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An Examination of an Isometric Core Rotation Test and its Relationship to Baseball Exit Velocity in Division II Collegiate Players

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The purpose of this study was to examine an isometric core rotation test and its relationship to baseball exit velocity in Division II collegiate players. This was a replication study based on Spaniol et al. (2010). Data collection involved assessing isometric core rotation force with a digital crane scale, followed by measuring baseball exit velocity with a radar gun. Both assessments were conducted for three trials on the dominant and non-dominant sides, respectively. The reliability of the three test trials for the isometric core rotation and baseball exit velocity tests for the non-dominant and dominant sides were assessed with Cronbach's alpha values. The reliability values were as follows: isometric core rotation test non-dominant side (0.873), isometric core rotation test dominant side (0.955), baseball exit velocity non-dominant side (0.942), and baseball exit velocity dominant side (0.922). Independent t-tests were conducted to assess differences between the dominant and non-dominant sides in isometric mean core rotation force and baseball mean exit velocity, respectively. Pearson correlations were conducted to assess the relationship between the isometric mean core rotation force and the baseball mean exit velocity. The key finding was a significant ($p = 0.026$) and moderate positive relationship ($r = 0.570$) between the dominant-side isometric mean core rotation force and the dominant-side baseball mean exit velocity. Additionally, a significant ($p = 0.002$) and moderate positive relationship ($r = 0.733$) was found between the non-dominant side isometric mean core rotation force and the dominant side baseball mean exit velocity. The isometric mean core rotation force was not significantly different between the dominant and non-dominant sides ($p = 0.86$); whereas the baseball mean exit velocity was significantly different between sides ($p = 0.0004$). Therefore, on the dominant side, players had learned to effectively transfer isometric core rotational force into a dynamic bat swing, as reflected in baseball exit velocity. These findings highlight the importance of isometric core rotation strength in baseball players, due to its moderate relationship with baseball exit velocity. The use of the crane scale, as in this study, represents a reliable, inexpensive, time-efficient, and practical method for monitoring sports-specific core fitness in baseball players.

Keywords: isometric core rotation, baseball exit velocity, collegiate baseball, reliability, crane scale

In 2015, Major League Baseball (MLB) introduced Statcast, which revolutionized baseball performance analysis by tracking player movements, pitch metrics, and ball trajectories. As a result, players began monitoring variables such as baseball exit velocity. It was reported that baseball exit velocities above 96 miles per hour (mph) were associated with batting averages above 0.300; while exit velocities above 100 mph and 108 mph, respectively, were associated with batting averages above 0.400 to as high as 0.700 (Baseball Savant, 2025).

Despite its significance, the specific factors that most strongly influence baseball exit velocity have received limited attention in scientific studies, particularly among collegiate players. While general strength training has become a fundamental component of baseball conditioning, the specific role of trunk strength in generating baseball exit velocity has received increased emphasis in the scientific literature. Neuromuscular control is the foundation of the strength and dynamic stability needed to optimize whole-body force production and upper-extremity transfer efficiency (Taniyama et al., 2021). Thus, improving trunk strength in a manner specific to a bat swing may promote greater force transfer from

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the lower extremities to the upper extremities and result in greater baseball exit velocity (Rodríguez-Perea et al., 2023).

The term trunk is sometimes used interchangeably with the term core which was recently defined as "parts of the axial skeleton (e.g., rib cage, vertebral column, pelvic girdle, shoulder girdle), associated passive tissues (cartilage, ligaments, joint capsules), and the active muscles that cause, control, or prevent motion in this region of the body" (Willardson, 2025). Many traditional core exercises are performed in the sagittal plane, with much less emphasis on the frontal and transverse planes, respectively (Willardson, 2025). Swinging a baseball bat requires coordinated activation of the lower extremity, core, and upper extremity muscles in the transverse plane. For example, Santana et al. (2015) contended that a left-side dominant baseball batter pre-loads the swing muscles with a quick pre-stretch that engages the right latissimus dorsi, left gluteus maximus, left hamstrings, and left gastrocnemius. The quick pre-stretch is immediately followed by the rotary swinging action to contact the ball, which engages the left serratus anterior, left external oblique, right internal oblique, right hip flexors, and right hip adductors.

