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Original Research

Lower-Body Strength Relationships with Sprint, Jump, and Sport-Specific Skill Performance in High School Girls Softball Players

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ABSTRACT

International Journal of Exercise Science 17(4): 86-98, 2024. Softball athletes require multiple fitness traits (e.g., strength, speed, power) and sport-specific skills (e.g., hitting, throwing) for success. Lower-body strength could underpin these qualities; this has received little analysis among high school female athletes. This research investigated correlations between absolute and relative lower-body strength with age, linear speed, lower-body power, and throwing and hitting velocity in high school girls softball athletes. Archival data collected from 34 high school girls softball players (age=14.91±1.00 years; height=1.66±0.07 m; body mass=63.21±9.59 kg) from a private strength and conditioning facility was analyzed. The data included: age, height, and body mass; 0-9.14 and 0-18.29 m sprint interval times; standing broad jump (SBJ) distance (lower-body power); batted ball exit (i.e., hitting) and throwing velocity; and absolute and relative three-repetition maximum (3RM) front squat and hexagonal bar deadlift (HBD). Pearson's correlations ($p<0.05$) derived relationships between absolute and relative strength with the fitness and sport-specific tests. The results indicated significant relationships between the 3RM HBD with age ($r=0.389$) and hitting velocity ($r=0.418$). The 3RM front squat related to the SBJ ($r=0.422$) and hitting velocity ($r=0.457$). Relative 3RM HBD correlated with the 0-18.29 m sprint interval ($r=-0.349$). These results suggested that a strength and conditioning program that improves the lower-body strength of high school girls softball players could contribute to faster sprinting speed, further horizontal jumps, and greater hitting velocity. The results from this study highlights the value of strength enhancement in high school girls softball athletes and provides support for strength and conditioning program provision for these individuals.

KEY WORDS: female athletes, front squat, hexagonal bar deadlift, hitting velocity, standing broad jump

INTRODUCTION

Participation in physical activity and sports can be essential in motor and physical development of adolescents. From a societal perspective, people that display superior movement competence during adolescence have a tendency to be more active as adults, which can affect the health and fitness outcomes of the general population (35). Specific to sport, motor skills are often crucial components required for performance. What is important to recognize for the strength and conditioning practitioner is that motor skill performance could be impacted by the fitness of the adolescent athlete (19, 34, 40).

One sport that requires multiple components of fitness and specific skills is softball, which is a popular sport for high school girls from the USA (21). Softball is a bat-and-ball game contested by team's with nine players on each side (39). Each player generally falls into one of four categories: pitcher, catcher, infielder (shortstop, first base, second base, and third base), and outfielder (left, center, and right). Although each position has specific needs, there are some general fitness characteristics important for softball. Especially at the high school-level, almost all softball athletes will need to be able to hit and throw. Sprinting speed could contribute to successful softball performance (24), as athletes need to sprint when running the bases or attempting to field a ball in play. Lower-body power is also considered an important fitness quality for softball athletes (24). Notably, lower-body strength may provide a foundation for the afore-mentioned characteristics.

There has been some analysis of strength in adult softball athletes. Guthrie et al. (11) found that collegiate softball athletes were significantly ($p < 0.05$) stronger than field hockey, soccer, and volleyball athletes in the one-repetition maximum (1RM) back squat and bench press. Interestingly, when the sample of collegiate athletes was combined, Guthrie, Fields, Thompson and Jones (11) did not find a significant correlation ($r = 0.229$) between the 1RM back squat and standing broad jump (SBJ), which provided a metric for lower-body power. Nimphius, McGuigan and Newton (24) found that strength assessed by the relative three-repetition maximum (3RM) back squat correlated with speed measured by a 10-meter (m) sprint, 18.29-m sprint (60 feet, or the distance to first base), and a sprint to second base (~36.58-m sprint), with very large relationships ($r = –0.75$ to $–0.87$) over the course of a season. Subsequent to a literature review, Szymanski, DeRenne and Spaniol (36) suggested that upper- and lower-body strength should contribute to bat swing velocity in softball. Although softball athletes were not the sample for a study conducted by Negrete, Hanney, Kolber, Davies and Riemann (23), the authors found that strength measured by modified pull-up repetitions related to a softball throw for distance ($r = 0.70$, $p = 0.001$) in recreationally-active men and women. Nonetheless, the relationships between strength and sport-specific performance (i.e., sprinting speed, jump performance, hitting, and overhand throwing) in high school girls softball athletes has received little analysis. This is especially notable as girls in high school sports often do not receive similar strength and conditioning programs typically administered to boys (29). If research does document significant correlations between lower-body strength and softball-specific performance tests, this could provide an impetus to provide strength and conditioning programs for high school girls.

