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RELATIONSHIPS BETWEEN HORIZONTAL DROP JUMP TEST AND SPRINT PERFORMANCE

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Researchers and trainers are continually looking for determinants of soccer talent in the youngest and in the relationship between individual motor features relevant to this kind of sport. There is a fundamental consensus in the opinion that sprinting and jumping share a number of similar characteristics in soccer players. To the authors' knowledge, the majority of the studies has been conducted in adult and young athletes and there has yet to be an analysis with pre-pubescent male players.

Therefore, *the purpose of this study* was to investigate the relationships between the standing long jump, the three-hop test and sprint performance in prepubescent male soccer players.

Material and methods. This study comprised 112 prepubescent soccer players (aged 12.08±1.79 years; height: 154.35±12.50 cm; body mass 43.69±10.28 kg). They were assessed for a 30-m linear sprint with three split sprint times, standing long jump test and three-hop test. The associations and relationships between horizontal jump performance in three-hop test and standing long jump with 0-5m, 10-m, 20-m and 30-m sprint times were investigated.

Results and discussion. Correlations and linear regressions were assessed. There were weak and large associations between sprint and jump measures ($r = -0.21$ to -0.66 ; $p < 0.001$). Linear regressions all included standing long jump as a predictor, but not three-hop test.

There were no regression equations that would predict sprint times from triple hop distance that were significant. In their study of national team female athletes Agar-Newman and Klimstra, (2015) showed contradictory results. In their athletes, triple hop distance was a better predictor than standing long jump of both initial sprint speed, and maximal sprint speed. Thus, this area requires further research to better understand the mechanisms through which both sprint and jump performances are achieved in prepubescent male soccer players.

Conclusion. Overall, the results of our study support the use of 30-m linear sprint and horizontal jump performance tests for prepubescent male soccer players. This research showed that sprint times correlated to horizontal jump performance in three-hop test and standing long jump tests. It showed the utility of the standing long jump test to evaluate lower limb performance between prepubescent male soccer players.

Keywords: Soccer, prepubescent players, running speed, broad jump, three hop test.

Introduction. In many team sports, match performance was proven to be dependent to the capacity of the player to produce varied high-speed actions [1, 2]. Despite these actions contribute only to 11% of the total distance covered by the player, they contribute directly to winning possession of the ball and to scoring or to conceding of goals [3].

In soccer, the capacity of a player to produce varied high-speed actions is known to impact soccer match performance. High-speed actions are grouped into actions requiring acceleration, agility, or maximal speed [4]. Acceleration is the rate of change in velocity that allows a player to reach maximum velocity in a minimum amount of time. Agility is often defined as the ability to change direction and start and stop quickly and maximum speed is the maximal velocity at which a player can sprint [4]. Assessing sprinting times over given distances is a common practice to evaluate running speed capacities in soccer players. In addition, the estimation of maximal speed has received growing interest in past years [5, 6, 7].

Ballistic movements such as jumps, require the expression of force and velocity of the lower limb musculature. Due to its similarity to sport task demands such as short sprints, tackles, and change of direction, as well as ease of administration, the standing long jump is considered to be one of the best field-based tests to utilize as a proxy for power of the lower limbs [8].

Standing long jump ability has, however, shown significant correlations with ski jump distance while countermovement vertical jump ability has shown non-significant correlations with ski jump distance [9].

Indicating that horizontal jumping ability may be a better modality than vertical jump ability when training for and tracking training progress for some types of power oriented athletic performances.

Hop tests are performance-based measures used to assess the combination of muscle strength, neuromuscular control, confidence in the limb, and the ability to tolerate loads related to sports-specific activities [10].

Hops tests are alternative to estimate lower limb explosive power of selected population of athletes including soccer [11]. Single leg hop tests, were designed to replicate the demands of sport and exercise. These tests can be measured objectively and have been shown to be reliable [12]. The triple hop distance (THDT) test is one of the single leg hop tests. The perceived advantages of the THDT are that it requires minimal space, time, and equipment and may be especially helpful at youth or high school levels, where resources are limited and sophisticated testing equipment is not available [12, 13].

Similarity between the requirements of jumping and sprinting is an important aspect to consider [14, 15, 16]. In soccer and in many team sports, sprint assessments are often collected in tandem with horizontal jumps to add to a comprehensive physical profile [17, 18, 19, 20, 21, 22].

