak Torque

INTRODUCTION

Coaches and strength training professionals utilize test batteries to determine appropriate training interventions. Strength, power, and speed are important performance measures across a variety of sport contexts. Both field-based functional outcome assessments and laboratory-based assessments may be utilized. Optimally, professionals should employ testing that is correlated or predictive of performance outcomes to address training variables that will have a direct impact on performance. Across a variety of sports contexts, field-based measures of vertical jump (VJ), standing broad jump (SBJ), and sprint speed are valid outcome measures for performance (1–4). Functional outcome assessments are an important part of any sport program and can provide valuable data related to training interventions.

In sports that involve sprinting, performance should be assessed to determine both training needs and the effectiveness of training. Sprint speed splits which assess the various phases of the sprint, including the acceleration phase, are considered superior to simply recording total sprint times (5). Assessment of sprint speed splits at specified distances can assist professionals in identifying deficient areas and implementing programs that will facilitate specific training adaptations to improve overall times.

Isokinetic Measures and Injury Risk

Similarly, compared to functional field-based outcomes, measures of isokinetic strength have been traditionally used in injury prevention and rehabilitative contexts. In collegiate and high school sports, it is estimated that more than half of all injuries are to the lower extremity with the majority affecting the ankle, knee, and thigh (6,7). Hamstring strain injuries (HSI) in particular pose a significant risk for athletes who engage in sprinting as part of their sport. Identifying the imbalances of hamstring and quadricep ratios (H:Q) may be beneficial so that prevention programs can be implemented to help mitigate the injury risk associated with muscular imbalances. The ratio H:Q is defined as the ratio between PTof the hamstring and the quadriceps and can be measured both concentrically and eccentrically using an isokinetic dynamometer. Measures of isokinetic strength have historically been important for sports medicine professionals in determining injury risk, identifying areas of strength development for increased performance, and for assessing rehabilitation outcomes following anterior cruciate ligament reconstruction (ACLR). A conventional H:Q ratio assesses concentric contractions of the hamstrings relative to the quadriceps (H_{con}:Q_{con}) with values 0.5 to 0.8 to be interpreted as normal with higher ratios occurring at faster angular knee velocities during isokinetic testing (8–12). In addition to analyzing at the H:Q ratio in a single limb, H:Q ratios are often compared bilaterally to determine deficiencies. When comparing bilaterally, a PT difference of 15% or greater between limbs is often considered a significant asymmetry that may increase injury risk (13).

A systematic review and meta-analysis investigating risk factors for hamstring muscle strains cited strength as one contributing risk (14) factor for hamstring injury. Specifically, hamstring strength imbalance quantified by measuring hamstring strength asymmetry bilaterally or by H:Q is a contributing factor for hamstring strains (14–16). The normal H:Q strength ratio in the general population is approximately 0.5 to 0.8 as applied to the full range of motion for the knee (8,10). In athlete populations, several cut-off H:Q ratios have been utilized to determine increased injury risk of the hamstring muscle group based on H:Q ratios. Isokinetic H:Q norms for healthy active females and males have been established at 60°/sec: 0.50 ± 0.05 (female dominant limb), 0.49 ± 0.04 (female non-dominant limb), 0.55 ± 0.07 (male dominant limb), 0.48 ± 0.08 (male non-dominant limb) (12). Additionally, a cut-off H:Q ratio of 0.6 has been a suggested threshold of injury risk (16). Other studies have determined that a H:Q ratio cut-off value for predicting injury risk may not be appropriate because H:Q can vary among different sports and player positions (17,18).

