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Influence of maximal strength performance in front squat and deadlift on linear sprint and jump performance in male youth elite basketball players

Introduction

Match-play demands in team sports indicate that players usually perform several high-intensity activities during a game (Bloomfield, Polman, & O'Donoghue, 2007; Hulton et al., 2022). Especially in basketball reaching high maximal strength values as quickly as possible is an essential motor skill (Abdelkrim, El Fazaa, & El Ati, 2007; Rodríguez-Rosell, Mora-Custodio, Franco-Márquez, Yáñez-García, & González-Badillo, 2016), since literature reports 997 ± 183 major actions including jumping and sprinting in typical game (McInnes, Carlson, & McKenna, 1995). Actions such as jumps or sprints or change of direction (COD) performance (Vázquez-Guerrero et al., 2019) are important for scoring, winning or losing duels and even determining the outcome of the game (Brughelli, Cronin, Levin, & Chaouachi, 2008). From this, basketball is defined by high-intensive, intermittent load in which 52% of actions last 1–5 s, while only 3% last longer than 15 s (Taylor, Wright, Dischiavi, Townsend, & Marmon, 2017) with an increased physical demand as playing level increases (Sekulic et al., 2017). Therefore, the inclusion of testing maximal jumping height, sprinting- or COD performance

is of great interest to adapt the training accordingly.

As early as 1987, Schmidtbleicher showed that explosive strength performance is positively influenced by maximum strength. Accordingly, there are numerous studies showing that one repetition maximum (1 RM) in the back squat is strongly correlated with jumping and sprinting performance. Wisløff, Castagna, Helgerud, Jones, and Hoff (2004) found strong correlations for maximal strength in the half back-squat and sprint performance over 10 m ($r = 0.94$), 30 m ($r = 0.71$) as well as vertical jump height ($r = 0.78$) in the countermovement jump (CMJ). Möck, Mickel, Rosenkranz, Hartmann, and Wirth (2018) and Comfort, Haigh, and Matthews (2012) demonstrated high correlations between maximum strength in the back squat and sprint performance ($r = 0.79$) up to 30 m, the squat jump (SJ; $r = 0.762$) and CMJ ($r = 0.76$), while Requena et al. (2009) found correlations between 1 RM half squat and CMJ and SJ of $r = 0.50$. While there are many studies investigating the influence of the back squat on sport-specific performance, there is limited literature pointing out correlations between the front squat and sport-specific performance. To the best of our knowledge, only Hori et al. (2008) and Barr, Sheppard, Agar-Newman, and

Newton (2014) demonstrated a positive influence of maximum strength in the front squat on sprinting performance up to 40 m ($r = 0.41$–0.60); however, no additional research could be found investigating the correlations between front squat maximal strength and jumping and sprinting performance, therefore also not in youth basketball players. Another promising multijoint strength exercise to increase sport-specific performance is the deadlift. Nigro and Bartolomei (2020) described the deadlift as a primary exercise when trying to increase lower extremity maximal strength and thereby athletic performance as well, but there is no literature examining the influence of the deadlift on jumping and sprinting performance. Only a review by Krause Neto, Vieira, and Gama (2019) discussed the possible influence of the deadlift based on high innervation of musculature involved in sprinting. Styles, Matthews, and Comfort (2016) included Romanian deadlifts to their study design as they investigated the influence of strength training on sprint performance showing increases in sprint performance with Cohen's $d = 0.55$.

To measure an athlete's physical abilities, several sport-specific tests have been established. These include the agility T-Test (aTT) to test sprints in frontal plane as well as backwards

Table 1 ICC for test–retest reliability

	ICC (CI95%)	CV (CI95%)
5 m LSp	0.92 (0.85–0.95)	1.81% (1.33–2.35)
10 m LSp	0.95 (0.91–0.97)	1.51% (1.18–1.84)
20 m LSp	0.98 (0.96–0.99)	0.95% (0.68–1.22)
CMJ	0.98 (0.97–0.99)	2.18% (1.51–2.95)
SLJ	0.98 (0.97–0.98)	1.82% (1.35–2.37)
aTT	0.85 (0.75–0.92)	3.11% (2.37–4.06)

ICC intraclass correlation coefficient, *LSp* linear sprint performance, *CMJ* countermovement jump, *SLJ* standing long jump, *aTT* agility T-Test, *CV* coefficient of variability

Table 2 Descriptive statistics of sprinting, jumping, and strength values

Test	N	Minimum	Maximum	Mean ± SD (95%CI)
5 m LS	42	0.66	0.90	0.76 ± 0.06 (0.74–0.78)
10 m LS	42	1.62	2.18	1.88 ± 0.15 (1.83–1.92)
20 m LS	42	2.8	4.01	3.31 ± 2.29 (3.22–3.39)
CMJ	42	21.2	53.6	35.21 ± 8.34 (32.74–37.73)
SLJ	42	150	301	224.66 ± 40.65 (212.05–235.85)
aTT	42	9.19	13.2	10.78 ± 1.17 (10.42–11.13)
FSQ	42	20	125	66.01 ± 31.11 (57.14–75.0)
DL	42	20	180	87.56 ± 43.16 (73.16–100.3)

LSp linear sprint, *CMJ* countermovement jump, *SLJ* standing long jump, *aTT* agility T-Test, *FSQ* front squat, *DL* deadlift

running, the CMJ or SJ to determine vertical jump performance as well as linear sprints (LSp) over 5–20 m (Delextrat & Cohen, 2008). In professional basketball players, medium to strong correlations between short sprints up to 40 m and SJ (r = 0.53–0.74) as well as CMJ (r = 0.45–0.74) have been found (Shalfawi, Sabbah, Kailani, Tønnessen, & Enoksen, 2011). However, there is a lack of empirical data about the relationship between lower extremity maximal strength and sport-specific jump tests in (youth) basketball (Rodríguez-Rosell et al., 2016).