According to Hicks et al. (2019) [14], jumping and sprinting share a number of similar characteristics such as the magnitude and direction of force applica-

tion and the velocity of movement. It was suggested that horizontal jump performance can provide similar, yet unique insight into physical performance when compared to sprint tests [23]. For example, there are significant associations between horizontal jumping ability and acceleration ($r = -0.353$ to -0.560) and maximum speed ($r = -0.353$ to -0.590) [20, 24] and the associations between sprint and jump ability appears to be similar to those of non sprint trained physical education students to many field sport athletes [17, 24, 25, 26]. This research has been conducted in mature athlete cohorts, there has yet to be an analysis of a young prepubescent soccer players. Understanding the relationships between sprint ability and horizontal jump performance, based on prepubescent subjects can provide great insight into the shared and independent value of sprint and jump performance tests to support athlete testing and development.

Therefore, **the purpose of this research** was to investigate the relationship between horizontal jump distance and sprinting time from prepubescent male soccer players.

Material and methods. In total, 112 male soccer players were enrolled in the study (age = 12.08 ± 1.79 years, Maturity offset = -2.38 ± 1.26 , body mass = 43.69 ± 10.28 kg, height = 154.35 ± 12.50 cm, sitting height = 74.83 ± 6.00 cm). The maturity offset of the participants was determined according to the method of Malina and Kozielec, (2014) [27]. The subjects had been playing soccer for at least 4 years. They participated in four weekly training sessions of the same duration and played a 70 min match each weekend. Informed consent was received from both the participants and their parents. The participants were provided with detailed information regarding the purpose and the potential risks of the study. In accordance with the 1975 Declaration of Helsinki, the human subject committee of the local institution (i.e., the Higher Institute of Sport and Physical Education of Ksar-Saïd, Tunis, Tunisia) approved this study.

All anthropometric measures were taken by the same experienced researcher. Dimensions included stature, body mass and sitting height. Stretch stature was measured with a wall-mounted stadiometer (± 0.1 cm, Holtain Ltd, Crosswell, UK), sitting height with a stadiometer mounted on a purpose-built table (± 0.1 cm, Holtain Ltd, Crosswell, UK) body mass with a weighing device (± 0.1 kg). Skinfolds measurements were taken in the right-hand side of the body (Stewart & Marfell-Jones, 2011) at four sites (biceps, triceps, subscapular and supraspinal) using Harpenden skin fold calipers (Harpenden Instruments, Cambridge, UK). Skin fold data were used to estimate body fat mass and fat free mass.

Field tests were performed outdoor on an artificial turf pitch at the same time of day (between 5 and

7 pm). Participants wore their regular training uniform and soccer cleats. They were instructed to maintain consistent dietary and sleeping patterns for 48 hours prior to each session and to refrain from strenuous activity for 24 h prior to each session.

A standardized warm-up consisting of 10 minutes of jogging and 5 minutes of coordination movements was performed before the lab and field tests. Thereafter, a 5-minute specific warm-up was performed using exercises mimicking and priming test movements. No static passive stretching was allowed during warm-up, and 3 minutes of recovery separated the warm-up from the tests [13].

The performance of a 30-m linear sprint with split sprint times of 5-m, 10-m and 20-m, were recorded using an infrared photocell system (Microgate). The between-trial recovery time was three minutes. The best performance out of two trials was used for further analysis.

The starting position of the standing long jump (SLJ) required subjects to stand with their feet shoulder-width apart behind a starting line and their arms loosely hanging down. On the command ready, set, go, participants executed a countermovement with their legs and arms and jumped at maximal effort in the horizontal direction. Participants had to land with both feet at the same time and were not allowed to fall forward or backward. The horizontal distance between the starting line and the heel of the rear foot was recorded via tape measure to the nearest 1 cm.

The THDT consists of three consecutive strides with joined feet position at the start and end of the jumps. From the starting joined feet position, the participant was not allowed to perform any back step with any foot; rather, he had to directly jump to the front with a leg of his choice. After the first two strides, he had to end the test again with joined feet. If the player fell back on completion of the last stride, the test was performed again. THDT performance was measured with a tape measure from the front edge of the player's feet at the starting position to the rear edge of the feet at the final position. The person assessing the landing had to focus on the last stride of the player in order to exactly determine the last footprint. The starting position was set on a fixed point.