Landmark work by Orchard et al. (11) examined hamstring injuries in Australian Rules Football players. This study reported that hamstring muscle injuries were significantly associated with preseason isokinetic hamstring measures of PT at 60º/sec (injured: 1.75 +/- 0.27, uninjured: 2.08 +/- 0.31, 2.61, P=0.000), H:Q ratio (injured: 0.550 +/- 0.065, uninjured: 0.662 +/- 0.071, P=0.000), and hamstring to opposite hamstring ratio (injured: 0.880+/- 0.072, uninjured: 1.005 +/- 0.103, P=0.005) when comparing injured to uninjured limbs. This finding supports isokinetic assessment to identify individuals who may be at risk of injury. Conversely, other research has determined that H:Q ratios were not successful in determining HSI risk (10). Since this early work, many other risk factors for HSI have been identified in the literature including previous injury and age (14,19). However, several studies maintain, despite the controversy in the literature, unresolved strength imbalances should be identified and addressed via strengthening interventions to prevent HSI (16,20,21). Overall, the evidence is inconclusive in determining the role of H:Q ratios in detecting injury risk; however, the evidence does support quadriceps PT as a risk factor in the prevention of HSI (14). Not only are hamstring strength (PT) and H:Q imbalances considered a possible risk factors for hamstring injuries, but muscular strength imbalances may also impact an athlete's performance.

For rehabilitation professionals, isokinetic values can provide a sound outcome measure to track strength across the rehabilitation process, particularly for individuals post-ACLR. Rehabilitation professionals often utilize a limb symmetry index (LSI) to assess peak torque between injured and uninjured limbs. LSI = Peak torque in injured limb/Peak torque in non-injured limb x 100%. An LSI of >90% in injured or post-operative patients is typically recommended when making return to activity decisions (12).

Isokinetic Measures and Sprint Performance

Isokinetic strength as a measure of peak torque is commonly reported as being related to sprint performance in the literature (22–24). For example, Anderson et al. (25) determined that the isokinetic concentric hamstring as measured at 60º/sec (r=0.57), average isokinetic concentric hamstring strength measured at 60º/sec (r=0.55), peak isokinetic hamstring strength at 30º/sec (r=0.43), and average isokinetic force for 1 RM (r=0.43) were all significant predictors of 40-yard dash time. In contrast, Cronin & Hansen (26) examined correlations between isokinetic strength measures and sprint speed and found them to be non-significant. Although there are some conflicting findings, the literature does support a relationship between isokinetic strength (measured as PT) and sprint performance.

However, there has not been a strong association between H:Q ratios and performance measures reported in the literature and the research examining the relationship is limited. Both Olmo et al. (27) and Rosene et al. (8) examined H:Q ratios by sport type or activity. Rosene et al. (8) examined H:Q ratios for participants within collegiate level soccer, volleyball, softball, and basketball and reported no significant difference between left and right sides. Additionally, no significant interactions or main effects for concentric H:Q ratio for Mean

Total Work were identified for women, whereas a significant difference was found for men with respect to velocity only. Additionally, Olmo et al. (27) indicated that a specific activity or sport may vary the H:Q ratios indicating that the individual H:Q ratio may be selective to a given activity, sport, or even position. There is limited research looking at the relationship of H:Q ratios and sprint performance specifically.

Jump Tests & Sprint Performance

Jump tests are closed-chain movements that involve the entire body. In this manner, lower extremity performance measures may be beneficial in predicting sprint times. Strong correlations have been reported between vertical countermovement jumping and sprint performance (28–31). Cronin & Hansen (26) examined correlations between isokinetic strength measures and sprint speed and found them to be nonsignificant [5-m time (r=-0.04 to -0.34), 10-m time (r=-0.00 to -0.31), and 30-m time (r=-0.05 to -0.17)]. Further, this study found significant correlations with jump squat and countermovement jump height and sprint speed at 5m, 10m, and 30m (r=-0.56 to -0.66).

Continued understanding of the relationship among isokinetic measures (H:Q ratio and PT), speed, and functional performance tests in sprinting athletes may assist in developing training protocols and injury prevention strategies. These measures of strength and power should be of concern to coaching personnel, strength and conditioning staff, but also to the medical team. Therefore, the purpose of this study was to identify the relationship between isokinetic measure of H:Q ratios and PT with lower extremity jump tests and sprint performance in track sprinting athletes.

