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Study of biomechanical variables controlling the good performance of some fundamental movement skill in male preschoolers (5-6 years).

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Abstract

OBJECTIVE
The aim of this study was to identify the kinematic variables that determine the good performance of running skill in male preschool children aged 5 to 6 years.
METHODS
Thirty children were evaluated, and for data collection, we used a test of running at maximum speed for 20 meters to measure the running skill in preschool children, and then photographed by a digital camera, which was set on the left side of the running line.
RESULTS
The discriminant analysis showed that the running speed achieved in a 20-meter run test in preschool males 5-6 years in addition to age and anthropometric characteristics (height and weight) is greatly influenced by the following kinematic variables: step length, step frequency, support phase time, as well as flight phase time, and among all the kinematic variables, the step length and step frequency are the most specific variables for the variation in running speed achieved by children.
CONCLUSIONS
Based on the previous results, the study recommended the developing of motor activities focusing on the above kinematic variables.

1. Introduction :

There is no doubt that excellence in sports field requires complete integration between the mind and the body, unlike some other fields (Tsaki & Zeyan, 2019), and the results in this field do not come from a vacuum but rather are the outcome of continuous and in-depth studies even in the simplest parts, based on modern scientific foundations similar to the science of biomechanics (Muhad and Sebaa, 2020), which is a science that shows and clarifies the errors and problems facing the athlete when performing (Jadid Abderrahmane et al, 2016), in addition, biomechanical analysis has an essential role in the study of movement, so the method of kinematic analysis of motor skills is concerned with clarifying and describing the different types of movements using several methods, such as instantaneous measurement by optical cells, optical impact imaging, optical impulses imaging, speed recording and video imaging (Ahsan Ahmed, 2019).

The preschool stage is considered as an important motor development stage for a child who has not exceeded the age of 7 years to join the first year in primary school (Ziyani and Qurari, 2018), as it is the basis upon which all future child movements are built, thus the child has the basic types of movement that play in addition to sport activities an essential role in childhood (Hishem Ahmed Muheib et al., 2010), Moreover, movement controls over the most prominent place in the promotion of some of the child's creative qualities such as motor fluency, motor flexibility, and motor originality (Uhoussin Ibrahim et al., 2020), so the child can walk, run, jump, etc., and perform all these basic motor skills with a degree of compatibility that only needs for a little bit of refinement and perfection (Jrady & Boubaker, 2016).

The majority of physical activities require the rapid movement of the body from one place to another. Thus, running in its various forms, is a basic skill essential to the performance of a variety of physical activities, it is a rapid form of human locomotion characterized by brief projections of the body over the ground alternately by each leg (Michael Duncan McDonald, 1980). Moreover, running is one of the most common basic motor skills in various sports activities; it involves converting muscular forces into transitional movement through mutual movement patterns that integrate almost all major muscles and joints in the body (Tim Anderson, 1996). In addition, the kinematic analysis model of running skill in children 5-6 years old is similar to the adult model (Ann Espenschade et al., 1980).

1.1. Literature Review :

Using some previous studies and research related to the subject of our study such as the study conducted by (Lennart Raudsepp and Matti Pasok, 1995) entitled "Gender differences in basic movement patterns, motor performance, and strength measurements for children before puberty." The study aimed to test gender differences in variables. Kinematic running at full speed, throwing from the top of the shoulder, motor performance, and muscle strength in children before puberty. The descriptive approach was adopted using cinematography, 60 children, 8 years old, participated in this study. The most important results of the study include the following: No There are differences between the two sexes in the kinematic variables of running, while in throwing from the top of the shoulder, motor performance and muscle strength, the males outperformed the females significantly, but in the test of flexibility and balance, the females outnumbered the males.

Another study of (Virginia L. Fortney, 2013) entitled "Kinematic and Kinetic Study of Running Skill in Children Age 2, 4 and 6 Years". The study aimed to know the most important Kinetic and Kinetic variables in the skill of the running among children 2, 4 and 6 years, the descriptive approach has been adopted using cinematography and strength measurement panels. The sample size reached (28) boys and girls 15 boys and 13 girls, and the most important conclusions are: that the enemy's speed improves with age, and that some Biomechanical variables also contribute to improving the enemy's skill, and the presence of significant differences in the kinematic and kinetic variables under study between the children of 2 years and 4-6 years. These differences were in the variable of distance, linear velocity as well as the momentum.

