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Sprint Speed and Musculoskeletal Fitness Test Performance in Youth

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24 Pages

Sprint speed is a common focus of adult strength and conditioning programming and research. However, the links between sprint speed and other tests of musculoskeletal performance have not been extensively studied in youth. PURPOSE: To investigate the relationship between sprint speed and tests of jumping performance, muscular strength/endurance, agility, and anaerobic capacity in children and adolescents. METHODS: The analysis included 402 boys and 148 girls (ages 7 to 18 years) participating in a baseline musculoskeletal fitness evaluation. Sprint speed was assessed via a 10-yard and 20-yard sprint. Agility and anaerobic capacity were assessed via the pro-agility and 200-yard shuttle run, respectively. Muscular strength and endurance was assessed by maximal number of chin-ups and jumping performance was assessed via vertical jump, broad jump, and 5-hop jump tests. Pearson correlations were used to determine the associations between each fitness test relative to the 10- & 20-yard sprints, controlling for age and sex. RESULTS: Correlations were stronger between 20-yard dash and musculoskeletal fitness test than the 10-yard dash and musculoskeletal fitness. For example, the highest correlations were with the pro-agility test which was r= 0.76 for the 20-yard dash and r= 0.66 for the 10-yard dash. Data shows stronger associations for the pro-agility and 200-yard shuttle run with the 20-yard dash compared to the other musculoskeletal fitness tests with correlations of r= 0.76 and 0.76, respectively. The broad jump had a slightly better relationship than other jumping performance tests with a correlation of r= -0.66. However, these jumps were generally very similar in strength with the relationships of r= -0.63 for the vertical jump test and r= -0.63 for the 5-hop test. CONCLUSIONS: These findings show stronger relationships with the agility and anaerobic capacity musculoskeletal fitness tests. In general, we found weak-to-moderate association between sprint speed and several dimensions of muscular fitness in youth. Future investigations are needed to determine if enhancement of these other aspects of fitness would lead to improvements in sprinting times.

KEYWORDS: Musculoskeletal Fitness Tests, Youth, Athletes, Sprint Speed, Performance

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CONTENTS

TABLES

Figures

CHAPTER I: SPRINT SPEED AND MUSCULOSKELETAL FITNESS TEST PERFORMANCE IN YOUTH

Introduction

Sprint performance is a necessity for the fundamental skills that are included in many sports (Rumpf et al. 2012) (Tottori and Fujita 2019) (Mendez-Villanueva et al. 2011). These fundamental skills are important for performance in adults as well as in youth (Tottori and Fujita 2019). Studies have found that there are different components that are related to being successful in sprinting. The components that are associated with competitive sprinting performance include the abilities of: acceleration, (Mendez-Villanueva et al. 2011) (Cometti et al. 2001) (Reilly 2005) maximum running speed, (Mendez-Villanueva et al. 2011) (Buchheit et al. 2010) (Little and Williams 2005) and repeated sprint ability (Mendez-Villanueva et al. 2011) (Rampinini et al. 2007) (Aziz et al. 2008). When athletes improve the fundamental skills of sprinting performance at younger ages they have a greater chance of developing into a better athlete (Tottori and Fujita 2019). Research has identified critical periods for children to develop specific skills for sprint training improvements. These time periods have been called 'windows of trainability' for athletes ranging from 5-9 and 12-15 years old (Borms 1986; Rumpf et al. 2012) (Branta, Haubenstricker, and Seefeldt 1984; Viru et al. 1999). The first critical period, ages 5-9, is the development of neural adaptation that is beneficial for agility, balance, coordination and speed (Viru et al. 1999) (Balyi and Way n.d.). The second window is dependent on maturation status and takes places around 12-15 years old, which is about the age when children reach their peak height velocity (Borms 1986; Rumpf et al. 2012; Viru et al. 1999). In this stage, young athletes develop higher level motor skills such as fast and precise foot movements (Mendez-Villanueva et al. 2011; Viru et al. 1999).