Prior studies and reviews on baseball and fast-pitch softball training have examined core rotation exercises utilizing medicine balls or other weight implements (DeRenne & Szymanski, 2009; Kobak et al., 2018; Szymanski, McIntyre, et al., 2007; Szymanski, Szymanski, et al., 2007; Szymanski et al., 2009). In collegiate baseball players, Taniyama et al. (2021) reported that rotational medicine ball throw velocity was significantly correlated with bat swing velocity ($r = 0.65$, $p = 0.003$), pitching velocity ($r = 0.62$, $p = 0.02$), and batted baseball velocity ($r = 0.53$, $p = 0.02$). Moreover, Buso et al. (2023) found that medicine ball rotational wall throws with whole-body vibration acutely improved bat speed (m·second^{-1}) and exit velocity (m·second^{-1}) in collegiate baseball players.

At present, there are no criterion-referenced assessments of core muscular fitness in baseball players (Nesser, 2025). When swinging a baseball bat, the greatest angular momentum should be expressed at ball contact to promote the greatest transfer to baseball exit velocity (Willardson, 2025). Maximal isometric core rotation force, assessed from a ground-based hitting position to simulate the point of ball contact, may have a positive relationship to baseball exit velocity. However, few studies have examined this relationship. Spaniol et al. (2010) reported that isometric (i.e., static) rotational strength exhibited a moderate positive relationship with bat speed ($r = 0.58$) and batted ball velocity ($r = 0.62$) in collegiate baseball players. Therefore, the purpose of this study was to examine an isometric core rotation test and its relationship to baseball exit velocity in Division II collegiate players. This was a replication study based on Spaniol et al. (2010).

Methods

Experimental Approach

This study utilized a correlational design to examine the relationship between an isometric core rotation test and baseball exit velocity. Subjects completed familiarization and experimental sessions on separate days. Subjects practiced both tests during the familiarization session and were then tested again during the experimental session. For the experimental session, subjects began with a dynamic warm-up that was a regular part of baseball workouts. Following the dynamic warm-up, data collection involved assessing isometric core rotation force using a digital crane scale and baseball exit velocity using a radar gun on the dominant and non-dominant sides, respectively. Pearson correlations were conducted to assess the relationship between isometric core rotation force and baseball exit velocity.

Participants

Fifteen members of an NCAA Division II baseball team participated in this study (see Table 1). All data collection took place near the end of the in-season. The Statistical Package for the Social Sciences (SPSS) software program was used to conduct an a priori sample size/power analysis. For a strong correlation (i.e., > 0.70), with a desired power value of 0.80 and an alpha level of 0.05, a sample size of $n = 13$ would be required. A bias-correction formula using Fisher's z-transformation was applied, given the expectation that a smaller sample size would be used in the present study (IBM Corp., 2024).

The sample consisted of players from the following positions: 3 Catchers, 2 First Basemen, 2 Shortstops, 2

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Third Basemen, 6 Outfielders. Of the fifteen players, 10 were dominant on the right side and 5 on the left. All subjects were injury-free at the time of data collection. The subjects were informed of the risks and benefits of the study prior to any data collection and then signed an institutionally approved informed consent document. This study was approved by the university's Institutional Review Board.

Procedures

Subjects completed familiarization and experimental sessions on separate days. Subjects practiced both tests during the familiarization session and were then tested again during the experimental session. All testing procedures were conducted in a climate-controlled, indoor practice facility. During the familiarization session, subjects signed an informed consent form, and sample characteristics were collected and recorded (i.e., age, height, body mass). Subjects were then familiarized with the study protocol and given the opportunity to practice the isometric core rotation and baseball exit velocity tests. On the day of the experimental session, subjects began with a dynamic warm-up used in regularly scheduled baseball workouts (see Table 2 and Figure 1). The experimental session was performed in the late afternoon prior to a regularly scheduled practice.

Figure 1: Outmate Digital Crane Scale.

