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# EFFECTS OF SHORT-TERM PLYOMETRIC TRAINING ON LOWER EXTREMITY POWER, STRENGTH, ENDURANCE AND KICKING SPEED IN MALE COLLEGE SOCCER PLAYERS

Eng Hoe Wee
*SEGi University, No. 9, Jalan Teknologi, Taman Sains Selangor, Kota Damansara PJU 5, 47810 Petaling Jaya, Selangor Darul Ehsan*
**weeenghoe@segi.edu.my*

Aik Hau Boon
*Armed Forces Football Club, Temasya Industrial Park, Section U1, 40150 Shah Alam, Selangor, Malaysia.*
*boonaikhau10@gmail.com,*

Hui Yin Ler
*Tunku Abdul Rahman University of Management & Technology, Jalan Genting Kelang, 53300 Kuala Lumpur, Malaysia*
*hyler@tarc.edu.my*

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## Corresponding Author

***Eng Hoe Wee, Prof Dr***
*Email: weeenghoe@segi.edu.my*
*SEGi University, No. 9, Jalan Teknologi,*
*Taman Sains Selangor, Kota Damansara PJU 5,*
*47810 Petaling Jaya, Selangor Darul Ehsan*



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# EFFECTS OF SHORT-TERM PLYOMETRIC TRAINING ON LOWER EXTREMITY POWER, STRENGTH, ENDURANCE AND KICKING SPEED IN MALE COLLEGE SOCCER PLAYERS

*Eng Hoe Wee[1*], Aik Hau Boon[2] , & Hui Yin Ler[3]*

*[1] SEGi University, No. 9, Jalan Teknologi, Taman Sains Selangor, Kota Damansara PJU 5, 47810 Petaling Jaya, Selangor Darul Ehsan.*
*[2]Armed Forces Football Club, Temasya Industrial Park, Section U1, 40150 Shah Alam, Selangor, Malaysia.*
*[3] Tunku Abdul Rahman University of Management & Technology, Jalan Genting Kelang, 53300 Kuala Lumpur, Malaysia*

## ABSTRACT

*This study investigated the effects of 6 weeks plyometric training [PT] on leg power and strength and kicking velocity. Nineteen male soccer players (age = 19.2 + 1.3 years) were randomly assigned into control group (CG, n=9) and experimental group (EG, n=10) after pre-tests on the five measures (maximal ball velocity (MBV), squat jump [SJ], countermovement jump [CMJ], squat test [ST], and isokinetic leg strength.). Both groups performed similar bi-weekly soccer training program (technical, tactical, and matches) together, and EG also performed PT twice per week. Wilcoxon signed-rank test on the pre-test median scores between EG and CG showed insignificant differences in kicking speed, leg power, leg strength, and leg endurance. However, significant post-test comparison was found for leg strength (U=19.0, p=0.034) between EG and CG. In the pre and post-test comparisons, EG showed significant gains relative to CG in MBV ($p < .05$, $d = 1.37$), leg power ($p < .05$, $d = 0.97$), and leg strength ($p < .05$, $d = 0.95$) while CG only achieved significant improvement in the MBV ($P < .05$, $d = 1.16$). It concludes that adding plyometric training to regular soccer training improved leg strength in college soccer players.*

***Keywords***: *Plyometric training, maximal ball velocity, leg power, isokinetic leg strength, leg endurance.*



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## INTRODUCTION

Soccer involved explosive movements, maximal and high-intensity muscle motions (sprinting, jumping, kicking, passing, tackling, pacing, changing of direction, and diving) during a 90-minute match (Barnes, Archer, Hogg, Bush, & Bradley, 2014; Bangsbo, Mohr & Krustrup 2006; Meckel, Machnai & Eliakim, 2009; Ramirez-Campillo et al., 2014, 2015). Those above-mentioned physical movements require production of numerous physical fitness components (Bloomfield, Polman, & O'Donoghue, 2007; Jovanovic, Sporis, Omrcen & Fiorentini, 2011; Krustrup, Mohr, Ellingsgaard, & Bangsbo, 2005). Although those high intensity movements only represent 10-15 percent of the distance ran by a player in a match, they could occur at a crucial moment which contribute to superior ball possessions and scoring performance of players (Di Salvo et al., 2007; Faude, Koch, & Meyer, 2012; Reilly, Williams, Nevill, & Franks, 2000) as well as competition results (Bangsbo et al., 2006; Di Salvo et al., 2007). In addition, those physical attributes are linked to leg strength and leg power (Arnason, Sigurdsson, Gudmundsson, Holme, Engebretsen, & Bahr, 2004; Wisloff, Castagna, Helgerud, Jones, & Hoff, 2004).