Since multiple factors are relevant to sprint performance, there may be multiple measures, or dimensions of fitness, in any testing battery that are indicators for sprint speed development and overall development of young athletes. For example, a previous research study looked at the reliability of the vertical jump test when comparing it to sprint and strength performance (Rodríguez-Rosell et al. 2017). In this study they compared the vertical jump with a 20 meter (m) sprint and concluded that this test was a reliable for the estimation of explosive force of the lower limbs and was statistically significant with sprint performance in soccer and basketball players (Rodríguez-Rosell et al. 2017). A different study examined the effect of repeated shuttle sprints and explosive training on sprinting ability (Buchheit et al. 2010). The shuttle run group focused on 15 to 20 m sprints and the explosive strength group focused on jump and plyometric training. The study found that repeated shuttle sprints and explosive training both were equally efficient at enhancing maximum sprinting speed performance (Buchheit et al. 2010).

Although, laboratory-based tests or kinematic evaluations may be more specific to the individual components of sprinting, they are also less accessible to youth athletes and coaches. Therefore, linking field tests of fitness to these sprinting components may be a more realistic application for the practitioner. In addition, the different categories of fitness each musculoskeletal test is focused around has been limitedly studied and there is more research that needs to be done to examine the information each test provides to coaches. Therefore, the purpose of this study is to quantify the relationship between various field tests of fitness and sprint speed performance. This study hopes to determine what test are the most useful to focus on for training to become better sprinters for performance benefits in sports.

Methods

There was a total of 550 (402 boys and 148 girls) children ages 7 to 18 years old that participated in the musculoskeletal fitness evaluations that were used for this study. Figure 1 shows how many subjects participated in the study based on age. Subjects reported to the training center, were given a verbal description of the purpose of the evaluations and participated in 5 musculoskeletal fitness tests used to assess athletic ability and performance across 4 different dimensions of fitness. The pro-agility and 200-yard shuttle run were used to determine agility and endurance. Power was determined by the vertical jump, broad jump, and 5 hop tests. Upper body muscular strength and endurance was measured via chin ups. Participants also completed two sprint tests; the 10- and 20-yard sprint.

Procedures

Participants and parents were first verbally instructed of the evaluation, along with a timeframe so the parents and child were aware of the expectations of the evaluation. The participant would then start the evaluation with the CSCS trained coach. The evaluation varied each session with 1 to 8 participants at a time. For the first 5 to 10 minutes, all participants in the evaluation session completed a warmup together. The warmup consisted of 2 sets of 10 repetitions each for the following exercises: power squats, jumping jacks, seal jacks, and highland flings. Once two sets of those exercises were completed, they proceeded to 2 sets of 15 yards of the following agility drills: front skip, side shuffle, and backward cycle. Once the participants were warmed up, they moved on to the musculoskeletal fitness assessment portion of the evaluation. The participants participated in 7 different musculoskeletal fitness assessments that will be discussed in respective order.

10-and 20-yard sprint. The participants were timed to sprint down 10- and 20-yards, respectively. For both sprint tests, the first trial did not count in order to familiarize the participant with being timed and was instructed to run straight through the 10- and 20- yard marks. Second trial was recorded for both of the sprints.

Pro-agility. The participants were timed, using a stopwatch, to assess how fast they completed a sprint that consisted skills of acceleration and quick change of direction. The subjects were set up in the middle of two lines that were 10-yards a part with their hand on the ground of the direction they will run in first. They started by sprinting 5-yards and quickly turned to sprint 10-yards the opposite direction, followed by another quick turn 5 more yards back to where they originally started. The subjects were instructed to touch the line for the first 5-yards and for 10-yard sprint. Subjects were instructed to run through the line on the final five yards. The stopwatch ended as the subjects' hip passed through the starting line. The athlete was able to have up to two attempts for this test.

Vertical jump. The vertec was used for this measurement. The subject was instructed to stand next to the vertec and reach up as high as they could while maintaining both feet flat on the floor to obtain the appropriate height for each participant, at the 10-inch mark. They were instructed to stand in line with the pole facing outwards. The subject performed a countermovement jump with arm swing. Each participant had 3 attempts; highest score was recorded.

Broad jump. Each participant would start behind the line and jump forward as far as they could using their arms and legs. They were instructed to land with both feet on the ground and without moving their feet until the measurement was completed at the back of the heel. The distance was measured in inches using a measuring wheel. Results were then converted from inches to centimeters for the analysis. Two attempts were given.

