The effects of plyometric training on selected physical abilities and kinematic variables in youth female football players

El efecto del ejercicio pliométrico sobre capacidades físicas seleccionadas y variables cinemáticas seleccionadas en jugadoras jóvenes de fútbol

Authors

Haya Qatami [1]
Hashem A. Kilani [2]

[1] The Hashemite University (Jordan)
[2] The University of Jordan (Jordan)

Corresponding author:
Hashem Kilani
hashemkilani@gmail.com

Received: 31-03-26
Accepted: 15-05-26

How to cite in APA

Qatami, H., & Kilani, H. A. (2026). The effects of plyometric training on selected physical abilities and kinematic variables in youth female football players. *Retos, 81*, 293-300. https://doi.org/10.47197/retos.v81.119142

Abstract

Introduction: Plyometric training is widely recognized as an effective method for enhancing explosive physical performance in sport.
Objective: This study aimed to examine the effects of an eight-week plyometric training program on selected physical abilities and kinematic variables in youth female football players.
Methods: A quasi-experimental pre–post design was employed involving adolescent athletes aged 15–17 years. Participants were allocated according to team training schedules and logistical considerations; therefore, randomization was not feasible. Performance variables included explosive power, agility, muscular endurance, and hopping ability. Kinematic variables such as step length, step frequency, and running velocity were also assessed using standardized field tests and video-based analysis.
Results: The experimental group demonstrated significant improvements across all physical performance variables compared with the control group. Explosive power and hopping performance showed the greatest relative gains. Agility improved significantly, reflected by reduced completion times. Kinematic analysis revealed increased step length, running velocity, and effectiveness index, whereas step frequency showed no significant change. Effect size analysis indicated large practical effects of the plyometric training program.
Conclusions: Plyometric training may represent a practical training strategy associated with improvements in physical performance and selected kinematic variables in youth female football players. Coaches are encouraged to incorporate structured plyometric exercises into training programs to optimize neuromuscular development and sport-specific performance.

Keywords

Plyometric training; explosive power; agility; youth athletes; female football.

Resumen

Introducción: El entrenamiento pliométrico es ampliamente reconocido como un método eficaz para mejorar el rendimiento físico explosivo en el deporte.
Objetivo: Este estudio tuvo como objetivo examinar los efectos de un programa de entrenamiento pliométrico de ocho semanas sobre determinadas capacidades físicas y variables cinemáticas en jóvenes jugadoras de fútbol femenino.
Métodos: Se empleó un diseño cuasi experimental pre-post con atletas adolescentes de 15 a 17 años. Los participantes fueron asignados según los cronogramas de entrenamiento de los equipos y consideraciones logísticas; por lo tanto, la aleatorización no fue factible. y a un grupo de control, que continuó con sus rutinas de entrenamiento habituales. Las variables de rendimiento incluyeron potencia explosiva, agilidad, resistencia muscular y capacidad de salto. También se evaluaron variables cinemáticas como la longitud de la zancada, la frecuencia de la zancada y la velocidad de carrera mediante pruebas de campo estandarizadas y análisis de vídeo.
Resultados: El grupo experimental demostró mejoras significativas en todas las variables de rendimiento físico en comparación con el grupo de control. La potencia explosiva y el rendimiento en el salto mostraron las mayores ganancias relativas. La agilidad mejoró significativamente, reflejada en tiempos de finalización reducidos. El análisis cinemático reveló un aumento en la longitud de la zancada, la velocidad de carrera y el índice de efectividad, mientras que la frecuencia de la zancada no mostró cambios significativos. El análisis del tamaño del efecto indicó importantes efectos prácticos del programa de entrenamiento pliométrico.
Conclusiones: El entrenamiento pliométrico es una estrategia eficaz para mejorar el rendimiento físico y determinadas variables cinemáticas en jugadoras de fútbol femenino juvenil. Se recomienda a los entrenadores incorporar ejercicios pliométricos estructurados en los programas de entrenamiento para optimizar el desarrollo neuromuscular y el rendimiento específico del deporte.

Palabras clave

Entrenamiento pliométrico; potencia explosiva; agilidad; atletas jóvenes; fútbol femenino.

Introduction

Modern training methodologies increasingly emphasize the development of explosive physical abilities as a key determinant of athletic performance, particularly in sports that require high levels of speed, power, and rapid force production. In football and sprint-related activities, performance outcomes are strongly influenced by neuromuscular efficiency, rate of force development, and the ability to generate maximal force within short time intervals (Cormie et al., 2018).