Isometric Core Rotation Test

The isometric core rotation test was conducted utilizing an Outmate digital crane scale (see Figure 2). According to the manufacturer, the Outmate digital crane scale uses a load cell to measure up to 300 kg with 0.1 kg graduations, in accordance with the International Organization of Legal Metrology (OIML) R76 standards. A calibration procedure was conducted according to the manufacturer's instructions; the zero button on the digital crane scale was pressed and held to enter calibration mode. All external weight was removed from the scale, and then the zero point was confirmed.

Figure 2: Isometric Core Rotation Test Set-Up.

The crane scale was then anchored at one end to a typical strength-training cable machine and at the opposite end to a handle, which the subject held in line with the sternum (see Figure 3). The cable machine was adjusted to provide sufficient resistance so that the core rotation test was isometric (i.e., static), with the force (i.e., Newtons) measured by the crane scale. Subjects adopted a wide stance and grasped the attached handle by interlacing the fingers, while fully extending the elbows and flexing the shoulders to approximately 90 degrees (see Figure 3). Subjects were closely monitored during each trial, with the scale readout visible to the researcher. Subjects were placed in position with the cable tightened prior to the signal to pull.

Subjects were positioned so that their line of pull on the attached handle was at an approximate 90-degree angle to the crane scale. Subjects were given the following verbal instructions prior to the test: "While keeping your hips square, attempt to pull the cable across your body using only your core." Subjects were closely monitored during each trial, with the scale readout visible to the researcher. Subjects were placed into position with the cable tightened prior to the signal to pull. Three trials were performed on the dominant and non-dominant sides, respectively. The dominant side was considered the side on which a player was at bat most frequently. The non-dominant (ND) side was completed first, followed by the dominant (D) side. Subjects were given an auditory

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Table 1: *Subject Characteristics (n = 15).*

	Age (yrs)	Body Mass (kg)	Height (cm)	BMI (kg/m^2)
Mean	21.20	86.52	181.69	26.13
Standard Deviation	1.32	9.31	4.88	2.33

Table 2: *Dynamic Warm-Up Protocol.*

Exercise
Adductor and Abductor Walk (45 feet each)
High Knees (2 x 45 feet)
World's Greatest Stretch (45 feet)
Reverse Lunge with Reach (45 feet)
Flying Shuffle (2 x 45 feet each direction)
Shuffle-Shuffle, Lean-Lean (2 x 45 feet)
High Knee Karaoke (2 x 45 feet each direction)
Quick Feet Karaoke (2 x 45 feet each direction)
Hamstring Walk (45 feet)
Quad Reach (45 feet)
Ankle – Knee Pull (45 feet)
Walking RDL "Table Top" (45 feet)
Frankesteins (45 feet)
Shuffle-Shuffle Squat and Inside Pivot (45 feet)
Quick Skips (2 x 45 feet)
Power Skips (2 x 45 feet)
Side Skips (2 x 45 feet each direction)

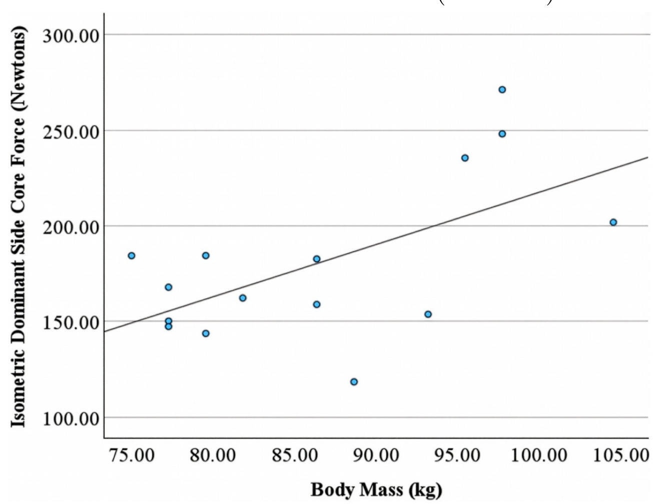
Figure 3: Baseball Exit Velocity Test Set-Up.

signal (i.e., "pull"), and then exerted maximal effort for five seconds during each of the three trials. It was felt that the 5-second time period allowed for maximal effort, based on prior use of the test during regular training sessions and during familiarization for the present study. Subjects recovered for at least one minute between repeated trials. The force value in Newtons (N) from the crane scale was recorded for further analysis. Once the isometric core rotation test was completed, subjects proceeded to the batting cage to warm up and prepare for the baseball exit velocity test.

