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The Effects of Single Deep Jump Training on Slopes on Selected Biomechanical Variables of the Triple Jump in Athletes Under 20 Years of Age

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Abstract

The study aimed to investigate the effect of individual long jump slops and its effect on some biomechanical variables of U20 of triple jump. It is hypothesized that there is statistically significant difference between the results of the pre and posttests in the biomechanical variables of U20 of triple jumps. To achieve the aim of the study, one group pre-test post-test experimental design is used. A sample of (6) triple jump players under 20 years from the specialized schools of the Ministry of Youth and Sports, is non-randomly chosen during the academic year (2023-2024). The pilot study was carried out to on Tuesday and Wednesday (10/24/2023) at 4:00 p.m. at the Ministry of Youth and Sports stadiums on a group of (6) players who participated in the main study. A three-month training program was applied for 11 weeks, three training sessions per week. The training sessions were designed to gradually increase in intensity on a daily, weekly, and monthly basis, following a scientific and precise method regarding intensity and rest periods between repetitions and sets. This approach was tailored according to the specific goals of each training session and the biomechanical variables targeted for development in each session. It was concluded that the work of the angles of the lead leg during push-off for athletes in the triple jump who are under 20 years old is positively affected by individual long jump training.

Keywords: Long Jump, slopes, Motor transition indicator, Instantaneous Velocity.

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Introduction

Reaching achievement is accomplished by following the guidelines provided by the sciences, including biomechanics, which links athletes' movements to physiological conditions. Its main concern lies in overcoming the mechanical obstacles within human joints or body mass. Among the most valuable studies are those directed toward analyzing athletes' movements in order to improve motor performance during sports activities. This necessitates the study and analysis of the moments acting on the distal axes of the legs at each ground contact, as well as the rotations occurring at the hip, knee, and ankle joints at the instant of full extension of the take-off leg. These moments are countered by rotational torques of the leading leg, the spine, and the arms. Accordingly, a skilled athlete is one who possesses a sufficient level of physical capacities that allow them to perform the motor task effectively with minimal errors. We all know that the body can do what you teach it to do with enough consistent effort. As such, the most effective way to develop strength should be towards modern methods of training like unilateral-slope-jump. Triple jumping is a complex and compound event in track and field since the balance and muscle coordination play very important roles for validity of all these four parts: The approach, Hop, Step, Jump. This complexity highlights the requirement of harmony and synchrony in muscle action to achieve the most efficient mechanical configuration for performing a task. Therefore, muscle activity in the distal extremity is important for effective propulsion of the body's center of gravity and its transference over phases of the triple jump (approach–hop–step–jump). It requires high levels of dynamic balance, coordinated functioning of the working muscles to produce torque forces which are balanced around all other body moments so as to ensure a successful performance.

Stride of sprinters is considered as a typical example of plyometric activity (Chu, 2013). The jump loads the muscles of the leading leg by gravity with tension. Eccentric muscles functioning around the hip and thigh are important for efficiency by minimizing body collapse while avoiding a deep center of mass. These eccentric contractions play a role in attenuating the effects of jumping by acting as shock absorbers, decreasing stress on ligaments and skeletal muscles. Of particular note, is the fact that the force in a muscle during eccentric contractions can be more than 40% greater than in any other muscle action, an extent perfectly illustrated by the force requirement of jumps (Chu & Mayer, 2013).

Jack Pioss (1988) noted that slope training is a form of training aimed at developing specific physical abilities related to the demands of the sport (Pioss, 1988).

Based on the above, the researchers must review related studies concerning the investigated variables, including:

The Effect of Deep Jump Training on Explosive Power and Performance Level in Junior Long Jumpers (Saeed, 2020).

The researcher employed the experimental method with a single-group pre–intermediate–post-test design, applied to a sample of 11 long jump athletes under 20 years. Findings revealed that improvements in performance level were associated with enhancements in speed, explosive strength, and agility—key physical components responsible for developing long jump performance. Explosive strength was identified as the primary determinant of take-off success.