Therefore, this study investigated the relationships between lower-body strength and age, linear sprinting speed, SBJ, and sport-specific skills (i.e., hitting and throwing velocity) in high school girls softball players. Age was included in the analysis as fitness test performance tends to improve with age in adolescents (38). Archival data was provided by a private strength and conditioning facility that specialized in training high school softball players. It was hypothesized that lower-body strength would significantly relate to age, linear speed, jump performance, and hitting and throwing velocity in high school girls softball athletes. However, the relationships with the fitness and sport-specific skills tests would be stronger than that for age.

METHODS

Participants

As stated, this study involved the retrospective analysis of data collected as part of standard practice by staff from a private facility. Athletes over 18 years of age provided their consent for their data to be analyzed. Athletes under 18 years of age provided their assent for their data to be analyzed and their parents/guardians provided their consent. This resulted in de-identified data for 34 high school girls softball athletes being provided to the researchers. Participant details are shown in Table 1. This data encompassed all available athletes who were about to begin an 8-week strength and conditioning program at the time of this study. The girls came from different high school programs and played a range of different positions. G*Power software (v3.1.9.2, Universität Kiel, Germany) confirmed post hoc that the sample size of 34 was appropriate for a point biserial correlation model such that data could be interpreted with a small effect level of 0.50 (12), and a power level of 0.90 when significance was set at 0.05 (6). The study was approved by the Institutional Review Board (HSR-22-23-112). The research adhered to the ethical guidelines set forth by the editorial board for the International Journal of Exercise Science (22).

Table 1. Age, height, and body mass data (mean ± standard deviation [SD]) for the study participants.

Descriptive Data	Mean ± SD
Age (years)	14.91 ± 1.00
Height (m)	1.66 ± 0.07
Body Mass (kg)	63.21 ± 9.59

Protocol

Although this study involved archival data analysis, the testing procedures adopted by the staff will be detailed. Staff used pre- and post-testing about a training block to track progress for their athletes, and the testing sessions had a duration of 45-60 minutes each. Only pre-testing data was considered in this study, as the focus for this study was on investigating relationships prior to a specific training intervention. All staff involved with testing had completed Bachelor's degrees in Kinesiology or related fields and were certified Strength and Conditioning Specialists through the National Strength and Conditioning Association. All testing was conducted on-site in the afternoon at the facility. Prior to the pre-testing session, athletes completed a 5–10-minute dynamic warm-up consisting of dynamic exercises, mobility exercises, and fundamental movement skills. The researchers did not select or conduct any of the tests; they were, however, standard practice within this facility. As this facility specialized in softball, staff also included softball-specific hitting and throwing tests. The tests were performed in the order presented hereafter, which followed established guidelines (18). Due to time constraints, between-trial recovery periods of about 60 seconds (s) were allotted for the sprint, jump, hitting, and throwing trials. Though potentially not ideal, short-duration power events may not completely deplete phosphagen stores (28), which can then be recovered very quickly (30). Moreover, any potential issues with fatigue were limited with the analysis of the best trial for each test event.

An 18.29-m (20-yard) sprint was used to measure linear sprinting speed, with the procedures following published research (17). Sprint testing was conducted outside of the training facility on a blacktop surface. Timing gates (Dashr Motion Performance Systems, Lincoln, USA) were placed at 0 m, 9.14 m (10 yards), and 18.29 m to quantity the 0-9.14 m and 0-18.29 m intervals. The height of each gate was approximately 0.73 m. Athletes took a two-point start (feet staggered and on the balls of their feet with their opposite arm of their forward leg up and forward) behind the start line, which was marked 0.5 m behind the first pair of timing gates. On the command “Ready”, the athlete sprinted as fast as possible over the required distance. Each athlete performed three trials. Time was recorded to the nearest millisecond with the best trial analyzed.