Soccer players must possess excellent strength, speed as well as power to accomplish more (Lovell, Midgley, Barrett, Carter, & Small, 2011). Strength and power development in soccer players enable players to train with higher intensity and help reduce the risk of injuries (Wisloff, Helgerud & Hoff, 1998). Furthermore, there was a distinction in strength and power among players from successful compared to unsuccessful teams (Arnason et al., 2004, Cometti, Maffiuletti, Pousson, Chatard, & Maffuli, 2001, Dellal et al., 2011, Wisloff, Helgerud & Hoff, 1998). Success in soccer depends on players' physiological abilities and technical skills (Kellis & Katis, 2007) and ball kicking is one of the predominant variables in high standard achievement (Bacvarevic, Pazin, Bozic, Mirkov, Kukolj, & Jaric, 2012). Goal scoring success could be measured by higher match goal shooting frequency (Lago-Penas & Lago-Ballesteros, 2011) and maximal ball velocity (Asai, Carre, Akatsuka, & Haake, 2002; Rada et al., 2019) which is contributed by velocity and quality of foot impact (Asai, Carre, Akatsuka, Haake, 2002; Andersen & Dorge, 1999). Kicking performance requires leg power and leg strength (Garcia-Pinillos, Martinez-Amat, Hita-Contreras, Martinez-Lopez, & Latorre-Roman, 2014; Marques, Pereira, Reis, & van den Tillaar, 2013). During a soccer match, amateur players can achieve a length of between 9.5 and 12.4 kilometers (Silva, Ramirez-Campillo, Ceylan, Sarmento, & Clemente, 2022), run at an intensity of 270 to 1750 m (Mohr, Krustrup, & Bangsbo, 2003). Thus, soccer players require superb leg muscular endurance to endure continuous submaximal exertions in a match, to repeatedly perform a task for a long period of time.

The explosive movements in soccer and PT are similar (Bedoya, Miltenberger, & Lopez, 2015), thus PT training programs are frequently used to enhance physical fitness of players (Meylan, Cronin, Oliver, Hughes, & Manson, 2014; Ozbar, Ates, & Agopyan, 2014; Ramirez-Campillo et al., 2016; Sedano Campo, Vaeyens, Philippaerts, Redondo, De Benito, & Cuadrado, 2009), and are widely used to increase strength and power in soccer (Bauer et al., 2019; de Hoyo et al., 2016; Ramirez-Campillo et al., 2020; Vaczi, Tollar, Meszler, Huhasz, & Karsai, 2013) as well as speed (Haghighi, Moghadasi, Nikseresht, Torkfar, & Haghighi, 2012; Vaczi et al., 2013). According to Ozbar, Ates, and Agopyan (2014) PT has beneficial impact on jumping and sprinting in soccer. PT involves fast and strong concentric multi-joint movements, and eccentric contractions (Taube, Leukel, & Gollhofer, 2012). It has been proven scientifically that muscle could generate more power with a stretched muscle than a muscle


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that is not stretched (Booth & Orr, 2016; de Villareal, Requena, & Newton 2010). Besides, PT involving legs would increase leg muscle strength (Booth & Orr, 2016; Markovic & Mikulic 2010; Micahilidis et al. 2013), lower muscle power, kicking distance and velocity (Booth & Orr, 2016; Ozbar et al., 2014; Ramirez-Campillo et al., 2016).