Plyometric training has emerged as an effective training approach for enhancing explosive strength through the utilization of the stretch–shortening cycle, enabling athletes to produce maximal force in minimal time. Previous systematic reviews have consistently demonstrated that plyometric training improves strength, sprint performance, agility, and explosive power in team-sport athletes (Markovic, 2007; Slimani et al., 2016; Chaabene et al., 2019). This method involves high-velocity movements such as jump squats, bounding drills, and sprint-based exercises that closely replicate sport-specific biomechanical demands (Loturco et al., 2023).

Previous research has demonstrated that plyometric training induces significant neuromuscular adaptations, including improved motor unit recruitment, enhanced intermuscular coordination, and increased efficiency of the stretch–shortening cycle (Suchomel et al., 2018; Kilani et al., 1989). These adaptations are particularly relevant in football, where repeated explosive actions such as sprinting, jumping, and rapid changes of direction are essential for performance.

In youth female athletes, the implementation of structured strength and power training is especially important due to ongoing physiological development. Well-designed plyometric programs have been shown to be safe and effective when properly supervised and progressively implemented (Morris et al., 2022). Furthermore, female athletes may exhibit distinct neuromuscular characteristics, including differences in strength levels and muscle activation patterns, highlighting the importance of targeted training strategies (Bishop et al., 2021).

Several studies have demonstrated the effectiveness of plyometric training in improving physical performance variables in football players and youth athletes.. Similarly, Ramírez-Campillo et al. (2024) demonstrated that combined plyometric and speed training enhances physical performance and change-of-direction ability in young athletes. These findings support the application of plyometric training within developmental sport contexts.

Despite the growing body of literature, limited research has examined the combined effects of plyometric training on both physical abilities and kinematic variables in youth female football players. While improvements in performance outcomes have been widely reported, fewer studies have incorporated biomechanical analysis to explain the mechanisms underlying these adaptations. Integrating kinematic variables such as step length, step frequency, and running velocity provides deeper insight into movement efficiency and performance enhancement (Cormie et al., 2011; Bishop et al., 2021).

Therefore, the present study aimed to examine the effects of an eight-week plyometric training program on selected physical abilities and kinematic variables in youth female football players. It was hypothesized that plyometric training would result in significant improvements in both performance and movement efficiency.

Method

Study Design

The study sample consisted of 20 youth female football players aged 15–17 years recruited from organized football clubs in Jordan. All participants had a minimum of two years of systematic football training experience and regularly participated in competitive training and matches.

Participants were allocated into:

an experimental group (n = 10), and

a control group (n = 10)

according to team training schedules and logistical considerations; therefore, randomization was not feasible.

Inclusion criteria included

regular participation in football training,

age between 15 and 17 years,

minimum two years of organized training experience,

and medical clearance for participation in high-intensity physical activity.

Exclusion criteria included

musculoskeletal injury within the previous six months, neurological disorders, participation in other structured strength-training programs, or absence from more than 10% of training sessions during the intervention period.

No participant withdrawals or sample losses occurred during the intervention period.

Participants and their legal guardians provided written informed consent prior to participation. All procedures were conducted in accordance with the Declaration of Helsinki and approved by the institutional ethics committee.

Study Variables

Independent Variable

Plyometric training intervention (experimental vs control)

Dependent Variables

Physical abilities: explosive power, muscular endurance, agility, and hopping performance

Kinematic variables: step length, step frequency, running velocity, effectiveness index

Football skill variables: release angle, and ball range

Plyometric Training Program

Training intensity was progressively increased throughout the intervention according to the athletes' adaptation and technical proficiency. Exercises were performed at moderate-to-high intensity corresponding approximately to 60–80% of maximal perceived effort. Training volume progressed from 80–100 ground contacts during the initial phase to approximately 120–140 contacts during the final weeks of the program. Recovery intervals between sets ranged from 60–120 seconds to maintain movement quality and minimize fatigue accumulation. All sessions were supervised by certified strength and conditioning specialists to ensure safety and correct execution

The program included high-velocity exercises based on the stretch–shortening cycle, such as:

Jump squats, bounding drills, resisted sprints and medicine ball throws.