Statistical analysis

Statistical analyses were carried out using SPSS 19.0 program for Windows (SPSS, Inc, Chicago, IL, USA). Descriptive statistics were generated for all variables. The significance level considered in the present study was set at $p < 0.05$. The normality assumption was checked using a Shapiro-Wilk test before any further analysis and all variables showed normal distributions.

Pearson product moment correlation was computed between sprint and THDT and SLJ tests. Vin-

cent, (1999) [28] has suggested that an absolute correlation coefficient of 0.5 - 0.7 is considered low, one of 0.7 - 0.8 is considered moderate, and one of 0.9 or above is considered high or strong. Multiple linear regression was also used to test the relationship between the vertical jump height and the explanatory body size variables.

Results and discussion. As far as authors know, this is the first study to assess the relationships between horizontal jump and sprint metrics for prepubescent male soccer players. There were significant correlations between jump and sprint metrics in our athletes. When examining the multiple regression results there were only SLJ jump predictors of sprint ability in our prepubescent soccer players.

All data presented normal distribution ($P > 0.05$). Results from the different physical tests are summarized in **Table 1**. The results obtained in sprint tests for our prepubescent soccer players are presented in **Table 1**. Comparing these scores with those of Nèji et al. (2019) [29] in prepubescent soccer players too; we found similar 5-m, 10-m, 20-m and THDT performances.

Table 1 – Sprint Test, Three Hop Test for distance and Standing Long Jump measured variables (n = 112)

	Sprint Test (sec)				THDT (cm)	SLJ (cm)
	5-m	10-m	20-m	30-m		
Mean	1.16	1.99	3.57	5.12	467.20	164.20
SD	0.13	0.25	0.31	0.49	100.81	25.37

Notes: THDT: The Triple Hop Distance; SLJ: Standing Long Jump; SD: Standard Deviation

The relationship between sprint and jumping in prepubescent soccer players is still unclear. In the present study, significant correlations between all horizontal jump and sprint metrics were observed as well as between these tests and anthropometric indices in our athletes (**Table 2**). Similarities in the direction of motion, lower limb inter and intra-muscle coordination and ballistic muscle action have been given as rationale for this observed association between jump and sprint ability [30, 31]. These correlations suggest that THDT, SLJ horizontal jump tests and 5-m, 10-m, 20-m and 30-m sprint times, in the present study, can be used as proxies for one another when examining general prepubescent male soccer player physical performance.

As can be seen in (**Table 2**), and for the THDT and SLJ tests, correlations between 30-m linear sprint with split sprint times of 5-m, 10-m and 20-m and jump tests were higher with 30-m sprint compared with 5-m, 10-m and 20-m sprints. These results contradict those of Kugler and Janshen, (2010) [32] who found that the most consistent correlations (0.93, $p < 0.001$) were found between horizontal jumps and acceleration in male and female physical education students.

It appears therefore, that a more in-depth analysis between jump and sprint ability should include some understanding of the sprint ability of prepubescent male soccer players to allow meaningful interpretation of the results.

Table 2 – Correlations between Sprint test, three hop test for distance and standing long jump, measured variables (n = 112)

		Sprint Test (sec)			
		5-m	10-m	20-m	30-m
THDT	r =	-0.30	-0.50	-0.56	-0.58
	p =	0.002	0.000	0.000	0.000
SLJ	r =	-0.50	-0.55	-0.61	-0.66
	p =	0.000	0.000	0.000	0.000
BM	r =	-0.28	-0.21	-0.28	-0.38
	p =	0.001	0.01	0.01	0.000
BH	r =	-0.48	-0.36	-0.48	-0.59
	p =	0.000	0.000	0.000	0.000
SH	r =	-0.38	-0.31	-0.38	-0.46
	p =	0.000	0.000	0.000	0.000
BF	r =	0.28	0.28	0.28	0.28
	p =	0.001	0.02	0.001	0.001
PHV	r =	-0.52	-0.40	-0.52	-0.62
	p =	0.000	0.000	0.000	0.000

Notes: SH: Sitting Height; BF: Body Fat; PHV: Peak Height Velocity; THDT: The triple hop distance; SLJ: Standing Long Jump; BM: Body Mass; BH: Body Height;

