Acute Effect of Caffeine-based Multi-Ingredient Supplement on Reactive Agility and Jump Height In Recreational Handball Players

Piotr Kaczka (kaczor81@o2.pl)
Akademia Wychowania Fizycznego imienia Jerzego Kukuczki w Katowicach https://orcid.org/0000-0002-1730-6335
Katarzyna Kubicka
Academy of Physical Education in Katowice
Amit Batra
Academy of Physical Education in Katowice
Marcin Maciejczyk
Academy of Physical Education in Cracow: Akademia Wychowania Fizycznego im Bronislawa Czecha
Rafał Jastrząb
Academy of Physical Education in Katowice
Edyta Kopera
Academy of Physical Education in Katowice
Justyna Bira
Academy of Physical Education in Katowice
Halina Zakliczyńska
Centre of Nutritional Education and Sport
Tomasz Zając
Academy of Physical Education in Katowice

Research article

Keywords: pre-workout supplementation, agility, countermovement jump, CMJ, caffeine, multi-ingredient performance supplement, MIPS, 1-1-2 reactive agility test, Y-test

Posted Date: March 23rd, 2022

DOI: https://doi.org/10.21203/rs.3.rs-150255/v2

Version of Record: A version of this preprint was published at Nutrients on April 9th, 2022. See the published version at https://doi.org/10.3390/nu14081569.

Abstract

Background: The purpose of this study was to examine the acute effect of a caffeine-based multi-ingredient supplement (MS) on the reactive agility and jump performance in recreational handball male players.

Methods: A randomized, double-blind, crossover study involved twenty-four male handball players. All participants were tested under three conditions: placebo, caffeine, or MS ingestion 45 minutes before exercise tests. Participants performed a reactive agility test (Y-test: 1-1-2 test) and countermovement jump (CMJ).

Results: None of the supplements improved countermovement jump height. The time needed to complete the 1-1-2 test was significantly shorter in MS condition compared to placebo. The differences in agility between PL vs. caffeine and MS vs. caffeine conditions were not statistically significant.

Conclusions: The results of this study indicate that the caffeine-based multi-ingredient performance was effective in improvement in reactive agility but not in jump height in recreational handball male players. A similar effect was not observed with caffeine ingestion alone. Further comparative studies (MS ingestion vs. only caffeine ingestion) and MS with different compositions are needed.

Introduction

Muscle power and agility are strongly associated with athletic performance. Agility and power are needed in such sports as tennis and badminton, Taekwon-Do, or team sports [1]. Sheppard and Young [2] have defined reactive agility as a rapid whole-body movement with a change of velocity or direction in response to a stimulus. In many sports disciplines, agility and/or speed can result in a score or a shift in the game's momentum [3]. On the other hand, muscle power is essential to perform dynamic movements requiring both speed and strength. It is necessary not only in speed and power sports but also in those where jumping ability is needed, such as team games like handball.

Many athletes believe that pre-workout supplementation improves concentration, decreases reaction time, increases power and endurance, and reduces fatigue [4, 5]. The most popular pre-workout supplement is caffeine (CAF) which enhances performance through peripheral and central mechanisms [6]. The effects of caffeine ingestion on aerobic performance is well documented [7], and in recent years studies have focused on the impact of caffeine consumption on anaerobic performance [8, 9]. However, the effects of caffeine on muscle strength, power, speed, and agility reported in previous studies are inconsistent [9]. Previous studies reported a slight improvement in reactive agility [10] or no effect [7] of caffeine at the same dose of 6 mg/kg. Regarding jump height (power), similarly, both improvement [11] and no effect [12] of caffeine were observed. The type of exercise test used, participant characteristics (e.g., age and training experience), and form of caffeine (or composition of multi-ingredient supplement) may be responsible for the inconsistent results [8].