The Effect of Different Heights of Deep Jumps on Certain Aspects of Muscular Strength in Handball Players Aged 15–17 Years (Al-Hayali et al., 2013).

The experimental method was used with 24 players divided into three equal groups of eight, aged between 15–17 years, randomly assigned. Results indicated that using deep jump training with varying box heights contributed to developing explosive strength of the legs and improving leg speed-strength.

The Effect of Training on Slopes of Different Heights and Distances on Certain Physical Abilities, Kinematic Variables, and Performance in the 100–200 m Sprint (Dahash).

The researcher used the experimental method with a sample of young sprinters aged 18–19 years from Al-Najaf Al-Ashraf. The sample was divided into two experimental groups (six athletes each). The first group trained with straight running, uphill running, followed by straight and downhill running, while the second group trained with only uphill or downhill running. Results showed that the training enhanced physical and kinematic attributes and improved performance in both groups. Moreover, variation in step length and frequency demonstrated that mechanical changes in one variable significantly affect the other, where an increase in one is accompanied by relative stability in the other.

Methodology

The researchers adopted the experimental approach using a one-group experimental design. This design involves conducting the experiment on a single group, which is subjected to a pre-test, followed by the introduction of the experimental variable (the applied training program), and finally a post-test, with the pre- and post-measurements compared statistically.

The research population was intentionally selected due to the specific requirements of the study and consisted of six triple jump athletes under 20 years of age, registered in the specialized schools for athletics during the 2023/2024 season. After deliberation, the researchers identified the study variables based on a review of Arabic and international scientific sources, and by consulting experts in sports training science and biomechanics. Several biomechanical variables were determined through video recording and motion analysis of the triple jumpers' performance.

Variables under Analysis from the Take-off Phase

1. Speed (during hop, step, and jump phases)
   From speed and time analysis, the following variables were derived:
2. Motor transfer index (during hop, step, and jump phases)
3. Force (during hop, step, and jump phases)

Instruments and Equipment

- Three modern video cameras (Sony, 120 fps)
- Laptop (Dell)
- Data documentation device
- Two electronic stopwatches
- Scale for body mass measurement (Chinese-made)
- Regulation jumping field
- Six markers
- Measuring tape
- Twelve yellow training shirts
- Two whistles
- Plyometric boxes of various heights (31, 34, 38, and 43 cm) for training
- One box (50 cm) for testing purposes

Pilot Study

The small scale trial is an important part of the development process of the implemented research. However, it is used to sample and check the research tools and procedures before commencing the main study. The primary purpose was clarity and validity of the new biomechanical tests that underpin the training program.

The first pilot study was carried out on October 24 and 25, 2023 (Tuesday and Wednesday) around 4:00 pm in the triple jump field at the Ministry of Youth and Sports (Specialized Schools), with a research team. The research sample numbers were 6 and 29 for either compound. Procedures consisted of taking the proposed tests (3 test capabilities), recording for biomechanical analysis and verification of:

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- Field suitability for testing
- Participants' readiness for performance
- Possible difficulties and obstacles in the main trial
- Time required for test administration
- Familiarization of research staff and participants with the tests
- Functionality of video and other measuring devices

The second pilot study was carried out on 26 October 2023 (Thursday afternoon at 4:00 pm), also with the six athletes. The aim was to determine the workload for the plyometric boxes from maximum repetitions and optimal resistance in each of the exercises. This enabled the researchers to:

- Define box heights and repetitions based on training intensity
- Establish slope-jump exercises after determining box intensity and the appropriate slope angle

Therefore four boxes were constructed (width 40 cm, height ranged from 65 to 90% of the maximum intensity minimum), arranged 1 m apart at the following heights; 31 cm, 34 cm, 38cm and 43cm.

Training Program

The pre tests took place on Nov 2, 2023 at4:00 p.m) in the sport field of the Ministry for Sports and Youth (Technology school for Athletes). Kinetic data were recorded using video analysis.