5-hop jump. This assessment was instructed the same as the broad jump, however, the participant would jump 5 times stopping in between every jump. It was important to ensure that the child did not take any steps in between to obtain appropriate distance of the 5 hops for each individual. Two attempts were given.

Chin-up. The participants were at a pull up bar where they were instructed to do as many chin ups as they possibly could. A chin up was only counted if the child started with straight arms and successfully brought their chin above the bar. Assistance was given to children that needed assistance to reach the pull up bar. One attempt was given.

200 yard shuttle run: The participants were recorded with a stopwatch in order to complete this run as quickly as possible. The participants started at the 30-yard line and sprinted to the 5-yard line and back. They would complete a 25-yard run 4 times to equate to 200-yards. One attempt was given.

Statistical Analysis

Descriptive statistics were conducted for all participants along with genders for the following variables: age, 10-yard sprint, 20-yard sprint, pro-agility, 200-yard shuttle, vertical jump, broad jump, 5-hop, and chin-ups by means and SD. After, a regression analysis was performed for all musculoskeletal fitness tests for the 10- and 20-yard sprints. A regression analysis was performed for all participants controlling for age and sex. Another regression analysis was performed based on the fitness tests separating by gender. The last regression test that was ran was to divide the sample into younger ages and older ages based on correlations of sprint speed and musculoskeletal tests. Lastly, an independent t-test was used to find the associations for subjects' 10- and 20-yard sprint times and average chin ups for athletes in the top 20% and bottom 80% groups. The average chin ups for boys was 8 and 2 for girls. The older subjects were used and divided into girls and boys.