The study of (Aya Miyamoto, 2018) in the same subject aimed to clarify whether foot strike patterns are associated with different sprint performance and kinematics in preadolescent boys. The study enrolled 24 healthy 10–11-year-old boys in the fifth grade at public elementary schools in Japan. The participants performed the 50-m sprint with maximum effort. Sprint motion was recorded using a high-speed video camera (120 fps) placed on the left side of a line drawn at 35-m from the start line. Kinematic variables were calculated based on manually digitized body landmark coordinates. The participants were categorized into two groups according to their foot strike pattern (rear foot strikers, RF group, n = 12; forefoot or mid-foot strikers, FF/MF group, n = 12). The time taken to complete the 50-m sprint in the

FF/MF group (9.08±0.52 s) was faster than that in the RF group (9.63±0.51s). The FF/MF group had greater sprint speed, higher step frequency, and shorter foot contact time than the RF group. Regarding the association between foot strike pattern and sprint kinematics, we found that the RF group had a greater range of knee flexion during the support-leg phase, whereas the FF/MF group had shorter horizontal distance from the heel of the support leg to the centre of mass at the touchdown, greater maximal knee flexion velocity during the swing-leg phase, and higher the maximum hip extension velocity during the support-leg phase. The current results suggested that, in preadolescent boys, forefoot or mid-foot strike (rather than rear foot strike) is effective for obtaining a higher step frequency and sprint speed through greater magnitude of knee flexion and hip extension movement velocities during the swing and support phases, respectively. The current findings will be useful for understanding the characteristics of the development of sprinting performance in preadolescent children.

Upon the researchers' work in the sports field, they have noted the presence of deficiencies and distortions in the running skill among adults, which reflects the absence of a real and continuous follow-up to these people when they were in early childhood, which led to the emergence of many defects and shortcomings in the way they run, and accordingly and with the aim of evaluating the running skill and correcting errors that may occur in preschool children, which would reflect negatively on their future performance in the advanced stages of life. The researchers resorted to an in-depth biomechanical study in order to determine the most important kinematic variables that control the good performance of this skill by answering the following question:

Do the biomechanical variables have a relationship in improving the performance of the running skill of male preschool children (5-6 years)?

2. Method and Materials :

.21. Participants:

The sample of the study consisted of 30 children aged 5-6 years belonging to three kindergartens in Batna city, Batna province, who were chosen in a simple random manner within the study population consisting of 151 preschool children distributed among three kindergartens in Batna city.

2.2. Materials:

Researchers used the following tools to collect data:

- Running skill test used in the study: running 20 meters' skill of preschool children.

- Statistical analysis: The arithmetic mean and standard deviation of all variables were calculated in addition to the correlation coefficient, and the multiple regression was also calculated to test the relative contribution of kinematic variables to the variance in the calculated distance of the jump and the statistical treatment was done using the Statistical Package for Social Sciences program SPSS: (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp):

- Kinovea Program: used to measure various mechanical variables and to determine the various kinetic analysis options for video related to the subject of the study.

2.4. Design and Procedure :

Test of running at maximum speed for 20 meters.

The purpose of the test: To measure the running skill of preschool children.

Tools: flat ground, measuring tape drawn on the starting line.

Performance specifications: The child runs 20 meters, the test is repeated three times and the best result is preserved. Running time is measured from the start line to the end of the 20-meter distance (Jonatan R Ruiz et all, 2011, p. 520).

A video camera was set in the sagittal plane, on the left side of the finish line. The recorded video was used to accurately determine the total time between the moment the start cue was issued and the moment when the participant crossed the finish line situated at 20-m from the start line. In addition, a high-speed digital video camera (EXILIM EX-FH25; CASIO COMPUTER Co., Ltd, Tokyo, Japan) was set in the sagittal plane on the left side of a line drawn at a distance of 20 m from the start line to record the sprint motion The high-speed camera was fixed onto a tripod so that the optical axis was perpendicular to the runway.