Afterwards, the experimental group was subjected to an intervention that incorporated unilateral depth jump training on gradients. The program started November 4, 2023 (Saturday) and ended January 16, 2024 (Tuesday), covering an overall period of 11 weeks with a total of thirty-two training sessions being performed (three times per week at maximum over Saturdays, Tuesdays and Thursdays).

The main training phase of each unit lasted between 27–40 minutes, with intensity levels ranging from 75–100%. Training loads were regulated based on box heights and repetitions, averaging the values obtained for the group during pilot testing. Training intensity progression followed wave patterns of (2–1) within a single week and (3–1) across weeks.

Post-tests were administered after the program to assess changes in the targeted biomechanical variables.

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Statistical Methods

The researchers utilized SPSS for data analysis, applying the following statistical tools:

- Arithmetic mean
- Standard deviation
- Skewness coefficient
- Paired sample t-test

Results

Table 1. *Calculated t-value and significance level for the pre-test and post-test of the speed variable under investigation*

Biomechanical Variables	Phases	Unit of Measurement	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Mean Difference	Std. Error	*t*-value	Sig.
Speed	Hop	sec – m/s	6.83 ± 0.12	7.13 ± 0.19	0.30	0.08	8.21	0.00
	Step	sec – m/s	6.21 ± 0.19	6.43 ± 0.21	0.21	0.07	7.05	0.00
	Jump	sec – m/s	5.41 ± 0.11	5.63 ± 0.13	0.21	0.09	5.39	0.00

Significant at df = (6–1 = 5), p = 0.05.

Table 2. *Calculated t-value and significance level for the pre-test and post-test of the force variable across the take-off phases under investigation*

Force Variable	Phases	Unit of Measurement	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Mean Difference	Std. Error	Variance	*t*-value	Sig.
Force	Hop	N (Newtons)	4425.83 ± 247.63	4567.66 ± 267.84	141.83	69.99	28.57	4.963	.00
	Step	N (Newtons)	3808.83 ± 130.09	3887.16 ± 167.46	78.33	44.11	18.01	4.349	.00
	Jump	N (Newtons)	3069.16 ± 53.44	3194.33 ± 95.38	125.16	43.54	17.77	7.041	.00

Significant at df = (6–1 = 5), p = 0.05.

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Table 3. *shows the calculated t value and the error ratio for the pre- and post-tests of the motor transfer index variable under investigation*

Motor Transfer Index	Phases	Unit of Measurement	Pre-test Mean	Post-test Mean	Mean Difference	Std. Dev.	Std. Error	*t*-value	Sig.
	Hop		40.00	48.00	0.07	0.04	0.01	4.50	.00
	Step		36.00	38.00	0.02	0.00	0.00	11.06	.00
	Jump		41.00	48.00	0.07	0.03	0.01	5.69	.00

Significant at degree of freedom (6–1 = 5), with an error level of (0.05).

Discussion

The researcher attributes the significant differences between the pre- and post-test results for the variable of speed across the three phases of the triple jump, in favor of the post-test results of the study sample, to the nature of the single deep jump training on slopes applied within the training program. The researcher explains that these differences arise from the effect of deep jump exercises, which play a crucial role in activating a large number of fast-twitch muscle fibers simultaneously and within the shortest possible time, thereby positively influencing the development of movement speed during the hop, step, and jump phases.

In terms of the three phases of the triple jump, speed works to oppose take off angle. For that reason, the author applied this principle in the training program by implementing jumps with an optimal take-off angle. This incorporation was supported by the motor transfer index in scores indicating very easy movement sequences and the best appropriate T/O angles which positively predicted post-testing results. In particular, the absolute horizontal velocity decreases in all of these phases of motion, especially between the hop and step phases, so it is important to obtain a high take-off speed during the hop phase with an effective take-off angle to provide for enough speed in the subsequent step phase and jump phase. This discrepancy is consistent with that reported by Al-Fadhli et al. (2023) who observed a systematic reduction in absolute horizontal velocity across the phases of triple jumping which is most pronounced between the step and jump take-offs.