METHODS

This study was approved by the Institutional Review Board (IRB) of the institution where the study was conducted. It is a cross-sectional study design. Participation in the study included three phases:1) Informed consent and health history questionnaire (HHQ), 2) Anthropometric measures and isokinetic testing, and 3) Field testing which included vertical jump (VJ), standing broad jump (SBJ), and 40m sprint. The HHQ included questions related to personal history, family history, medical history, and exercise history of the participant. Anthropometric measures were collected in a laboratory environment. A Health-O-Meter stadiometer and scale (Health-O-Meter Products Inc., Beford Heights, OH USA) were used to measure height (in meters, measured to the nearest centimeter) and weight (in kilograms, measured to the nearest gram). The Body Comp Scale (Valhalla Scientific, CA USA) was used to assess body composition (percent body fat) via bioelectrical impedance.

Participants

Participants were recruited from an NCAA Division I Track team, and 6 male and 4 female NCAA Division I Track athletes who were classified by the coaching staff as sprint athletes were included. The subjects were between the ages of 18 and 23. Subjects included any individuals who participated in the following sprint events: 100-m, 100-m hurdles, 200-m, and 400-m. Subject characteristics can be found in Table 1. Participants engaged in testing protocols and data collection during their respective off-season. During the initial meeting with the participants, a health history questionnaire (HHQ) was completed. If the participant had an ongoing lower extremity injury (with or without surgical intervention), they were excluded from the study. However, participants that received clearance from a physician to return to activity were eligible to participate in the study. Written informed consent was completed prior to testing protocols and data collection.

Procedures

Isokinetic Strength Ratios

Bilateral testing of the lower extremity was performed utilizing a Biodex Multi-Joint System Pro Isokinetic Dynamometer System 4 Pro (Biodex Medical Systems Inc., Shirley, NY USA). Isokinetic dynamometers have been shown to be reliable and valid in assessing muscular strength and are frequently utilized in strength measurement studies (32). The test protocol for this study utilized test speeds at 60º/sec and 180º/sec.

Prior to testing, each participant underwent a five-minute warmup period on a Monarch Ergometer stationary bicycle at a self-selected resistance and cadence. After the warm-up, participants were seated on the Biodex chair at an 85º incline with stabilization straps connected across the trunk, lap, the active leg mid-thigh and the ankle. The test knee was placed at 90º of flexion (reference: 0º is equivalent to full extension) and the axis of the device lever arm was aligned with the rotation point of the knee (reference: lateral femoral condyle). Subsequently, participants then performed a practice protocol of five repetitions at each speed to familiarize themselves with the testing device and testing procedure. The order of the limbs to be tested was randomized. Participants were asked to fold their arms across their chest to isolate the lower extremity. Participants were then instructed to "kick" (or extend) the test knee and then "bend" (or flex) the test knee through a complete range of motion as established by the participant. Participants were instructed to perform five repetitions with maximal effort at 60º/sec. Participants were then given a two-minute rest interval after the fifth repetition was completed. Next, the participants then were asked to perform the test at 180º/sec for 25 repetitions. At the conclusion of the protocol, the Biodex was adjusted to facilitate the testing of the opposite lower extremity. Peak torque was collected for knee flexion and extension for each protocol at 60º/sec and 180º/sec. H:Q ratios for each protocol were calculated as follows: [Hamstring PT/Quadricep PT] x 100. Peak Torque and H:Q ratios were further examined in the data analysis.

Power Field Test Measures

Field measures in this study included two power measures: VJ and SBJ. Vertical jump testing was achieved by using the Just Jump (Probotics Inc., Huntsville, AL USA) Mat. The validity of the Just Jump mat (JJM) has been established using a comparison to 3-dimensional photographic equipment. The Pearson r between the video and JJM was significant ($r = 0.967$, $p<0.01$) (33). The reliability of the JJM is also reported as excellent with ICC ranging from 0.90 to 0.96 (34). To assess the counter movement VJ, the participants stood on the mat with feet shoulder-width apart, arms relaxed and palms parallel with the hips. When the participant was ready, they performed a countermovement with the arms and jumped as high as possible while maintaining outstretched legs and landing on both feet. The JJM handheld computer reported the vertical jump measures in inches. In order to score the attempt, the participant must have landed with both feet on the mat. The vertical jump trial was repeated for a total of three trials. The maximum jump of the three trials was recorded. A minimum amount of a two-minute rest interval followed each trial.