Therefore, the aim of the study is to evaluate the influence of lower body maximal strength measured via the deep barbell front squat and deadlift on basketball-specific motor tests (CMJ, standing long jump [SLJ], aTT and LSp over 5, 10, 20 m). It is hypothesized that both strength tests show comparable medium to strong correlations to the listed basketball-specific motor tests because both exercises show similar hip and knee kinetics (Choe, Coburn, Costa, & Pamukoff, 2021).

Methods

The aim of this study was to investigate the correlations between the lower extremity maximum strength in the front squat as well as the deadlift and sprinting and jumping performance. For this purpose, 42 young male basketball players were recruited from the first teams of their respective age group from a first league basketball club who all perform in the highest national leagues. The players were tested regarding their lower extremity maximum strength assessed via front squat and deadlift as well as their sprinting performance over 5, 10, and 20 m. Furthermore, the aTT was used to investigate basketball-specific lateral sprinting performance as well as changes of direction. Jumping performance was investigated using the CMJ and SLJ. Consequently, the following parameters were determined: 3 RM in front squat and deadlift, sprint times for 0–5 m, 0–10 m, and 0–20 m, sprint time in aTT, jump height in CMJ and jump distance in SLJ.

Subjects

In all, 42 (age: 14.7 ± 2.4 years, range: 13–18 years, height: 179.1 ± 15.3 cm, weight: 69.8 ± 19.2 kg) male youth athletes playing in the first teams of their respective age class from a German first league basketball club were recruited for this study who all compete in the highest national league in their respective age group. Athletes who had less than 6 months of supervised athletic training and/or were unable to perform deep front squats or deadlifts were excluded from the study. Participants had to be able to perform the front squat and deadlift without rounding the (lower) back when reaching the deep squat position (femur below parallel to the ground) and without collapsing the knee joints into a valgus position.

All participants were part of the first team within their respective age group with three to five basketball training sessions and two to three athletic training sessions per week as well as competitive games on weekends. All subjects were injury-free for at least 6 months and none of the participants reported pain prior to as well as after testing. All participants and their parents were informed about the experimental risks involved with the research. All participants and their parents provided written informed consent to participate in the present study. Furthermore, approval for this study was obtained from the institutional review board (Carl von Ossietzky University of Oldenburg, No. Drs. EK/2022/027-01). The study was performed with human participants in accordance with the Helsinki Declaration.

Procedures

To avoid fatigue as much as possible, the tests were spread over 2 days with 48 h of rest in-between. All tests were performed in the afternoon between 3 pm and 7 pm on all three test days. On test day one, maximal strength (3 RM) was assessed in the front squat and deadlift. The second day of testing comprised three attempts each in CMJ, SLJ, LSp over 20 m and aTT—in this order. All subjects received verbal encouragement for

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Abstract

Background. Strength and speed are two major factors that determine performance in basketball players especially sprinting, jumping and change of direction. This study examined relationships of maximal strength in the front squat and the deadlift with basketball-specific sprint and jump performance tests that are commonly used in test batteries of athletic diagnostics.
Materials and methods. In all, 42 youth male elite basketball players (age: 14.7 ± 2.4 years, age range: 13–18 years, height: 179.1 ± 15.3 cm, weight: 69.8 ± 19.2 kg) volunteered to take part in the present study. The one repetition maximum (1 RM) in the front squat and deadlift were used to determine maximum strength. Countermovement jump (CMJ) and standing long jump were evaluated to determine jump performance and 5, 10, and 20 m linear sprint as well as agility T-test were performed to determine sprint performance. Pearson correlation analysis was used to assess the relationships between strength and jump and sprint performance.
Results. Strong positive correlations were found between maximal strength and jump heights (r = 0.85–0.91, $p < 0.001$) and strong negative correlations were determined between maximal strength and measured sprint times r = (–0.71 to –0.85, $p < 0.001$).
Conclusion. The measured maximal strength in the front squat and deadlift seem to be good predictors for basketball-specific jump and sprint performance. From this, it seems to be beneficial to include training of maximal strength via front squat and deadlift into training routines as well as performance diagnostics.

Keywords

Correlation · Maximum strength · Jumping · Sprinting · Deep squat

each attempt. Participants rested 3 min between attempts and 5 min after completion of each test item. The pretest for familiarization with the measurement apparatuses was performed 1 week before testing and consisted of the sport-specific performance tests used in the following order: CMJ, SLJ, LSp, and aTT.

Dynamic maximal strength tests

Warm-up on day one included two sets of 20 repetitions (reps) bodyweight squats, two sets of 19 reps Cossack squat for each side and two sets of ten lunges. In addition, squat-specific mobility drills were implemented prior to the first set of front squats.

Subjects performed two sets of five reps with the empty 20 kg barbell. After that, participants only performed three reps on each subsequent set. The increases in weight were based on each athlete's workout routine to attempt to reach the predicted 3 RM within five attempts. The front squat was performed in a power rack with height adjusted safety spotter bars with an experienced athletic coach behind the subjects for additional safety. In-between sets the subjects rested for 3 min. Exercise order was standardised for all subjects meaning front squat first and deadlift second on day one. Depth in the front squat was reached when the athlete's hips were below the knees meaning femur being below parallel to the ground. Two athletic coaches with several years of coaching experience determined whether depth was reached independently from one another. The same two coaches judged the deadlift. The lift was good if the subject kept a neutral spine and locked the weight at full hip extension. A given weight was considered successfully lifted only at consent of both coaches. All subjects that were initially recruited completed all items of the test battery. The strength tests were stopped if the spotter had to step in or if a safe execution of a given movement over the full range of motion was no longer possible. Grgic, Lazinica, Schoenfeld, and Pedisic (2020) describe 1 RM testing as a reliable test of muscle strength with a median intraclass correlation coefficient (ICC) of 0.997.

