HUMAN MOVEMENT
2014, vol. 15 (3), 152–159

EFFECT OF RESISTANCE TUBE EXERCISES ON KICKING ACCURACY, VERTICAL JUMP AND 40-YARD TECHNICAL TEST IN COMPETITIVE FOOTBALL PLAYERS – AN EXPERIMENTAL STUDY

doi: 10.1515/humo-2015-0005

ALEKHYA TIRUMALA*, BASAVARAJ MOTIMATH
Sports Physiotherapy Department, KLE University Institute of Physiotherapy, Belgaum, Karnataka, India

ABSTRACT
Purpose. Kicking, jumping and agility are important skills in football. These activities require adequate lower limb strength, which can be enhanced with resistance training. The objective of the study was to evaluate the effect of resistance tube exercises on kicking accuracy, vertical jump performance and 40-yard technical test results in competitive football players. **Methods.** The study involved 23 competitive football players (11 males, 12 females) aged from 18–20 years recruited from three different universities in Belgaum, Karnataka, India. Back heel kick accuracy, vertical jump height and 40-yard technical test time were evaluated before and after a 2-week resistance tube exercise program. **Results.** Significant improvements in post-intervention kicking accuracy were found when males and females were treated as a single group ($p = 0.01$). Vertical jump height also showed a highly significant post-intervention improvement in the males and for the combined group of males and females ($p = 0.001$). The 40-yard technical test values significantly improved in the females and in the combined results for males and females ($p = 0.001$). **Conclusions.** The two-week resistance tube exercise program was found to have an effect on kicking accuracy, vertical jump height and 40-yard technical test performance in competitive football players. Resistance tube exercises can thus be included as a component of a regular strength training program for such athletes.

Key words: resistance training, resistance tubing, back heel kick, performance, agility

Introduction

Football is one of the oldest and most popular sports in the world, with around 150 football-playing countries. In 1984, it was estimated that 60 million players were licensed whereas another 60 million were unlicensed, with the latter group consisting of youth and recreational players involved in local football leagues [1]. In 2006, it was estimated that 265 million males and females (including 5 million referees), or about 4% of the world's population, were actively involved in football [2]. In India, football has been gaining popularity throughout the country irrespective of a lack of investment and proper planning.

As a team sport, football has a highly intermittent and unpredictable activity pattern [3]. It is considered to be sport dominated by randomized, intermittent, dynamic and skilled movement [4]. A study comparing the distances covered on the field in different team sports found a professional male or female football player to cover 10–12 km per game, considerably more than other team games [5, 6].

The physical fitness level of football players is crucial as it determines both game efficiency and tactical performance [7]. On the field, football requires explosive bursts of energy in the form of sprinting, jumping, kicking, changing directions and maintaining balance [8]. To attain an appropriate fitness level for such tasks, it is recommended that players train according to the demands of the game [9]. As such, a football training program should improve performance by inducing adaptations in the neuromuscular system, whereas the level of this adaptation depends on the type of training program [10]. One of the more important components of physical fitness in football is strength, as it determines the performance of numerous on-field physical tasks and movements. The US National Strength and Conditioning Association states that besides strength, the advantages of strength training in football include increased local power and endurance and improved performance in the sport [10].

One of the most important and widely used skills in football is kicking [11], as it is used to deliver the ball over a desired distance to an intended target [12]. The effectiveness of a smooth kicking action depends on various factors, including the maximal strength of the involved muscles, neuromuscular coordination, rate of force development and the level of coordination between muscle agonists and antagonists [13]. Furthermore, the final stage of kicking, when the knee is extended, requires maximal force production and strength from the hamstrings and quadriceps [14]. Among the various types of kicks, one kick worthy of mention is the back heel kick. It can be used in a regular pass and also as a penalty kick [15]. This kick can be as effective as any other, especially in deceiving an opponent as it is so unexpected [16]. Regardless of the type of kick used, the importance of maximal strength for power production in kicking has been highlighted by Haghighi et al. [17].