For the Standing Broad Jump (SBJ) testing, the participant stood with toes behind the starting line (scratch line). When the participant was ready, they performed a countermovement arm swing and jumped as far as possible into a sandpit. The participant was required to land on both feet in order to score the attempt. The jump was measured from the starting line to the participant's rearmost heel. The participant completed three trials of the SBJ, and the maximum jump value for each participant was recorded. A minimum amount of a two-minute rest interval followed each trial.

Speed Field Test Measures

Speed testing was recorded utilizing a Brower Timing TC-System (Brower Timing Systems, Draper, UT USA) to the thousandth of a second. Photogates with light beam sensors were placed at the interval distances of 5m, 10m, 20m, and 40m respectively. Participants began the test in a four-point stance (both hands and both feet in a staggered position) with both hands behind the starting line. The participants were told to start at their discretion. The timing system activated when the hands were initially moved off the starting sensors. Participants were instructed to sprint the entire 40 meters. Times at each interval (5m, 10m, 20m, 40m) were recorded using the Brower Timing TC-System. The test was followed by a minimum of a two-minute rest interval. The sprint test was then repeated, and the faster of the two trials was recorded.

Data Analysis

Data were analyzed using GraphPad Prism 9.2.0 statistical software (GraphPad Software, San Diego, CA). Subject demographics were reported as means and standard error. The relationship between isokinetic variables with speed measures and power measures were calculated as two-tailed correlations and are reported as Pearson r values with statistical significance set at 0.05. Pearson r values also effectively serve as effect sizes for the Pearson correlation and were interpreted as low (< 0.3), moderate (0.3-0.5), and large (> 0.5) (35). The absolute value of the correlation coefficient will be used to interpret effect size.

RESULTS

There were ten participants is this study (6 males and 4 females). All participants were collegiate NCAA division I track sprinting athletes. The mean age for participants was 19.9 ± 1.3 years old (females =20.3 ± 1.3 and males = 19.7 ± 1.4). Participants mean height was 174.0 ± 7.1cm (females = 168.3 ± 1.3cm, males = 177.5 ± 6.9cm). Mean body fat among participants was 14.5 ± 6.4% (females = 20.6 ± 4.3%, males = 10.4 ± 3.6%). Descriptive statistics are displayed in Table 1. Examination of the means for males and females separately does improve the variance observed in the sample.

H:Q ratios at both 60º/sec and 180º/sec bilaterally revealed ratios in the normal range of 0.6 – 0.8 (8,10). Countermovement jumps means of 279.91 ± 34.54cm (SBJ) and 80.01 ± 13.72cm (VJ) were recorded for all participants. Jump means for males were 306.07 ± 4.8cm (SBJ) and 90.42 ± 1.78cm (VJ) and 240.79 ± 9.65cm (SBJ) and 64.26 ± 1.52 (VJ) for females.

Sprint time means for all participants were 5.37 ± 0.37s (40m), 3.15 ± 0.19s (20m), 1.92 ± 0.12s (10m), and 1.19 ± 0.06s (5m). Lesser variance was observed among female means of 5.77 ± 0.02s (40m), 3.36 ± 0.03s (20m), 2.05 ± 0.04s (10m), and 1.24 ± 0.03s (5m) and male means of 5.10 ± 0.18s (40m), 3.01 ± 0.09s (20m), 1.84 ± 0.06s (10m), and 1.16 ± 0.04s (5m).

Correlations between isokinetic measures (H:Q and PT) with field measures (VJ and SBJ) are listed as Pearson r values in Table 2. There were no significant correlations between H:Q and jump measures (VJ and SBJ). The r values for H:Q at 60º/sec and the two jump measures were low (<0.3) on both the left and rights sides. Correlations of jump tests with the higher velocity of 180º/sec H:Q, yielded moderate correlations (0.3 – 0.5), but none where statistically significant. PT was highly correlated with both VJ and SBJ with r values exceeding 0.5 across all variables. Statistically significant correlations were calculated for all PT and jump variables apart from PT at 60º/sec on the left side.