Vertical and horizontal jump performance testing

Warm-up for day two comprised of five sideline-to-sideline (regular basketball court) runs ascending in intensity with 30 s of rest in-between runs. The athletes were instructed to complete the last run with a subjectively perceived 80% of full sprint speed. Subsequently, participants performed several dynamic mobility exercises as well as two sets of five reps on jump squats. All warm-ups were supervised by an athletic coach.

The CMJ is known to be a valid test for vertical jump performance and therefore for explosive strength (Markovic, Dizdar, Jukic, & Cardinale, 2004). CMJ height was calculated via flight time using a force plate with a surface area of 80 × 60 cm.

Subjects started in an erect position with their hands placed on the hips. Participants were instructed to quickly descend to a self-selected depth and initiate the concentric phase with maximal explosive effort to reach maximal height. During flight and landing, subjects had to keep knees and hips extended toes as well elevated. CMJ has a high test–retest reliability of ICC = 0.88–0.98 (Slinde, Suber, Suber, Edwén, & Svantesson, 2008; Yáñez-García, Rodríguez-Rossel, Mora-Custodio, & González-Badillo, 2019).

Since horizontal jump performance is part of many performance tests (Alricsson, Svensson, Olausson, & Werner, 2018; Alves, Marta, Neiva, Izquierdo, & Marques, 2016), we used the SLJ as an additional jump test. A starting line as well as a tape measure were fixed on the floor. Participants were instructed to use arm swing and aim for maximal distance. Attempts were only valid if the participant landed on flat feet meaning no tipping over or touching the ground with any other body part. The distance was determined by the investigator using a measuring bar consisting of two sticks aligned in an exact 90° angle. Markovic et al. (2004) describe the ICC for SLJ with r = 0.95.

Table 3 Correlation coefficients and *partial correlation coefficients* for relationship between maximal strength measurements and sport-specific movement tasks

Test	CMJ	SLJ	LSp 5 m	LSp 10 m	LSp 20 m	aTT
3 RM FSQ	0.89 [0.81 to 0.94], $p < 0.001$ *0.70 [0.47 to 0.84], p < 0.001*	0.91 [0.85 to 0.95], $p < 0.001$ *0.75 [0.61 to 0.85], p < 0.001*	−0.76 [−0.87 to −0.6]. $p < 0.001$ *−0.41 [−0.62 to −0.16], p = 0.008*	−0.82 [−0.9 to −0.69]. $p < 0.001$ *−0.55 [−0.72 to −0.35], p < 0.001*	−0.88 [−0.93 to −0.78], $p < 0.001$ *−0.63 [−0.78 to −0.44], p < 0.001*	−0.86 [−0.93 to −0.78], $p < 0.001$ *−0.61 [−0.77 to −0.41], p < 0.001*
3 RM DL	0.85 [0.73 to 0.92], $p < 0.001$ *0.54 [0.27 to 0.74], p < 0.001*	0.88 [0.78 to 0.93], $p < 0.001$ *0.61 [0.40 to 0.79], p < 0.001*	−0.71 [−0.84 to −0.52], $p < 0.001$ *−0.23 [−0.49 to 0.052], p = 0.143*	−0.73 [−0.85 to −0.55], $p < 0.001$ *−0.30 [−0.57 to 0.00], p = 0.058*	−0.82 [−0.90 to −0.68], $p < 0.001$ *−0.40 [−0.68 to −0.07], p = 0.01*	−0.84 [−0.91 to −0.71], $p < 0.001$ *−0.44 [−0.67 to −0.19], p = 0.004*

CMJ countermovement jump, *SLJ* standing long jump, *aTT* agility T-Test, *LSp* linear sprint, *FSQ* front squat, *DL* deadlift

Linear sprint performance testing

LSp was measured using light barriers (WittyGATE, Microgate Srl, Mahopac, NY, USA) on basketball parquet floor over a 20 m distance at 5, 10, and 20 m. The light barriers were positioned 40 cm above the floor. Subjects started in the two-point stance with their front foot on the starting line positioned 10 cm in front of the first light barrier. The ICC for the test–retest reliability can be classified as high ($r = 0.82$–0.97; Austin, Gabbett, & Jenkins, 2013).

Change of direction performance testing

Change of direction performance was tested via the basketball-specific aTT using the same light barrier system as for LSp. Participants started in the two-point stance with their front foot on the starting line which was placed 10 cm in front of the first light barrier. Subjects sprinted 10 m straight forward to the first cone, 5 m side steps left to the second cone, 10 m side steps right to the third cone, 5 m side steps left back to the first cone and 10 m backwards through the light barriers. Every time the participant changed direction upon passing a cone, he had to touch the cone with one hand. The aTT performance was measured in seconds. Stewart et al. (2012) report a high test–retest reliability for the aTT with an ICC of $r = 0.95$.

All subjects were familiar with the tests. To ensure familiarization with the test equipment, the subjects underwent a habituation session in the CMJ, SLJ, LSp and aTT exercises 1 week before the day of testing.