Figure 1. Demographics

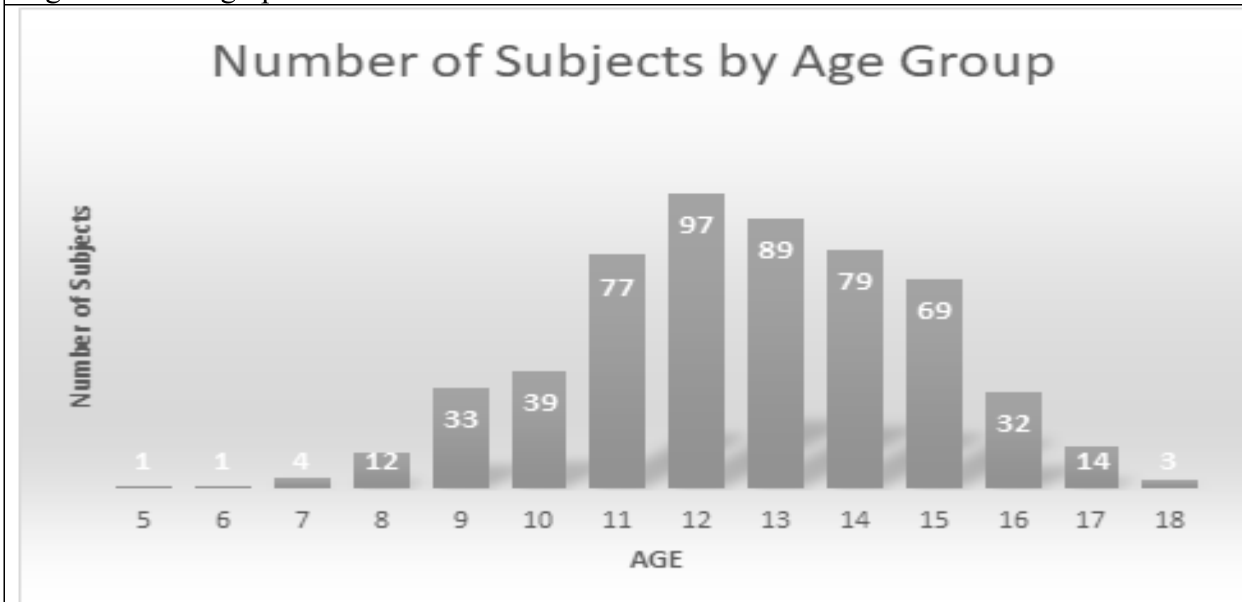

Table 1. Descriptive Statistics			
	All	Boys	Girls
Age (years)	n=548	n=400	n=148
	12.6(2.2)	12.7(2.2)	12.5(2.1)
10-Yard Sprint (sec)	n=548	n=400	n=148
	2.15(0.27)	2.12(0.28)	2.23(0.24)
20-Yard Sprint (sec)	n=548	n=398	n=147
	3.63(0.45)	3.58(0.45)	3.77(0.39)
Pro-Agility (sec)	n=548	n=400	n=148
	5.67(0.65)	5.59(0.66)	5.89(0.59)
200-yard Shuttle (sec)	n=492	n=358	n=134
	45.76(6.14)	45.11(6.22)	47.48(5.58)
Vertical Jump (cm)	n=435	n=303	n=132
	43.7(11.6)	45.2(12.7)	40.2(7.5)
Broad Jump (cm)	n=392	n=287	n=105
	176.5(36.2)	181.3(38.6)	163.3(24.5)
5-Hop (cm)	n=467	n=345	n=122
	943(186.7)	971.6(195.6)	862.1(128.5)
Chin-Ups	n=547	n=400	n=147
	2.8(4.1)	3.3(4.3)	1.4(2.9)

Table 2. Sprint Time and Fitness Test Correlations of All Youth Athletes			
		All	
Fitness Test	Sprint	r	r^2
Pro-Agility	10-yard	0.66	0.58
	20-yard	0.76	0.72
200-yard Shuttle	10-yard	0.64	0.56
	20-yard	0.76	0.73
Vertical Jump	10-yard	-0.62	0.54
	20-yard	-0.63	0.61
Broad Jump	10-yard	-0.56	0.49
	20-yard	-0.66	0.63
5-Hop	10-yard	-0.54	0.48
	20-yard	-0.63	0.62
Chin-Ups	10-yard	-0.38	0.37
	20-yard	-0.41	0.47
Note: All values are statistically significant ($p < 0.001$)			

Table 3. Sprint Time and Fitness Test Correlations of Boys and Girls					
		Boys		Girls	
Fitness Test	Sprint	r	r^2	r	r^2
Pro-Agility	10-yard	0.62	0.57	0.74	0.58
	20-yard	0.72	0.72	0.83	0.74
200-yard Shuttle	10-yard	0.62	0.57	0.66	0.49
	20-yard	0.74	0.73	0.78	0.67
Vertical Jump	10-yard	-0.64	0.58	-0.56	0.37
	20-yard	-0.64	0.8	-0.63	0.69
Broad Jump	10-yard	-0.54	0.70	-0.61	0.65
	20-yard	-0.65	0.81	-0.68	0.73
5-Hop	10-yard	-0.51	0.69	-0.58	0.63
	20-yard	-0.60	0.79	-0.68	0.73
Chin-Ups	10-yard	-0.37	0.62	-0.33	0.42
	20-yard	-0.41	0.51	-0.34	0.23
Note: All values are statistically significant ($p < 0.001$)					

Table 4. Sprint Time and Fitness Test Correlations of Younger Ages and Older Ages					
		Younger Ages, 7-11		Older Ages, 12-18	
Fitness Test	Sprint	r	r^2	r	r^2
Pro-Agility	10-yard	0.70	0.57	0.63	0.51
	20-yard	0.79	0.68	0.73	0.65
200-yard Shuttle	10-yard	0.69	0.55	0.62	0.50
	20-yard	0.76	0.68	0.76	0.68
Vertical Jump	10-yard	-0.59	0.43	-0.64	0.53
	20-yard	-0.60	0.45	-0.67	0.58
Broad Jump	10-yard	-0.55	0.33	-0.57	0.47
	20-yard	-0.61	0.40	-0.69	0.61
5-Hop	10-yard	-0.56	0.38	-0.53	0.42
	20-yard	-0.64	0.47	-0.62	0.55
Chin-Ups	10-yard	-0.34	0.14	-0.37	0.25
	20-yard	-0.38	0.16	-0.41	0.30
Note: All values are statistically significant ($p < 0.001$)					

Results

Table 2 shows the descriptive data of age and musculoskeletal fitness characteristics for all subjects that participated in the study along with the differences between genders. Complete data collection was gathered for all participants for 10-yard sprint, 20-yard sprint and pro-agility. Boys appeared to have a faster sprint speed average than girls.

