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Effect of drop height on different parameters of drop jump among soccer players

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Abstract
Introduction. **Drop jump is one of the most researched plyometric exercises. Different drop heights were earlier investigated for ground reaction forces, biomechanical analysis, and other parameters. There has been no research into the influence of drop height on maximum jump height during drop jump among soccer players.** Aim of Study. **This study aimed to find out the optimal drop height for maximum vertical jump height in drop jumps.** Material and Methods. **The researchers selected 17 male soccer players (mean ± SD; age 21 ± 2 years, height 174 ± 8 cm, body mass 63 ± 5 kg, isometric leg strength 122 ± ± 18 kg) for the study. Drop jump from different heights (35 cm, 45 cm, 50 cm, 65 cm, and 72 cm) was investigated for jump height, take-off force, take-off speed, impact force, maximum concentric power, and peak speed.** Results. **Repeated measures ANOVA revealed significant difference in jump height from different drop height ($F_{2.54,40.59}$ = 5.605, p = 0.004, partial η^2 = 0.259). Post-hoc analyses through Bonferroni adjustment showed significant differences between jump height from 35 cm box and 45 cm box (t_{16} = 4.31, p = 0.001, d = 0.47) and 35 cm box to 72 cm box (t_{16} = 3.52, p = 0.003, d = 0.60). However, no significant differences could be observed in take-off force, impact force, maximum concentric power, peak speed, and take-off speed from different drop heights. Isometric leg strength were significantly correlated with jump height from 35 cm (p = 0.014), 45 cm (p = 0.021) and 50 cm (p = 0.022) drop height.** Conclusions. **The study concludes that to improve maximum jump ability of soccer players, box height ranging around 65 cm to 72 cm may be selected for training purposes and thus may help improve the body's ability to convert the momentum generated by a run to maximum vertical height.**

KEYWORDS: drop jump, drop height, jump height, soccer players.

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Introduction

Soccer is among the most popular sports and is being played by many countries across the globe. Now and then, the teams want to perform better than their opponents. Moreover, thus, changes in training methodology to improve the performance of soccer players are very much accepted by teams all around the world [22]. This has led to more researches being conducted in soccer, and one such widely researched area is plyometric training for soccer players [22, 28]. Even if soccer player's aerobic capacity is critical in a soccer game [25], high-intensity player's efforts cannot be overlooked as they play a vital role in a soccer match [1, 8]. These high-intensity bouts include repeated kicking actions, changing directions, explosive sprinting, and jumping, all making significant contributions to the soccer player's performance [25, 26, 29]. Developing a soccer player's ability to generate power quickly would be an advantage to the soccer player during a match [20].
The successful transition of plyometric training to soccer performance is probably because many soccer activities need

movements with rapid stretch-shortening sequence, with players having to bounce against the surface with minimal surface contact phases [2, 17, 20]. Soccer coaches widely use plyometric exercises in their training periodization as it may increase the VO_2 peak percentage in soccer players [9], increase endurance and power generation in muscles [23], and also improve the ball velocity during soccer kick [6]. Drop jump is one of the most commonly used plyometric exercises to develop and evaluate jumping performance [15, 19]. Due to its proper metrics, such as reliability, validity, and sensitivity, the implementation of drop jump as a standard test has also been widely used and well supported in the literature [3, 12, 15, 27]. Thus, drop jump has been a choice of soccer coaches in developing muscle power of lower limbs for a long time [3, 15]. Also, numerous studies on drop jump revealed positive effects on jumping performance after the inclusion of drop jump in training or rehabilitation program [13, 14].

A drop jump is attempted by dropping from an elevated surface and attempting to make a vertical jump for maximum height after landing on the ground. A characteristic pattern is observed while the muscle elastic energy is retained and used during a drop jump. The gravitational force causes the body to move down, and energy is retained in the elastic components of the stretched muscles during the eccentric process. Furthermore, when the body moves up during the concentric process, it uses the muscle's stored energy [5, 10].

Many types of research were carried out to see the impact of the technique, optimum drop height, ground reaction force, body mass on peak power output, and drop jump intensity [11, 15, 19]. Our study was being conducted to find out the best possible drop height (from 35 cm to 72 cm) for maximizing the vertical jump of soccer players.