Statistical analyses

The data was analyzed using SPSS 28 (IBM, Ehningen, Germany). The significance level for all statistical tests was set at $p < 0.05$. The descriptive statistics for all measurements are presented as the mean (M) ± standard deviation (SD). Reliability analyses were performed for pretest (habituation session) best and the actual test's best value using the ICC with 95% confidence interval (CI) and the coefficient of variability (CV). The Shapiro–Wilk test was used to check normality of data. A bivariate one-tailed Pearson correlation analysis was used to assess the relationship between maximal strength in the lower extremity measured with the front squat and the deadlift and the motor ability performance values in the 5, 10, and 20 m LSp, the CMJ and SLJ as well as the aTT. In addition, the correlations were controlled for the influence of age via the calculation of a partial correlation. Consequently, five subgroups were formed and the respective correlations between the performance variables were calculated for the individual subgroups as well as tested for differences. To ensure no significant differences in correlation coefficients in the subgroups, the data was z-transformed according to Fisher's z' transformation ($z = \frac{z'_1 - z'_2}{\sqrt{\frac{1}{n_1-3}+\frac{1}{n_2-3}}}$). Afterwards, Benjamini and Hochberg's method was used to control the study wise false discovery rate to be 0.05 (Ferreira & Zwinderman, 2006). Only the best performances for CMJ, SLJ, LSp and aTT as well as the tested 3 RM for the front squat and deadlift were used for statistical analyses. The ICC values listed in ◘ Table 1 describe the test-retest reliability between the best value of the habituation session and the best value measured at the day of testing. Relationships were classified as follows: 0 = no correlation, $0 < |r| < 0.2$ = very low correlation, $0.2 \le |r| < 0.4$ = low correlation, $0.4 \le |r| < 0.6$ = moderate correlation, $0.6 \le |r| < 0.8$ = high correlation, $0.8 \le |r| < 1.0$ = very high correlation (Cohen, 1988). In addition, correlations between the front squat and motor ability performance as well as the deadlift and motor ability performance were z-transformed to investigate if there are significant differences in relationship for the front squat and deadlift with sprinting and jumping performance.

Results

Testing for normal distribution using Shapiro–Wilk test shows that the requirements for Pearson's product–moment correlation are fulfilled. ICC with 95% CIs, CV, and correlations for the performance tests are listed in ◘ Table 1. With high ICC values between 0.85 and 0.98, a good reliability can be assumed for the motor ability performance tests.

◘ Table 2 shows descriptive statistics of measured values.

Correlation coefficients between subgroups did not statistically differ ($p < 0.05$). Therefore, all correlation coefficients were analyzed for the total group. Correlation coefficients between maximal strength in the front squat and the deadlift and the jump and sprint performance show strong to very strong correlations ($|r| = 0.71 - |r| = 0.91$, $p < 0.001$). The strongest correlations were found between 3 RM front squat and SLJ with $r = 0.914$, $p < 0.001$ followed
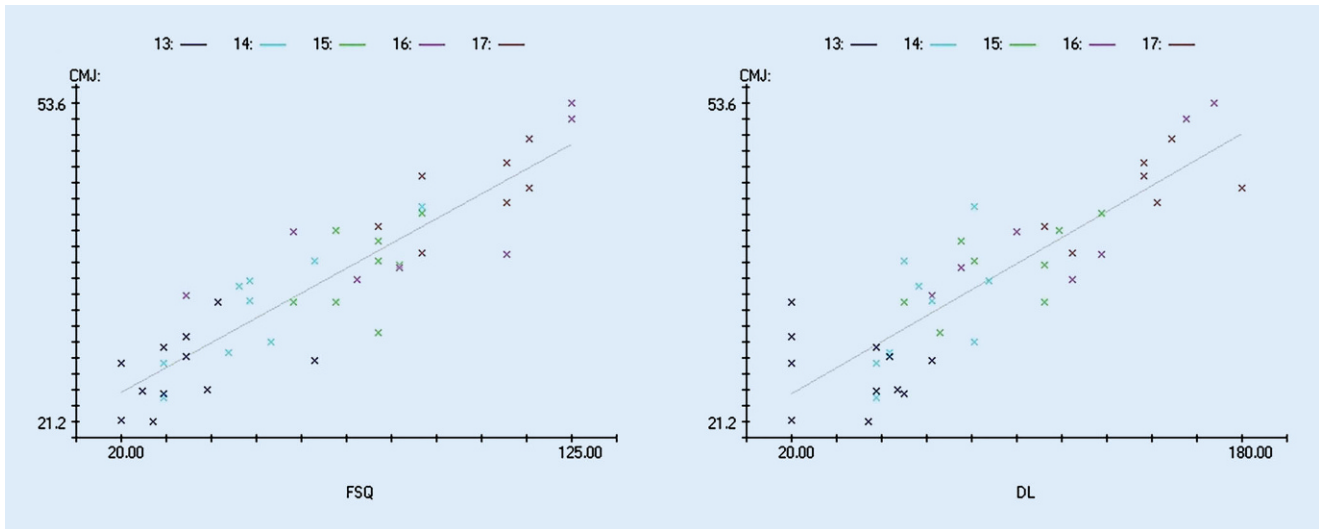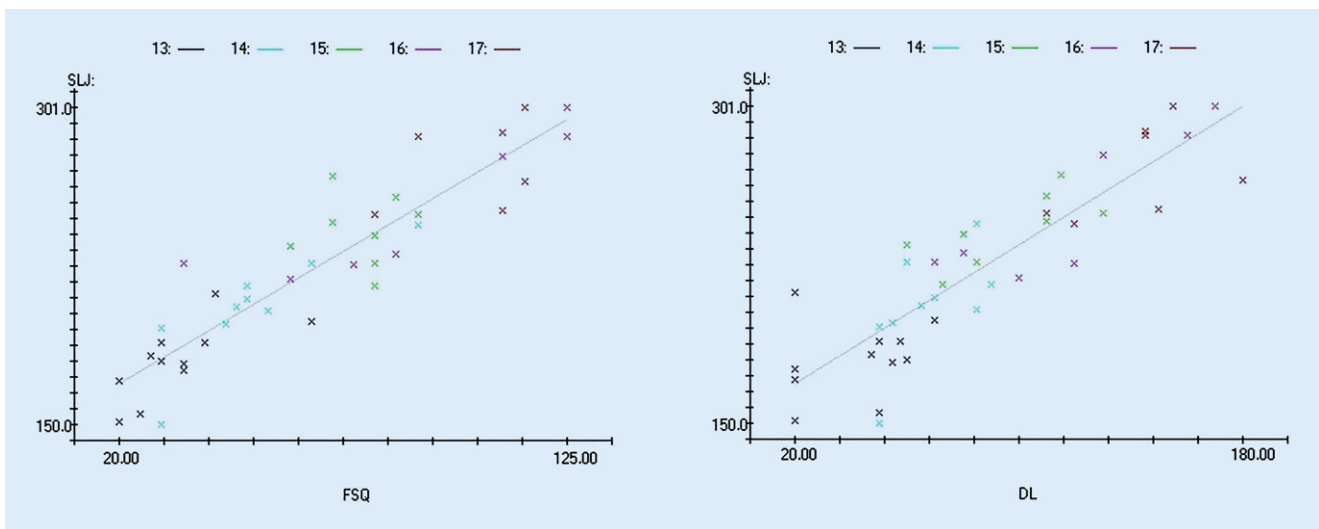
Fig. 1 ▲ Scatterplot with linear trend line of countermovement jump with front squat performance (r = 0.89, 95% confidence interval [95%CI] 0.81–0.94; r_{part} = 0.70, 95%CI 0.48–0.84; $p < 0.001$) and with deadlift performance (r = 0.85, 95%CI 0.74–0.92; r_{part} = 0.54, 95%CI 0.26–0.73; $p < 0.001$). *SLJ* standing long jump, *DL* deadlift, *FSQ* front squat, *blue crosses* 13-year-olds, *turquoise crosses* 14-year-olds, *green crosses* 15-year-olds, *purple crosses* 16-year-olds, *brown crosses* 17-year-olds