The previous study [13] reported an increase in jump height after caffeine ingestion, but at the same time emphasized that it was not known whether the observed effect was due to caffeine content or the presence of other substances such as taurine. A significant relationship was shown between taurine content and performance but not between caffeine content and performance [14]. Ingredients found in many MS such as caffeine, arginine, beta-alanine, creatine, citrulline, or different plant ingredients that use other physiological mechanisms of action may also have synergistic effects improving athletic performance [4, 15]. Caffeine and other sympathomimetic ingredients of MS could be more effective in performance improvement than caffeine per se. The dopaminergic and catecholaminergic impact may also be enhanced by tyrosine, a component of many MS. Multiple ingredients potentially interact, increasing or decreasing supplement effectiveness. Pre-workout MS typically consists of numerous active ingredients, which can modify pharmacodynamics and pharmacokinetics and thus result in different bioavailability properties and physiological effects, like in the case of various amino acids [16, 17].

It was hypothesized that ingesting MS may be more effective than consuming caffeine alone in improving agility and power - the synergistic effect of biologically active ingredients in multi-ingredient supplements based on caffeine may be more effective than caffeine ingestion per se. Therefore, this study aimed to examine the acute effects of a MS on reactive agility and jump height in recreationally-trained handball male players.

Given the importance of jumping ability and agility in many popular sports, determining the effect of supplementation with caffeine-based supplements on agility and power would be of great scientific and practical interest.

Materials And Methods

Study design

Players were recruited from academic handball teams according to the criteria for inclusion and exclusion. Inclusion criteria were as follow: men, age 18-45, good general health determined based on a medical examination including the assessment of resting ECG and resting blood pressure. Exclusion criteria were hypersensitivity to any of the product components (verified based on a declaration in a personal questionnaire) and no injury in the six months preceding the study. Players were asked to refrain from consuming caffeine, strong tea, any additional supplements or ergogenic aids, alcohol-containing products for the two weeks preceding the survey, and not doing strenuous training for 24 hours before the examination. The participants were asked not to consume anything for 3 hours before the test.

All participants attended a familiarization session one week before the study. In the main part of the study the players were tested under three conditions: placebo, caffeine, and MS supplementation in random order. Participants repeated the testing session every three days. After consuming either a placebo or the supplement solution (CAF or MS), handball players rested for 15 minutes. Standard warm-up started with 10 min run at 60%–75% of maximal heart rate. After the run participants performed various dynamic stretching exercises for five minutes. First, the agility test was performed, followed by a countermovement jump.

Players were acquainted with the purpose and course of research. They also provided their written consent to participate in the project. In the case of soccer players. The study was approved by the Ethical Committee of the University of Physical Education in Katowice (Poland; opinion No. 2/2018) and conformed to the ethical requirements of the 1975 Helsinki Declaration.

Participants

Twenty–four recreationally-trained handball male players (body mass = 74.6±8.8 kg; body height = 179±7.2 cm; age = 23.8±1.4 years) were involved in this study. Participants trained up to three pieces of training per week with medium to high-intensity (including resistance training) and played one match (academic league) in a week.

Supplementation

Forty-five minutes before testing, players were randomly provided with either a) placebo (PL): 250 ml of the flavored water; or b) caffeine, flavored water containing: anhydrous caffeine (200 mg) (Biesterfeld International, Poland) and guarana extract (200 mg) (EVER Pharma, Lyon, France): 300 mg of caffeine in total, mixed with water (250 ml), or c) 9.6 g MS powder, (Olimp, Poland), mixed with 250 ml of water. MS contained: L-citrulline (3 g), beta-alanine (2 g), taurine (750 mg), L-arginine (500 mg), L - tyrosine, anhydrous caffeine (200 mg), guarana extract (200 mg; in total 300 mg of caffeine), barley extract (150 mg), cayenne pepper seed extract (25 mg), black pepper extract (7.5 mg) and Huperzia serrata extract (3 mg). The guarana extract was standardized for 50% caffeine content. The amount and chemical form of caffeine consumed by players were the same in the caffeine and MS conditions, and its dosage was about 5 mg/kg.

Reactive agility test: 1-1-2 (Y-test)

Four pairs of electronic timing gates system (Fusion Smart Speed PRO, Brisbane, Australia) have been set, as pointed out in Figure 1. Participants began each trial 20 cm in front of the starting line. After the first 5 meters run at maximum speed in a straight line toward the second timing gate, the system indicated the further direction of the subject's movement. After crossing the middle gate, the next gate lights turned on, forcing the participant to change direction as quickly as possible while maintaining the maximum possible speed run for the last 10 m. Participants had completed the test until two sprints to either side were recorded. The best trial for each side was used for analysis. The test 1-1-2 scheme is shown in Figure 1.