Aim of Study

The aim of the present study was to (a) to compare drop jump parameters shown by soccer players from different drop height, and (b) investigate the relationship of isometric leg strength with jump height from different drop height. It was hypothesized that soccer players would exhibit significant differences in drop jump parameters from different heights and a significant correlation between isometric leg strength and jump height from different drop heights.

Material and Methods

Subjects

Seventeen male subjects who were a part of the university soccer team which participated in national university games were selected for the study (mean ± SD; age 21 ± ± 2 years, height 174 ± 8 cm, body mass 63 ± 5 kg, isometric leg strength 122 ± 18 kg). The subjects had a minimum playing experience of 6 years during the collection of data. Plyometrics had been included and been a part of the training sessions of soccer players for 3 or more years. The subjects who participated in this study were physically active and training for national competitions. The inclusion criteria in this investigation were the absence of recent lower limb injury, lower back injury, or any musculoskeletal dysfunction within 6 months, which could hinder the execution of a proper drop jump. The execution of the study was in line with the Helsinki declaration's ethical principles for human research. Subjects were asked to fill out forms of informed consent. The research was approved by the institution's Sports Biomechanics department's research committee.

Procedure

All the subjects performed 10-minutes warm-up, which included dynamic stretching, plyometric exercises, and mobility exercises for the joints before the conduct of the test [26]. The subjects had to perform drop jump from varying heights (35 cm, 45 cm, 50 cm, 65 cm, 72 cm) with an instantaneous vertical jump intended for maximum height [11]. Participants were instructed to jump right after landing and cover the maximum vertical height possible. Each subject was allowed three trials in each box height. The order of the box height for drop jump was randomly assigned. The subject performed a total of 15 jumps. A rest interval of 30-seconds was allowed in between each trial [11].

BTS G-Sensor (S.P.A., Italy) which has tri-axial accelerometer with multiple sensitivity (±1.5 g, ±6 g), tri-axial magnetometer and tri-axial gyroscope with multiple sensitivity (±300 gps, ±1200 gps) was used to measure the outcomes of the drop jump. The protocol was set to drop jump in G Studio's (ver. 3.3.22.0) jump protocol section. Jump height, take-off force, impact force, maximum concentric power, peak speed, and take-off speed were the outcome variables of drop jump using the G-sensor and G-studio software. The drop jump with the maximum jump height among three trials was selected for analysis [26].

To measure the isometric leg strength, a leg and back dynamometer (T.K.K. 5402, Takei Scientific Instrument CO., LTD, Japan) was used. The subjects were asked to stand upright on the base of the dynamometer with the feet shoulder-width apart. Arms were hanged straight down to hold the bar at the centre with both hands, and palms facing towards the body. The knee was allowed to flex approximately 110 degrees, and then the chain was adjusted. The subjects were then asked to pull as hard as possible and asked to straighten the legs without bending the back [30].

Statistical analysis
Statistical analysis of the acquired data was performed using IBM SPSS (version 20.0.0). Shapiro–Wilk test was conducted to check the violations of the assumptions of normality. Non-parametric tests equivalent to its parametric counterpart were used for the analysis of non-normal data. Single-factor repeated measures ANOVA with five levels (box heights) were used separately for jump height, peak speed, and take-off speed. Greenhouse-Geisser corrections were used in cases where we found violations of assumptions of sphericity using the Mauchly's sphericity test. Post-hoc paired t-test with a Bonferroni adjustment (p = 0.01) was used to find any significant differences between the levels. Friedman's test (non-parametric) was used to analyze take-off force, impact force, and maximum concentric power, since one or more variables failed the test of normality and violated the assumptions of RMA. The relationship between isometric leg strength and output variables from various drop heights was evaluated with the Pearson product-moment correlation.
The effect sizes were calculated using partial η^2 for repeated measures ANOVA, with 0.01 defining small, 0.06 medium, and 0.14 large effect. While for Friedman's test, Kendall's W was calculated with 0.1 defining small, 0.3 moderate, and 0.5 large effects [7]. For Pearson correlation r = 0.10 specifies a low, r = 0.30 a moderate, and r = 0.50 a high association [7]. Cohen's d was calculated to determine the effect size for the student's t-test for paired sample, with d = 0.20 defining a small, d = 0.50 defining a medium and d = 0.80 defining a large effect size. The level of significance for all tests was set at 0.05.