* Corresponding author.

Although there have been studies examining the effect of strength training on kicking performance, the results are inconsistent.

On the field, apart from kicking, jumping ability is also an important component of football. The literature reveals that jumping ability depends on inter-limb coordination, muscle fibre type and muscle strength [18]. Studies have shown that vertical jump height improves through training interventions involving jumping exercises, plyometric exercises, depth jumps and resistance training.

Another important component of football is agility, used to outmanoeuvre the opposition and also protect players from injury. According to Sporis et al. [12], agility is the ability which helps the athlete change directions, make quick stops and perform fast and smooth repetitive movements. Several factors are known to affect the level of agility, some of them being joint mobility, flexibility, dynamic balance, power, energy resources and muscle strength. Certain studies have shown the positive results of plyometric training on both vertical jump height and agility [12], also stating that both maximal jumping and sprinting are considered to be dynamic movements requiring high muscle power and should therefore be closely related. The literature suggests that increasing the force of muscular contraction in appropriate muscle groups results in increased acceleration and speed and is therefore critical in the previously-mentioned components of agility, including turning, sprinting and changing directions and pace [4].

Resistance tubes or elastic tubes have been commonly employed in resistance training. The basic difference between resistance tubes and other forms of resistance training is that tubes are used to generate a controlled and consistent force depending on the needs of the individual. The tubing provides a resistive force during exercise with a low or high load stretch [19]. They are made of natural rubber latex and are available in progressive levels of resistance (yellow, red, green, blue, black and silver, respectively). A manufacturer of resistance tubing, the Thera-Band Academy, cites numerous studies on their effectiveness in improving strength, mobility and function [20]. A study on elderly individuals suggests that such tubes have a positive impact on improving muscle power, balance and body composition [21]. However, little information on the effect of resistance tube exercise in young individuals was found. Additionally, there is a paucity of literature on the effect of resistance tube exercises on football performance.

While there exist numerous studies analysing the effect of resistance exercises on football performance, there is a lack of general information on the effect of resistance training on kicking accuracy [18]. Some authors have found that plyometric training improves kicking performance as it induces neuromuscular adaptations to the stretch reflex. Others have reported a positive effect of resistance training combined with plyometric exercises in enhancing vertical jump height [22]. However, research on the effect of resistance exercises using only resistance tubing is lacking. There is also a dearth of data on resistance training involving resistance tubes for the enhancement of agility in football players.

Hence, the present study was undertaken to analyse all of the above factors and add to the literature on the effects of resistance training using resistance tubes and analyse its impact on kicking accuracy, vertical jump height and agility as measured by the 40-yard technical test in a group of football players. It was hypothesised that resistance tube exercises would improve all three tested variables.

Material and methods

After attaining approval from the Institutional Ethical Committee at the KLE University Institute of Physiotherapy, 25 competitive football players (13 males, 12 females) were recruited using convenience sampling from three different universities in Belgaum, Karnataka, India (Gogte College of Commerce, GSS College of Science and KLE University). Participants were included in the study if they were between 18 and 25 years, competed in football events, volunteered to participate in the study and were pain-free at the time of testing. Participants were excluded if they had any recent trauma to the knee, ankle or hip in the past 6 months, had a history of any recent (6 months prior) lower limb orthopaedic surgery, or sustained any injury or suffered from any medical illness during the course of the study. The purpose of the study was explained and written informed consent was obtained from all participants. Participants' BMI was calculated and information on their football playing history was collected. Two of the male participants dropped out, one due to poor participation and one due to an ankle injury sustained during the study. The study was performed during the off-season, and the participants were asked to refrain from all other forms of strength training during the study duration.

Measures

Measures assessing back heel kicking accuracy, vertical jump height and 40-yard technical test time were collected before a resistance tube exercise program for the lower limbs was administered. All pre-intervention measures were gathered one day before the training commenced; post-intervention measures were collected one day after the training program was completed. Both pre- and post-measures were evaluated on the same field where the participants regularly practiced.