Multiple regression analysis revealed the strength of associations through correlational analyses. For the 5-m sprint time a significant, multiple regression equation explained 0.25% of the variance ($F = 5.07$; $p < 0.000$):

$$5\text{-m (s)} = 1.38 - 0.003 \times \text{SLJ}$$

For the 10-m sprint time a significant, multiple regression equation explained 33% of the variance ($F = 5.07$; $p < 0.000$):

$$10\text{-m (s)} = 1.87 - 0.007 \times \text{SLJ}$$

For the 20-m sprint time a significant, multiple regression equation explained 41% of the variance ($F = 10.30$; $p < 0.000$):

For the 10-m sprint time a significant, multiple regression equation explained 57% of the variance ($F = 19.40$; $p < 0.000$):

$$30\text{-m (s)} = 5.34 - 0.023 \times \text{SH} + 0.054 \text{ BH} - 0.007 \times \text{SLJ}$$

There were no regression equations that would predict sprint times from THDT that were significant. In their study of national team female athletes Agar-Newman and Klimstra, (2015) [17] showed contradictory results. In their athletes, THDT was a better predictor than SLJ of both initial sprint speed, and maximal sprint speed. Thus, this area requires further research to better understand the mechanisms through which both sprint and jump performances are achieved in prepubescent male soccer players.

Conclusion. To conclude, 30-m sprint test with its split sprint times of 5-m, 10-m and 20-m were found to be correlated with THDT and SLJ tests in our male prepubescent soccer players. These results support the use interchangeably either jump or sprint tests to differentiate sprint ability in male prepubescent soccer players and that in environments without the space or equipment requirements to conduct a sprint assessment, SLJ assessment provides a useful alternative predictor of sprint time.

Prospective. Future research is suggested to be conducted on determining if other jump tests such as unilateral jumps or bounding that could provide more information on sprint ability due to increased movement similarity.

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Conflicts of Interest and Source of Funding. The authors have no conflict of interest to declare.

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ВЗАЄМОЗВ'ЯЗОК МІЖ СТРИБКОВИМИ ТЕСТАМИ ТА РЕЗУЛЬТАТАМИ СПРИНТА

**Аттія Ахмед, Неджи Зіед, Фархат Неджіб, Хемірі Аймен,
Коука Ахмед, Реджеб Неджіб, Халіфа Ріад, Гайед Чортане Сабрі**

Резюме. Дослідники і тренери постійно ведуть пошук способів оцінювання індивідуальних рухових здібностей юних футболістів, які відображали б їх схильність до досягнення успіху саме в цьому виді спорту. Існує фундаментальна думка про те, що з цієї точки зору спринт і стрибки є найбільш інформативними тестовими вправами для футболу. Наскільки відомо авторам, більшість досліджень проводилася із залученням дорослих і молодих спортсменів, але ще не було робіт, присвячених аналізу аналогічних характеристик серед футболістів в препубертатному віці.

Мета даного дослідження - вивчити взаємозв'язок між стрибковими тестами (в довжину з місця та з послідовним виконанням трьох стрибків) і результатами спринту у футболістів-чоловіків препубертатного віку.

У дослідженні взяли участь 112 футболістів препубертатного віку (вік $12,08 \pm 1,79$ року; зріст $-154,35 \pm 12,50$ см; маса тіла $43,69 \pm 10,28$ кг). Для оцінювання рухових здібностей використовували такі тести: біг на 30 метрів з аналізом проходження трьох ділянок, стрибкові вправи з горизонтальним переміщенням (в довжину з місця, з послідовним виконанням трьох стрибків). Були досліджені взаємозв'язки між виконанням стрибкових тестів і бігом на 0-5 м, 10 м, 20 м і 30 м.

Результати. Оцінювалися кореляції і лінійні регресії. Між спринтом і стрибками спостерігалися слабкі і сильні зв'язки (r = від $-0,21$ до $-0,66$; $p < 0,001$). Всі лінійні регресії включали стрибок в довжину з місця в якості предиктора, але це не стосувалося тесту з виконанням трьох стрибків.