The associations of the different musculoskeletal fitness tests that were used to assess the relationship with sprint speed is shown in Table 3. There were stronger associations for the 20-yard sprint test with the other musculoskeletal fitness tests than for the 10-yard sprint test, controlling for age and sex. There were higher correlations for the pro-agility and 200-yard shuttle run with the 20-yard sprint compared to the other musculoskeletal fitness tests. We saw a slightly better relationship with the broad jump test than the other jumping tests. Although, all jumps had a similar strength association. The weakest relationship for the musculoskeletal fitness tests was for chin ups.

Table 4 also shows the relationships of these musculoskeletal fitness test between genders controlling for age. The associations were similar to our correlations with all participants of the study. However, we saw higher correlations with the pro-agility test compared to the boys during the 20-yard sprint. The boys had a greater association between the 20-yard sprint and the chin ups compared to the girls. There were also very little differences in association between the two sprint distances and chin up for girl participants. As for the boys, there was almost no correlation differences between the two sprints and vertical jump.

The relationships between the musculoskeletal fitness tests were also shown between ages that are also shown in table 5. We classified age into younger groups (ages 7-11 years) and older groups (ages 12-18 years). This comparison was also similar to the relationships of all participants. However, there were stronger association for the younger group for the pro-agility, and five hop tests when compared to the older group. Therefore, the older group had stronger associations for chin ups, vertical jump, and broad jump compared to the younger group. The 200-yard shuttle run test appeared to have a similar strength relationship for both age groups.

Youth in the top percentile of chin-up performance had faster sprint times for both the 10- and 20-yard sprint. Boys of the top 20% of chin ups ran faster sprint times than the bottom 80% of chin up boys by -0.23 and -0.41 for the 10- and 20-yard dash, respectively. The difference was statistically significant, 10-yard sprint was t (281) -6.26, $p=0.0001$ and 20-yard sprint was t (279) -7.68, $p=0.0001$. Girls of the top 20% of chin ups ran faster sprint times than the bottom 80% of chin up girls by -0.16 and -0.24 for the 10- and 20-yard dash, respectively. The difference was statistically significant, 10-yard sprint was t (97) -3.08, $p=0.003$ and 20-yard sprint was t (96) -2.90, $p=0.005$.

Discussion

The purpose of this study was to assess if there was a relationship between sprint speed and various tests of jumping performance, muscular strength/endurance, agility, and anaerobic capacity in youth athletes. Overall, the present study found that there were stronger correlations between the musculoskeletal tests and the 20-yard sprint compared to the 10-yard sprint. The results indicated that tests that measured agility and anaerobic capacity were the most correlated with the 10- and 20-yard sprint times. This provides coaches with useful information that incorporating exercises that focus on change of direction movements or training anaerobically may help improve athletes sprint times. The jumping performance tests assessed lower body power showed strong relationships with quicker sprinting times. However, the broad jump had the highest correlation among the two other jump tests, but all correlations were similar in strength. This indicates that it is possible that increasing lower body power may increase sprint speed, but a longitudinal study would be needed to confirm this effect. Boys and girls have similarly moderate results between all musculoskeletal fitness test compared to both sprint speeds. Boys had stronger correlations for chin ups and the 20-yard sprint compared to the girls, $r= -0.41$ and -0.34, respectively. However, girls seemed to have higher correlations compared to boys for the pro-agility test ($r=0.83$ and 0.72). As for the jumping tests, girls and boys both had the highest correlations for the broad jump and 20-yard dash. Between younger (7-11 years) and older (12-18 year) athletes had stronger correlations with the musculoskeletal fitness tests and the 20-yard sprint as well. The older athletes had stronger correlations with the 20-yard sprint and chin-ups, vertical jump and broad jump tests compared to the younger athletes. The younger athletes had higher correlations for the five hop and pro-agility during the 20-yard sprint compared the older athletes.

