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# Effect of *Kaempferia parviflora* Extract on Physical Fitness of Soccer Players: A Randomized Double-Blind Placebo-Controlled Trial

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**Background:** Physical fitness is a fundamental prerequisite for soccer players. *Kaempferia parviflora* is an herbal plant that has been used in some Asian athletes with the belief that it might prevent fatigue and improve physical fitness. This study aimed to determine the effects of *Kaempferia parviflora* on the physical fitness of soccer players.




**Material/Methods:** Sixty soccer players who routinely trained at a sports school participated in a double-blind placebo-controlled trial and were randomly allocated to the treatment group or the placebo group. The participants in both groups were given either 180 mg of *Kaempferia parviflora* extract in capsules or a placebo once daily for 12 weeks. Baseline data were collected using the following 6 tests of physical performance: a sit-and-reach test, a hand grip strength test, a back-and-leg strength test, a 40-yard technical test, a 50-metre sprint test, and a cardiorespiratory fitness test. All of the tests were performed every 4 weeks throughout the 12-week study period.

**Results:** The study showed that after treatment with *Kaempferia parviflora*, the right-hand grip strength was significantly increased at weeks 4, 8, and 12. The left-hand grip strength was significantly increased at week 8. However, the back-and-leg strength, the 40-yard technical test, the sit-and-reach test, the 50-metre sprint test, and the cardiorespiratory fitness test results of the treatment group were not significantly different from those of the placebo group.

**Conclusions:** Taking *Kaempferia parviflora* supplements for 12 weeks may significantly enhance some physical fitness components in soccer players.

**MeSH Keywords:** **Physical Fitness • Muscle Strength • Soccer**

**Full-text PDF:** <http://www.basic.medscimonit.com/abstract/index/idArt/894301>

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## Background

The technical and tactical skills of soccer players are highly dependent on the players' physical condition [1]. Athletes need to simultaneously exhibit aerobic endurance, speed, flexibility, agility, and strength during competition [2]. Consequently, the integration of scientific principles from exercise theory is important in the planning and execution of training regimes in contemporary elite soccer [3]. Exercise training induces adaptations that improve subsequent exercise capacity and reduce fatigue [4]. In soccer, training at an elite level imposes stress on the physiological systems to improve various fitness components [5]. The relationship between training and nutrition is also important because optimal adaptation to the demands of repeated training stimuli requires sufficient nutrient intake to sustain muscle energy reserves [6]. Previous studies have shown that nutritional interventions in soccer players influenced the outcome of games by reducing the detrimental attributes of fatigue and inducing optimal utilization of the players' physical and tactical skills [7].

Nutritional interventions for exercise training in soccer include foods and supplements. Because of the high-intensity activity involved, soccer performance requires a high energy expenditure with a heavy reliance on carbohydrates as an energy source [8]. Other food components, such as vitamins E and D, folate, calcium, magnesium, zinc, vitamin A, and iron, have also been shown to influence soccer performance [9].

*Kaempferia parviflora* Wall. ex Baker is a plant in the family Zingiberaceae. It has long been used in traditional Asian medicine to treat various ailments, including allergies, fatigue, sexual dysfunction, and ulcers. In addition, it has been used as a longevity-promoting substance. *Kaempferia parviflora* rhizome extract contains numerous flavonoids [10], which have previously been reported to possess antioxidant activity and neuroprotective and cognition-enhancing effects [11]. A recent study reported that it promoted vascular endothelial function by increasing nitrite and endothelial nitric-oxide synthase (eNOS) mRNA and protein expression in human umbilical vein endothelial cells [12], thus improving vasorelaxation [13]. This finding implies that *Kaempferia parviflora* could have potential beneficial effects on human exercise performance that may be similar to the effects of vasodilator ginsenosides extracted from ginseng and acting via the nitric oxide signalling pathway [14]. In this study, we aimed to investigate the effect of *Kaempferia parviflora* on the physical fitness of soccer players.