Although PT had been linked to induce improvement in physical qualities of soccer players, limited research was available to assess the impact of PT on kicking velocity and leg endurance among amateur college players. Similarly, there is scarcity in soccer research which involves 6-week of plyometric training and with a frequency of twice per week. To date there are only 8 research that full-filled the criteria above. Among them, only two studies that examined college soccer players (Kumar, 2015; Vadivelan & Sudhakar, 2015), one investigated amateur players (Ramirez-Campillo et al., 2015), while others examined elite or sub-elite players (Chimera, Swanik, Swanik, & Straub, 2004: national colleague league; Marques, Pereira, Reis, & van den Tillaar, 2013: National,; Ramirez-Campillo et al., 2015: sub-elite; Thomas, French, Hayes, 2009: semi-professional; Vaczi et al., 2013: Third League); Moreover, all the research only investigated PT effects on maximal vertical jump, speed, agility, aerobic endurance, anaerobic endurance, and none of them investigated kicking velocity and leg endurance. With that previous research findings are inconclusive, limited, and inadequate to confirm the impact of PT on physical attributes, thus there is an urgency to examine the effects of PT on MBV and leg endurance in soccer players. Thus, this study aimed at investigating the consequences of PT on instep kicking velocity, leg power, leg strength and leg endurance among college soccer players.

## METHODS

*Research subjects*

Study subjects were enlisted after the research proposal was approved by the university college ethical committee. Subjects were recruited from the college soccer team via soccer team coach. All subjects were briefed on experiment method, and risk-benefit of the study. Upon agreement with the disclosed information, participants signed informed consent forms. A total of 19 subjects were allocated randomly to CG (Age = 20.0±1.4 yrs., Height = 172.2±6.1 cm, BW = 62.4±8.2 kg, soccer experience = 8.1±2.4 yrs.) and EG (Age = 18.6±0.7 yrs., Height = 175.6±3.8 cm, BW = 70.2±14.9 kg, soccer experience = 4.7±2.9 yrs.). All subjects were of good health and free of any major past injury.

*Instrumentation and procedures*

Research subjects were familiarised with the tests to measure MBV, CMJ, SJ, and isotonic strength tests. A pre-test was conducted before the 6-week intervention, and a post-test at the end of the period. The tests were performed in a similar sequence, adhering to the same evening duration (5 to 7 pm), and utilizing similar outdoor and indoor venues.

Maximal ball velocity was measured using Nikon J1 video camera and Kinovea 0.8.15 was used to analyse the recorded video to determine the maximal ball velocity using the formula: Maximal ball velocity = Change in displacement (m)/ Time (s). Best of 3 trials was used for analysis of data.

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A Vertex apparatus was used to determine the SJ and CMJ height of all participants. The procedures conformed to the guidelines as proposed by Miller (2011). For SJ, participants assumed a half-squat position with 90º bent at the knee and jumped as high as possible to reach maximum height with the dominant hand. For CJ, participants stand in a straight upright position, descend into a squat with arms swinging backward, and jump upward to a maximum point using their dominant hand. The jumping height was calculated by subtracting the standing height from the maximum height achieved. All participants performed 3 consecutive trials, and the best trial was considered for data analysis.

Humac Norm (Model 770) was used to measure isokinetic leg strength (isokinetic quadriceps and hamstrings strength in peak torque (Nm)). The dynamometer speeds were set at 60º/sec, 180º/sec and 300º/sec. All participants performed three maximal trials with their dominant leg only for each of the dynamometer speeds with 30 seconds rest between speeds. The peak torque extensor and strength out of three trials were used for data interpretation.

Leg endurance of the participants was measured using a squat test. All participants started by standing with feet shoulder width apart before a 45cm height chair. The participant completed one repetition of half squat by bending the knee down gently until their buttock touched the chair and stood up to the original position. The participants were told to perform as many repetitions as possible until exhaustion or are unable to perform one repetition within two second count. Total repetitions to exhaustion were used to determine the performance.

***Training program***

Soccer training program (STP) was conducted twice a week for 6 weeks (Table 1), 126 minutes per session. CG only performed STP while EG completed PT (Table 2) in addition to STP. The PT intervention program was adapted from Vaczi et al. (2013).