Kicking accuracy was measured as per Finoff et al. [23]. The participant was asked to stand in front of a 243.5 cm wide × 122 cm high piece of cardboard at a distance of 20 m. Carbon paper was pasted on the

Figure 1. Setup used to measure kicking accuracy; cardboard covered with carbon paper and marked with a bullseye

cardboard (see Figure 1) and a bullseye was drawn. The participant performed five trails with the back heel kick. Deviations from the bullseye were measured using a measuring tape. The most accurate kick was considered for analysis.

The vertical jump was measured as suggested by Changela et al. [24]. The participant stood against the wall with both feet on the ground and reached as high as possible with one hand; the height at the tips of the fingers was measured. The participant then bent their knees and jumped as high as possible, where the height at which tips of the fingers of the same hand reached was measured. The difference between the first height and the second height was calculated. The best result of three trials was recorded.

The 40-yard technical test was performed according to the Utah Youth Soccer Association [25]. Four cones were placed on a field, where the first cone (A) represented the starting point. The second cone (B) was placed 10 yards directly in front of the first cone. The third cone (C) was placed 5 yards to the left of the second cone and the fourth cone (D) was placed 5 yards to the right of the second cone. Starting in a standing position, the participant was timed on how long it took them to sprint from cone "A" to cone "B", then sidestep to cone "C", then sprint to cone "D", sidestep back to cone "B", and finish with a backward sprint to cone "A".

Training protocol

The resistance tube exercise program lasted 2 weeks and was performed four times per week. All the participants completed a general warm up before each training session by stretching the lower limbs (hamstrings, quadriceps, calf muscles and adductors). The resistance tube exercises consisted of the one-leg press, knee lift, seated leg extension, side leg raise and standing leg curl, with each exercise performed for 3 sets of 8–12 repetitions. The resistance of the tube was individually selected for each participant using the blue, black and silver colours. Difficulty was increased by increasing the resistance of the tubing and the number of repetitions as well as training on an uneven surface (side leg raise and standing leg curl). The exercises were performed as below:

– *One-leg press* The participant was asked to sit on the ground with their legs out in front of them, knees slightly bent. They were asked to hold one end of the resistance tube in each hand and place it around the sole of the right foot keeping the right knee slightly bent. They then straightened their right leg (without locking their knee) while pulling on both sides of the resistance tube. The participant continued to pull against the resistance tube as they returned to the original bent position. The exercise was then repeated with the left leg (Figure 2).

– *Knee lift* The participant was asked to sit in a comfortable position with the hip and knees perpendicular to each other. Holding the tube in their hands, the participant stretched the tube by pulling their knees in toward the chest so as to increase the resistance against their lower abs and front thighs. They then slowly returned to the starting position (Figure 3).

Figure 2. One-leg press

Figure 3. Knee lift

Figure 4. Seated leg extensions

Figure 5. Standing leg curls

Figure 6. Side leg raises on uneven surface

– *Seated leg extension* The participant sat on a bench with a straight back with the feet and knees shoulder-width apart. Holding both ends of the tube in the left hand, they were asked to slowly straighten the left knee and lift their foot until the leg was straightened (at a 90-degree angle to the torso). The participant was then asked to slowly bend the left knee and return to the starting position. The exercise was then repeated with the right leg (Figure 4).

– *Standing leg curl* Two participants were involved in this exercise. One participant held the two ends of the resistance tube that was placed around the second participant's foot. The second participant was asked to keep the knees close together and smoothly lift their right heel up toward their bottom. This exercise was then repeated with the other leg (Figure 5).