The standing broad jump (SBJ) indirectly measured horizontal lower-body power and was measured using established protocols (17). Although jump performance may not always be the best interpretation of lower-body power (20), it still is useful within a high school athlete population. Softball athletes will need to project their body during match-play (e.g., diving for a catch in the field), so absolute jump performance still has application for these athletes. Moreover, the SBJ also provides an indicator for motor skill performance (35). Testing was conducted indoors at the facility on turf. The athletes started with their toes behind the zero line, before performing a countermovement to jump as far forwards as possible and landing with both feet concurrently. Distance was measured by a tape measure as the perpendicular line from the zero line to the back surface of the heel at the landing. Each athlete performed three trials and the best trial was analyzed.

Hitting velocity (measured in kilometers per hour; km/hr) was quantified using a portable hitting tracker (Hitting 2.0, Rapsodo®, St. Louis, USA). The tracker used advanced camera and radar technology to measure and analyze swing metrics (26). The focus of the staff was the exit velocity of the batted ball, which is referred to as hitting velocity by the staff and within the context of this research, so that variable included in this study. The procedures used were similar to that from the literature (41), with manufacturer guidelines adopted to set up the tracker (26). The tracker was placed 0.35 m (14 inches) from the front of home plate at ground level. Athletes were instructed to perform 3-5 minutes of practice hits off the batting tee that sat directly on top of home plate. Each athlete set the tee to their own desired height, which was kept constant throughout their trials. A standard 0.18-kg (6.25-ounce) softball and the athlete’s own composite bat were used for hitting. Following the practice hits, athletes were instructed to hit the softball off the batting tee with maximal effort three more times; the best trial was used for analysis.

Throwing velocity (also measured in km/hr) was evaluated by a portable pitching tracker (Pitching 2.0, Rapsodo®, St. Louis, USA). As for the hitting tracker, the pitching tracker used camera and radar technology to assess throwing metrics, including velocity (27). This equipment has been used in recent studies investigating pitching and throwing (4). Following manufacturer guidelines (27), the tracker was placed 4.70 m (15 feet, 6 inches) from the front of home plate. A line was marked 13.11 m (43 feet) from home plate where athletes would throw. The throwing distance was also equal to the distance of home plate to the pitching rubber on a softball field (39). Athletes were instructed to perform 3-5 minutes of self-selected warm-up throws into the net stationed behind home plate. Athletes were permitted to step before throwing the ball; however, they had to keep one foot on the throwing line. As for the hitting test, a standard 0.18-kg softball was used for throwing. After the warm-up throws, athletes were instructed to throw into the target with maximal effort three more times. The best trial was analyzed.

Two lower-body strength tests were used by staff from the facility, with the first being the 3RM front squat. Staff used a 3RM due to safety considerations for working with younger athletes (2). Staff also had several reasons for selecting a front squat over a back squat as part of their testing battery. Reduced trunk flexion occurs during a front squat (9), which alleviated some concerns of low back injuries. Following a review of literature, Bird and Casey (1) also suggested that front squat may reduce compressive stress in the knees compared to the back squat. The procedures for the front squat were similar to previous research (2). The athletes' feet were positioned approximately shoulder-width distance apart, with their toes pointed forward/slightly outward, and athletes were required to descend until the top of the thighs were parallel with the floor for the repetition to be successful. The bar rested above and behind the anterior deltoids and on the upper clavicle region (1). To obtain the 3RM, athletes progressively worked their way up to this load by first beginning with a weight that they could lift comfortably for at least 5 repetitions. Following this, the weight was gradually increased by 10-20% for two more sets of 3-5 repetitions, followed by 3RM testing sets until failure. A between-set rest interval of 2-3 minutes was afforded between 3RM trials. Additional rest time was provided for the strength tests in an attempt by staff to ensure proper lifting technique by athletes and maximal effort for each lift. In addition to the absolute load for the 3RM front squat, relative strength was also calculated (*3RM front squat/body mass*).

The 3RM HBD was the second strength test conducted by the staff. The movement required in the HBD was similar to that described in previous research, with the athletes starting the lift within the frame of the hexagonal bar while holding the handles with a closed, neutral grip (16). The same loading scheme that was used during the front squat test to obtain the 3RM was also applied for the HBD. A successful HBD repetition occurred when the athlete was standing upright within the frame of the bar via knee extension and shoulder retraction (16). Relative 3RM HBD strength was calculated via the formula: *3RM HBD/body mass*.