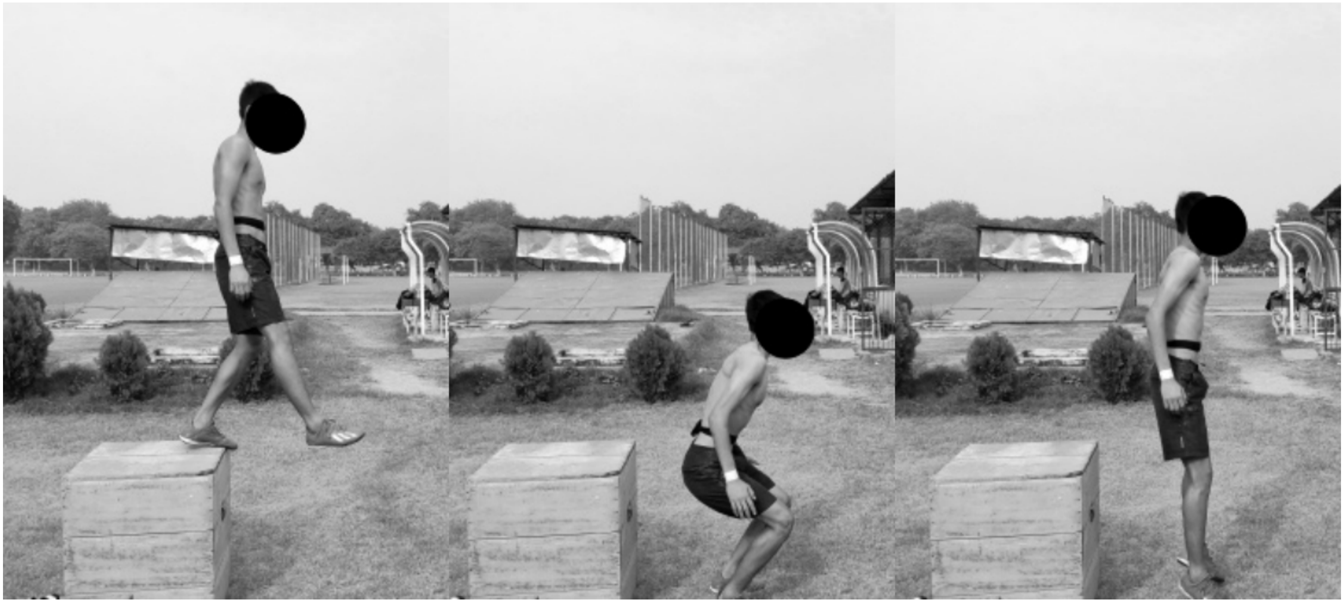

Figure 1. Subject performing drop jump with the BTS G-sensor tied on the waist of the subject

Results

Table 1 shows the values of all the measured variables. The outcome of the repeated measures ANOVA was significant in jump height from different box height, $F_{2.54,40.59} = 5.605$, p = 0.004, partial $\eta^2 = 0.259$. Post-hoc analyses by means of Bonferroni adjustment discovered significant differences between jump height from 35 cm box and 45 cm box ($t_{16} = 4.31$, p = 0.001, d = 0.47) and 35 cm box to 72 cm box ($t_{16} = 3.52$, p = 0.003, d = 0.60).
There were no significant differences in take-off force (p = 0.198), impact force (p = 0.455), maximum concentric power (p = 0.858), peak speed (p = 0.828), and take-off speed (p = 0.883) from different drop heights.
There was a statistically significant correlation between the isometric strength of the leg and the height of the jump from 35 cm (p = 0.014), 45 cm (p = 0.021), and 50 cm (p = 0.022) drop heights.

Table 1. Drop jump parameters using G-sensor from the different drop heights

	Box (35 cm) Mean ± SD; *median (IQR)*	Box (45 cm) Mean ± SD; *median (IQR)*	Box (50 cm) Mean ± SD; *median (IQR)*	Box (65 cm) Mean ± SD; *median (IQR)*	Box (72 cm) Mean ± SD; *median (IQR)*	p-value (effect size: partial η^2 or Kendall's W)
Jump height (cm)	34.71 ± 6.06	37.46 ± 5.9	36.96 ± 4.5	36.49 ± 4.32	38.18 ± 5.22	**0.004*** (0.259)
Take off force (kN)	0.73 ± 0.22	*0.69 (0.53-0.84)*	0.71 ± 0.24	0.71 ± 0.17	0.66 ± 0.24	0.198 (0.088)
Impact force (kN)	1.02 ± 0.23	1.02 ± 0.3	0.93 ± 0.23	*0.95 (0.77-1.12)*	0.97 ± 0.32	0.455 (0.054)
Maximum concentric power (kW)	*3.03 (2.72-3.61)*	*3.1 (2.72-3.61)*	3.21 ± 0.76	3.23 ± 0.69	*3.16 (2.64-3.56)*	0.858 (0.019)
Peak speed (m/s)	2.81 ± 0.27	2.83 ± 0.3	2.82 ± 0.31	2.85 ± 0.27	2.85 ± 0.25	0.828 (0.023)
Take off speed (m/s)	2.7 ± 0.27	2.72 ± 0.3	2.71 ± 0.3	2.73 ± 0.29	2.73 ± 0.26	0.883 (0.018)