*Table 1: Biweekly college soccer team training program*

| Program | Duration (min) |
|---|---|
| Jogging 5 laps. | 10 |
| Static stretching | 5 |
| Rest | 2 |
| Soccer specific drills (Ball control, passing, tactical) | 40 |
| Rest | 2 |
| Game stimulation | 60 |
| Rest | 2 |
| Team-talk | 5 |

Briefly, PT included unilateral and bilateral exercises involving horizontal and vertical jumps. The jump exercises used both cyclic and acyclic arm swings. PT started with a preparatory phase in the first two weeks. The training volume was increased in the next three weeks, followed by a reduced volume during week-6 for tapering. There were a total of six different exercises (Table 2, pg.115). Training sessions were performed twice per week on non-consecutive days. During PT, participants were directed to reduce time of contact with the ground and maximized vertical and horizontal distance to trigger a faster coupling time. Soccer training was conducted by the college soccer coach while the PT was administered by the researcher.



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*Table 2: The Plyometric training program*

| Plyometric exercises | Week 1 -2 | | 3 – 5 | | 6 | |
|---|---|---|---|---|---|---|
| | **S1** | **S2** | **S1** | **S2** | **S1** | **S2** |
| | Sets x Repetitions | | | | | |
| Double legs hurdle jump (77 cm) | 4x5 | - | 6x5 | - | 3x5 | - |
| Single leg lateral cone jump (30 cm) | 3x10 | - | 4x10 | - | 2x10 | - |
| Single leg forward hop | 3x5 | - | 4x5 | - | 2x5 | - |
| Double legs depth jump (48cm) | - | 4x5 | - | 6x5 | - | 2x5 |
| Double legs lateral cone jump (30cm) | - | 4x5 | - | 6x5 | - | 2x5 |
| Single leg hurdle jump (32cm) | - | 3x10 | - | 4x10 | - | 2x10 |
| Total unilateral foot contact/ leg/ session | 45 | 30 | 60 | 40 | 30 | 20 |
| Total bilateral foot contact/ leg/ session | 20 | 40 | 30 | 60 | 15 | 20 |

*Note: S = Training session*

*Statistical Analysis*

IBM SPSS statistics software (ver. 23.0) was used to analyse data. Descriptive statistics were reported using mean and standard deviation. Changes in performance were calculated in percentages based on pre and post-tests results. Prior to analysis of data on MBV, VJ, CMJ, and leg strength, Shapiro-Wilk was observed to ensure data was normally distributed. Performances of CG and EG in four measures were compared using Mann-Whitney U Test. For the performance in each group, pre and post test scores were computed using Wilcoxon Signed-Rank Test. A p-value of less than 0.05 was used to determine significance of the statistical analysis.

## RESULTS

Prior to intervention, insignificant results were obtained for the pre-test median scores between EG and CG for all the 4 parameters of kicking speed (U=29.5, p=0.205), leg power (U=43.5, p=0.902), leg strength (U=41.0, p=0.774), and leg endurance (U=27.5, p=0.152). The result showed that the two groups started equal. However, significant post-test results were only found for leg strength (U=19.0, p=0.034) between EG and CG. Results in Table 3 revealed that EG showed greater improvement in leg strength, leg power, leg endurance and kicking speed as compared to CG. While CG showed decrease in leg power and leg endurance performance.


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*Table 3: Comparison of leg strength, leg power, leg endurance and kicking speed between the EG and CG.*