The skill of sprinting involves horizontal and vertical impulses, and training various horizonal and vertical jumps may improve speed (McCurdy et al. 2010). We found moderate strength correlations (ranging from r=-0.51 to -0.69) between sprint speed and performance on the vertical, broad, and 5-hop tests. Similarly, a prior study comparing associations between bilateral and unilateral jumping performance and 10- and 25-m sprint performance times in female soccer players found that horizontal and vertical jumps were significantly correlated with the 10 and 25-m sprint, but relationships were stronger for unilateral jumps (McCurdy et al. 2010). Unilateral jumps might be useful in terms of the association with sprint speed; however, unilateral movements are more complicated and may be more difficult to replicate in youth subjects. Regardless, we found that bilateral jumps were also significantly associated with sprint speed.

The pro-agility test was one of the highest correlated tests of our study in regard to sprint speed (ranging from r=0.62 to 0.83). A study by Young et al. (Young, McDowell, and Scarlet 2001) compared agility and straight sprinting tests were interested in determining if training in either tests would transfer into the other. To clarify, if training agility exercises, would that training transfer to improve sprinting in a straight line and vice versa. Young et al. also found that there were significant improvements of sprint speed with sprint training but limited improvements with agility training and sprint speed. The study found that the more complex the agility tests were the less likely there were improvements in sprint speed. However, one of the agility tests, only changed direction two times therefore, showed significant improvements in straight sprint speed (Young, McDowell, and Scarlett 2001). The research of Young et al. supports the present study because the pro-agility test is an agility drill but only comprises of change direction on two occasions.

Chin ups can be represented as a measure of upper body muscular strength and endurance (Sekerak and Zimmermann 2008). We found that boys and girls with that were included in the top 20% groups of chin ups had shorter 10- and 20-yard sprint times. A study found that subjects with longer arms or taller stature required more work than for people with a shorter stature (Sekerak and Zimmermann 2008). They found the taller the subjects the more they weigh, which requires the increased work compared to shorter people (Sekerak and Zimmermann 2008). This study gives us an indication that the chin up performance may have more variables involved that create an athlete to be faster sprinters. We see in our study that youth athletes in the top 20% were better sprinters. Future studies can examine if upper body strength through chin up has an association with sprint speed or is it primarily dependent on weight and stature.

These tests were conducted by a CSCS, Parisi Speed School certified Sports Performance Coach, therefore, the validity of technician was a major strength for this study's measurements. Having the same coach complete all the evaluations ensures that all evaluations were conducted and instructed the same way each time. Another strength of the study was that there was a large sample size of participates. These protocols and tests were all designed from the Parisi Speed School who has had many successes in improving athletes' performance.

In this present study, we had a larger sample of boys that participated in the study compared to girls. This may serve as a limitation for the study in order to obtain an accurate depiction on these musculoskeletal tests when comparing them between the genders. Not having access to each athlete's height and weight was a major limiting factor for the entire study. Having the BMI for the subject would have been helpful to understand if the athletes were quicker or better at certain fitness tests because of the children's weight or from other variables. This measurement would have been particularly useful for the chin up test to measure if the child's upper body strength had a correlation with sprint speed or if how light the child weighed play a bigger role.

Parisi Speed School uses these musculoskeletal tests during evaluations of youth athletes prior to starting the program in order to obtain a baseline score. The tests that were the most correlated to sprint speed was our agility test, pro-agility, and the anaerobic test, 200-yard shuttle run. These findings can support that focusing on sprinting drills will ultimately help athletes become better sprinters. There were also strong relationships between our lower body power tests: vertical jump, broad jump and five hop. Making sure to incorporate these jumps to increase lower body power will also increase an athlete's ability to be faster at sprinting. Although, the upper body strength test was the weakest association for sprint speed. We did find that running a test on older athletes showed that higher chin up repetitions resulted into the athletes having lower sprinting times. Future research should investigate how incorporating body weight and height impacts the association between sprinting times and chin ups, as well as all the other tests. In general, we found weak-to-moderate association between sprint speed and several dimensions of muscular fitness in youth. Future investigations are needed to determine if enhancement of these other aspects of fitness would lead to improvements in sprinting times.