## Material and Methods

### Participants

Sixty male soccer players aged 15–18 years who routinely trained at a sports school participated in this double-blind placebo-controlled trial. The participants were randomly allocated to the treatment group (age 15.73±0.81 years; body height 170.26±6.02 m; body mass 20.05±1.84 kg) or the placebo group (age 15.76±0.94 years; body height 170.90±5.74 m; body mass 20.37±1.96 kg). The participants were healthy males with no history of cardiovascular disease, alcohol addiction, or smoking. All of the participants agreed to abstain from products containing caffeine and alcohol for a minimum of 12 hours prior to the test sessions. This study was approved by the Ethics Committee of Human Research (HE 562123). Each volunteer provided informed consent. All of the recruited participants underwent a health status screening by a physician. In addition, each participant underwent a blood chemistry test and analysis before and after the 12-week study period to monitor the effects of the treatment on liver and kidney functions.

### *Kaempferia parviflora* preparation

The standardization and conformity of the *Kaempferia parviflora* extract were assured by strict in-process controls during manufacturing and complete analytical control of the resulting dry extract. Capsules containing 90 mg of plant rhizome extract also included 5,7 dimethoxy flavone (2.1%), 5,7,4-trimethoxyflavone (3.1%), and 3,5,7,3,4-pentamethoxyflavone (2.3%). Ninety-milligram placebo capsules were also manufactured using the same pharmaceutical excipient and packaging. Random allocation was performed by the third investigator. Each participant was encouraged to consume 2 capsules of the *Kaempferia parviflora* product or the placebo before breakfast for 12 weeks.

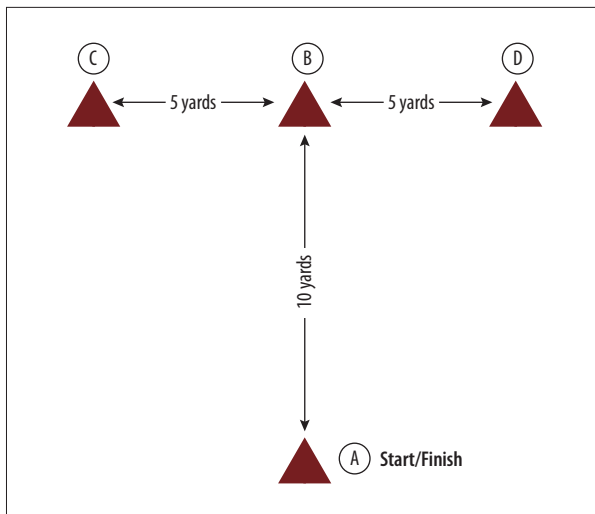
### Measures

#### Physical fitness tests

The body weights and heights of the participants were measured, and basic capability and physical fitness tests were administered [15].

#### Grip strength test

Grip strength was measured using a digital dynamometer (No. TTK 383008 Neighbor Group Company, Japan). Each of the participants held the dynamometer in the tested hand with the arm at a right angle and the elbow by the side of the body. When ready, the participant was instructed to squeeze with maximum effort and maintain the squeeze for 5 seconds. No other



**Figure 1.** The 40-yards technical test.

body movement was allowed. The participants performed the test twice (alternating between hands), with a 1-minute rest period between measurements. The best value in terms of kg/body weight of 2 trials for each hand was chosen.

#### *Back-and-leg test*

This test measured the strength of back and leg muscles simultaneously using a digital dynamometer (No.TKK 383012Neighbor Group Company, Japan). Each participant performed the test twice, with a 1-minute rest period between measurements. The test started with the participant's arms hanging straight down as the participant held the centre of the bar with both hands and with the palms facing toward the body. The chain was adjusted so that the knees were bent at approximately 110 degrees. Then, the participant was instructed to pull as hard as possible on the metal rod hooked to the chain without bending his back and to attempt to straighten his legs while keeping his arms straight. The best value in terms of kg/body weight was registered.

#### *Sit-and-reach test*

This test involved the flexibility of the upper body and hips. The participant was asked to reach forward from a long sitting position as far as possible along a measuring line. After some practice reaches, the participant reached out and held that position for two seconds while the distance was recorded. Each participant performed the test twice, and the highest value was registered.