– *Side leg raise* Two participants were involved in this exercise. Both participants were asked to stand next to each other and have each place one foot on the resistance tube and the other foot at its end. The participants then lifted the leg placed in the end of the tubing straight out to the side until the foot attained a height of 15 to 30 cm off the ground. They then returned the leg to the starting position. The participants were asked to keep an erect torso throughout the movement and slightly bend the leg supporting their body. The exercise was then repeated with the other leg (Figure 6).

The range of motion in the exercises was not quantified although they were performed by increasing the resistance of the resistance tube. Body position was fixed in terms of bending at the torso in the standing or sitting positions. The upper extremities holding the ends of the resistance tubes were also fixed in order to not bring any variation in the movement. The remaining body segments were allowed to remain mobile and moved according to the exercise. The length of the tube was not controlled and varied according to the needs of each participant. This was done as every participant required a different threshold of resistance to perform the exercise.

Statistical analysis involved calculating the means and standard deviations of the collected data. The kicking accuracy, vertical jump and 40-yard technical test measures were compared pre- and post-intervention by the paired samples *t* test. Intra-group comparison between male and female participants was analysed using the unpaired form of the *t* test.

Results

The demographic data demonstrated that males had higher BMI and longer playing experience than their female peers (Table 1).

Comparisons of pre- and post-intervention kicking accuracy values (Table 2) showed significant improvements for the combined results of both males and fe-

Table 1. Intra-group comparisons of BMI and length of football playing career (mean ± s)

	BMI (kg/m^2)	Playing career (years)
Male	21.15 ± 1.14	7.27 ± 2.49
Female	19.14 ± 2.06	3.83 ± 2.69
t value	2.85	3.17
p value	< 0.01**	< 0.01**

** indicates high significance

males (p = 0.01). No statistically significant differences were noted separately for males and females (p = 0.052 and p = 0.054, respectively). Intra-group comparisons between the male and female participants (Table 3) did not show any statistically significant differences pre-intervention (p = 0.94) and post-intervention (p = 0.59).

The combined (male and female) pre- and post-intervention vertical jump values (Table 2) showed a significant enhancement (p = 0.001). The male participants showed a higher statistically significant improvement (p = 0.001) compared with the female participants. Intra-group comparisons between the male and female participants (Table 3) showed statistically significant differences post-intervention (p = 0.01)

The results for the 40-yard technical test showed statistically significant improvements (Table 2) pre- and post-intervention (p = 0.001). The male and female participants also showed significant improvements (p = 0.01 and p = 0.001, respectively). Intra-group comparisons (Table 3) showed significant differences in the results pre- and post-intervention (p = 0.01).

Discussion

The present study used resistance tubes in a two-week resistance training intervention for competitive football players. Its purpose was to see the effects of resistance tube exercises on kicking accuracy, vertical jump height and 40-yard technical test time pre- and post-intervention, with the results finding significant improvements in all three measures.

Table 2. Comparison between pre- and post-intervention kicking accuracy, vertical jump height and 40-yard technical test time (mean ± s)

Measures	Pre-intervention	Post-intervention	Difference	*t* value	*p* value	Cohen's *d*
Kicking accuracy (cm)						
Male	88.82 ± 34.40	66.45 ± 31.79	22.36	2.20	0.052	–0.71
Female	89.83 ± 34.59	74.33 ± 36.75	15.50	2.16	0.054	–0.43
Combined	89.35 ± 33.71	70.57 ± 33.93	18.78	3.11	< 0.01**	–0.55
Vertical jump (cm)						
Male	33.27 ± 4.74	40.27 ± 4.29	–7.00	9.32	< 0.001***	1.63
Female	28.42 ± 6.83	32.92 ± 5.00	–4.50	1.98	0.078	0.76
Combined	30.74 ± 6.30	36.44 ± 5.92	–5.70	4.60	< 0.001***	0.93
40-yard technical test (s)						
Male	12.12 ± 1.88	11.15 ± 1.65	0.96	4.35	< 0.01**	–0.57
Female	14.43 ± 1.44	13.05 ± 1.35	1.38	4.57	< 0.001***	–0.99
Combined	13.32 ± 2.01	12.14 ± 1.76	1.18	6.18	< 0.001***	–0.62