| Test | CG (n=9) | | | EG (n=10) | | |
|---|---|---|---|---|---|---|
| | Pre-test | Post-test | Improvement | Pre-test | Post-test | Improvement |
| | (Mean + SD) | | (%) | (Mean + SD) | | (%) |
| **Maximal ball velocity (m/s)** | 19.21+2.16 | 21.23+2.18 | 10.52 | 17.88+1.72 | 21.03+2.49 | 17.62 |
| **Leg power (cm)** | 57.73+7.86 | 56.94+6.89 | -1.37 | 57.70+9.01 | 61.89+7.71 | 7.26 |
| Squat jump | 54.62+8.57 | 53.62+7.24 | -1.83 | 54.91+9.18 | 58.56+8.13 | 6.65 |
| Counter-movement jump | 60.84+7.52 | 60.26+6.77 | -0.10 | 60.49+9.31 | 65.21+7.39 | 7.80 |
| **Leg strength (Nm)** | 103.75+14.14 | 104.29+18.43 | 0.05 | 100.49+19.62 | 121.70+15.31 | 21.12 |
| Quadriceps strength at 60º/sec | 172.33+17.97 | 166.10+29.24 | -3.62 | 178.83+48.67 | 188.06+36.83 | 5.16 |
| Quadriceps strength at 180º/sec | 112.93+17.03 | 118.10+16.62 | 4.58 | 108.18+26.89 | 139.67+25.16 | 29.12 |
| Quadriceps strength at 300º/sec | 84.19+12.16 | 83.58+19.35 | 0.07 | 83.83+20.90 | 100.44+16.35 | 19.81 |
| Average quadriceps strength | 123.15+10.22 | 122.59+17.30 | -0.05 | 123.61+24.20 | 142.72+25.07 | 15.52 |
| Hamstrings strength at 60º/sec | 116.56+21.94 | 115.20+33.83 | -1.17 | 103.92+24.88 | 129.25+18.37 | 24.37 |
| Hamstrings strength at 180º/sec | 72.12+23.58 | 86.71+17.83 | 20.23 | 70.36+28.49 | 96.33+9.15 | 36.91 |
| Hamstrings strength at 300º/sec | 64.35+16.36 | 56.08+17.74 | -12.85 | 57.80+28.03 | 76.44+8.09 | 32.25 |
| Average hamstrings strength | 84.34+19.40 | 86.00+20.52 | 1.97 | 77.36+22.92 | 100.67+10.37 | 30.13 |
| **Leg endurance (reps)** | 115.56+72.52 | 115.22+54.65 | -0.03 | 159.20+79.96 | 163.5+ 94.12 | 2.70 |

The Wilcoxon signed-rank test results in Table 4 showed EG improved significantly in all parameters except ‘squat jump’, ‘quadriceps strength at 60º/sec’, ‘hamstrings strength at 180º/sec’, and ‘leg endurance’. While CG showed significant improvement in kicking speed, and ‘hamstrings strength at 180o/sec’.

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*Table 4: Comparison of pre-test and post-test scores.*

| Test | CG (n=9) | | | EG (n=10) | | |
|---|---|---|---|---|---|---|
| | Pre-test | Post-test | P | Pre-test | Post-test | P |
| | (Median) | | | | (Median) | |
| **Maximal ball velocity (m/s)** | 19.65 | 22.15 | 0.02* | 18.00 | 20.54 | 0.01* |
| **Leg power (cm)** | 55.00 | 57.56 | 0.95 | 57.56 | 62.13 | 0.02* |
| Squat jump | 52.45 | 54.77 | 0.81 | 53.73 | 59.26 | 0.07 |
| Counter-movement jump | 59.89 | 60.93 | 0.77 | 61.40 | 65.00 | 0.01* |
| **Leg strength (Nm)** | 99.64 | 107.87 | 0.52 | 102.21 | 122.05* | 0.02* |
| Quadriceps strength at 60°/sec | 180.08 | 165.30 | 0.31 | 183.27 | 194.39 | 0.96 |
| Quadriceps strength at 180°/sec | 113.53 | 123.53 | 0.86 | 111.60 | 142.45* | 0.01* |
| Quadriceps strength at 300°/sec | 83.39 | 91.94 | 0.77 | 92.45 | 99.94* | 0.04* |
| Quadriceps strength | 119.93 | 124.71 | 0.77 | 124.52 | 146.04* | 0.02* |
| Hamstrings strength at 60°/sec | 119.73 | 106.72 | 0.59 | 111.33 | 135.54* | 0.05* |
| Hamstrings strength at 180°/sec | 83.39 | 91.94 | 0.03* | 69.97 | 96.14 | 0.07 |
| Hamstrings strength at 300°/sec | 52.21 | 52.21 | 1.00 | 50.73 | 75.53* | 0.05* |
| Hamstrings strength | 77.70 | 88.27 | 0.14 | 81.50 | 101.88* | 0.04* |
| **Leg endurance (reps)** | 100.00 | 120.00 | 0.44 | 119.50 | 133.00 | 0.72 |

*P< 0.05.