Note: IQR = interquartile range, SD = standard deviation
* denotes significant differences at 0.05 level of significance

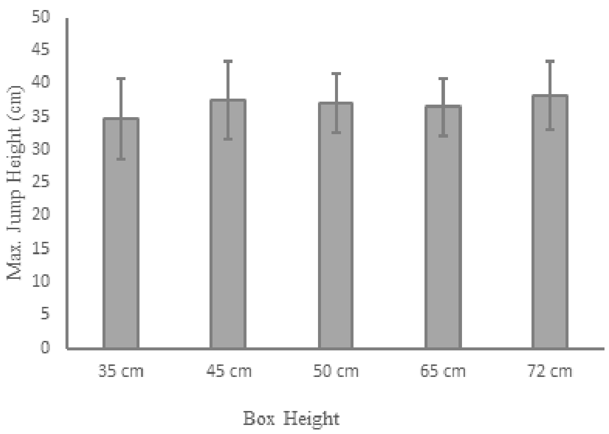

Figure 2. Bar diagram of maximum jump height from different box height

Table 2. Correlation of isometric leg strength with jump height from different drop heights

	Box (35 cm)	Box (45 cm)	Box (50 cm)	Box (65 cm)	Box (72 cm)
Isometric leg strength (r)	0.585*	0.556*	0.550*	0.328	0.478
p-value	0.014	0.021	0.022	0.199	0.052

* denotes significant correlation at 0.05 level

Discussion

In this present study, the assumption was that different drop heights would contribute to different vertical jump height for drop jump amongst soccer players. When the drop height rose from 35 cm to 45 cm, there was a significant increase in the height of the jump with a medium effect size. While the height of the jump did not differ significantly between 45 cm, 50 cm, and 65 cm drop height. A significant difference could also be seen in jump height when drop height increased from 35 cm to 72 cm with a medium effect size. A similar finding was observed in a study conducted by Ramirez-Campillo et al. [22], where the transference effect coefficient (TEC) was found higher for drop jump training from 40 cm than 20 cm height. The results of this study suggest that, with the increase in drop height, the height of the jump increases. A study conducted by Ramirez-Campillo et al. reported an increase in ground reaction force when the height of drop was increased from 20 cm to 40 cm and 60 cm when the toes and heels were in contact with the ground. A similar study by Caster found an increase in the maximum GRF when drop height was increased by 15 cm, 30 cm, 45 cm, and 60 cm. Some other studies were also conducted with different heights, like McKay et al. [16] who investigated 10 cm, 30 cm, and 50 cm, while Seegmiller and McCaw [24] investigated 30 cm, 60 cm, and 90 cm. All these experiments showed that there were higher ground reaction forces with a drop height increase. Also, our finding suggests that a height of 45 cm, 50 cm, and 65 cm used for drop jump yield similar jump height, and thus using any drop height between 45 and 65 cm would have the same effect on the jump height of soccer players.

No significant differences in take-off force, impact force, maximum concentric power, peak speed, and take-off speed between different drop heights were observed.

Soccer is a body contact sports [31], which includes jumps ranging from 1 to 36 during a top-level game [18]. A soccer player, thus, is accustomed to numerous jumps and landing during his entire career, including games and training. This might have led the soccer players capable of maintaining a similar impact force, take-off force, maximum concentric power, peak speed, and take-off speed throughout the jumps from different heights.