Physical performance was assessed before and after the intervention using standardized field tests:

Explosive power: standing long jump

Muscular endurance: sit-ups test

Agility: agility run test

Hopping performance: single-leg hop test

Prior to baseline testing, all participants completed two familiarization sessions to ensure correct execution of the physical performance tests and plyometric exercises. Standardized verbal instructions and demonstrations were provided by the research team.

Kinematic variables were analyzed using video-based motion analysis. A Sony digital video camera (25 frames per second) was used to capture movement, and variables including step length, step frequency, and running velocity were derived from the recorded footage.

All measurement procedures followed established protocols and demonstrated acceptable reliability based on previous literature. Prior to the main data collection, pilot testing was conducted to assess measurement consistency. Intraclass correlation coefficients ranged from 0.82 to 0.91 across the primary physical and kinematic variables, indicating acceptable reliability.

Statistical Analysis

Descriptive statistics (mean ± standard deviation) were calculated for all variables. A two-way mixed-design analysis of variance (ANOVA) was conducted to examine the effects of group (experimental vs. control) and time (pre-test vs. post-test) on physical performance and kinematic variables. Interaction effects (group × time) were used to determine whether changes over time differed between groups.

When significant interaction effects were identified, Bonferroni-adjusted post hoc comparisons were performed. Effect sizes were calculated using partial eta squared (η^2p) for ANOVA analyses and interpreted according to conventional thresholds. Statistical significance was set at $p \leq 0.05$. All analyses were conducted using standard statistical software.

Results

Baseline results

Baseline comparisons revealed no statistically significant differences between the experimental and control groups across all measured variables ($p > 0.05$), indicating initial group equivalence. Following the eight-week intervention, the experimental group demonstrated greater improvements in physical performance and selected kinematic variables compared with the control group.

Independent sample comparisons revealed no statistically significant differences between the experimental and control groups at baseline across all measured variables ($p > 0.05$), confirming initial group equivalence (Table 1).

Table 1. Pre-Test Comparison Between Experimental and Control Groups

Variable	Group	Mean ± SD	t-value	p-value
Standing Long Jump (m)	Experimental	149.7 ± 15.0	1.22	0.236
	Control	142.0 ± 13.0		
Sit-ups (reps)	Experimental	24.0 ± 2.1	1.47	0.157
	Control	22.2 ± 3.3		
Agility Test (s)	Experimental	19.42 ± 0.81	0.23	0.820
	Control	19.61 ± 2.37		

No statistically significant differences were found, indicating group equivalence at baseline.

Effects of Plyometric Training on Physical Performance

Descriptive analysis indicated that both groups had comparable values at baseline. Following the eight-week intervention, the experimental group demonstrated substantial improvements across all physical performance variables, whereas the control group showed only minor or non-significant changes.

Within the experimental group, post-test results showed significant improvements in all measured variables following the plyometric training program (Table 2). Explosive power, assessed by the standing long jump, improved significantly ($p < 0.01$), indicating enhanced lower-limb power output. Muscular endurance also increased significantly, as evidenced by improved sit-up performance ($p < 0.01$). Agility performance demonstrated a significant reduction in completion time ($p < 0.01$), while hopping performance over 30 m showed marked improvement ($p < 0.01$), reflecting enhanced neuromuscular coordination.

Table 2. Effects of Plyometric Training on Physical Performance Variables

Variable	Group	Pre-Test Mean ± SD	Post-Test Mean ± SD	% Change	p-value	Effect Size (η^2p or d)
Standing Long Jump (m)	Experimental	149.7 ± 15.0	165.4 ± 12.1	+10.5%	<0.01	1.25
	Control	142.0 ± 13.0	147.2 ± 13.6	+3.7%	NS	—
Sit-ups (reps)	Experimental	24.0 ± 2.1	29.8 ± 2.3	+24.2%	<0.01	1.42
	Control	22.2 ± 3.3	23.6 ± 3.1	+6.3%	NS	—
Agility Test (s)	Experimental	19.42 ± 0.81	17.90 ± 0.75	−7.8%	<0.01	1.10
	Control	19.61 ± 2.37	19.30 ± 1.92	−1.6%	NS	—
Hop Performance (s)	Experimental	9.40 ± 0.66	7.85 ± 0.51	−16.5%	<0.01	1.30
	Control	9.31 ± 0.72	9.10 ± 0.68	−2.3%	NS	—

The experimental group demonstrated substantially greater improvements in all physical performance variables following the plyometric intervention.