#### *40-yard technical test*

This test evaluated the agility needed to run 40 yards. The participant ran forward as fast as possible from cone A to cone

B and touched the top of the cone with his hand. He then turned left and shuffled sideways to cone C. He touched the top of the cone, this time with his left hand. He then shuffled sideways to the right to cone D and touched the top with his right hand. Then, he shuffled back to cone B, touched it with his left hand, and ran backward to cone A. The total time in seconds was recorded (Figure 1) [16].

#### *50-metre sprint test*

This test measured running speed over a distance of 50 meters. The participant stood in a stationary position with one foot in front of the other. An instructor gave the instructions "set", then "go". The participant was instructed not to slow down before crossing the finish line. The time in seconds was recorded.

#### *Cardiorespiratory fitness (VO<sub>2</sub> max) test*

The participants' cardiorespiratory fitness (VO<sub>2</sub>max) was measured using cycle ergometry following the Astrand-Rhyming protocol [17]. After they were informed of the test procedures and precautions, the participants were fitted with a Polar heart rate monitor and asked to perform 5 minutes of stretching exercises for their knee flexor, knee extensor, and ankle dorsiflexor muscles. The test began by having the participants sit on a bicycle ergometer with an appropriate seat height. The participants cycled for 1 minute with no load following the tick of a metronome set at 50 rpm (or 18 km/h). Then, the load was increased to achieve a heart rate between 120 and 150 bpm. VO<sub>2</sub>max was estimated with the Astrand-Rhyming nomogram based on the work rate and average heart rate from minutes 5 and 6. The heart rates at the end of minutes 5 and 6 were recorded, and the average VO<sub>2</sub>max was calculated using the following formula:

$$\text{average VO}_2\text{max (ml/kg/min)} = \frac{[\text{VO}_2 \text{ (L/min)} \times 1000]}{\text{weight (kg)}} \times \text{age factor.}$$

This value was converted to ml/kg/min by multiplying the above number by 1000 to obtain the units of ml·min<sup>-1</sup> and then dividing the result by the participant's body weight in kilograms.

#### *Blood chemistry determination*

The liver enzyme levels of the participants were checked before and after the experimental period. The complete blood count (CBC) was measured using BC-2800, serum activities of electrolytes (sodium, potassium, and chloride) and carbon dioxide levels were also measured using Cobas Integra 400. However, they assessed serum activities of aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), as well as serum concentrations of urea nitrogen (BUN) and creatinine were measured using the clinical chemistry Analyzer Cobas c501.

## Procedures and intervention

To evaluate the five major components of health-related fitness (cardiorespiratory endurance, muscular endurance, muscle strength, flexibility, and body composition), this study applied six tests, namely a sit-and-reach test, a hand grip strength test, a back-and-leg strength test, a 40-yard technical test, a 50-metre sprint test, and a  $VO_2$ max test. The participants' physical fitness was assessed every 4 weeks throughout the experimental period. All of the participants met the following inclusion criteria: healthy male students aged 15–18 years attending a sports school whose blood chemistry tests.

The review of compliance with the supplements and side effects was performed independently by the investigators, who were also blind to the group allocations. Adverse effects were assessed during every study visit.

## Statistical analysis

All data are expressed as the mean  $\pm$  standard deviation (SD). Estimation of the sample size was based on a previous study [18] that compared the effect of a per-workout supplement containing caffeine, creatine, and amino acids during 3 weeks of high-intensity exercise on aerobic and anaerobic performance. Based on this study, a standard deviation of  $VO_2$ max after treatment of both groups was used to calculate the sample size for a power of 90% at  $\alpha$  5% significance. This study allowed for estimating the final sample size with data generated by STATA 10 (using the principle of intention to treat) and estimated sample size for samples with repeated measures. The sample size was 1 participant, which is unlikely to be near reality. Therefore, it was decreased the different at 18.18%. The sample size would be appropriately at 27 participants and a drop-out rate of 5%. According to these criteria, 60 participants were required. This study aimed to analyze between-group comparisons and comparisons between baseline data and the results obtained at various physical fitness assessment time points were analyzed by analysis of covariance (ANCOVA). The within-group comparisons and blood chemistry parameter analyses were performed using one-way analysis of variance (repeated measurements). Statistical significance was set at  $p < 0.05$ .