Table 3 provides correlations between isokinetic measures with speed field measures listed as Pearson r values. P values are also listed for each table. In general, there were significant negative correlations with sprint intervals at 5, 10, 20, and 40 meters and isokinetic measures of PT. Isokinetic PT at 60º/sec for left extension did not yield significant correlations with speed at 5m but did yield a moderate r value of -0.45. Additionally, the 5m sprint time with isokinetic parameters set to 180º/sec for left flexion did not yield a significant correlation, but the r value of -0.63 indicates a large correlation between the variables. H:Q and sprint times were not significantly correlated, and r values were generally low (< 0.3).

Table 1: Descriptive Data

	Males (n = 6)	Females (n = 4)	All (n = 10)
Age(years)	19.7 ± 1.4	20.3 ± 1.3	19.9 ± 1.3
Height (cm)	177.5 ± 6.9	168.3 ± 1.3	174.0 ± 7.1
Weight (Kg)	74.2 ± 9.2	62.4 ± 8.0	69.5 ± 10.3
Body Fat %	10.4 ± 3.6	20.6 ± 4.3	14.5 ± 6.4
Standing Broad Jump (cm)	306.07 ± 4.8	240.79 ± 9.65	279.91 ± 34.54
Vertical Jump (cm)	90.42 ± 1.78	64.26 ± 1.52	80.01 ± 13.72
5m-Sprint Time (s)	1.16 ± 0.04	1.24 ± 0.03	1.19 ± 0.06
10m-Sprint Time (s)	1.84 ± 0.06	2.05 ± 0.04	1.92 ± 0.12
20m-Sprint Time (s)	3.01 ± 0.09	3.36 ± 0.03	3.15 ± 0.19
40m-Sprint Time (s)	5.10 ± 0.18	5.77 ± 0.02	5.37 ± 0.37
H:Q R. 60	0.54 ± 0.05	0.56 ± 0.13	0.55 ± 0.08
H:Q R.180	0.59 ± 0.07	0.63 ± 0.07	0.61 ± 0.07
H:Q L. 60	0.54 ± 0.09	0.52 ± 0.04	0.53 ± 0.07
H:Q L. 180	0.64 ± 0.13	0.55 ± 0.04	0.60 ± 0.11
PT R. E. 60	159.5 ± 13.4	108.9 ± 20.1	139.2 ± 30.3
PT. R.F 60	86.1 ± 5.1	59.9 ± 11.6	75.6 ± 15.6
PT.R.E.180	115.3 ± 11.0	77.6 ± 16.3	100.2 ± 23.2
PT.R.F.180	68.3 ± 10.5	49.2 ± 12.0	60.7 ± 14.4
PT.L.E.60	161.1 ± 33.0	118.3 ± 21.6	143.9 ± 35.3
PT.L.F.60	85.7 ± 14.0	61.3 ± 9.1	75.9 ± 17.2
PT.L.E.180	112.7 ± 23.3	76.5 ± 8.2	98.2 ± 25.9
PT.L.F.180	70.8 ± 16.7	42.3 ± 5.9	59.4 ± 19.6

Table 2: Correlations of Isokinetic Measures with Power Field Test Measures. Data are presented as r values with p values in parentheses

		VJ	SBJ
H:Q	60º, Left	0.15 (0.687)	0.27 (0.452)
	60º, Right	-0.09 (0.809)	0.05 (0.896)
	180º, Left	0.39 (0.261)	0.41 (0.234)
	180º, Right	-0.32 (0.364)	-0.29 (0.414)
PT	60º, Left Extension	0.58† (0.077)	0.56† (0.094)
	60º, Left Flexion	0.68† (0.028*)	0.73† (0.016*)
	60º, Right Extension	0.86† (0.002*)	0.81† (0.005*)
	60º, Right Flexion	0.87† (0.001*)	0.91† (0.0003*)
	180º, Left Extension	0.68† (0.030*)	0.72† (0.018*)
	180º, Left Flexion	0.72† (0.020*)	0.77† (0.009*)
	180º, Right Extension	0.80† (0.005*)	0.86† (0.001*)
	180º, Right Flexion	0.63† (0.049*)	0.71† (0.021*)