The kinematic analysis revealed statistically significant improvements in step length, running velocity, and effectiveness index in favor of the experimental group, while step frequency did not show significant change. This indicates that performance enhancement was primarily attributed to increased stride efficiency rather than cadence alteration. (Table 3).

Table 3. Effects of Plyometric Training on Kinematic Variables

Variable	Experimental Mean	Control Mean	p-value
100 m Time (s)	15.38	16.81	0.010*
Step Length (m)	2.02	1.87	0.000*
Velocity (m/s)	6.52	5.99	0.011*
Effectiveness Index	13.16	11.21	0.001*
Release Angle (°)	44.80	39.80	0.007*
Ball Range (m)	22.20	18.10	0.004*

* Significant at $p \leq 0.05$

The experimental group demonstrated superior improvements in selected biomechanical and football-specific kinematic variables following the intervention.

Figure 1. Percentage improvement in vertical jump, agility, and muscular strength following a plyometric training program.

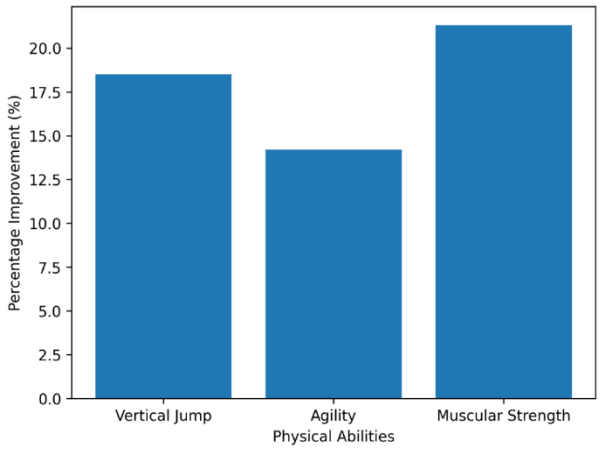


Figure 2. Kinematic Improvement for Sprinters (Post-Test Exp-Con), 100 m Time, Step Length, Velocity, Effectiveness

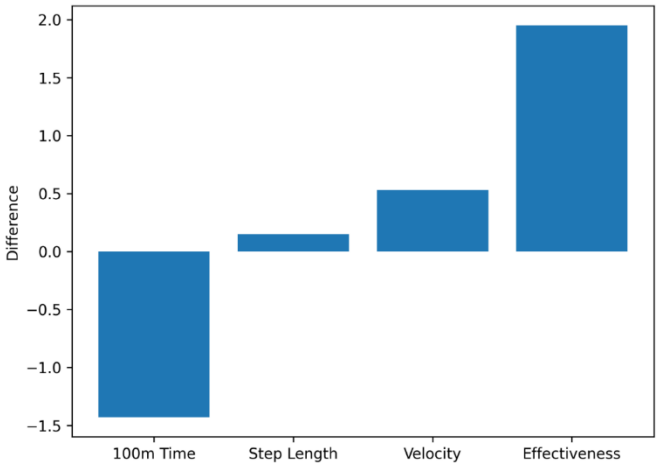
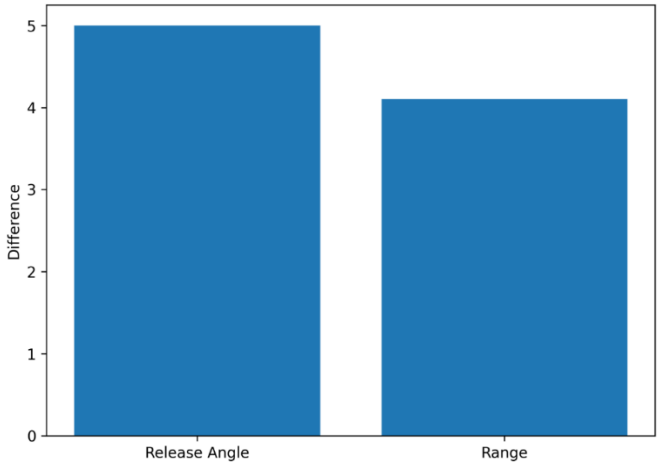


Figure 3. Kinematic Improvement for Football Players, (Post-Test Exp-Con), Release Angle, Range



Discussion

The purpose of this study was to examine the effects of an eight-week plyometric training program on selected physical abilities and kinematic variables in youth female football players. The findings suggest that plyometric training may contribute to improvements in explosive power, muscular endurance, agility, hopping performance, and selected kinematic variables, including step length, running velocity, effectiveness index, release angle, and ball range. These findings are illustrated in Figures 1–3.