Fig. 2 ▲ Scatterplot with linear trend line of standing long jump with front squat performance (r = 0.91, 95% confidence interval [95%CI] 0.85–0.95; r_{part} = 0.75, 95%CI 0.61–0.86; $p < 0.001$) and with deadlift performance (r = 0.88, 95%CI 0.79–0.93; r_{part} = 0.61, 95%CI 0.38–0.78; $p < 0.001$). *SLJ* standing long jump, *DL* deadlift, *FSQ* front squat, *blue crosses* 13-year-olds, *turquoise crosses* 14-year-olds, *green crosses* 15-year-olds, *purple crosses* 16-year-olds, *brown crosses* 17-year-olds

by CMJ and 3 RM front squat with $|r| = 0.894$, $p < 0.001$. Strong negative correlations can be observed between maximal strength in the front squat and deadlift and all LSp times with the strongest negative correlation between 20 m LSp and 3 RM front squat with $r = -0.88$, $p < 0.001$. The least significant correlation coefficients were found for deadlift and 5 m LSp ($r = -0.71$, $p < 0.001$) and deadlift and 10 m LSp ($r = -0.73$, $p < 0.001$).

No significant differences in correlations with motor ability performance could be determined between front squat and deadlift ($p = 0.157$–0.351) in overall correlations as well as in partial correlations ($p = 0.08$–0.6). Correlation coefficients are provided in ◘ **Table 3** and graphically illustrated in ◘ **Figs. 1**, **2**, **3**, **4**, **5**, **6 and 7**.