Figure 1.

Countermovement jump

The Optojump system (Optojump, Microgate, Bolzano, Italy) consisting of two bars (transmitting and receiving, 1 m apart) was used to evaluate the jump height in the countermovement jump. CMJ was performed without arm swing (i.e., hands placed on hips). Participants were instructed to start from an erect position and make a downward movement before taking off from the floor. During the CMJ, there was no interval for rest between the 2 phases of the jump (eccentric and concentric phases. All players performed two trials with a 60 s interval between each attempt. The better result of these two trials was taken for further analysis as previously described [18, 19, 20].

Statistical analysis

The data are presented as means and standard deviations (mean ± SD). The significance of differences between conditions was done using analysis of variance (ANOVA). Post hoc analysis was carried out using Tukey's test. Data distribution was checked using the Shapiro–Wilk test. Homogeneity of variance within the groups was tested via Levene's test (variance of the analyzed parameters was similar in both groups). The effect size (partial eta squared (η^2) was calculated and interpreted as small (0.01), medium (0.06), or large (0.14) [21]. Statistically significant results were defined as a *p*-value of <0.05. The following software was used to perform the calculations: STATISTICA 13.1 (StatSoft, Tulsa, OK, USA).

Results

No side effects were observed. The reactive agility results observed a statistically significant difference between three conditions (f=4.24, p=0.02). The time needed to complete the 1-1-2 test was significantly shorter in MS condition than PL (-3.4%; p=0.02). The differences in agility between PL vs. CAF and MS vs. CAF conditions were not statistically significant (p=0.88 and p=0.07, respectively). There was no significant difference between jump height conditions (f=2.89, p=0.06) (Table 1).

Table 1.

Discussion

This study aimed to examine the acute effects of a MS on reactive agility and jump height in recreationally-trained handball male players. Our study showed that ingestion of MS before exercise improved the players' agility but did not improve jumping height. Surprisingly, a similar effect was not observed after caffeine ingestion alone - ingestion of caffeine alone had no significant impact on either agility or jumping power. The observed effects of MS ingestion were not a result of caffeine alone but rather a synergistic effect of other active substances contained in MS. To our best knowledge, this is the first study comparing MS and the same amount and chemical forms of caffeine on reactive agility and jump height.

Training status (trained vs. untrained) appears to play an essential role in the response to caffeine intake [8]. Improved reactive agility may be limited to trained individuals as no ergogenic effect may be observed in untrained individuals performing the pro agility test [7]. Moreover, the result tends to be stronger for exercises involving large muscle groups [22]. Participants in this study were physically active, however, they were not advanced or elite players, yet we noted improved agility after MS ingestion, but not after caffeine consumption. Our results are in line with results reported by Rocha et al. [12] who suggested that pre-exercise caffeine ingestion is not effective to improve the upper and lower limb muscle power in handball players. Grgic et al. [23] indicated that ingesting a placebo or caffeine may enhance countermovement jump performance, but no significant effects of condition were found on maximal power output generated during takeoff. In contrast, the meta-analysis by Grgic et al. [8] supports caffeine as an effective for increases in muscle power expressed as vertical jump height. Another study conducted in the group of elite volleyball players also showed improvements in CMJ parameters such as flight time (+5.3%), peak power (+16.2%), and peak concentric force (+6.5%) without any side effects of caffeine ingestion in the amount of 5 mg/kg [24].