The significant improvement in standing long jump performance is consistent with previous research indicating that plyometric training enhances the efficiency of the stretch–shortening cycle and increases the rate of force development through high-velocity muscle actions (Kilani et al., 1989; Cormie et al., 2011; Suchomel et al., 2018). These neuromuscular adaptations are particularly relevant in football, where explosive lower-limb actions are essential for sprinting, jumping, and rapid changes of direction (Kilani & Al-Qatami, 2006). These findings are consistent with previous meta-analytical evidence demonstrating that plyometric interventions improve explosive performance and movement efficiency in youth and team-sport athletes (Asadi et al., 2016; Chaabene et al., 2019).

The present findings are also in agreement with previous studies demonstrating that plyometric training improves neuromuscular efficiency and sport-specific performance in football and team-sport athletes (Ramírez-Campillo et al., 2024). Notably, Previous research has reported similar improvements in agility, sprint performance, and explosive power following plyometric interventions, supporting the effectiveness of this training approach in youth and female football populations.

Improvements in muscular endurance observed in the present study may be attributed to increased neuromuscular activation and enhanced core stability during plyometric exercises. Previous research has shown that power-oriented training can improve trunk stability and repeated force production, which are essential for maintaining performance during prolonged match play (Behm et al., 2017) This is particularly important for female football players, as trunk endurance contributes to both performance efficiency and injury prevention.

The observed improvements in agility performance further support existing literature indicating that plyometric training enhances change-of-direction ability by improving motor unit recruitment and movement coordination (Sheppard & Young, 2006). From a biomechanical perspective, these adaptations facilitate more efficient force application, faster braking, and more effective re-acceleration phases.

Enhanced hopping performance reflects improvements in reactive strength and neuromuscular control. These adaptations are consistent with findings demonstrating that plyometric training improves lower-limb stiffness and the effective utilization of elastic energy during dynamic movements (Markovic & Mikulic, 2010).

From a biomechanical standpoint, running velocity is determined by the interaction between step length and step frequency. The present findings indicate that plyometric training primarily improved performance through increased step length and force application, rather than changes in step frequency. This suggests that neuromuscular adaptations enhanced propulsion efficiency and stride mechanics without altering cadence.

Similarly, improvements in football-specific kinematic variables, such as release angle and ball range, indicate enhanced coordination and more efficient transfer of force through the kinetic chain. These findings may indicate that plyometric training is associated not only with physical performance improvements but also with selected aspects of technical execution.

Importantly, the inclusion of kinematic variables in the present study provides a deeper biomechanical explanation of performance improvements. While many studies focus solely on performance outcomes, the integration of biomechanical analysis strengthens the explanatory power of the findings by linking neuromuscular adaptations to movement efficiency.

The large effect sizes observed across all variables further emphasize the practical significance of the training program. These findings indicate that plyometric training produces meaningful performance improvements beyond statistical significance and supports its application in youth football training programs.

Compared with traditional resistance training, plyometric training more closely replicates the velocity and movement patterns required in sport-specific actions. Therefore, plyometric training may represent a practical and sport-specific training strategy for developing performance-related physical abilities in youth female football players.

Conclusions

Plyometric training may be an effective approach for improving explosive power, agility, muscular endurance, and hopping performance in youth female football players. The program was also associated with improvements in selected kinematic variables, particularly step length, running velocity, movement efficiency, release angle, and ball range.

These findings highlight the potential value of plyometric training as a sport-specific intervention for improving both physical and biomechanical performance components. Coaches and practitioners may consider incorporating structured plyometric exercises into youth football training programs while ensuring appropriate supervision and progressive overload.

Acknowledgements

The authors acknowledge the support provided by the Faculty of Physical Education and Sport Sciences at The Hashemite University and the School of Sport Sciences at The University of Jordan.

Financing

This research received no external funding.