Discussion

The aim of the present study was to investigate the influence of maximal strength in the front squat and the deadlift on athletic performance in youth elite basketball players. It was analyzed whether the maximal strength performance in the exercises tested (front squat and deadlift), and additionally the variable age, have an influence on the correlation with athletic performance. The data show strong cor-
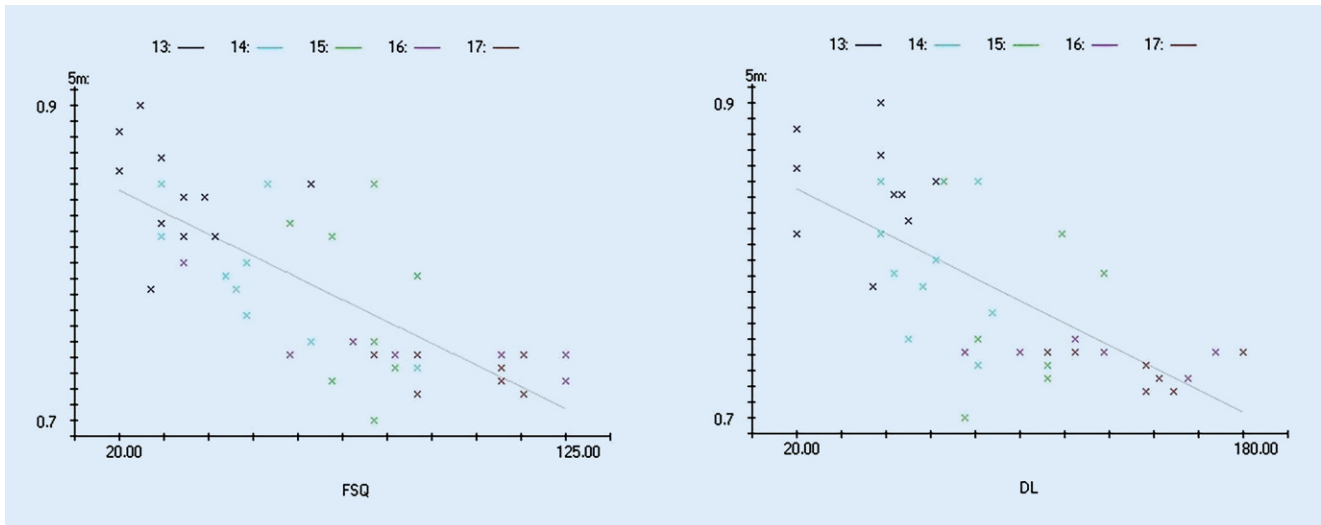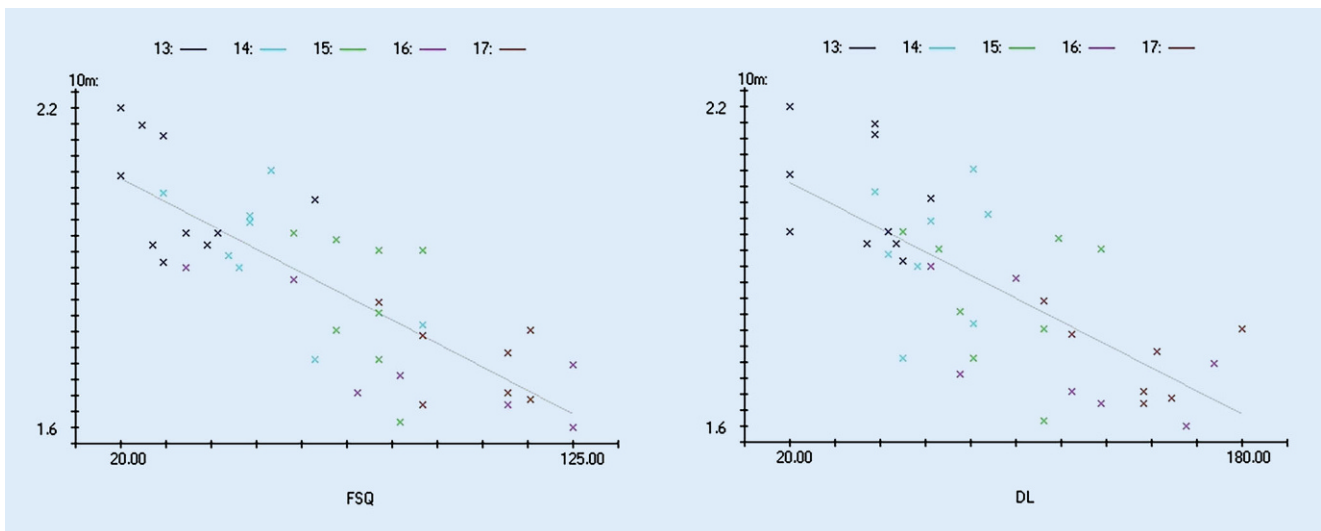
Fig. 3 ▲ Scatterplot with linear trend line of 5 m sprint with front squat performance (r = −0.76, 95% confidence interval [95%CI] −0.87 to −0.60; r_{part} = −0.40, 95%CI −0.62 to −0.17; p = 0.008) and with deadlift performance (r = −0.71, 95%CI −0.835 to −0.523; r_{part} = −0.23, 95%CI −0.48 to 0.05; p = 0.143). *5 m* 5 m linear sprint, *DL* deadlift, *FSQ* front squat, *blue crosses* 13-year-olds, *turquoise crosses* 14-year-olds, *green crosses* 15-year-olds, *purple crosses* 16-year-olds, *brown crosses* 17-year-olds

Fig. 4 ▲ Scatterplot with linear trend line of 10 m sprint with front squat performance (r = −0.82, 95% confidence interval [95%CI] −0.90 to −0.69; r_{part} = −0.55, 95%CI −0.70 to −0.36; p < 0.001) and with deadlift performance (r = −0.73, 95%CI −0.85 to −0.55; r_{part} = −0.30, 95%CI −0.56 to 0.02; p = 0.058). *10 m* 10 m linear sprint, *DL* deadlift, *FSQ* front squat, *blue crosses* 13-year-olds, *turquoise crosses* 14-year-olds, *green crosses* 15-year-olds, *purple crosses* 16-year-olds, *brown crosses* 17-year-olds

relations of maximal strength with athletic performance regardless of the exercise used to test the strength performance. In addition, there are no significant differences in the level of correlation apart from the youngest age group.