** indicates high significance, *** indicates very high significance

Table 3. Intra-group comparisons of kicking accuracy, vertical jump height and 40-yard technical test times between the male and female participants (mean ± s)

Measure	Male	Female	*t* value	*p* value	Cohen's *d*
Kicking accuracy (cm)					
Pre-intervention	88.82 ± 34.40	89.83 ± 34.59	0.07	0.94	–0.03
Post-intervention	66.46 ± 31.79	74.33 ± 36.75	0.55	0.59	–0.23
Vertical jump (cm)					
Pre-intervention	33.27 ± 4.74	28.42 ± 6.83	1.96	0.06	0.85
Post-intervention	40.27 ± 4.29	32.92 ± 5.00	3.77	< 0.01**	1.62
40-yard technical test (cm)					
Pre-intervention	12.12 ± 1.88	14.43 ± 1.44	3.34	< 0.01**	–1.43
Post-intervention	11.15 ± 1.65	13.05 ± 1.35	3.02	< 0.01**	–1.3

** indicates high significance

In terms of kicking accuracy, the results are in disagreement with Haghighi et al. [17], who studied 30 elite football players divided into control, plyometric and resistance training groups. After training for 8 weeks, the study found that both plyometric and resistance training improved sprinting speed and dribbling performance. However, no significant improvements in terms of kicking accuracy were shown. It needs mentioning that the resistance training program in Haghighi et al. consisted of 2–4 sets of weight training exercise at an intensity of 60–90% 1-RM, whereas this study used three sets of 8–12 repetitions of resistance tube exercises for 2 weeks. In addition, their study did not mention the type of kick the players were asked to perform as a measure of kicking accuracy.

One of the reasons behind the significance in our study, as suggested by Manolopaulos et al. [26], could be that the football kick utilizes the stretch-shortening cycle characteristics of the involved muscles, especially the knee extensors. In a developed kicking action, it has been found that the thigh comes forward while the knee is still flexing. This action serves to stretch the thigh extensor muscles before they need to shorten so that they are able to generate large end-point speed. Manolopaulos et al. emphasized the importance of utilizing the stretch-shortening cycle of the muscles of the kicking leg. According to their study, one of the main mechanisms that may improve kicking performance is the action of the thigh that slows down or reverses its motion prior to full knee extension. This is indicative of a more 'powerful' shot following training.

The present study used resistance tubes as a form of strength training as a way to develop strength, balance and coordination. According to a study by Patterson et al. [19], such tubing provides for controlled stretching and strengthening of muscle tendon units and joints and allows for a pre-stretching effect as well as controlled repeatability throughout the movement. This may be related to what Manolopaulos et al. [26] proposed on improving kicking performance. The standing leg curl exercise used in our study started with a concentric contraction of the quadriceps and ended with a concentric contraction of the hamstrings. It is supposed that this could have improved the back heel kick as it was specific to this type of action.

The present study showed no statistically significant results in the kicking accuracy of male players and female players when analysed separately by sex. The reasons for this could be attributed to those expounded by Lyons [27], who proposed that females have weaker hamstrings in relation to their quadriceps as compared with their male counterparts. This could have been the rationale behind the lack of a significant improvement in females alone as the kicking accuracy using the back heel kick, which requires optimal strength of the hamstrings to kick the ball backwards. Another reason could be due to the training duration, where 2 weeks may not have been sufficient enough to produce a significant effect individually in the females as well as males. One other possibility for the lack of significant changes could be due to the relatively small sample size.