Не виявлено рівнянь регресії, які передбачали б значущий час спринту на основі тесту з виконанням трьох стрибків. У своєму дослідженні спортсменок національної збірної Агар-Ньюман і Клімстра (2015 г.) отримали суперечливі результати. У їх спортсменів тест з виконанням трьох стрибків був більш інформативним, ніж стрибок в довжину з місця, як для початкової швидкості спринту, так і максимальної швидкості спринту. Таким чином, ця область вимагає подальших досліджень, щоб краще зрозуміти механізми, за допомогою яких досягаються як бігові, так і стрибкові характеристики у футболістів-чоловіків в препубертатному віці.

Висновки. Результати даного дослідження підтверджують валідність використання бігу на 30 метрів і стрибкових тестів для оцінювання рухових здібностей футболістів чоловічої статі препубертатного віку. Це дослідження показало, що час спринту корелює з характеристиками стрибкових тестів (в довжину з місця та з послідовним виконанням трьох стрибків). Дослідження показало необхідність використання стрибка в довжину з місця в якості тестового вправи для оцінювання працездатності нижніх кінцівок у футболістів-чоловіків препубертатного віку.

Ключові слова: футбол, гравці препубертатного віку, швидкість бігу, стрибки в довжину, тест на три стрибки.

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ВЗАИМОСВЯЗЬ МЕЖДУ ПРЫЖКОВЫМИ ТЕСТАМИ И РЕЗУЛЬТАТАМИ СПРИНТА

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Резюме. Исследователи и тренеры постоянно ведут поиск способов оценивания индивидуальных двигательных способностей юных футболистов, которые отображали бы их предрасположенность к достижению успеха именно в этом виде спорта. Существует фундаментальное мнение о том, что с этой точки зрения спринт и прыжки являются наиболее информативными тестовыми упражнениями для футбола. Насколько известно авторам, большинство исследований проводилось с привлечением взрослых и молодых спортсменов, но еще не было работ, посвященных анализу аналогичных характеристик среди футболистов в препубертатном возрасте.

Таким образом, *цель* данного исследования – изучить взаимосвязь между прыжковыми тестами (в длину с места и с последовательным выполнением трех прыжков) и результатами спринта у футболистов-мужчин препубертатного возраста.

Объект и методы исследования. В исследовании приняли участие 112 футболистов препубертатного возраста (возраст $12,08 \pm 1,79$ года; рост - $154,35 \pm 12,50$ см; масса тела $43,69 \pm 10,28$ кг). Для оценивания двигательных способностей использовали такие тесты: бег на 30 метров с анализом прохождения трех участков, прыжковые упражнения с горизонтальным перемещением (в длину с места, с последовательным выполнением трех прыжков). Были исследованы взаимосвязи между выполнением прыжковых тестов и бегом на 0–5 м, 10 м, 20 м и 30 м.

Результаты. Оценивались корреляции и линейные регрессии. Между спринтом и прыжками наблюдались слабые и сильные связи (r = от -0,21 до -0,66; $p < 0,001$). Все линейные регрессии включали прыжок в длину с места в качестве предиктора, но это не касалось теста с выполнением трех прыжков.

Не выявлено уравнений регрессии, которые предсказывали бы значимое время спринта на основе теста с выполнением трех прыжков. В своем исследовании спортсменок национальной сборной Агар-Ньюман и Климстра (2015 г.) получили противоречивые результаты. У их спортсменов тест с выполнением трех прыжков был более информативным, чем прыжок в длину с места, как для начальной скорости спринта, так и максимальной скорости спринта. Таким образом, эта область требует дальнейших исследований, чтобы лучше понять механизмы, с помощью которых достигаются как беговые, так и прыжковые характеристики у футболистов-мужчин в препубертатном возрасте.

Выводы. Результаты данного исследования подтверждают валидность использования бега на 30 метров и прыжковых тестов для оценивания двигательных способностей футболистов мужского пола препубертатного возраста. Это исследование показало, что время спринта коррелирует с характеристиками прыжковых тестов (в длину с места и с последовательным выполнением трех прыжков). Исследование показало необходимость использования прыжка в длину с места в качестве тестового упражнения для оценивания работоспособности нижних конечностей у футболистов-мужчин препубертатного возраста.

Ключевые слова: футбол, игроки препубертатного возраста, скорость бега, прыжки в длину, тест на три прыжка.

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