References

Asadi, A., Arazi, H., Ramirez-Campillo, R., Moran, J., & Izquierdo, M. (2016). Influence of maturation stage on agility performance following plyometric training: A systematic review and meta-analysis. *Journal of Strength and Conditioning Research, 30*(9), 2609–2617. https://doi.org/10.1519/JSC.0000000000001326

Behm, D. G., Young, J. D., Whitten, J. H. D., Reid, J. C., Quigley, P. J., Low, J., & Granacher, U. (2017). Effectiveness of traditional strength vs. power training on muscle strength, power, and speed with youth: A systematic review and meta-analysis. *Frontiers in Physiology, 8*, 423. https://doi.org/10.3389/fphys.2017.00423

Bishop, C., Turner, A., & Read, P. (2021). Effects of strength training on movement performance in female athletes. *Sports Medicine, 51*(2), 243–266.

Chaabene, H., Negra, Y., Moran, J., Prieske, O., Sammoud, S., Ramirez-Campillo, R., & Granacher, U. (2019). Effects of plyometric training on physical fitness in team sport athletes: A systematic review. *Journal of Human Kinetics, 67*, 91–111. https://doi.org/10.2478/hukin-2018-0060

Cormie, P., McGuigan, M. R., & Newton, R. U. (2011). Developing maximal neuromuscular power: Part 1—Biological basis of maximal power production. *Sports Medicine, 41*(1), 17–38. https://doi.org/10.2165/11537690-000000000-00000

Cormie, P., McGuigan, M. R., & Newton, R. U. (2018). Developing maximal neuromuscular power. *Sports Medicine, 48*(1), 11–27.

Kilani, H., & Al-Qatami, H. (2006). The development of explosive strength through involuntary vibrations and plyometric training. *Dirasat: Educational Sciences, 33*(2).

Kilani, H., Palmer, S., Adrian, M., & Gapsis, J. (1989). Block of the stretch reflex of vastus lateralis during vertical jumps. *Human Movement Science, 8*(3), 247–269. https://doi.org/10.1016/0167-9457(89)90009-2

Loturco, I., Pereira, L. A., Freitas, T. T., Moura, T. B., Mercer, V. P., Fernandes, V., & Bishop, C. (2023). Plyometric training practices of Brazilian Olympic sprint and jump coaches: Toward a deeper understanding of their choices and insights. *Journal of Human Kinetics, 88*, 131–145. https://doi.org/10.5114/jhk/169167

Markovic, G. (2007). Does plyometric training improve vertical jump height? A meta-analytical review. *British Journal of Sports Medicine, 41*(6), 349–355. https://doi.org/10.1136/bjsm.2007.035113

Markovic, G., & Mikulic, P. (2010). Neuro-musculoskeletal and performance adaptations to lower-extremity plyometric training. *Sports Medicine, 40*(10), 859–895. https://doi.org/10.2165/11318370-000000000-00000

Morris, S. J., Oliver, J. L., Pedley, J. S., Haff, G. G., & Lloyd, R. S. (2022). Comparison of weightlifting, traditional resistance training and plyometrics on strength, power and speed: A systematic review with meta-analysis. *Sports Medicine, 52*(7), 1533–1554. https://doi.org/10.1007/s40279-021-01627-2

Ramírez-Campillo, R., Miñano, J., Traver Gil, P., & Sáez de Villarreal Sáez, E. (2024). Efectos del entrenamiento combinado de pliometría, velocidad y cambio de dirección en jugadoras de fútbol sobre el rendimiento físico. *Retos, 59*, 1081–1091. https://doi.org/10.47197/retos.v59.104527

Sheppard, J. M., & Young, W. B. (2006). Agility literature review: Classifications, training and testing. *Journal of Sports Sciences, 24*(9), 919–932. https://doi.org/10.1080/02640410500457109

Slimani, M., Chamari, K., Miarka, B., Del Vecchio, F. B., & Chéour, F. (2016). Effects of plyometric training on physical fitness in team sport athletes: A systematic review. *Journal of Human Kinetics, 53*, 231–247. https://doi.org/10.1515/hukin-2016-0026

Suchomel, T. J., Nimphius, S., & Stone, M. H. (2018). The importance of muscular strength in athletic performance. *Sports Medicine, 48*(4), 765–785. https://doi.org/10.1007/s40279-018-0862-z

Authors and translators' details:

Haya Qatami	qutamih@yahoo.com	Author
Hashem Kilani	hashemkilani@gmail.com	Author