Strong correlations between maximal strength and jumping and sprinting performance are not influenced by the exercise choice being either front squat or deadlift. Strong correlations for maximum strength measured via front squat and deadlift with speed strength measured via LSp, maximal vertical and horizontal jumping can possibly be explained by similar physiological requirements like maximal neuronal activation of the motor units (Fleck & Kraemer, 2004; Zatsiorsky, Kraemer, & Fry, 2020). Although the results are not statistically different, the proximity in the movement execution of the squat with the jump tests should be kept in mind which is less pronounced in the deadlift

which entails differences in muscle activation. Delgado, Drinkwater, Banyard, Haff, and Nosaka (2019) showed similar activation in the glutes comparing squat movements with (Romanian) deadlift but a higher and simultaneous activation of the knee extensors which may play a key role in jumping performance. In addition, higher joint moments in the hip were observed performing the deadlift; there seems a higher focus on knee extensors when performing squat
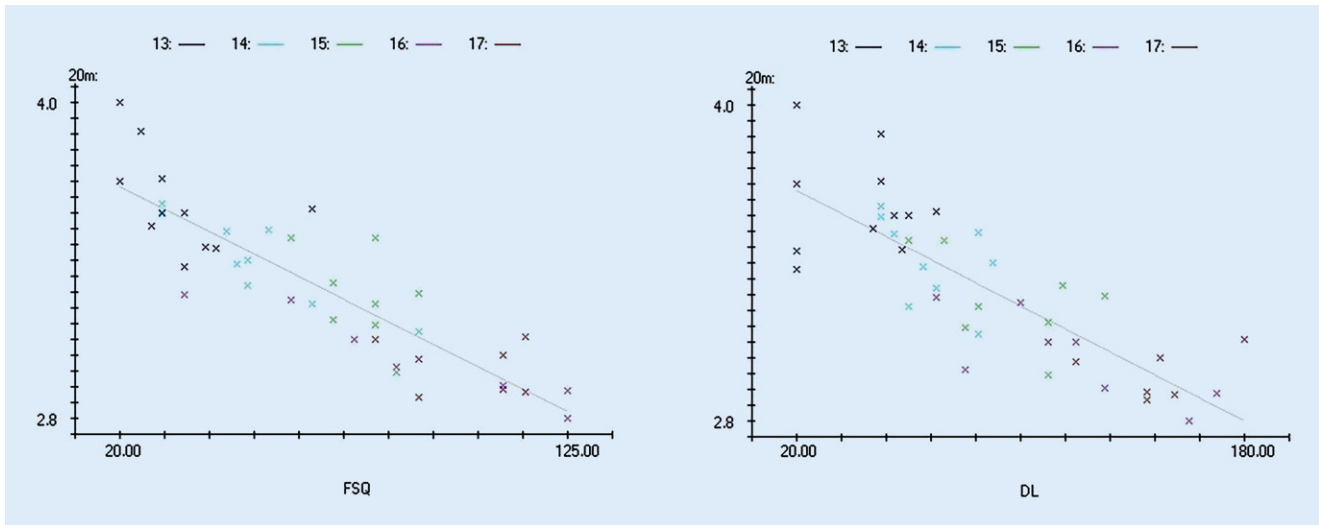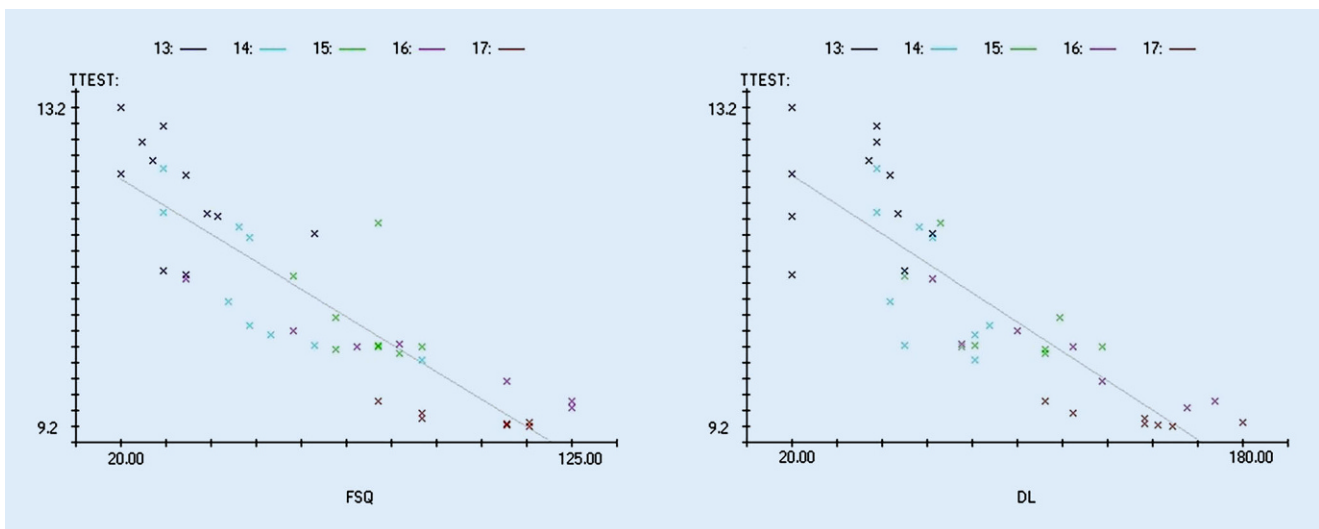
Fig. 5 ◂ Scatterplot with linear trend line of 20 m sprint with front squat performance (r = −0.88 95% confidence interval [95%CI] −0.93 to −0.78; r_{part} = −0.63, 95%CI −0.78 to −0.44; $p < 0.001$) and with deadlift performance (r = −0.82, 95%CI −0.9 to −0.68; r_{part} = −0.40, 95%CI −0.66 to −0.03; $p = 0.01$). *20 m* 20 m linear sprint, *DL* deadlift, *FSQ* front squat, *blue crosses* 13-year-olds, *turquoise crosses* 14-year-olds, *green crosses* 15-year-olds, *purple crosses* 16-year-olds, *brown crosses* 17-year-olds