With respect to the vertical jump, the present study showed a highly significant increase between pre-intervention and post-intervention values. Adibpour et al. [28] compared the effects of plyometric and weight training on vertical jump height in 35 female basketball players, concluding that both plyometric and weight training produced significant improvements in vertical jump height in females. The increase in vertical jump height in the present study was approximately 5.7 cm in total, or 1.3 cm less than reported by Adibpour et al, although this may stem from the fact that their study combined both plyometric exercises and weight training. In addition, the increase in vertical jump height in the above study may be attributed to the strengthening of the leg muscles, therefore boosting instant energy resources. Such an increase in muscle strength could also be the rationale for the improvements observed in the present study.

The results of this study imply that vertical jump test performance increased by recruiting greater muscle mass (with both legs simultaneously working as well as the inclusion of upper-body musculature) and therefore generating significantly greater power. Additionally, greater muscle strength induced by the resistance tube exercises must have increased the ATP supply, which would lead to enhanced anaerobic power in the initial phase of any power activity, including jumping.

The present study showed a significant improvement in the vertical jump height of the male football players, with a difference of at least 7 cm noted before and after the intervention. This is compared with the female football players, where a difference of only 4.5 cm was noted and which was not significant. This result could be correlated to a study done on elite male football players by Wisloff et al. [29], where it was suggested that football players should focus on developing maximal strength with a focus on concentric movements in order to improve vertical jump height. A similar conclusion can be reached in the present study, which also used maximal and controlled concentric and eccentric exercises such as the one leg press. This mid-range semi knee flexion to a full knee extension movement of the quadriceps and hamstrings may have promoted strength development in these muscle groups. The other exercises in the present study included knee lifts to strengthen the hip flexors and side leg raises to strengthen the abductors. A combined increase in the strength of these muscles might have brought about a larger coupled force and led to improved vertical jump height. The non-significant results in the female participants can again be attributed to a reduced quadriceps-to-hamstring strength ratio in comparison with their male counterparts.

The results of the 40-yard technical test demonstrated significant improvements when comparing the combined male and female pre- and post-intervention values. Separately, both the results of the female and male participants showed highly significant improvements. This is consistent with the results reported by Taheri et al. [30], in which 30 male football players were divided into plyometric and resistance training groups and trained for 8 weeks. The resistance training group performed exercises such as the smith press, seated press, squat, leg extension, leg press, standing barbell curl, lying barbell extension, and sit up with an intensity initially at 60% of 1RM, increased by 10% every 2 weeks. The results found that the resistance training group showed better improvements in a 4 × 9 agility test compared with plyometric group. The investigators reasoned that muscle fibre hypertrophy induced by resistance training may have improved the ability to change position and direction rapidly without losing balance and coordination. A similar conclusion can be reached in the present study, where significant improvements were also noted for agility as measured by the 40-yard technical test. However, muscle hypertrophy alone could not have caused this improvement. as it involves at least 4–6 weeks of training according to Moritani and deVries [31]. However, the 2 weeks of resistance tube training in the present study may have led to a significant improvement in muscle strength. Based on a literature review by Deschenes and Kraemer [32], the initial phase (lasting up to 4 weeks) of 'high volume' resistance training should involve at least 3 sets of 8–12 repetitions for each exercise. This review also suggested that muscle strength significantly progresses during the first 4 weeks of resistance training and could be attributed to neural adaptations, leading to increased firing of neural impulses and therefore greater recruitment of high-threshold motor units, thus gaining strength.

Resistance tubes appear to be effective in developing strength [30], balance and coordination due to the controlled movements in exercise with such tubing. The last two components can be explained by the exercises used herein, such as the side leg raise and standing leg curl, as they were performed by the participants in the standing position, with the difficulty of these exercises increased by performing them on an uneven surface. These two factors, the standing position and change in surface, are believed to have enhanced the balance and coordination components.

Conclusions

The results of the present study show that a 2 week resistance tube exercise program had a positive effect on back heel kicking accuracy, vertical jump height and 40-yard technical test times in competitive football players.