Statistical Analysis

All statistical analyses were computed using the Statistics Package for Social Sciences (version 28.0; IBM Corporation, NY, USA). Descriptive statistics (mean ± standard deviation [SD]) were computed for each variable. Preceding the correlation analysis, normality of the data was evaluated by the Shapiro-Wilk test. Skewness and kurtosis scores between 0±2 were considered acceptable (8). If data was not normally distributed and outside the skewness and/or kurtosis range, stem-and-leaf plots were visually assessed to determine whether there were any outliers for the specific variable. Data that was not normally distributed and outside skewness and/or kurtosis ranges were treated with a winsorization method (15). Shapiro-Wilk output, skewness and kurtosis scores, and stem-and-leaf plots were then checked again to confirm normal data distribution and acceptability of parametric statistical analysis. Following this confirmation, Pearson's correlations (*r*) calculated relationships between lower-body strength (absolute and relative 3RM front squat and HBD) with linear speed (0-9.14 m and 0-18.28 m sprint intervals), SBJ, hitting velocity, and throwing velocity. An alpha level of $p < 0.05$ was required for significance. Correlation strength was defined as per Hopkins (13), and are shown in Table 2.

Table 2. Correlation (*r*) strength definitions (13).

r	*r* Strength
±0-0.3	Small
±0.31-0.49	Moderate
±0.5-0.69	Large
±0.7-0.89	Very Large
±0.9-1.0	Near Perfect

RESULTS

Initial data review indicated that 10 of 12 variables were normally distributed (p = 0.065-0.864; skewness = ±0.036-0.968; kurtosis = ±0.020-1.252). Age was not normally distributed ($p < 0.001$), but had acceptable skewness (1.359) and kurtosis (1.959), so was not treated. The 3RM HBD was not normally distributed ($p = 0.023$) and had a kurtosis outside the accepted range (2.895). One outlier was treated via the winsorization process. Following this, the 3RM HBD was normally distributed ($p = 0.152$) and had acceptable skewness (-0.234) and kurtosis (-0.788). Thus, the parametric Pearson's correlation analysis was used for the study.

Descriptive data is exhibited in Table 3, with the correlations displayed in Table 4. There was a significant moderate positive correlation between the 3RM HBD and age of the athletes. Relative 3RM HBD had a significant moderate negative relationship with the 0-18.29 m sprint interval. The 3RM front squat had a significant moderate positive relationship with the SBJ. Both the 3RM front squat and 3RM HBD had significant moderate positive relationships with hitting velocity.

Table 3. Descriptive statistics for high school girls softball athletes (N = 34) for 0-9.14 m sprint time, 0-18.28 m sprint time, standing broad jump distance, hitting velocity, throwing velocity, absolute and relative three-repetition maximum (3RM) front squat, and absolute and relative 3RM hexagonal bar deadlift (HBD).

Variable	Mean ± SD
0-9.14 m Sprint (s)	1.82 ± 0.08
0-18.28 m Sprint (s)	3.12 ± 0.14
Standing Broad Jump (m)	1.94 ± 0.17
Hitting Velocity (km/hr)	107.27 ± 9.35
Throwing Velocity (km/hr)	93.76 ± 5.77
3RM Front Squat (kg)	66.30 ± 11.67
Relative 3RM Front Squat (kg/body mass)	1.06 ± 0.19
3RM HBD (kg)	99.26 ± 16.74

Relative 3RM HBD (kg/body mass)	1.60 ± 0.24

Table 4. Pearson's correlations (*r*) for relationships between absolute and relative three-repetition maximum (3RM) front squat, and absolute and relative 3RM hexagonal bar deadlift (HBD) with 0-9.14 m sprint time, 0-18.28 m sprint time, standing broad jump (SBJ) distance, hitting velocity, and throwing velocity in high school girls softball athletes (N = 34).

Variable		3RM Front Squat	Relative 3RM Front Squat	3RM HDB	Relative 3RM HDB
Age	*r*	0.264	–0.035	0.389*	0.241
	p	0.131	0.843	0.023	0.169
0-9.14 m Sprint	*r*	–0.284	–0.205	–0.241	–0.318
	p	0.103	0.245	0.170	0.066
0-18.29 m Sprint	*r*	–0.314	–0.276	–0.179	–0.349*
	p	0.071	0.113	0.311	0.043
SBJ	*r*	0.422*	0.315	0.290	0.255
	p	0.013	0.069	0.096	0.145
Hitting Velocity	*r*	0.457*	-0.027	0.418*	0.019
	p	0.007	0.880	0.014	0.914
Throwing Velocity	*r*	0.299	0.103	0.262	0.083
	p	0.086	0.564	0.135	0.639

* Significant ($p < 0.05$) relationship between the two variables.