As far as the eliciting effect of single deep jump training on slopes is concerned, the results clearly demonstrated a speed improvement. This is in accordance with Mohammed (2005) who reported that motor speed development occurs as a result of muscular strength such as attained in plyometric exercises. Instantaneous speed or the speed at a given time was analysed by the researcher using Kinovea software according to instantaneous speed = instantaneous distance / time. This approach is consistent with Al-Fadhli and Al-Bayati (2012) who argued that instantaneous speed describes the positional change at an instant in time which could take place

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during jump-take-off or ball-striking during football. Moreover, Jabbar and Kazem (2018) described that the speed is the space crossed or covered by mass in a given time.

The development of means to improve speed and rate of power production has become a cornerstone in the quest for optimal skill levels across all sports. A great debate exists as to the ideal speed of execution. Some researchers prescribe high-speed explosive exercises and others slower execution at a moderate speed. Advocates of high-velocity execution argue that in order to produce "explosive power" the training stimulus should be explosive (or sharp) and rapid (Al-Fadhli et al., 2019). It is single deep jump training that forms the basis of this principle since athletes have to overcome inertia and elevate themselves at high instantaneous speeds against gravity. This feature was a key aspect of the training, which concentrated on reducing running time as doing so is an important factor in speed.

As noted by Jabbar Ali et al. (2014) speed is that one of the most important factors in determining the height to which a projected body will ascend. Specialized training of deep jumps with slope had a great influence on the acceleration level during the triple jump phases among subjects. The negative relationship between time and force is such that decreasing take-off time leads to an increase in the amount of force generated. Thus, in view of the slight reduction in horizontal velocity noted, a lack of any significant output force errors was inferred during take-off; that is, good motor performance. This derives further support from the motor transfer index, which showed the ability to hold take-off angles well in both hop phase and thus aid better propulsion for step and jump phases.

From force-versus-time relationship, one can perceive that minimizing temporal loss is paramount for efficient transfer of momentum, as reported by Al-Fadhli (2010). The researcher believes that the substantial differences in post-test speed outcomes are a result of the unique nature of slope-based deep jump training, which is particularly difficult as it also requires lower extremity muscles to deal with interactions between gravity, drop height and resistance of the slope. This increased muscular demand helps to develop power and speed, which agrees with Al-Fadhli's (2007) suggestion that resistance situations will improve take-off force and acceleration. Likewise, Mohammed et al. (2011) stressed the very high levels of force and speed that are required for explosive actions to occur, referring to instantaneous power as the product of those two variables.

Whole-body momentum (mass times velocity) can be tan determine at both ground contact and take-off. This transfer of momentum takes place in the running phase and throughout all three phases of the triple jump. Thus, changes in momentum (when mass is held constant although velocity changes) can be said not only to inform the quality of technical execution but also

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advance optimal angles – specifically take-off angle, which acts as a proxy for motor transfer. Al-Fadhli (2020) noted that the motor transfer of horizontal jumps can be measured from an impulse reduction at take-off, combined with take-off angle. Considering that the conversion of linear to horizontal projections requires only small angles and maximal launch speeds, we can then express the motor transfer index as:

Motor Transfer Index for Horizontal Movements = Take-off Angle ÷ Momentum Reduction

A greater calculated value is indicative of better motor transfer. According to the momentum principle, an increase in velocity with no change in body mass will result in a greater transfer of force during triple jump performance, as long as optimal take-off angles are maintained for each phase. Therefore, the author credits the great differences in motor transfer index in favor of the post-test group to slope single deep jumps exercises that increased instantaneous power and speed-strength and also took-off more effectively. In the hop and jump phases, increase was maximal and slightly less for the step phase. This result is consistent with Stone et al. (2002) who explained that as plyometric training is one of the most efficient strategies to increase muscle power because it improves strength and speed together, this approach yields enhanced performance efficiency compared to traditional training forms.

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