There are nonetheless a number of limitations in the present study that should be considered. Firstly, the study involved only 23 participants, which provides a small sample size. Secondly, no follow up was performed in order to evaluate the duration of the training effects, where post-intervention measures were studied a day after the training ended. Thirdly, although the participants were asked to not partake in any other strength training during the study, the investigators had no control over any other sport activities or practice sessions the participants attended. This factor may have influenced the results.

Additional studies should be pursued using a resistance tube exercise program in a larger population with a longer training duration so as to evaluate the long-term effect of such an intervention. Future research should also include additional study groups, such as a control and a group involved in a traditional resistance training program, so as to allow for a better understanding of the effect of resistance tubes alone. Finally, the back heel kick should also be taken into consideration in future studies, as an effective back heel kick can lead to improved match results.

References

1. Ekblom B., Applied Physiology of Soccer. *Sports Med*, 1986, 3 (1), 50–60, doi: 10.2165/00007256-198603010-00005.
2. Kunz M., 265 million playing football. *FIFA Magazine*, July 2007, 10–15. Available from: http://www.fifa.com/mm/document/fifafacts/bcoffsurv/emaga_9384_10704.pdf.
3. Mohr M., Assessment of training and game load in team sports. University of Copenhagen, Denmark. Available from: http://legacyus.powerbar.nastage.com/psnn/pdf/1.pdf
4. Jovanovic M., Sporis G., Omrcen D., Fiorentini F., Effects of Speed, Agility, Quickness Training Method on Power Performance in Elite Soccer Players. *J Strength Cond Res*, 2011, 25 (5), 1285–1292, doi: 10.1519/JSC.0b013e3181d67c65.
5. Mohr M., Krustrup P., Andersson H., Kirkendal D., Bangsbo J., Match Activites of Elite Women Soccer Players at Different Performance Levels. *J Strength Cond Res*, 2008, 22 (2), 341–349, doi: 10.1519/JSC.0b013e318165fef6.
6. Krustrup P., Mohr M., Ellingsgaard H., Bangsbo J., Physical Demands during an Elite Female Soccer Game: Importance of Training Status. *Med Sci Sports Exerc*, 2005, 37(7),1242–1248,doi:10.1249/01.mss.0000170062.73981.94.
7. Hadi I.F.A, Ali H.A.A., Effect of the development of explosive power, shooting accuracy and flexible thighs joint, spine on penalty kick accuracy for the students majoring in soccer in faculty of physical education. *World J Sport Sci*, 2012, 6 (3), 228–236, doi: 10.5829/idosi.wjss.2012.6.3.1136.
8. 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.
9. Reilly T., Training Specificity for Soccer. *Int J Appl Sports Sci*, 2007, 7 (2), 17–25.
10. Shahidi F., Mahmoudlu A.G., Kandi Y.M.N.P, Lotfi G., The effect of two resistance training types on muscle fitness and anaerobic capacity in 16–18 years old male