DISCUSSION

The current study analyzed the relationships between lower-body strength and age, linear speed, jump performance, and hitting and throwing velocity in high school girls softball athletes. This research was important as high school girls softball athletes (and high schools girls athletes in general) often do not receive strength and conditioning programs typically afforded to boys athletes (29). It was hypothesized that lower-body strength would significantly relate to age, 0-9.14 m and 0-18.29 m sprint intervals, the SBJ, and hitting and throwing velocity in high school girls softball athletes. The hypothesis was proven partially correct. The 3RM front squat correlated with the SBJ and hitting velocity, while the 3RM HBD related to age and hitting velocity. Relative 3RM HBD had a significant relationship with the 0-18.29 m sprint interval. However, in contrast to the study hypothesis, no significant relationships with the maximal strength tests was found for the 0-9.14 m sprint interval or throwing velocity. As will be discussed, the study results apply to high school girls softball athletes, and the potential benefits they could receive from an appropriate strength and conditioning program.

Fitness test performance tends to improve with age in adolescents (35), which would be in part due to physiological and physical development that occurs with maturation. However, only one measure of maximal strength correlated with age in the current sample. The moderate relationship with the 3RM HBD indicated that older girls softball athletes tended to lift a greater HBD load. Previous research has shown in boy's water polo, varsity athletes had greater isometric leg/back strength compared to the junior varsity athletes (38). Nonetheless, absolute and relative 3RM front squat and the relative 3RM HBD did not relate to age. Although further research is required, training history for a girls high school athlete may be more important than just growth and maturation for developing maximal strength. This would suggest that appropriate strength and conditioning programs should be beneficial for developing maximal force output in girls high school athletes of different ages. Previous research has shown this can occur in high school girls soccer players (20); future studies should ascertain whether this is also the case for girls softball athletes.

It could be expected that maximal strength would relate to sprint acceleration, which encompassed both the 0-9.14 m and 0-18.29 m sprint intervals measured in this study. Athletes need to overcome their own inertia when accelerating, which is where high force output can take on great importance (13). Previous research in adolescent girls from different sports (netball, soccer, field hockey, lacrosse, swimming, athletics, badminton, and rowing) indicated a significant relationship between absolute (r = –0.44) and relative (r = –0.60) isometric leg/back strength and speed over 10 m (31). Interestingly, absolute and relative 3RM front squat and deadlift did not significantly relate to the 0-9.14 m sprint interval. A positive change in the relationship between maximal strength and sprint acceleration could occur after the provision of exercises that target these qualities (25). Indeed, the athlete data analyzed was prior to the provision of a strength and conditioning program. The athletes investigated in this study may need more training time, or a different approach to manipulating training volume and intensity (e.g., microdosing, which divides the total volume within a microcycle, across frequent, short-duration, repeated bouts) (3), to harness their maximal strength qualities within the initial acceleration technique required for a maximal sprint. However, it should also be noted that some athletes on a softball team are not selected for their sprinting speed. Nimphius et al. (25) noted that players with larger body sizes may be selected as 'power hitters', so they may be strong but are not as concerned with using their acceleration to increase their on-base percentage or game contributions.

Nevertheless, relative 3RM HBD had a significant moderate negative relationship with the 0-18.29 m sprint interval. Relative strength should be important when sprinting due to the need to move one's body mass rapidly (31). Sommerfield et al. (31) also found that relative isometric leg/back strength related to speed over 20 m in adolescent girls (r = –0.457). Similarly, Nimphius et al. (25) found that relative 3RM back squat related to an 18.29-m sprint to first base in adult women's softball athletes (r = –0..82 to –0.90). The results from this study suggest that improvements in relative lower-body strength measured by the HBD could contribute to a faster sprinting speed over 18.29 m in high school girls softball athletes. This result has practical relevance for softball as 18.29 m is the distance between the bases (37). Future research should be used to inform whether a strength and conditioning program can concurrently improve relative lower-body strength and sprinting speed in high school girls athletes.