Caffeine affects cognitive performance in a dose-dependent and person-specific manner, especially in the case of sleep deprivation or comparing the effect in tired versus well-rested people [25, 26]. Pre-exercise caffeine ingestion between 3.0 and 6.0 mg/kg seems to be a safe ergogenic aid for players in team sports. However, the efficacy of caffeine varies depending on various factors like the nature of the game, physical status, and caffeine habituation [27]. But on the other hand, participants' habituation status with caffeine does not seem to affect either aerobic or anaerobic exercise [6]. The previous studies indicated the positive effect of caffeine in the dose range of 32-300 mg (0.5–4.0 mg/kg) on the central nervous system and essential cognitive functions enhancing arousal and the ability to concentrate [28] and attention, vigilance, and reaction time [25, 29, 30]. However, the limitation of the studies based on pre-planned tests was that none tested the caffeine's effect on reactive agility in-game conditions and demanding behaviors during the match when a perceptual component forces players to initiate the movement response [27]. In this study, a dose of 5 mg/kg was used, which may have been too low for the fitness level of the study group. Pontifex [31] indicated that even higher doses of caffeine (6 mg/kg BM) had no influence on reactive agility time measured with a modality similar to in this study.

In our study, participants consumed the same amount of caffeine in both conditions (MS and CAF), but the effects were different. Although we did not report a result of both conditions on jump height, MS was more effective than CAF on agility. This confirms our hypothesis that this may be a synergistic effect of the substances in MS. The impact of caffeine could be enhanced by other ingredients which share an additive (synergistic) or similar mechanism of action. Considering that plant alkaloids such as piperine or capsaicin, present in the examined MS, may cause increased secretion of catecholamines [32]. In addition to caffeine, guarana seeds also contain potentially psychoactive components such as flavonoids, saponins, and tannins, positively stimulating cognitive functions [33, 34].

The limitation of this study is that we did not examine the effect of the different combinations of ingredients of MS with caffeine and their impact alone on the exercise performance outcomes. Thus, we cannot identify which component could be the most responsible for the potential synergistic effect. The second limitation is focusing on the acute effect in this study. Although no side effects were reported in the participants during the research, the impact of chronic exposure to the investigated product was not examined.

Conclusions

Pre-exercise ingestion of the caffeine-based MS can significantly improve reactive agility performance but not jump height in recreational handball male players. Further comparative studies (MS ingestion vs. only caffeine ingestion) are needed - a similar effect was not observed with caffeine ingestion alone. It also seems necessary to determine which combination of MS components will have the most significant effect on improving performance.

Declarations

Funding: Not applicable

Competing Interest: Piotr Kaczka and Amit Batra are former employees of Olimp Laboratories. Their current work and scientific activity are not related to dietary supplement companies. Olimp Laboratories had no role in study design, data collection, and analysis, preparation of the manuscript and did not fund this study. The remaining authors declare no conflict of interest.

Author Contributions: Conceptualization: PK; Methodology: PK; Investigation and data collection: AB; Analysis and interpretation: PK, AB, and MM; Statistical analysis: MM; writing, original draft preparation: AB, MS; Writing and editing: AB, MM, ATŁ, MS; Supervision: PK. All authors have read and agreed to the published version of the manuscript.

Acknowledgments: Not applicable

Data Availability: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to restrictions of privacy.

References

1. Zemková, E., & Hamar, D. (2014). Agility performance in athletes of different sports specializations. *Acta Gymnica*, *44*(3), 133–140.
2. Sheppard, J. M., & Young, W. B. (2006). Agility literature review: classifications, training and testing. *Journal of Sports Sciences*, *24*(9), 919–932.
3. Nimphius, S., Callaghan, S. J., Bezodis, N. E., & Lockie, R. G. (2018). Change of Direction and Agility Tests: Challenging Our Current Measures of Performance. *Strength & Conditioning Journal*, *40*(1), 26.
4. Jagim, A. R., Jones, M. T., Wright, G. A., St. Antoine, C., Kovacs, A., & Oliver, J. M. (2016). The acute effects of multi-ingredient pre-workout ingestion on strength performance, lower body power, and anaerobic capacity. *Journal of the International Society of Sports Nutrition*, *1*(13), 1–10.