Fig. 6 ◂ Scatterplot with linear trend line of change of direction sprint with front squat performance (r = −0.88, 95% confidence interval [95%CI] −0.93 to −0.78; r_{part} = −0.61, 95%CI −0.77 to −0.41; $p < 0.001$) and with deadlift performance (r = −0.85, 95%CI −0.92 to −0.74; r_{part} = −0.44, 95%CI −0.64 to −0.17; $p = 0.004$). *aTTest* agility T-Test, *DL* deadlift, *FSQ* front squat, *blue crosses* 13-year-olds, *turquoise crosses* 14-year-olds, *green crosses* 15-year-olds, *purple crosses* 16-year-olds, *brown crosses* 17-year-olds

movements (Choe et al., 2021). Therefore, neuronal adaptations to training processes also lead to a high degree of specificity of strength training (Folland & Williams, 2007). Interestingly, the correlations for the overall group between strength performance (independent of the strength exercise tested) and sprint, jump, and COD performance (despite differences in target performance complexity) consistently show a strong corre-

lation. Generally, this confirms the high importance of strength for explosive performance (Schmidtbleicher, 1987).

The partial correlations (adjusted for age) have slightly lower coefficients, indicating an influence of age on the correlations between maximal strength and explosive strength performances. However, analysis of differences in correlation coefficients between age groups showed that there is no significant influence of

age on the correlations, with exception for the 13-year-olds. Therefore, especially the subgroup of 13-year-olds could be responsible for the reduction of the coefficient in the partial correlation analysis. However, the nonsignificant differences in the age groups could also explain the significant level of the overall effect due to the (partly) small number of subjects. Generally, differences might be attributed to variations of biological
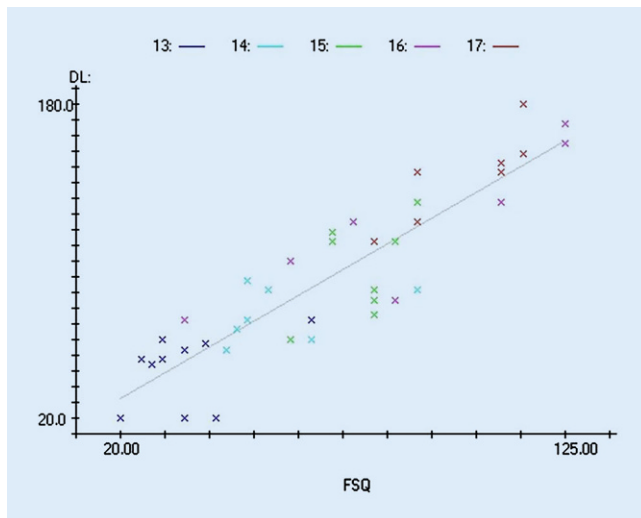
Fig. 7 ◄ Scatterplot with linear trend line of deadlift with front squat performance (r = 0.90, 95% confidence interval [95%CI] 0.82–0.94; r_{part} = 0.68, 95%CI 0.47–0.81; p < 0.001). *DL* deadlift, *FSQ* front squat, *blue crosses* 13-year-olds, *turquoise crosses* 14-year-olds, *green crosses* 15-year-olds, *purple crosses* 16-year-olds, *brown crosses* 17-year-olds

age as well to body growth and associated coordinative deficits. Furthermore, it can be hypothesized that subjects with less strength training experience are more focused on proper movement technique in the highly demanding exercises front squat and deadlift and as a result not being able to focus on producing high 3 RM values (Suchomel, Nimphius, & Stone, 2016). In this study, younger subjects (especially the 13-year-olds) had less training experience compared to older participants in the front squat and deadlift. Subsequently, older subjects might have been able to focus more on loading the barbell than on technique. Therefore, the varying training experience could also be responsible for the reduction of the coefficients of the partial correlations, not the age of the subjects. This can, however, not be verified from the data collected in this study.

The study is limited by the ad hoc sample, moreover, the sometimes small number of subjects in the subgroups, which increases the sampling error. The results should therefore be interpreted with caution. Future studies should investigate correlations between maximal strength and sport-specific performance values in children and youth athletes with higher strength levels as well as higher subject numbers for each age group. In addition, the present study was conducted with male participants only. Female subjects should be added in future studies. Nonetheless, in a cross-sectional analysis, gender is not expected

to influence the results. In summary, the results show strong correlations between strength performance and athletic performance in young basketball players, regardless of the strength exercise tested. Moreover, there are no significant differences in the level of correlation except for the youngest age group, which, however, can be explained by low experience in the strength exercises tested in this study.

Practical application

This study found strong correlations in the front squat and deadlift performance and sprinting and jumping ability in young basketball players. It can be concluded that maximum strength in both exercises is strongly correlated to vertical and horizontal jumping performance as well as sprinting performance in LSp and aTT, which can be seen as important performance parameters in basketball. Based on this, maximum strength testing in the front squat and deadlift seem to be valid predictors for jump and sprint performance and should be included in performance monitoring even in the youth. The effect of strength training on explosive strength performance is well documented for team sports, especially soccer (Faigenbaum & Myer, 2010; Keiner, Kadlubowski, Sander, Hartmann, & Wirth, 2022). Strength training in children and adolescents cannot only be deemed unproblematic but as beneficial for the health and mental development as long as training is super-

vised and proper technique is learned and used (Faigenbaum & Myer, 2010; Stricker, Faigenbaum, & McCambridge, 2020).

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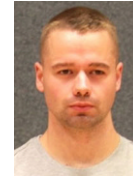
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Declarations

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