Horizontal jumping ability could be of benefit to high school softball players. A greater SBJ distance has been linked to faster pro-agility shuttle performance in collegiate women's volleyball players (16), faster sprinting speed in male collegiate soccer players (18), and notably for adolescents, the SBJ been used a measure of motor skill competence (32). If lower-body strength can influence a motor skill such as the SBJ, this provides some evidence as to the value of developing strength in high school girls athletes. The results indicated that greater absolute strength measured by the 3RM front squat related to a further SBJ. In adolescent girls, Sommerfield et al. (31) found that greater absolute isometric leg/back strength significantly related (r = 0.27) to a higher vertical countermovement jump. Sommerfield et al. (31) linked the value of strength to jump performance due to the need to generate force to move one's own body mass. Similarities in muscle recruitment could have influenced why the front squat significantly related to the SBJ while the HBD did not (39). Analogous to the recommendations based on youth male basketball players provided by Warneke et al. (39), the current data suggest improving maximal strength as measured by the front squat could benefit horizontal jumping in high school girls softball athletes.

Hitting is an essential skill in softball. Although there are other important factors that will influence whether a softball athlete is a good hitter (e.g., decision-making about the pitch to hit, swing technique) (34), exit velocity does at least provide an indication whether an athlete can hit a ball hard into play (33). The results from this study indicated that absolute strength, measured by the 3RM front squat and 3RM HBD, related to hitting velocity. Force generation from the lower-body initiates the swing in softball (40), and the ability to produce absolute maximal force appears to be an important factor for high school girls softball athletes. These results are notable as there is the potential for enhancements in maximal lower-body strength influencing the sport-specific skill of hitting in softball. Further research is needed to determine whether improvements in lower-body strength translates to increased hitting exit velocity. Moreover, given the rotational actions required for hitting, investigations including tests of rotational strength and power (e.g., using a cable pulley system) (1), relative to high school girls softball players, would be applicable.

Throwing is a biomechanically complex skill, where force generated from the lower-body needs to be properly coordinated with the actions of the upper-body to generate an effective throw (36). Throwing velocity has also been used as a metric for motor skill competence (32). However, potentially due to skill complexity, throwing velocity did not significantly relate to any of the measures of strength in high school girls softball players. Similar to hitting, it is plausible that a test of rotational strength or power may have application for throwing (1). Furthermore, upper-body strength was not measured in this study, and it is possible that upper-body strength could have contributed to throwing velocity in girls softball players. For example, grip strength has correlated with throwing velocity in elite women's water polo players (7). It should also be noted that these results may not discount the value of strength relative to throwing velocity in high school athletes. Wakely et al. (38) discovered that a 4-week training program could improve throwing velocity with a water polo ball in junior varsity and varsity boys water polo athletes. It should be clarified that there would be technical differences between throwing with a softball and water polo ball, and this would influence the important physical qualities for each skill. Nonetheless, the results from Wakely et al. (38) do provide some context for how a measure of strength could relate to a throwing action. Regardless, the current data indicated that the triple-extension movements of the front squat and HBD did not significantly relate to throwing velocity in high school girls softball athletes.

There are several limitations to this research that should be discussed. The investigators were not involved with test selection or data collection. However, it should be reemphasized that the staff who collected the data were all experienced and educated in best practice for exercise testing. The participants were all athletes who had financially committed to participate in a specialized strength and conditioning program, and they came from different schools and likely had different training backgrounds. Training history of the athletes was not included in this study and could have influenced the results. As stated, the researchers did not select the tests used in this study. While all had application to softball, it would have been beneficial to have data for upper-body strength (e.g., grip strength) (7, 38) and change-of-direction speed (e.g., the 505 or base running sprints) (25). This study only considered data collected prior to an 8-week strength and conditioning program. It is possible that the relationships between strength and softball-specific fitness may change over the course of a training program (25). Future research could examine the relationships between lower-body strength and age, linear sprinting speed, SBJ, and sport-specific skills (i.e., hitting and throwing velocity) in high school girls softball players after a training intervention.

The results from the current study did indicate that absolute and relative lower-body strength had select relationships with sport-specific fitness in high school girls softball players. Regarding absolute strength, the 3RM front squat correlated with the SBJ and hitting velocity, while the 3RM HBD related to age and hitting velocity. Relative 3RM HBD significantly correlated with the 0-18.29 m sprint interval. Although further research is needed to confirm this supposition, it could be expected that a strength and conditioning program that improves the lower-body strength of high school girls softball players could contribute to faster sprinting speed, further horizontal jumps, and greater hitting velocity. The study results indicated the value of strength development in high school girls softball athletes for sport-specific fitness, and provide support for delivering strength and conditioning programs for high school girls.

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