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CHAPTER II: EXTENDED REVIEW OF THE LITERATURE

The ability to sprint is a vital component of performance for a majority of sports (Rumpf et al. 2012) (Tottori and Fujita 2019) (Mendez-Villanueva et al. 2011) (Pavei et al. 2019) (McCurdy et al. 2010). Having the skills to accelerate (Mendez-Villanueva et al. 2011) (Cometti et al. 2001) (Reilly 2005), reach maximum sprinting speeds (Mendez-Villanueva et al. 2011) (Buchheit et al. 2010) (Little and Williams 2005) and the endurance to repeat sprints are associated with competitive sprinting performances (Mendez-Villanueva et al. 2011) (Rampinini et al. 2007) (Aziz et al. 2008). There are three different phases of sprinting that includes acceleration, maximum speed, and deceleration (Pavei et al. 2019). Acceleration is a skill that is influenced by the development of concentric forces, knee extensor activity and impulses (Mendez-Villanueva et al. 2011) (Sleivert and Taingahue 2004). To be able to accelerate is the ability to cover a distance in the shortest amount of time possible by relying on individuals' power production (Pavei et al. 2019). A successful athlete has the ability to produce and apply a high amount of horizontal force and power in order to accelerate (Pavei et al. 2019) (Hunter, Marshall, and McNair 2005) (Morin, Edouard, and Samozino 2011) (Samozino et al. 2016). Acceleration is the most important phase in many sports, for example, sports like football or track. Maximum speed is activated by the stretch-shortening cycle, lower limb stiffness and hip extensors (Mendez-Villanueva et al. 2011) (Sleivert and Taingahue 2004). The skill of repeated sprint ability is mostly related to parts of the metabolism functions and motor unit activation (Mendez-Villanueva et al. 2011) (Buchheit et al. 2010) (Glaister 2005) (Spencer et al. 2005). Sprinting involves the ability to transfer energy from the hip to ankle joint and other factors (Papaiakovou et al. 2009). Age is a factor that is strongly associated with sprinting speed (Papaiakovou et al. 2009).

Starting to improve the fundamental skills of sprinting at younger ages aids in the development of better athletes (Tottori and Fujita 2019). Developing sprint speed has two critical periods during growth and maturation, which are known as 'windows of trainability' from ages 5-9 and 12-15 (Rumpf et al. 2012) (Borms 1986) (Branta, Haubenstricker, and Seefeldt 1984) (Viru et al. 1999). The first critical period is an age dependent time that focuses on the development of neural adaptations for children 5-9 years old and is beneficial for developing sprint speed (Viru et al. 1999) (Balyi and Way n.d.). The central nervous system is 95% developed by the age of 7 which aids in the development of movements such as agility, balance, coordination and speed indicating that fundamental movement and sport specific skills should be developed during this stage (Balyi and Way n.d.). Coordination and fast movements are specific training methods used to improve these neural/neuromuscular adaptations (Rumpf et al. 2012) (Praagh 1998). The second critical period is dependent on maturation of the child which focuses on acceleration adaptations. This period takes place around 12-15 years old (Borms 1986) (Viru et al. 1999), about the age when children reach peak height velocity (PHV) (Rumpf et al. 2012). Most of youth athletes develop high level motor skills such as fast and precise foot movements during ages 12 to 14 years of age (Mendez-Villanueva et al. 2011) (Viru et al. 1999). Aerobic training should be the focus at the onset of PHV and maximal strength training should begin after PHV (Balyi and Way n.d.). During the growth of children before PHV, they experience a period of rapid growth which leads to a change in leg and arm span, and center of gravity that effects performance skills such as coordination and speed, opening up the trainability period for aerobic capacity (Balyi and Way n.d.). Once children reach PHV there is a deceleration of growth that provides an excellent trainability period for aerobic power and strength (Balyi and Way n.d.). As children mature, they have an increase in hormones that increase strength and power. Therefore, sprint training should have a large focus on the muscular system (Viru et al. 1999).

The skills that are included in sprinting involve multiple components. The different components that we were looking at in our study were sprint speed, jumping performance (power), muscular strength/endurance, agility, and anaerobic capacity in youth athletes. There are relationships between motor skills that are common in different sports such as sprinting, jumping and agility in relation to performance (Vescovi and McGuigan 2008).