Further analysis of the relationship of isometric leg strength with jump height from different drop height revealed that a significant correlation was established among isometric leg strength and 35 cm, 45 cm, and 50 cm drop height while the relationship could not be established with the higher end of drop height. Pedersen et al. [21] conducted a study, where improved maximal strength was found not to be associated with jump height in countermovement jump in high-level female soccer players. This study partially supports our study. The jump height in the lower end of drop height may be contributed more by isometric leg strength. This might mean that the higher the isometric strength of the leg, the higher the jump height will be in drop heights from 50 cm and below. The results also reveal that the isometric strength of the leg does not contribute significantly to drop heights above 50 cm. The reason for this may be more flight time allowed during a drop from heights above 50 cm, which allows the body to generate more momentum, which then is utilized by the body to gain maximum vertical heights [4].

Conclusions

From the results and findings of the study, it can be concluded that soccer coaches may utilize different box height ranging from 35 cm to 72 cm to improve maximum concentric power, take-off speed and force ability, and ability to minimize the impact force while landing since all drop heights had shown a similar contribution to all those parameters. To improve maximum jump ability of soccer players, box height ranging around 65 cm to 72 cm may be selected for training purposes since these two drop heights exhibited maximum jump height, and thus may help improve the body's ability to convert the momentum generated by a run to maximum vertical height. Further, more studies are required in this area to investigate the effects of drop heights on other sports athletes, who require improvement in jump ability.

References

1. Barnes C, Archer D, Hogg B, Bush M, Bradley P. The evolution of physical and technical performance parameters in the English Premier League. Int J Sports Med. 2014; 35(13): 1095-1100. DOI: 10.1055/s-0034-1375695.
2. Bates NA, Ford KR, Myer GD, Hewett TE. Timing differences in the generation of ground reaction forces between the initial and secondary landing phases of the drop vertical jump. Clin Biomech. 2013; 28(7): 796-799. DOI: 10.1016/j.clinbiomech.2013.07.004.
3. Bobbert MF. Drop jumping as a training method for jumping ability. Sports Med. 1990; 9(1): 7-22. DOI: 10.2165/00007256-199009010-00002.
4. Bompa TO. Power training for sport: plyometrics for maximum power development. Oakville, New York, London: Mosaic Press; 1996.
5. Bosco C, Tihanyi J, Komi PV, Fekete G, Apor P. Store and recoil of elastic energy in slow and fast types of human skeletal muscles. Acta Physiol Scand. 1982; 116(4): 343--349. DOI: 10.1111/j.1748-1716.1982.tb07152.x.
6. Campo SS, Vaeyens R, Philippaerts RM, Redondo JC, de Benito AM, Cuadrado G. Effects of lower-limb plyometric training on body composition, explosive strength, and kicking speed in female soccer players. J Strength Cond Res. 2009; 23(6): 1714-1722. DOI: 10.1519/JSC.0b013e3181b3f537.
7. Cohen J. Statistical power analysis for the behavioural sciences. Hillsdale: Lawrence Erlbaum Associates; 1988.
8. Faude O, Koch T, Meyer T. Straight sprinting is the most frequent action in goal situations in professional football. J Sports Sci. 2012; 30(7): 625-631. DOI: 10.1080/02640414.2012.665940.
9. Grieco CR, Cortes N, Greska EK, Lucci S, Onate JA. Effects of a combined resistance-plyometric training program on muscular strength, running economy, and VO2peak in division I female soccer players. J Strength Cond Res. 2012; 26(9): 2570-2576. DOI: 10.1519/JSC.0b013e31823db1cf.
10. Kollias I, Panoutsakopoulos V, Papaiakovou G. Comparing jumping ability among athletes of various sports: vertical drop jumping from 60 centimeters. J Strength Cond Res. 2004; 18(3): 546-550. DOI: 10.1519/1533-4287(2004)18<546:CJAAAO>2.0.CO;2.
11. Makaruk H, Sacewicz T. The effect of drop height and body mass on drop jump intensity. Biol Sport. 2011; 28(1): 63-67. DOI: 10.5604/935873.
12. Malfait B, Sankey S, Firhad Raja Azidin RM, Deschamps K, Vanrenterghem J, Robinson MA, et al. How reliable are lower-limb kinematics and kinetics during a drop vertical jump? Med Sci Sports Exerc. 2014; 46(4): 678--685. DOI: 10.1249/MSS.0000000000000170.
13. Markovic G. Does plyometric training improve vertical jump height? A meta-analytical review. Br J Sports Med. 2007; 41: 349-355. DOI: 10.1136/bjsm.2007.035113.