## Results

The flow of participants in the study is shown in Figure 2. The baseline demographic data of the participants in the treatment and placebo groups were not significantly different with respect to age, weight, height, systolic and diastolic blood pressure, pulse rate, and body mass index (Table 1).

Daily consumption of 180 mg of *Kaempferia parviflora* extract for 12 weeks seemed to have small effects on several blood

chemistry parameters (Table 2). Concentration of hemoglobin and the level of hematocrit, monocytes, and eosinophils were slightly increased in both groups. The white blood cell counts of the placebo group were slightly increased, and the lymphocyte counts of the treatment group were also slightly decreased. There were no changes in neutrophil levels in either group. The concentration of BUN and activities of ALP of both groups were slightly increased but there were no changes in the activities of AST and ALT. The creatinine levels of both groups were slightly decreased. The blood levels of 3 electrolytes (sodium, potassium, and chloride) were slightly decreased in both groups. The carbon dioxide levels of the treatment group were also slightly increased. However, the changes of all of these values remained within normal limits.

The daily consumption of 180 mg of *Kaempferia parviflora* extract for 12 weeks affected several parameters of physical fitness. Compared with the placebo group, the supplemented group at a dose of 180 mg/day showed a greater tendency toward increased muscle strength; we observed that the right-hand grip strength was significantly enhanced at weeks 4, 8, and 12. The left-hand grip strength was significantly enhanced after 8 weeks of *Kaempferia parviflora* extract consumption. The back-leg strength did not differ significantly between the groups (Table 3). The right-hand grip strengths of the *Kaempferia parviflora*-treated group were significantly increased at week 4 compared with the baseline data (Table 4).

Regarding flexibility, the oral administration of *Kaempferia parviflora* capsules at a dose of 180 mg/day did not affect the sit-and-reach test results. However, both the treatment and placebo groups showed a significant decrease in the results of this test at week 4, with no between-group differences.

Regarding agility and speed, the oral administration of *Kaempferia parviflora* capsules at a dose of 180 mg/day significantly decreased the times for the 40-yard technical test at week 12 compared with the baseline data. The 50-metre sprint times of both groups were significantly increased at week 8 compared with the baseline values. However, there were no significant differences between the groups.

The oral administration of *Kaempferia parviflora* capsules at a dose of 180 mg/day for 12 weeks gradually increased cardiorespiratory fitness, as indicated by  $VO_2$ max values. However, there was no significant difference between the groups.

## Discussions

The main objective of this study was to determine the effect of *Kaempferia parviflora* on the physical fitness of soccer players. We found *Kaempferia parviflora* significantly enhanced the