5. Froiland, K., Koszewski, W., Hingst, J., & Kopecky, L. (2004). Nutritional supplement use among college athletes and their sources of information. *International Journal of Sport Nutrition and Exercise Metabolism*, *14*(1), 104–120.
6. Davis, J. K., & Green, J. M. (2009). Caffeine and anaerobic performance: ergogenic value and mechanisms of action. *Sports Medicine*, *39*(10), 813–832.
7. Lorino, A. J., Lloyd, L. K., Crixell, S. H., & Walker, J. L. (2006). The effects of caffeine on athletic agility. *Journal of Strength and Conditioning Research, 20*(4), 851–854.
8. Grgic, J., Trexler, E. T., Lazinica, B., & Pedisic, Z. (2018). Effects of caffeine intake on muscle strength and power: a systematic review and meta-analysis. *Journal of the International Society of Sports Nutrition*, *15*(1), 1-10.
9. McCormack, W. P., & Hoffman, J. R. (2012). Caffeine, energy drinks, and strength-power performance. *Strength & Conditioning Journal*, *34*(4), 11-16.
10. Duvnjak-Zaknich, D. M., Dawson, B. T., Wallman, K. E., & Henry, G. (2011). Effect of caffeine on reactive agility time when fresh and fatigued. *Medicine and Science in Sports and Exercise*, *43*(8), 1523–1530.
11. Bloms, L. P., Fitzgerald, J. S., Short, M. W., & Whitehead, J. R. (2016). The effects of caffeine on vertical jump height and execution in collegiate athletes. *Journal of Strength and Conditioning Research*, *30*(7), 1855–1861.
12. Rocha, J. C. C., da Rocha, A. L. S., da Silva Santos Soares, G., & Correia-Oliveira, C. R. (2021). Effects of caffeine ingestion on upper and lower limb muscle power of handball players: a double-blind, placebo-controlled, crossover study. *Sport Sciences for Health*, *17*(4), 1039-1044.
13. Abian-Vicen J, Puente C, Salinero JJ, González-Millán C, Areces F, Muñoz G, Muñoz-Guerra J, Del Coso J. (2014) A caffeinated energy drink improves jump performance in adolescent basketball players. *Amino Acids*, *46*, 1333–41.
14. Souza, D. B., Del Coso, J., Casonatto, J., Polito, M. D. (2017) Acute effects of caffeine-containing energy drinks on physical performance: a systematic review and meta-analysis. Eur J Nutr. 56:13–27.
15. Gonzalez, A. M., Walsh, A. L., Ratamess, N. A., Kang, J., & Hoffman, J. R. (2011). Effect of a pre-workout energy supplement on acute multi-joint resistance exercise. *Journal of Sports Science & Medicine*, *10*(2), 261–266.
16. Trommelen, J., Tomé, D., & van Loon, L. J. C. (2021). Gut amino acid absorption in humans: Concepts and relevance for postprandial metabolism. *Clinical Nutrition Open Science*, *36*, 43–55.
17. MacDonald, A., Singh, R. H., Rocha, J. C., & van Spronsen, F. J. (2019). Optimizing amino acid absorption: essential to improve nitrogen balance and metabolic control in phenylketonuria. *Nutrition Research Reviews*, *32*(1), 70–78.
18. Attia, A., Dhahbi, W., Chaouachi, A., Padulo, J., Wong, D. P., & Chamari, K. (2017). Measurement errors when estimating the vertical jump height with flight time using photocell devices: the example of Optojump. *Biology of Sport*, *34*(1), 63–70.