The broad jump and vertical jump are two field based assessments used to assess lower body explosive muscular strength or power in youth (Castro-Piñero et al. 2010). Other studies have found that muscular power is an important skill for sprinting performance and were able to use the vertical jump test to accurately measure power (Rampinini et al. 2007) (Helgerud et al. 2001) (Kotzamanidis et al. 2005) (Siegler, Gaskill, and Ruby 2003). Vertical jump is considered a complex movement and skill that relies on a high level of motor coordination of the upper and lower body (Rodríguez-Rosell et al. 2017) (Requena et al. 2014). Maximum vertical jump height is a reliable measure of leg muscular power and provides coaches with vital information about athletes functional capacity and performance in sports (Rodríguez-Rosell et al. 2017) (Bui et al. 2015). Past research have studied the reliability of the vertical jump test when comparing it to sprint and strength performance. In this study they compared the vertical jump with a 20-m sprint and concluded that this test was reliable for the estimation of explosive force of the lower limbs and was statistically significant with sprint performance in soccer and basketball players (Rodríguez-Rosell et al. 2017). Plyometric training such as vertical and horizontal jumps have been proven to increase sprinting performance in boys ages 9-12 years old (Tottori and Fujita 2019). Training sprints, different jumps and plyometric training improves running velocity for individuals (McCurdy et al. 2010) (Rimmer and Sleivert 2000). A study assessed the effect of incorporating a sprint specific plyometric program on sprint performance in male subjects of an average age of 24 years old. After the 8-week study they found that there were improvements in sprint time over the first 10-m of the subjects' sprints (Rimmer and Sleivert 2000). They also found changes in times for the 10- and 40-m sprints that were significantly greater for the plyometric group compared to the control group that only recorded pre and post sprint data (Rimmer and Sleivert 2000).

The chin up test is a measure of upper body muscular strength and endurance (Sekerak and Zimmermann 2008). One study looked at the amount of work it takes to perform a pull up based on individual stature. It appears that if a person has longer arms then it is more work for a chin up compared to others that are the same weight (Sekerak and Zimmermann 2008). Overall, the same study found that weight increases with body height so chin up work is relied upon body weight and achieving max chin up scores is highest among shorter stature people (Sekerak and Zimmermann 2008).

The ability to possess skills of sprinting and agility are important for many sports (Young, McDowell, and Scarlett 2001). These two skills involve different types of training that will have limited benefits on one another (Young, McDowell, and Scarlett 2001). Incorporating different training programs designated for agility and straight sprinting is important to improve both. A study found that an athletes' ability to cover greater distances during higher sprinting speed have a correlation with aerobic fitness/endurance (Rampinini et al. 2007). This study found that there were also strong correlations between running distances covered in a soccer match and sprint times on repeated sprint ability tests on top level soccer players (Rampinini et al. 2007). Another study found that including repeated shuttle sprints for improvement of their agility, had been shown to help with agility and maximal sprinting speeds (Buchheit et al. 2010). These studies have shown us that by practicing sprinting and agility training will ultimately result in improvements of overall sprint speed times. It was found that the more complex the agility training resulted less improvement in sprinting speed (Young, McDowell, and Scarlett 2001). Therefore, the repeated shuttle run showed agility training but also focused on sprinting in a straight line making this drill less complex and more beneficial for both skills.

The feasibility of having assess to laboratory equipment or having appropriately trained staff is limited. It can be difficult to train staff and clients to be familiar with the different movements, which leads to possible errors to gather accurate data in a safe and effective way for all subjects. Incorporating field tests involve easy movement patterns that are easy to instruct and repeat from athlete to athlete (Vescovi and McGuigan 2008). The shuttle run test is an accurate alternative field test to give us a measure of aerobic capacity because of its high correlation with maximum oxygen uptake (Rampinini et al. 2007) (Ahmaidi et al. 1992) (L. Léger and Boucher 1980) (L. A. Léger and Lambert 1982). There validity of the broad jump and vertical jump tests are still unclear. There are other studies that mention the limitations of the technical factors of this field test and how this test is dependent on anthropometric, mechanics and other coordination factors (Castro-Piñero et al. 2010) (Pandy and Zajac 1991). However, a different study found that broad jump was stronger associated with lower body muscular strength test in youth subjects (Castro-Piñero et al. 2010). The study also mention that the benefit of using broad jump as a field test is the practical, time efficient, and low cost for any field to use and repeat (Castro-Piñero et al. 2010).

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