## DISCUSSIONS

This research investigated the impacts of adding plyometric training to soccer training programs with biweekly PT for 6 weeks in amateur college soccer players. The results show considerable progress in MBV for EG and CG, and gains in leg strength and leg power for EG. However, no substantial gain was recorded in leg endurance for both groups. The performance in leg strength and leg endurance of the EG improved as compared to that of CG, suggesting that soccer training alone in CG was insufficient to enhance the performance of the two variables.

*Impact of PT on MBV*

Results in Table 3 and 4 showed that both the CG and EG had significant improvement in MBV with EG (Δ = 10.5%, d = 1.16) improved more than CG (Δ = 17.6%, d = 1.37). The improvement of MBV in EG could be due to improvement in bio-motor ability brought about by explosive movement of the plyometric training (Campo et al., 2009). Campo et al. (2009) examined 20 female soccer players who reported significant increase in kicking speed after 12


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weeks of PT. In another study of 10-week PT on female soccer players, Ozbar (2015) reported increase in kicking speed for plyometric group (PG) and CG with PG (Δ = 9.9%) improved more than CG. Similarly, Sedano et al. (2011) revealed in a study of elite soccer players with 10 weeks of PT; PG enhanced jumping in 6 weeks and kicking speed with dominant leg in 8 weeks while there were no significant changes in CG. Previous researchers reported that specific strength training (eg. PT) augmented mae soccer players' kicking performance (Dutta & Subramanium, 2002; Manolopoulos, Papadopoulos & Kellis, 2006).

Although numerous researchers have associated ball kicking velocity with leg strength in soccer players (Kalapotharakos, Strimpakos, Vithoulka, Karvounidis, Diamantopoulos, & Kapreli, 2006; Manolopoulos, Papadopoulos & Kellis, 2004; Vucetic, Sporis & Jukic, 2007), the improvement in kicking speed of CG of our research did not support the findings above as there was insignificant improvement in the leg strength of CG. Thus, the improvement in CG's kicking speed might be due to a variety of factors such as muscle strength, force generated, muscle coordination, and kicking angles that might help improve kicking speed (Cometti et al., 2001; Dorge et al., 2002; Kalapotharakos et al., 2006; Manolopoulos et al., 2006). Cometti et al. (2001) concur that MBV did not solely depend on physical ability.

*Effect of PT on leg power*

Our pre-post comparisons showed that leg power improved significantly in EG (Δ = 7.3%), but it deteriorated in CG (Δ = -1.37%, d = 0.97). The improvement in leg power of EG as compared to that of CG was supported by Ozbar et al. (2014) who reported that 8-week PT (1 day/week) could improve CMJ of EG female soccer players (Δ = 17.6%), which is more than CG players (Δ = 6.9%). Similarly, Vaczi et al. (2013) found male soccer players trained with PT significantly improved VJ performance (Δ = 9%) while CG did not. Earlier, Chimera et al. (2004) reported that 6-week PT (twice a week) significantly improved VJ (Δ = 5.8%) in collegiate female soccer players. While Kumar (2015) revealed that PT (three times per week) significantly improved VJ (Δ = 9.6%) in collegiate male soccer players.

However, our data showed that EG only significantly improved CMJ ($p = 0.01$) but not in SJ ($p = 0.07$). Chelly, Ghenem, Abid, Hermassi, Tabka, and Shephard (2010) explained the discrepancy that the CMJ maximized usage of stretch shortening cycle (SSC) to generate forces while SJ minimized SSC. In fact, according to Van Hooren, and Zolotarjova (2017), CMJ almost always outperformed SJ because CMJ utilized SSC effectively.

*Effect of PT on leg strength*

Our post-test analysis showed that EG's leg strength differed from that of CG ($p < .05$). Pre-post data comparisons revealed that EG (Δ = 21.1%, d = 0.95) performed much better than CG (Δ = 0.05%). Our result is supported by Arazi, Mohammadi, and Asadi (2014). They investigated the impacts of PT muscular performance on sand and land surfaces of male participants and reported improvement in 1-RM leg press performance in sand and land PT respectively (sand = 23.5 kg, d = 0.56; land = 15.3 kg, d = 0.49). On the contrary, in examining the impacts of 12-week resistance training (RT) and PT on soccer players, Negra, Chaabene, Stoggl, Hammami, Chelly, and Hachana (2020) reported that PT (Δ = 4.2%) performed worse than RT group (Δ = 27.9%), and CG (Δ = 9.1%) in muscular strength performance (1-RM half-squat test). Superiority of muscular strength performance was also found at 4$^{th}$ week and 8$^{th}$ week in RT group as compared to PT group and CG.