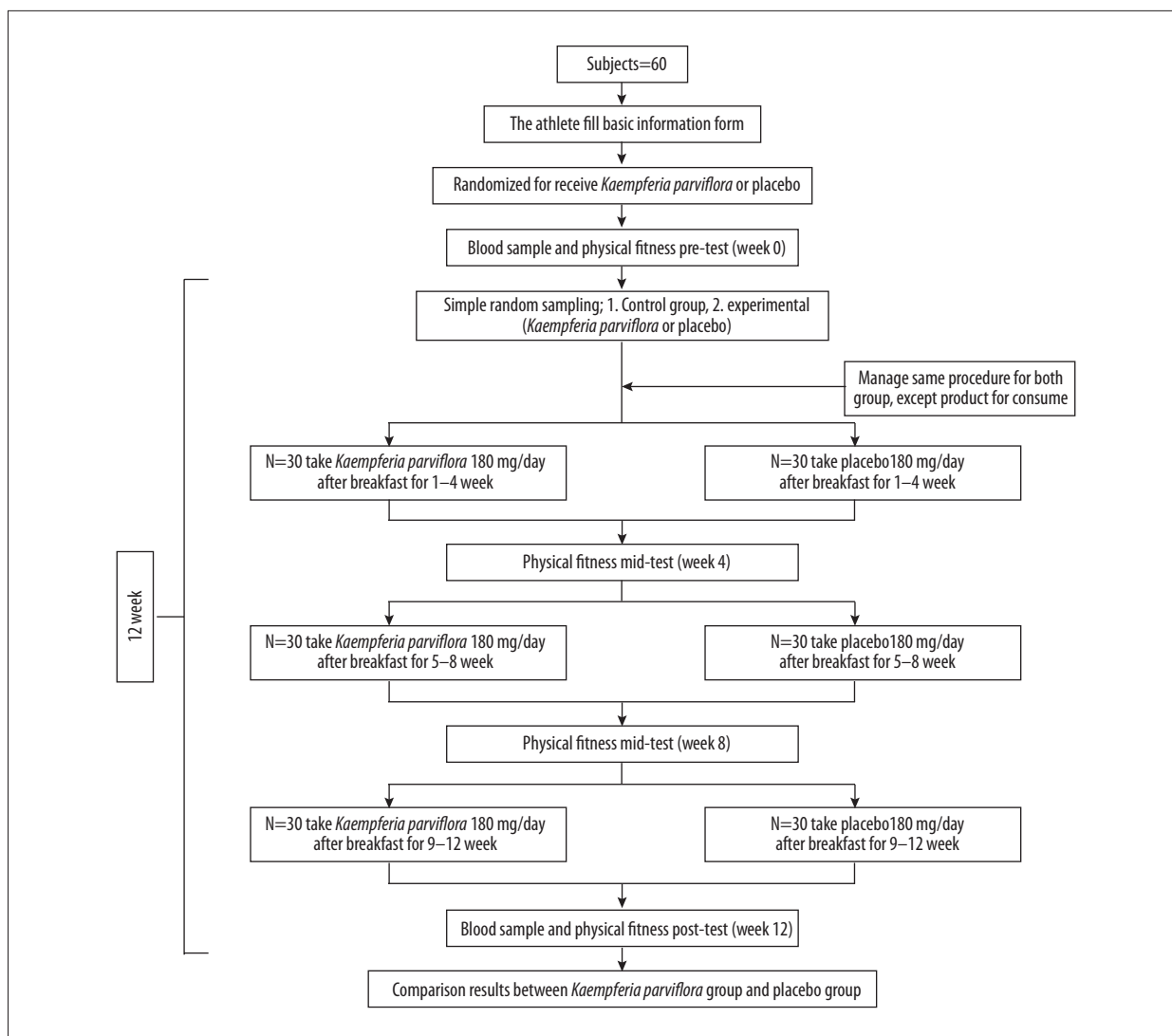


Figure 2. Flow of participants in the study.

Table 1. Demographic data of the participants.

General characteristics	Treatment (n=30)	Placebo (n=30)	p value
Age (years)	15.73±0.81	15.76±0.94	0.884
Systolic blood pressure (mmHg)	113.20±12.31	109.56±10.59	0.226
Diastolic blood pressure (mmHg)	61.40±6.865	60.90±4.63	0.742
Pulse rate (bpm/min)	71.16±11.13	70.16±7.96	0.691
Body mass index (kg/m <sup>2</sup> )	20.05±1.84	20.37±1.96	0.514
Weight (kg)	58.26±7.33	59.60±7.34	0.485
Height (cm)	170.26±6.02	170.90±5.74	0.678

right- and left-hand grip strengths. It was noted that *Kaempferia parviflora* also appeared to have an effect on cardiorespiratory fitness, especially at week 12 when the VO<sub>2</sub>max increased

from 45.09±9.88 to 51.05±8.40 ml/kg/min despite nearly statistical significance for between-group comparisons.