14. Markovic G, Mikulic P. Neuro-musculoskeletal and performance adaptations to lower-extremity plyometric training. Sports Med. 2010; 40(10): 859-895. DOI: 10.2165/11318370-000000000-00000.
15. Matic MS, Pazin NR, Mrdakovic VD, Jankovic NN, Ilic DB, Stefanovic DLJ. Optimum drop height for maximizing power output in drop jump. J Strength Cond Res. 2015; 29(12): 3300-3310. DOI: 10.1519/JSC.0000000000001018.
16. McKay H, Tsang G, Heinonen A, MacKelvie K, Sanderson D, Khan KM. Ground reaction forces associated with an effective elementary school based jumping intervention. Br J Sports Med. 2005; 39(1): 10-14. DOI: 10.1136/bjsm.2003.008615.
17. Michailidis Y. Effect of plyometric training on athletic performance in preadolescent soccer players. J Hum Sport Exerc. 2015; 10(1): 15-23. DOI: 10.14198/jhse.2015.101.02.
18. Mohr M, Krustrup P, Bangsbo J. Match performance of high-standard soccer players with special reference to development of fatigue. J Sports Sci. 2003; 21(7): 519--528. DOI: 10.1080/0264041031000071182.
19. Newton RU, Young WB, Kraemer WJ, Byrne C. Effects of drop jump height and technique on ground reaction force with possible implication for injury. Sports Med Train Rehab. 2001; 10(2): 83-93. DOI: 10.1080/15438620109512099.
20. Oliver JL, Barillas SR, Lloyd RS, Moore I, Pedley J. External cueing influences drop jump performance in trained young soccer players. J Strength Cond Res. 2019; 1. Epub Jan 22, 2019. DOI: 10.1519/jsc.0000000000002935.
21. Pedersen S, Heitmann KA, Sagelv EH, Johansen D, Pettersen SA. Improved maximal strength is not associated with improvements in sprint time or jump height in high-level female football players: a cluster-randomized controlled trial. BMC Sports Sci Med Rehabil. 2019; 11(1). DOI: 10.1186/s13102-019-0133-9.
22. Ramírez-Campillo R, Alvarez C, García-Pinillos F, Gentil P, Moran J, Pereira LA, Loturco I. Effects of plyometric training on physical performance of young male soccer players: potential effects of different drop jump heights. Pediatr Exerc Sci. 2019; 31(3), 306-313. DOI: 10.1123/pes.2018-0207.
23. Ramírez-Campillo R, Burgos CH, Henríquez-Olguín C, Andrade DC, Martínez C, Álvarez C, et al. Effect of unilateral, bilateral, and combined plyometric training on explosive and endurance performance of young soccer players. J Strength Cond Res. 2015; 29(5): 1317-1328. DOI: 10.1519/JSC.0000000000000762.
24. Seegmiller JG, McCaw ST. Ground reaction forces among gymnasts and recreational athletes in drop landings. J Athl Train. 2003; 38(4): 311-314.
25. Stølen T, Chamari K, Castagna C, Wisløff U. Physiology of soccer: an update. Sports Med. 2005; 35(6): 501-536. DOI: 10.2165/00007256-200535060-00004.
26. Thapa RK, Kumar A, Sharma D, Rawat JS, Narvariya P. Lower limb muscle activation during instep kick from different approach angles and relationship of squat jump with 10-m sprint, 30-m sprint, static balance, change of direction speed and ball velocity among soccer players. JPES. 2019; 19. DOI: 10.7752/jpes.2019.s6341.
27. Viitasalo JT, Salo A, Lahtinen J. Neuromuscular functioning of athletes and non-athletes in the drop jump. Eur J Appl Physiol. 1998; 78(5): 432-440. DOI: 10.1007/s004210050442.
28. Wang Y-C, Zhang N. Effects of plyometric training on soccer players. Exp Ther Med. 2016; 12(2): 550-554. DOI: 10.3892/etm.2016.3419.
29. Wisløff U, Castagna C, Helgerud J, Jones R, Hoff J. Strong correlation of maximal squat strength with sprint performance and vertical jump height in elite soccer players. Br J Sports Med. 2004; 38(3): 285-288. DOI: 10.1136/bjsm.2002.002071.
30. Wood R. Isometric Leg Strength Test. Retrieved from: https://www.topendsports.com/testing/tests/isometric-strength.htm.
31. Woods RB. Social issues in sports. Third edition. Champaign: Human Kinetics; 2015.