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Our result also revealed superior improvement of isokinetic quadriceps strength (15.5% vs -0.1%) and isokinetic hamstrings strength (30.1% vs 2.0%) in EG as compared to CG. This is supported by Vaczi et al. (2013) who demonstrated a significant improvement on isokinetic extensor strength after plyometric training. Similarly, Alemdaroglu, Dundar, Koklu, Asci and Dindikoglu (2013) conducted concurrent resistant and PT on 24 subjects and concluded that there was a statistical improvement in all of the isokinetic leg strength measure except the strength of the quadriceps at the speed of 60º per sec.

*Effect of PT on leg endurance*

Post-test comparison of Squat Test between EG and CG did not show significant difference. However, pre-post comparison yielded a small increase (2.7%) in EG and a decreased performance in CG (0.03%). The insignificant results in the post-test could be explained by meta-analysis conducted by de Villarreal et al. (2009) on variables affecting the benefits of PT. It was found that high volume PT (>10 weeks, >20 sessions) and high intensity PT (>50 jumps/session), seemed to produce significantly greater improvements in physical performance. Our results applied PT only for 6 weeks and 12 sessions with 2 sessions (week 6) using only < 50 jumps per session, these might be inadequate to produce better performance. In addition, previous research (Allerheiligen & Rogers, 1995; Holcomb, Kleiner, & Chu, 1998) emphasized that less experienced subjects benefited less from PT, similar to our findings where EG has soccer experience of 4.7±2.9 years as compared to that of CG (8.1±2.4 years). This explained the insignificant post-test result between EG and CG. Likewise, according to Ramírez-Campillo, Andrade and Izquierdo (2013) high training volume (240 jumps/week) induced greater explosive performance as compared to moderate training volume (120 jumps/week), and PT with moderate training volume on hard surfaces could increase explosive performance requiring SSC. Our study applied a weekly training volume between 85 and 190 jumps (average = 154 jumps/week) on grass surfaces (non-hard surfaces). These variables (volume and environment) confirmed the insignificant difference between CG and EG.

Our results are supported by drawing parallel to a study of Chris Tee (2013) on the benefits of 6-week PT on the physical fitness of Tae-kwon-do club athletes where it was found that post-test comparison of leg endurance using half-squat test between EG and CG was insignificant. However, EG significantly improved the half-squat-test ($\Delta$ = 53.4%, $p = 0.022$) as compared to insignificant improvement in endurance of CG ($\Delta$ = 29.7%, $p = 0.314$). Likewise, in examining the correlational effects of 12-week PT on leg strength, leg endurance and power of male university students among Depth Jumping Group (DJG), Rebound Jumping Group (RJG), Horizontal bounding with rings Group (HBRG), CG, Abbas (2005) reported that HBRG had the greatest leg endurance, followed by DJG, RJG, and CG.

## CONCLUSION

Our research findings demonstrate that adding PT to STP could improve some variables of physical performance in soccer. Six weeks of PT could improve leg strength. The improvement in leg strength can be transferred to kicking velocity in soccer players. Other findings (pre-post comparison) revealed that PT may be suited for improving leg power, MKV, and endurance. However, the influence of PT duration of more than 6 weeks, high training volume of 240 jumps per week and not less than 50 jumps per session should be considered to achieve better performance.


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***Author's Contribution***
Eng Hoe Wee - Corresponding author, conceptualization, methodology, data curation, data analysis and interpretation, draft preparation, reviewing and editing.
Aik Hau Boon – Conceptualization, methodology, data collection, data curation, data analysis and interpretation, communicating with all participants, and draft preparation.
Hui Yin Ler - Conceptualization, methodology, data analysis and interpretation, draft preparation, reviewing and editing.

***Conflict of Interest***
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