Baseball Exit Velocity Test

Subjects were permitted as many warm-up swings as desired until they indicated to the researcher that they were ready for the test trials. For the test, subjects performed three maximum-effort swings off of a batting tee with their non-dominant side first, followed by their dominant side. Subjects were given a minimum of 30 seconds of rest between trial swings. A radar gun (Pocket Radar) was placed behind protective netting 70 feet in front of the batter, aligned level with the baseball, and held steady for measurements (see Figure 4). Baseball exit velocity (from the tee) was measured and recorded initially in miles per hour (mph), then converted to meters per second (m·second^{-1}) for statistical analyses.

Figure 4: Scatterplot Body Mass (kg) and Isometric Dominant Side Core Rotation Force (Newtons).



Note. R^2 Linear = 0.360.

Data Analyses

All data are presented as the mean value plus or minus (+/-) the standard deviation (SD). The intra-session reliability of the three test experimental trials for the isometric core rotation and baseball exit velocity tests for the non-dominant and dominant sides was assessed with

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Cronbach's alpha values. The intra-session reliability values were as follows: isometric core rotation test non-dominant side (0.873), isometric core rotation test dominant side (0.955), baseball exit velocity non-dominant side (0.942), and baseball exit velocity dominant side (0.922). Given the acceptable reliability values, the average values for the isometric core rotation and baseball exit velocity tests for the non-dominant and dominant sides were subsequently used for analysis. Independent t-tests were conducted to assess differences between the dominant and non-dominant sides in isometric mean core rotation force and baseball mean exit velocity, respectively. Pearson r-values were then calculated to assess the correlations between isometric mean core rotation force, baseball mean exit velocity, and body mass. An alpha level of $p < 0.05$ was used to determine the statistical significance of comparisons and correlations. SPSS software was used to conduct all comparisons.

Results

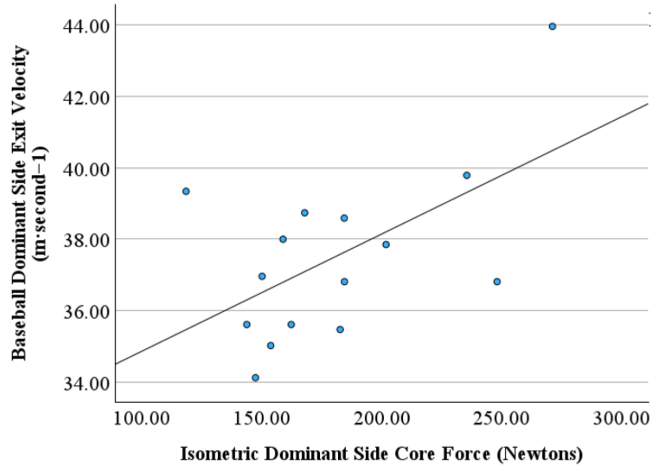
Table 3 shows the isometric core rotation force (N) values for the non-dominant and dominant sides. There was no significant difference ($p = 0.86$) between the overall mean values of the non-dominant and dominant sides. Table 4 shows the baseball mean exit velocity (m·second^{-1}) values for the non-dominant and dominant sides. There was a significant difference ($p = 0.0004$) between the non-dominant and dominant sides, respectively.