**Table 2.** Effect of *Kaempferia parviflora* on the blood chemistry of the participants.

Items		Pre-dose baseline score	Post-dose baseline score	P value	Normal value
White blood cells (cell/mm <sup>3</sup> )	Treatment (n=30)	6920±1246.62	7010±1247.43	0.608	4,000–10,000
	Placebo (n=30)	6770±1343.73	7176±957.61 *	0.031	4,000–10,000
Haemoglobin(g/dl)	Treatment (n=30)	13.61±0.84	13.90±0.79 *	0.000	13.0–18.0
	Placebo (n=30)	13.47±0.83	13.80±0.77 *	0.006	13.0–18.0
Haematocrit(%)	Treatment (n=30)	40.90±2.56	42.26±2.01 *	0.000	40–54
	Placebo (n=30)	40.53±2.50	42.10±2.00 *	0.000	40–54
Neutrophils(%)	Treatment (n=30)	57.76±5.73	59.40±5.27	0.262	40–74
	Placebo (n=30)	57.33±8.56	58.46±7.05	0.442	40–74
Lymphocytes(%)	Treatment (n=30)	40.13±5.91	36.73±5.21 *	0.020	19–48
	Placebo (n=30)	40.60±8.09	38.23±7.20	0.125	19–48
Monocytes(%)	Treatment (n=30)	0.90±0.84	1.66±1.53 *	0.013	0–6
	Placebo (n=30)	0.70±0.70	1.43±1.27 *	0.007	0–6
Eosinophils(%)	Treatment (n=30)	1.20±2.24	2.20±1.86 *	0.001	0–7
	Placebo (n=30)	1.36±2.67	1.90±1.56 *	0.164	0–7
Blood urea nitrogen (mg/dl)	Treatment (n=30)	10.60±0.34	12.43±0.36 *	0.000	7–21
	Placebo (n=30)	11.63±0.54	13.30±0.51 *	0.000	7–21
Creatinine(mg/dl)	Treatment (n=30)	1.02±0.10	0.91±0.92 *	0.000	0.7–1.4
	Placebo (n=30)	1.06±0.09	0.94±0.09 *	0.000	0.7–1.4
Alkaline phosphatase(U/L)	Treatment (n=30)	102.93±31.03	106.83±32.70*	0.018	26–117
	Placebo (n=30)	98.63 ±28.78	105.66±33.83 *	0.000	26–117
Aspartate transaminase(U/L)	Treatment (n=30)	25.43±4.38	25.93±3.75	0.378	0–38
	Placebo (n=30)	24.96±5.26	26.06±4.83	0.118	0–38
Alanine transaminase(U/L)	Treatment (n=30)	15.20 ±5.66	14.83±3.94	0.604	0–40
	Placebo (n=30)	15.03±4.10	16.40±5.78	0.071	0–40
Sodium (mmol/l)	Treatment (n=30)	142.36±2.73	137.80±1.24 *	0.000	135–148
	Placebo (n=30)	142.06±2.57	137.46±1.45 *	0.000	135–148
Potassium (mmol/l)	Treatment (n=30)	4.59±0.30	4.36±0.39 *	0.007	3.5–5.3
	Placebo (n=30)	4.45±0.31	4.24±0.28 *	0.010	3.5–5.3
Chloride (mmol/l)	Treatment (n=30)	103.53±2.34	94.66±16.11 *	0.006	98–107
	Placebo (n=30)	103.36±2.29	97.23±2.04 *	0.000	98–107
Carbon dioxide (mmol/l)	Treatment (n=30)	27.30±1.53	28.06±1.11 *	0.037	22–29
	Placebo (n=30)	27.23±1.04	27.7±1.60	0.182	22–29

Data are presented as the mean ±SD. P and normal values were compared between the pre-dose baseline and post-dose time points, \* significant difference compared with the pre-dose baseline and post-dose time point (p<0.05).

**Table 3.** The effect of *Kaempferia parviflora* on the physical fitness of the participants: comparisons between groups.