*p< 0.05, † indicates a large correlation and effect size (r > 0.5). Vertical jump (VJ), standing broad jump (SBJ), hamstring to quadriceps ratio (H:Q), peak torque (PT)

Table 3: Correlations of Isokinetic Measures with Speed Field Test Measures. Data are presented as r values with p values in parentheses

		5m	10m	20m	40m
H:Q	60º, Left	-0.16 (.665)	-0.18 (0.622)	-0.17 (0.642)	-0.16 (0.666)
	60º, Right	0.09 (.807)	0.14 (0.692)	0.09 (0.802)	0.02 (0.949)
	180º, Left	-0.23 (.527)	-0.42 (0.222)	-0.34 (0.330)	-0.34 (0.336)
	180º, Right	0.16 (.664)	0.08 (0.820)	0.20 (0.586)	0.18 (0.620)
PT	60º, Left Extension	-0.45 (0.197)	-0.61†(0.061)	-0.61† (0.062)	-0.62† (0.057)
	60º, Left Flexion	-0.60† (0.069)	-0.77† (0.009*)	-0.76† (0.012*)	-0.76† (0.011*)
	60º, Right Extension	-0.59† (0.074)	-0.76† (0.010*)	-0.78 (0.007*)	-0.76 (0.011*)
	60º, Right Flexion	-0.64† (0.045*)	-0.78† (0.008*)	-0.82† (0.004*)	-0.83† (0.003*)
	180º, Left Extension	-0.65† (0.044*)	-0.72† (0.018*)	-0.76† (0.012*)	-0.75† (0.013*)
	180º, Left Flexion	-0.63† (0.052)	-0.79† (0.006*)	-0.77† (0.009*)	-0.76† (0.010*)
	180º, Right Extension	-0.79† (0.006*)	-0.81† (0.004*)	-0.85† (0.002*)	-0.82† (0.003)
	180º, Right Flexion	-0.72† (0.019*)	-0.77† (0.009*)	-0.75 (0.012*)	-0.74† (0.014*)

*p< 0.05, † indicates a large correlation and effect size (r > 0.5). Hamstring to quadriceps ratio (H:Q), peak torque (PT)

DISCUSSION

The purpose of this exploratory study was to is to identify the relationship between the isokinetic measures of H:Q ratios and PT with lower extremity jump tests and sprint performance in track sprinting athletes. It was hypothesized that the correlation coefficient is not significantly different from zero when examining the relationship between isokinetic and field test measures. This study was novel in the examination of isokinetic and VJ, SBJ, and spring speed variables in NCAA track sprinters. There were strong correlations between the field-test performance measures (VJ and SBJ) with the isokinetic measures of PT. Specifically, PT was highly correlated with VJ, SBJ, and sprint times at 5, 10, 20, and 40 meters. Likewise, Nesser, et al. (23) reported that VJ, knee flexion PT and knee extension PT were significantly correlated ($p<0.05$) with 40m sprint times ($r > -0.5$) in male athletes ages 19-26 involved in football, baseball, and lacrosse. Studies examining the relationship between isokinetic measures of H:Q and PT along with VJ, SBJ, and sprint speeds in NCAA track sprinters are limited. Additionally, much of the normative data published in isokinetics, VJ, and SBJ is focused on male athletes and research in this area relative to female athletes is lacking.

When examining the descriptive statistics of the ten participants in this study, the variance was large when looking specifically at height, weight, body composition, and the jump tests. When descriptive data means were examined by male and female groups, the variance decreased and provided a more homogenous approach to the data. A larger sample of both male and female participants would allow for data analyses looking at these two groups independently. Additionally, years of experience or formal training in the current study may account for some of the variance and should be a consideration for future research in this area. Future research focused on NCAA female sprinters may fill a significant gap in the current literature.