Table 5 shows the Pearson r-values for the isometric core rotation force and baseball exit velocity for the non-dominant and dominant sides. The key finding was a significant ($p = 0.026$) and moderate positive relationship ($r = 0.570$) between the dominant-side isometric mean core rotation force and the dominant-side baseball mean exit velocity. Additionally, a significant ($p = 0.002$) and moderate positive relationship ($r = 0.733$) was found between the non-dominant side isometric mean core rotation force and the dominant side baseball mean exit velocity. The isometric mean core rotation force was not significantly different between the dominant and non-dominant sides ($p = 0.86$); whereas the baseball mean exit velocity was significantly different between sides ($p = 0.0004$). Therefore, on the dominant side, players had learned to effectively transfer isometric core rotational force into a dynamic bat swing, as reflected in baseball exit velocity. Lastly, a significant relationship was found between body mass and the mean isometric core rotation force on the dominant side ($r = 0.600$, $p = 0.018$).

Discussion

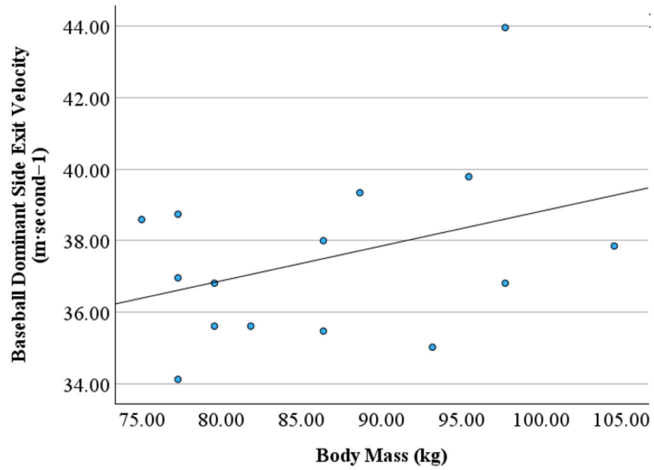
The purpose of this study was to examine an isometric core rotation test and its relationship to baseball exit velocity in Division II collegiate players. This was a replication study based on Spaniol et al. (2010). The key finding was a significant ($p = 0.026$) and moderate positive relationship ($r = 0.570$) between the dominant side isometric mean core rotation force and the dominant side baseball mean exit velocity, indicating that to a moderate degree, as the isometric core rotation force increased, the baseball exit velocity also increased. Additionally, a significant ($p = 0.002$) and moderate positive relationship ($r = 0.733$) was found between the non-dominant side isometric mean core rotation force and the dominant side baseball mean exit velocity.

Figure 5: Scatterplot Isometric Dominant Side Core Rotation Force (Newtons) and Baseball Dominant Side Exit Velocity (m·second^{-1}).



Note. R^2 Linear = 0.325.

Figure 6: Scatterplot Body Mass (kg) and Baseball Dominant Side Exit Velocity (m·second^{-1}).



Note. R^2 Linear = 0.138.

The current study assessed isometric core rotation force in a ground-based hitting position designed to simulate the point of ball contact in a baseball bat swing. Isomet-

Table 3: *Isometric Core Rotation Force (Newtons) for the Dominant (D) and Non-Dominant (ND) Sides (Mean ± Standard Deviation).*

	Trial 1 (ND)	Trial 2 (ND)	Trial 3 (ND)	Overall (ND)	Trial 1 (D)	Trial 2 (D)	Trial 3 (D)	Overall (D)	p-value
Mean	168.67	188.89	192.43	183.33	166.27	182.52	193.49	180.76	0.86
SD	43.06	43.69	48.93	40.44	40.57	46.52	45.52	42.42	
SEM	11.12	11.28	12.63	10.44	10.48	12.01	11.75	10.95	

Note. An Independent t-test was conducted to compare the Overall Means of the Dominant and Non-Dominant sides ($p <$ 0.05). SD = Standard Deviation; SEM = Standard Error of the Mean.