- Psychometric properties of the test:

- Test reliability: after performing the test and returning it after two weeks on a sample consisting of 10% of the original sample of children and in the same circumstances, the statistical treatment approved the results shown in the following table:

Table 01 shows the reliability coefficient and its significance for the test.

number	the stability factor	the test figure	The significance level at 0.05
1	Running at maximum speed distance of 20 meters	0.81	Statistically significant

Test validity: To obtain the validity of the test, we used the self-validity coefficient, which is calculated by the square root of the stability factor and the results were as follows:

Table 02 shows the validity coefficient and its significance for the test.

number	the validity factor	the test figure	The significance level at 0.05
1	Running at maximum speed distance of 20 meters	0.90	Statistically significant

2.1. Statistical Analysis :

All calculated variables were expressed as mean ± standard deviation. In addition, The Pearson's correlation coefficient was determined for the correlation among spatiotemporal variables. In addition, the correlations were calculated between sprint speed and kinematics variables. For the test, the significance level was set at $p < 0.05$ and the multiple regression was also calculated to test the relative contribution of the kinematic variables in the variation in the calculated result in the running skill. All statistical analyses were performed using statistical analysis software, and the statistical treatment was done using the statistical package program for social sciences: SPSS: (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp).

3. Results :

Table 03 shows descriptive characteristics (anthropometric and kinematic) of the sample. Variables were expressed as mean ± standard deviation

Variable	group (n = 30)
Age (years)	5.8 ± 1.9
Weight (kg)	20.2 ± 8.9
Height (cm)	112.3 ± 11.9
stride length (m)	1.05 ± 0.13
stride rate (m/s)	3.19 ± 0.45
time of single support (second)	0.18 ± 0.02
time of flight (second)	0,09 ± 0,03
time of stride (second)	0.38 ± 0.42
ankle angle at take off (º)	146.10 ± 0.10
knee angle at take off (º)	171.31 ± 0.11
hip angle at take off (º)	167.87 ± 0.24
Hip angle at mid-flight	181.77 ± 0.25
measured horizontal velocity (m/s)	4.05 ± 0.87
calculated horizontal velocity (m/s)	4.09 ± 0.63

Table 03 shows the kinematic variables of the study sample, where we find the mean for the length of step 1.05 with a standard deviation of 0.13, the step frequency was estimated at 3.19 with a standard deviation of 0.45, while the average support phase time and flight phase time were estimated at 0.18 and 0.09 respectively and a standard deviation of 0.02, 0,03 respectively. As for the heel, knee and hip joint corners at lift off, the arithmetic mean was estimated at 146.10, 171.31, and 167.87, respectively, and with standard deviations of 0.10, 1.10, and 24.0 respectively, and for horizontal velocity the calculated average horizontal velocity was estimated at 4.05 Standard deviation of 0.87 and the measured mean horizontal velocity is estimated at 094. A standard deviation of 0.63.

Table 04: shows the bivariate correlation analysis between kinematic variables and the calculated running speed and with the measured running speed.

kinematic variables	Measured running speed (m/s)	Calculated running speed (m/s)	significance (SIG) p
Stride length (m)	0.812**	0.791**	$p < 0.01$
Stride rate (m/s)	0.637**	0.668**	$p < 0.01$
time of stride (second)	0.190*	0.201*	$p < 0.05$
Time of single support (second)	0.588**	0.581**	$p < 0.01$
Time of flight (second)	0.334**	0.345**	$p < 0.01$
Hip angle at take off (º)	0.393**	0.385**	$p < 0.01$
Hip angle at mid-flight	0.182*	0.192*	$p < 0.05$
Knee angle at take off (º)	0.366**	0.316**	$p < 0.01$
Ankle angle at take off (º)	0.317**	0.285**	$p < 0.01$

* No significant differences at less than the 0.05 level. $p < 0.05$*
** No significant differences at less than the 0.01 level. $p < 0.01$**

Table 04 shows that the correlation coefficients between the kinematic variables and the calculated running speed as well as the measured speed were uneven and ranged between the lowest value of 0.285 to the highest value of 0.812, and all the kinematic variables showed a strong correlation with both the calculated speed and the measured speed of the running skill no in particular (stride length, stride frequency, support phase time as well as flight phase time).

Table 05: Stepwise regression models assessing the association of the kinematic variables with the calculated running speed.