soccer players. *Annals of Biological Research*, 2012, 3 (6), 2713–2717.
11. Barfield W.R., Kirkendall D.T., Yu B., Kinematic instep differences between elite female and male soccer players. *J Sports Sci Med*, 2002, 1 (3), 72–79.
12. Sporiš G., Milanović L., Jukić I., Omrčen D., Molinuevo J.S., The effect of agility training on athletic power performance. *Kinesiology*, 2010, 42 (1), 65–72.
13. Cometti G., Maffiuletti N.A., Pousson M., Chatard J.C., Maffulli N., Isokinetic strength and anaerobic power of elite, subelite and amateur French soccer players. *Int J SportsMed*, 2001, 22 (1), 45–51, doi: 10.1055/s-2001-11331.
14. Lipschutz D., The Biomechanics of Kicking a Football. BIOL-438, 2011. Available from https://sites.sas.upenn.edu/biol438/files/kickingppt.pdf
15. Hargreaves A., Bate R., Skills and Strategies for Coaching Soccer. 2nd Edition. Human Kinetics, Champaign 2009.
16. Parrish R., Types of kicking in soccer. Available from http://www.livestrong.com/article/464483-types-of-kicking-in-soccer [accessed: June, 2011]
17. Haghighi A., Moghadasi M., Nikseresht A., Torkfar A., Haghighi M., Effects of plyometric versus resistance training on sprint and skill performance in young soccer players. *Eur J Exper Biol*, 2012, 2 (6), 2348–2351.
18. Campo S.S., Vaeyens R., Pilippaerts R.M., Redondo J.C., Benito A.M., 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.
19. Patterson R.M., Stegink Jansen C.W., Hogan H.A., Nassif M.D., Material Properties of Thera-Band Tubing. *Phys Ther*, 2001, 81 (8), 1437–1445.
20. Thera-Band Systems of Progressive Exercise, Resistance Band & Tubing. Instruction Manual. Voulme 4. The Hygenic Corporation, Akron, USA 2006, Available from: http://thera-band.com/instructions.php.
21. Colado J.C., Garcia-Masso X., Pellicer M., Alakhdar Y., Benavent J., Cabeza-Ruiz R., A comparison of elastic tubing and isotonic resistance exercises. *Int J Sports Med*, 2010, 31 (11), 810–817, doi: 10.1055/s-0030-1262808.
22. Aguiar M., Abrantes C., Maçãs V., Leite N., Sampaio J., Ibáñez S., Effects of intermittent or continuous training on speed, jump and repeated-sprint ability in semi-professional soccer players. *The Open Sports Sciences J*, 2008, 1, 15–19.
23. Finnoff J.T., Newcomer K., Laskowski E.R., A valid and reliable method for measuring the kicking accuracy of soccer players. *J Sci Med Sport*, 2002, 5 (4), 348–353.
24. Changela P.K., Bhatt S., The correlational study of the Vertical Jump Test and Wingate Cycle Test as a Method to Assess Anaerobic Power in High School Basketball Players. *International Journal of Scientific and Research Publications*, 2012, 2 (6), 1–6.
25. Maas G., Fitness Tests for Soccer. Available from http://www.mshssca.org/resources/ soccerfitnesstests.pdf.
26. Manolopoulos E., Papadopoulos C., Kellis E., Effects of combined strength and kick coordination training on soccer kick biomechanics in amateur players. *Scand J Med Sci Sports*, 2006, 16 (2), 102–110, doi: 10.1111/j.1600-0838.2005.00447.x.
27. Lyons M.E., Isokinetic Hamstring: Quadriceps Strength Ratio in Males and Females: Implications for ACL Injury. *The Osprey Journal of Ideas and Inquiry*, 2006, Volume 5, Paper 65. Available from: http://digitalcommons.unf.edu/ojii_volumes/64.
28. Adibpour N., Bakht H.N., Behpour N., Comparison of the Effect of Plyometric and Weight Training Programs on Vertical Jumps in Female Basketball Players. *World J Sport Sci*, 2012, 7 (2), 99–104, doi: 10.5829/idosi.wjss.2012.7.2.1173.
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. Taheri E., Nikseresht A., Khoshnam E., The effect of 8 weeks of plyometric and resistance training on agility, speed and explosive power in soccer players. *Eur J Exp Biol*, 2014, 4 (1), 383–386.
31. Moritani T., deVries H.A., Neural factors versus hypertrophy in the time course of muscle strength gain. *Am J Phys Med*, 1979, 58 (3), 115–130.
32. Deschenes M.R., Kraemer W.J., Performance and physiologic adaptations to resistance training. *Am J Phys Med Rehabil*, 2002, 81 (11 Suppl.), S3–S16.

Paper received by the Editor: July 11, 2014.
Paper accepted for publication: September 21, 2014

Correspondence address
Alekhya Tirumala
Sports Physiotherapy Department
KLE University Institute of Physiotherapy
JNMC Campus
Nehru Nagar
Belgaum- 590010
Karnataka, India
e-mail: alekhya_tiru@yahoo.co.in