Items	Pre-dose baseline score	Post-dose baseline score					
		Week 4	P-value	Week 8	P-value	Week 12	P-value
Right-hand grip strength (kg/wt)							
Treatment (n=30)	0.65±0.09	0.70±0.09*	0.034	0.68±0.10*	0.024	0.65±0.08*	0.038
Placebo (n=30)	0.63±0.07	0.66±0.07		0.63±0.07		0.62±0.07	
Left-hand grip strength (kg/wt)							
Treatment (n=30)	0.62±0.08	0.65±0.10	0.469	0.64±0.08*	0.024	0.61±0.08	0.235
Placebo (n=30)	0.60±0.08	0.62±0.07		0.59±0.08		0.57±0.07	
Back-and-leg strength (kg/wt)							
Treatment (n=30)	2.77±0.54	2.68±0.55	0.61	2.77±0.55	0.377	2.79±0.59	0.993
Placebo (n=30)	2.45±0.39	2.45±0.51		2.44±0.40		2.53±0.52	
Sit-and-reach test (cm)							
Treatment (n=30)	17.98±4.60	16.43±5.15	0.926	16.88±5.19	0.452	18.28±5.10	0.729
Placebo (n=30)	16.14±4.93	14.64±4.92		14.61±5.24		17.01±4.55	
40-yard technical test (s)							
Treatment (n=30)	11.61±0.70	12.06±1.16	0.746	11.50±0.74	0.458	10.08±0.47	0.078
Placebo (n=30)	11.99±0.86	12.34±1.33		11.46±0.75		10.47±0.90	
50-metre sprint (s)							
Treatment (n=30)	6.24±0.31	6.26±0.31	0.752	6.37±0.26	0.255	6.33±0.24	0.204
Placebo (n=30)	6.29±0.37	6.33±0.49		6.50±0.50		6.47±0.52	
VO <sub>2</sub> max (ml/kg/min)							
Treatment (n=30)	45.09±9.88	46.95±7.61	0.657	49.40±8.40	0.578	51.05±8.40	0.053
Placebo (n=30)	45.09±9.96	47.85±10.08		48.34±7.17		47.10±8.45	

The effects of *Kaempferia parviflora* on physical fitness. P-values are presented as the mean±SD. \* Significant difference from the placebo group in the same week ( $p < 0.05$ ).

The results were in accordance with those of a previous study in which *Kaempferia parviflora* was found to facilitate increases in muscle strength, although that study included a different participant group than our study (elderly individuals vs. young athletes) [19]. A previous study revealed that *Kaempferia parviflora* supplements could increase blood flow to the organs [20] as a result of induced vasorelaxation effect that was partly mediated via cyclooxygenase- and nitric oxide-dependent pathways [21], and provide anti-inflammatory effects [20,22,23]. Thus, it is possible that the increased blood flow to the skeletal muscles combined with anti-inflammatory effects may facilitate muscle strength training among people who take *Kaempferia parviflora* supplements. Consequently, because of the increased blood flow to the muscles, it may enhance cardiorespiratory fitness of the participants in this treatment group.

Regarding agility, *Kaempferia parviflora* did not affect results of the 40-yard technical test, which measures the body's ability to change directions rapidly. In this test, the muscles must respond to nervous system commands effectively; eye-and-hand and eye-and-foot coordination is necessary to change directions quickly and accurately. The agility of the *Kaempferia parviflora* group seemed to be slightly decreased at week 12 as compared with the baseline data. However, the decreases in the agility test times were similar in both groups, suggesting that *Kaempferia parviflora* did not affect agility.

Although the mechanism of *Kaempferia parviflora* for increase cardiorespiratory endurance is not well understood, a previous study showed that acute effect of pycnogenol, a well-known antioxidant, significant increase cardiorespiratory endurance in

**Table 4.** The effects of *Kaempferia parviflora* on the physical fitness of the participants: comparisons between the pre- and post-dose baseline scores.