PT was highly correlated with both sprint speed and jump tests in the current study. This aligns with previous work establishing PT as a predictor of sprint performance (22–24). The correlations of the 5m sprint interval with PT at 60º/sec did not align with the high correlations observed with the other sprint intervals of 10m, 20m, and 40m. The 5m interval is unique in that this distance captures the acceleration phase of the sprint. This initial start phase and subsequent acceleration phase are often separated in the literature from sprint speed (22,36). The sprint start is often thought of as a phase requiring a great deal of skill. Additional considerations should be given to the use of starting blocks that sprint athletes typically utilize during training and competition. This study did not employ the use of starting blocks and had all sprint testing start with a four-point stance. The start and acceleration phase from 0-5 meters should be examined in future research.

H:Q ratios means for both males and females did fall within the normal range of 0.6 – 0.8 (8,10). However, the majority of the H:Q means for both males and females fell below the suggested cut-off of 0.6 suggested by Yeung (16) as a criterion for injury risk. Published literature establishing H:Q criteria that indicate increase injury risk in a healthy population is limited. Similar to findings presented by Rosene (8) and Olmo (27), the current study did not find large or significant correlations between H:Q and field test measures indicating that H:Q may not be a valuable metric in sprinting athletes. Examining asymmetries utilizing LSI scores, which are often utilized in clinical models, may prove to be a better metric than H:Q to identify asymmetries and injury risk.

SBJ means for males align with published norms in between the 60th percentile (294cm) and 70th percentile (309cm) for elite male athletes (37,38). For female participants, SBJ means aligned within the 40th percentile (234cm) and 50th percentile (249cm) for elite female athletes (37,38). VJ means of 90.42 ± 1.78cm (males) and 64.26 ± 1.52cm (females) exceed countermovement jump means reported by Philpott (39) for elite sprinters (males = 0.464 ± 0.061m and females = 0.371 ± 0.049m. Established norms for VJ in NCAA sprinters is limited. In terms of correlations, both VJ and SBJ were highly correlated PT.

The findings from this study indicate that practitioners may benefit from isokinetic testing, however, utilization of PT is likely more beneficial than calculating the H:Q for sprint performance. Additionally, these findings support the use of VJ and SBJ by the practitioner to assess lower limb functional strength and power. VJ and SBJ may be utilized in lieu of PT when isokinetic dynamometers are not available. The cost associated with isokinetic assessment often will preclude access to PT measures for the practitioner. In terms of injury prevention, VJ has been shown to successfully identify collegiate athletes who sustained ACL injuries within 66 days of tests (40). Similarly, lower leg functional performance tests (LEFPTs) such as jump and hop tests are often utilized by practitioners as a screening tool to determine injury risk and to make return-to-activity determinations following an injury (41). LEFPTs utilize running, hopping, and leaping actions similar to those used within sport and athletic activities (42,43). Functional performance tests are more accessible for practitioners and clinicians to utilize with their patients and clients. LEFTPs often assess asymmetries using an LSI of 95% or higher similarly to calculating LSI using PT (41).

Limitations

Although large effect size, this study examined a relatively small sample of track sprinting athletes. Homogeneity of the sample could be improved by increasing the sample size and examining males and females independently. Additional examination of limb dominance and training time would assist in clarifying the relationship between isokinetic measures and functional field test measures. Additionally, isokinetic protocols that collect eccentric isokinetic measures may align best with functional field-based performance measures. Concentric measures of H:Q are often considered to be the conventional measurement while eccentric measures are considered to be functional (12,44,45). During running or sprinting, the quadriceps contracts concentrically to produce forward motion while the hamstrings engage eccentrically. This action by the hamstrings is not fully captured in the conventional protocol. Finally, the isokinetic protocol employed for this study utilized isokinetic velocities at 60º/sec and 180º/sec. The question of accurate speed of motion to assess within different studies has been variable. Biodex (46) suggests for knee flexion and extension assessments for athletes that test speeds should be 180, 300, or 450º/sec. Although, Drouin, et al. (47) found a systematic decrease in the subject's velocity at speeds of 300º/sec and higher, minimizing the effectiveness of those speeds, it may be helpful to expand the protocol to include data collection at 300º/sec.

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Conflict of interest declaration

The authors have no conflict of interests.

Ethics

Institutional Ethics Research Committee approval was obtained for the study procedure. The study conformed to the provisions of the Declaration of Helsinki.

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