Table 4: *Baseball Exit Velocity (m·second^{-1}) for the Dominant (D) and Non-Dominant (ND) Sides (Mean ± Standard Deviation).*

	Trial 1 (ND)	Trial 2 (ND)	Trial 3 (ND)	Overall (ND)	Trial 1 (D)	Trial 2 (D)	Trial 3 (D)	Overall (D)	p-value
Mean	31.53	32.10	32.54	32.06	36.72	37.73	38.09	37.51	0.0004**
SD	5.46	4.49	5.12	4.77	2.64	2.78	2.44	2.44	
SEM	1.41	1.16	1.32	1.23	0.68	0.72	0.63	0.63	

Note. An Independent t-test was conducted between the Overall Means on the Dominant versus Non-Dominant sides ($p <$ 0.05). **Comparison is significant at the 0.01 level (2-tailed). SD = Standard Deviation; SEM = Standard Error of the Mean.

ric actions promote maximal active tension in muscles (Olson et al., 1972). It appears that the ability to create maximal isometric tension is moderately related to baseball exit velocity. Buso et al. (2023) stated that "the hitting motion in baseball requires generating a high angular velocity. Players must efficiently transfer torque from the lower extremities to the lumbo-pelvic-hip complex and then to the upper extremities during the swing." Although subjects were not dynamically rotating for the isometric core test in the current study, the intent was to create maximal torque through the core musculature. The intent to initiate core rotation, in an isometric action, might be interpreted by the central nervous system in a manner similar to actual dynamic rotation (Behm & Sale, 1993).

A stable core region via isometric muscle actions anchors the upper and lower extremities and, like a bridge, facilitates efficient transfer of mechanical energy to an external implement like a baseball bat (Willardson, 2025). Prior studies have reported positive relationships, either directly or indirectly, between isometric core fitness and dynamic performance measures. For example, Shinkle et al. (2012) reported that the power generated in a barbell push-press was significantly correlated with dynamic right- and left-side medicine-ball throws. The barbell push-press requires isometric core activation to stabilize the torso, whereas medicine ball throws require dynamic core action. Additionally, Spaniol et al. (2010) reported that isometric (i.e., static) core rotational strength exhibited a moderate positive relationship with bat speed (r = 0.58) and batted ball velocity (r = 0.62) in collegiate baseball players. Similar to the current study, Spaniol et al. (2010) measured isometric core rotational strength using a cable tensiometer at the contact point (bat and ball) in a hitting position, and baseball exit velocity was measured using a radar gun while hitting from a batting tee. Moreover, a prior study by Townsend et al. (2019) examined the relationship between the isometric midthigh pull (IMTP) and dynamic performance measures. Townsend et al. demonstrated that the IMTP was significantly correlated ($p < 0.01$) with the vertical jump (r = 0.809), the pro-agility shuttle (r = -0.657), and the 20-meter sprint (r = -0.693) in Division I collegiate basketball players. Therefore, training exercises involving isometric muscle actions could improve dynamic performance over time, and longitudinal studies should be conducted to this end.

Another finding from the current study was a significant (p = 0.002) and moderate positive relationship (r = 0.733) between the non-dominant-side isometric mean core rotation force and the dominant-side baseball mean exit velocity. The force from the core muscles on the non-dominant side might contribute to the dominant side's baseball exit velocity due to the stretch-shorten cycle (Turner & Jeffreys, 2010). In swinging a baseball bat, opposing muscle groups work reciprocally to pre-stretch the swing muscles or accelerate the bat, respectively. Santana et al. (2015), as well as others (Myers, 2014; Smith et al., 2023), have contended that myofascial connections between muscles are critical for force transmission. For example, Santana et al. (2015) explained that a left-side dominant baseball batter pre-loads the swing muscles with a quick pre-stretch that engages the right latissimus dorsi, left gluteus maximus, left hamstrings, and left

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Table 5: *Correlation Matrix Selected Variables.*

		Isometric Mean Core Rotation Force (N) Dominant	**Baseball Mean Exit Velocity ($m{\cdot}s^{-1}$) Non-Dominant**	**Baseball Mean Exit Velocity ($m{\cdot}s^{-1}$) Dominant**	**Body Mass (kg)**
Isometric Mean Core Rotation Force (N) Non-Dominant	Pearson Correlation	0.853**	0.539*	0.733**	0.589*
	SEr	0.145	0.234	0.189	0.224
	p-value	0.001	0.038	0.002	0.021
Isometric Mean Core Rotation Force (N) Dominant	Pearson Correlation		0.407	0.570*	0.600*
	SEr		0.253	0.228	0.222
	p-value		0.133	0.026	0.018
Baseball Mean Exit Velocity ($m{\cdot}s^{-1}$) Non-Dominant	Pearson Correlation			0.718**	0.420
	SEr			0.193	0.252
	p-value			0.003	0.119
Baseball Mean Exit Velocity ($m{\cdot}s^{-1}$) Dominant	Pearson Correlation				0.371
	SEr				0.258
	p-value				0.173