Item	Pre-dose baseline score	Post-dose baseline score			Within group	
		Week 4	Week 8	Week 12	F-test	P-value
Right-hand grip strength (kg/wt)						
Treatment (n=30)	0.65±0.09	0.70±0.09*	0.68±0.10	0.65±0.08	9.373	<0.001
Placebo (n=30)	0.63±0.07	0.66±0.07*	0.63±0.07	0.62±0.07	9.345	<0.001
Left-hand grip strength (kg/wt)						
Treatment (n=30)	0.62±0.08	0.65±0.10	0.64±0.08	0.61±0.08	3.195	0.039
Placebo (n=30)	0.60±0.08	0.62±0.07	0.59±0.08	0.57±0.07	6.617	0.001
Back-and-leg strength (kg/wt)						
Treatment (n=30)	2.77±0.54	2.68±0.55	2.77±0.55	2.79±0.59	0.968	0.404
Placebo (n=30)	2.45±0.39	2.45±0.51	2.44±0.40	2.53±0.52	0.771	0.475
Sit-and-reach test (cm)						
Treatment (n=30)	17.98±4.60	16.43±5.15*	16.88±5.19	18.28±5.10	6.212	0.002
Placebo (n=30)	16.14±4.93	14.64±4.92*	14.61±5.24*	17.01±4.55	12.449	<0.001
40-yard technical test (s)						
Treatment (n=30)	11.61±0.70	12.06±1.16	11.50±0.74	10.08±0.47*	42.964	<0.001
Placebo (n=30)	11.99±0.86	12.34±1.33	11.46±0.75*	10.47±0.90*	28.789	<0.001
50-metre sprint (s)						
Treatment (n=30)	6.24±0.31	6.26±0.31	6.37±0.26*	6.33±0.24	3.548	0.021
Placebo (n=30)	6.29±0.37	6.33±0.49	6.50±0.50*	6.47±0.52*	5.101	0.004
VO <sub>2</sub> max (ml/kg/min)						
Treatment (n=30)	45.09±9.88	46.95±7.61	49.40±8.40	51.05±8.40*	4.111	0.012
Placebo (n=30)	45.09±9.96	47.85±10.08	48.34±7.17	47.10±8.45	1.62	0.201

Effect of *Kaempferia parviflora* on physical fitness. P values are presented as the mean ±SD. \* significant difference compared with the pre-dose baseline score (p<0.05).

athletes [24]. Furthermore, 2 previous studies also have demonstrated that pycnogenol significantly increases vasodilatory response, which may improve micro-circulation and potentially remove lactic acid in muscle [25,26] and consequently increase cardiorespiratory endurance. Therefore *Kaempferia parviflora*, a well-known antioxidant [19], probably increases cardiorespiratory endurance by the same mechanism as pycnogenol (Table 4).

The results on the sit-and-reach test demonstrated that *Kaempferia parviflora* does not affect trunk and leg flexibility. The flexibility seemed to be slightly decreased in the *Kaempferia parviflora* group at week 4 as compared with the baseline data. Because the changes in the magnitude of flexibility were small and were similar in both groups, we suggest that these small changes may be due to systematic measurement errors.

In an animal study, the effective doses of *Kaempferia parviflora* are 250–500 mg/kg body weight and the toxicity data

demonstrated the safety of dose up to 500 mg/kg body weight. With the safety factor of 70, the dose up to 350 mg/kg is still safe for clinical trials [27]. Our preliminary pharmacokinetic study in healthy volunteers revealed the lower values of AUC, Cmax, and other parameters of 90 mg/kg dose than that of 180 mg/kg dose (unpublished data). Moreover, among several parameters of physical fitness determined in elderly volunteers only the 6-second chair test was changed, suggesting the low amount of blood methoxy flavones at the doses of 25 and 90 mg/kg used in the previous study [19]. Taken together, this study was designed to use the higher dose of 180 mg/kg in the younger healthy volunteers.

Considering harmful effects of daily consumption of 180 mg of *Kaempferia parviflora* extract for 12 weeks, we found that it did not affect any blood chemistry parameters because there was no significantly different when compare the results between the two groups (Table 2). The values of these parameters were within normal limits and no clinically important,



although there were small changes after the intervention. None of the participants had any side effects or dropped out from the study. These results were in line with a previous report in healthy elderly volunteers who consumed *Kaempferia parviflora* at dose of 90 mg/day for 8 weeks and revealed no remarkable lesions related to the toxicity of *Kaempferia parviflora* extract [20]. Therefore, it is reasonably safe to consume *Kaempferia parviflora* extract at this dosage.

## Conclusions

We conclude that the use of *Kaempferia parviflora* as a food supplement has the potential to enhance muscle strength and

may improve aerobic capacity, both of which are important components of physical fitness in soccer players.

## Conflict of interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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