Model included	β	change	P
Step 1			
Stride length (cm)	0.657	0.201	<0.001
Step 2			
Stride frequency (rate) (m/s)	0.330	0.083	<0.001
Step 3			
Time of single support (second)	0.169	0.020	<0.001
Step 4			
Time of flight (second)	0.133	0.015	<0.001

β = standardized regression coefficient = coefficient of determination expressing the percentage variability of the dependent variable explained adjusted for the number of explanatory terms.
Change = additional percent variability explained by the model due to the inclusion of a new term.

Table 05 shows the gradual regression models to evaluate the correlation of the kinematic variables with the calculated speed, where we find that the largest value of the determining factor that expresses the percentage of the change of the dependent variable was the length of the step 0.657 with a change of 0.201 and the lowest value of the determination factor was the time of the flight stage and the time of the support phase of 0.169 and 0, 133 respectively, with a change of 0.020 and 0.015 respectively.

4. Discussion :

The main finding in the present study indicates that the performance of the running skill test is highly determined by age and anthropometric parameters as well as kinematic variables, although two relevant kinematic variables have been identified to contribute highly in the performance, and according to the results of the equations suggested by Mirwald and others, they showed that children in this study did not reach the adequate level of maturity (Mirwald R.L et al, 2002), therefore, we cannot acknowledge the presence of the maturity factor on the results achieved in the skill of running. Moreover, the study of (Lennart Raudsepp and Matti Pasok, 1995) indicates that there were no significant differences in many of the kinematic variables involved in the performance of running skill between male and female children (Lennart Raudsepp and Matti Pasok, 1995), so, this study concluded that the sex factor is not important in the study of kinematic variables of children running, and accordingly, the researchers have studied only the kinematic variables in male children without females.

In the current study, the correlation coefficients between the kinematic variables with the calculated running speed and with the measured running speed are very similar, ranging from 0.182 ($p < 0.05$) to .812 ($p < 0.01$). it was found that the following kinematic variables (step length, step frequency, support stage time, flight stage time, heel joint knees, knee and hip at lift off) had a strong correlation with the calculated speed ($r = 0.812$, $r = 0.256$ $r = 0.334$ $r = 0.334$ $r = 0.334$ $r = 0.334$ and $r = 0.256$), respectively ($p <0.01$). All kinematic variables showed a significant correlation with both calculated running speed and measured running speed. When listing all the kinematic variables that showed a strong correlation with the running speed calculated to construct the stepwise regression analysis model, it appears that these four variables (the stride length, stride frequency, phase time support, as well as flight time) are the most influential in the performance of running a 20-meter running test in children.

This result is relatively consistent with the Michael Duncan McDonald's study of a year that reached the change in running speed in children that increases with age and length in addition to some of the kinematic variables represented by the stride length, the stride frequency of the stride time as well as the relative speed of the foot (Michael Duncan McDonald, 1980). Also, according to the study of (Aya Miyamoto et al., 2018); support stage time, step frequency and length Step have been identified to contribute significantly to running performance, (Aya Miyamoto et al., 2018).

There remains controversy in the literature in regards to improving maximum running speed via stride frequency vs. stride length. It has been suggested that both stride length and stride frequency increase linearly with running speed (Luhtanen, Pekka and Komi, P., 1973). Thus, it has been argued that there is a limit to how much an individual can increase stride length and thus increasing stride frequency would be more important in improving maximum running speed (Hamill, J and Knutzen, K., 1998). In the present study, both stride length and stride frequency significantly correlated with maximum running speed ($r = 0.791$), ($r = 0.668$) respectively.

5. Conclusion :

Our findings suggest that the running speed achieved in the 20-meter run test by children that were 5- to 6-years-old is highly influenced by age, anthropometric variables (i.e., height and weight) and by kinematic variables (i.e., stride length, stride frequency, support phase time, and flight stage time), thus, it is important to highlight that among all these kinematic variables, stride length and stride frequency accounted the most of the variation in the running speed. Physical education teachers and coaches should consider, with special attention, these anthropometric and kinematic aspects improving the running skill performance in 5- to 6-year-old children; developing games and activities that focus the improving of step length and step frequency.

Finally, the researchers note that this study remains open to other future studies in the field of improving the role of physical education and its various activities, mainly other fundamental motor skills such as throwing the ball, jumping, as well as stable and kinematic stability.

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