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed). SEr = Standard Error of the Correlation Coefficient.

gastrocnemius. The quick pre-stretch is immediately followed by the rotary swinging action to contact the ball, which engages the left serratus anterior, left external oblique, right internal oblique, right hip flexors, and right hip adductors. Greater force output in the non-dominant core rotators would enable greater storage of elastic mechanical energy during the pre-stretch phase, contributing to greater rotary acceleration during the bat swing (Turner & Jeffreys, 2010).

Lastly, there was a significant, moderate positive relationship between body mass and isometric mean core rotation force on the dominant side ($r = 0.600$, $p = 0.018$). However, as can be seen in Table 5 and the scatterplot in Figure 7, the relationship between body mass and baseball mean exit velocity by dominant side ($r = 0.371$, $r^2 = 0.138$, $p = 0.173$) was not significant. Conversely, as can be seen in Table 5 and Figure 6 scatterplot, there was a significant relationship between the isometric mean core rotation force dominant side and the baseball mean exit velocity dominant side ($r = 0.570$, $r^2 = 0.325$, $p = 0.026$). Therefore, based on the above evidence, more massive players do not necessarily hit farther, but players with greater isometric core rotational strength do.

There are currently no criterion tests for core fitness, with many tests outlined in the literature based on the wide variety of core functions in sports performance (Nesser, 2025). In collegiate baseball players, the isometric core rotation test, as administered in the current study, could be considered a reliable assessment of sports-specific core muscle function. The dominant-side isometric core rotation force and the dominant-side baseball exit velocity were moderately related. Training exercises involving isometric muscle actions could improve dynamic performance over time, and longitudinal studies should be conducted to this end. Future research could also expand on the current study's findings by examining the relationship between dynamic expressions of core rotational force and baseball batting performance.

The current study had some limitations that should be acknowledged. First, data were not collected during the familiarization session prior to the experimental session

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to determine inter-session reliability. The baseball athletes had used the crane scale isometric core rotation test regularly as part of team workouts. Unfortunately, data were not collected during workouts or during the familiarization session of the present study. This was a limitation in our research procedures. Our assumption was that, since participants were trained athletes and had performed the isometric core rotation test on several prior occasions, their values would be consistent across days with very little learning effect. Unfortunately, we could not quantify this assumption using a coefficient of variation (CV). However, the intra-session reliability values (i.e., Cronbach's alpha) suggested a high degree of consistency. Secondly, measurement with the crane scale yielded a single peak value, and the average of three single peak values from each of three trials was used in the data analysis. Thus, the crane scale used in the present study lacked the sensitivity to evaluate force over different time bands. Therefore, future research could assess more detailed measures of force output during isometric core rotation, including the rate of force development, to determine the effect on bat swing performance measures.

Conclusion

The purpose of this study was to examine an isometric core rotation test and its relationship to baseball exit velocity in Division II collegiate players. This was a replication study based on Spaniol et al. (2010). The key finding was a significant ($p = 0.026$) and moderate positive relationship ($r = 0.570$) between the dominant side isometric mean core rotation force and the dominant side baseball mean exit velocity, indicating that to a moderate degree, as the isometric core rotation force increased, the baseball exit velocity also increased. These findings highlight the importance of isometric core rotation strength in baseball players, due to its moderate relationship with baseball exit velocity. The use of the crane scale, as in this study, represents a reliable, inexpensive, time-efficient, and practical method for monitoring sports-specific core fitness in baseball players. Practitioners may apply these findings by designing exercises that elicit maximal isometric tension in the core rotator musculature to promote spinal stiffness, which may lead to more efficient energy transfer in the baseball swing.

License

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