19. Claudino, J. G., Cronin, J., Mezêncio, B., McMaster, D. T., McGuigan, M., Tricoli, V., Amadio, A. C., & Serrão, J. C. (2017). The countermovement jumps to monitor neuromuscular status: A meta-analysis. *Journal of Science and Medicine in Sport*, *20*(4), 397–402.
20. Petrigna, L., Karsten, B., Marcolin, G., Paoli, A., D'Antona, G., Palma, A., & Bianco, A. (2019). A Review of Countermovement and Squat Jump Testing Methods in the Context of Public Health Examination in Adolescence: Reliability and Feasibility of Current Testing Procedures. *Frontiers in Physiology*, *10*, 1384.
21. Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*; Routledge Academic: New York, NY, USA, 1988; https://doi.org/10.4324/9780203771587.
22. Timmins, T. D., & Saunders, D. H. (2014). Effect of caffeine ingestion on maximal voluntary contraction strength in upper- and lower-body muscle groups. *Journal of Strength and Conditioning Research*, *28*(11), 3239–3244.
23. Grgic, J., Venier, S., & Mikulic, P. (2020). Both caffeine and placebo improve vertical jump performance compared with a nonsupplemented control condition. *International journal of sports physiology and performance*, *16*(3), 448-451.
24. Zbinden-Foncea, H., Rada, I., Gomez, J., Kokaly, M., Stellingwerff, T., Deldicque, L., & Peñailillo, L. (2018). Effects of Caffeine on Countermovement-Jump Performance Variables in Elite Male Volleyball Players. *International Journal of Sports Physiology and Performance*, *13*(2), 145–150.
25. Nehlig, A. (2010). Is caffeine a cognitive enhancer? *Journal of Alzheimer's Disease: JAD*, *20 Suppl 1*, S85–S94.
26. McLellan, T. M., Caldwell, J. A., & Lieberman, H. R. (2016). A review of caffeine's effects on cognitive, physical, and occupational performance. *Neuroscience and Biobehavioral Reviews*, *71*, 294–312.
27. Chia, J. S., Barrett, L. A., Chow, J. Y., & Burns, S. F. (2017). Effects of Caffeine Supplementation on Performance in Ball Games. *Sports Medicine*, *47*(12), 2453–2471.
28. Goldstein, E. R., Ziegenfuss, T., Kalman, D., Kreider, R., Campbell, B., Wilborn, C., Taylor, L., Willoughby, D., Stout, J., Graves, B. S., Wildman, R., Ivy, J. L., Spano, M., Smith, A. E., & Antonio, J. (2010). International society of sports nutrition position stand: caffeine and performance. *Journal of the International Society of Sports Nutrition*, *7*(1), 5.
29. Lorist, M. M., & Snel, J. (2008). Caffeine, Sleep, and Quality of Life. W J. C. Verster, S. R. Pandi-Perumal, & D. L. Streiner (Red.), *Sleep and Quality of Life in Clinical Medicine* (s. 325–332). Humana Press.
30. Nehlig, A. (Red.). (2004). Coffee, tea, chocolate, and the brain. *Nutrition, brain, and behavior.*, *237*. https://doi.org/10.1201/9780203618851
31. Pontifex, K. J., Wallman, K. E., Dawson, B. T., & Goodman, C. (2010). Effects of caffeine on repeated sprint ability, reactive agility time, sleep, and next day performance. *The Journal of Sports Medicine and Physical Fitness*, *50*(4), 455–464.
32. Dudhatra, G. B., Mody, S. K., Awale, M. M., Patel, H. B., Modi, C. M., Kumar, A., Kamani, D. R., & Chauhan, B. N. (2012). A comprehensive review on pharmacotherapeutics of herbal bio-enhancers.

The Scientific World Journal, *2012*, 637953.

33. Hamerski, L., Vieira Somner, G., & Tamaio, N. (2013). Paullinia cupana Kunth (Sapindaceae): A review of its ethnopharmacology, phytochemistry, and pharmacology. *Journal of medicinal plant research*, *7*(30), 2221–2229.
34. Pomportes, L., Brisswalter, J., Casini, L., Hays, A., & Davranche, K. (2017). Cognitive Performance Enhancement Induced by Caffeine, Carbohydrate, and Guarana Mouth Rinsing during Submaximal Exercise. *Nutrients*, *9*(6). https://doi.org/10.3390/nu9060589.

Tables

Table 1. Effects of supplementation on reactive agility test and countermovement jump (PL –placebo, MS- multi-ingredient supplement, and CAF- caffeine condition).

TEST	PL	MS	CAF	ANOVA p (f)	η^2	Post-hoc (p)
1-1-2 [s]	2.595 ± 0.142	2.507 ± 0.087	2.58 ± 0.102	0.02 (4.24)	0.07	PL-MS:0.02 CAF- MS: 0.07 PL-CAF: 0.88
CMJ [cm]	48.12 ± 4.09	50.61 ± 4.01	48.16 ± 4.19	0.06 (2.89)	0.11	

PL -placebo; MS-multi-ingredient supplement; CAF – caffeine; CMJ – countermovement jump, 1-1-2 – agility test

Figures

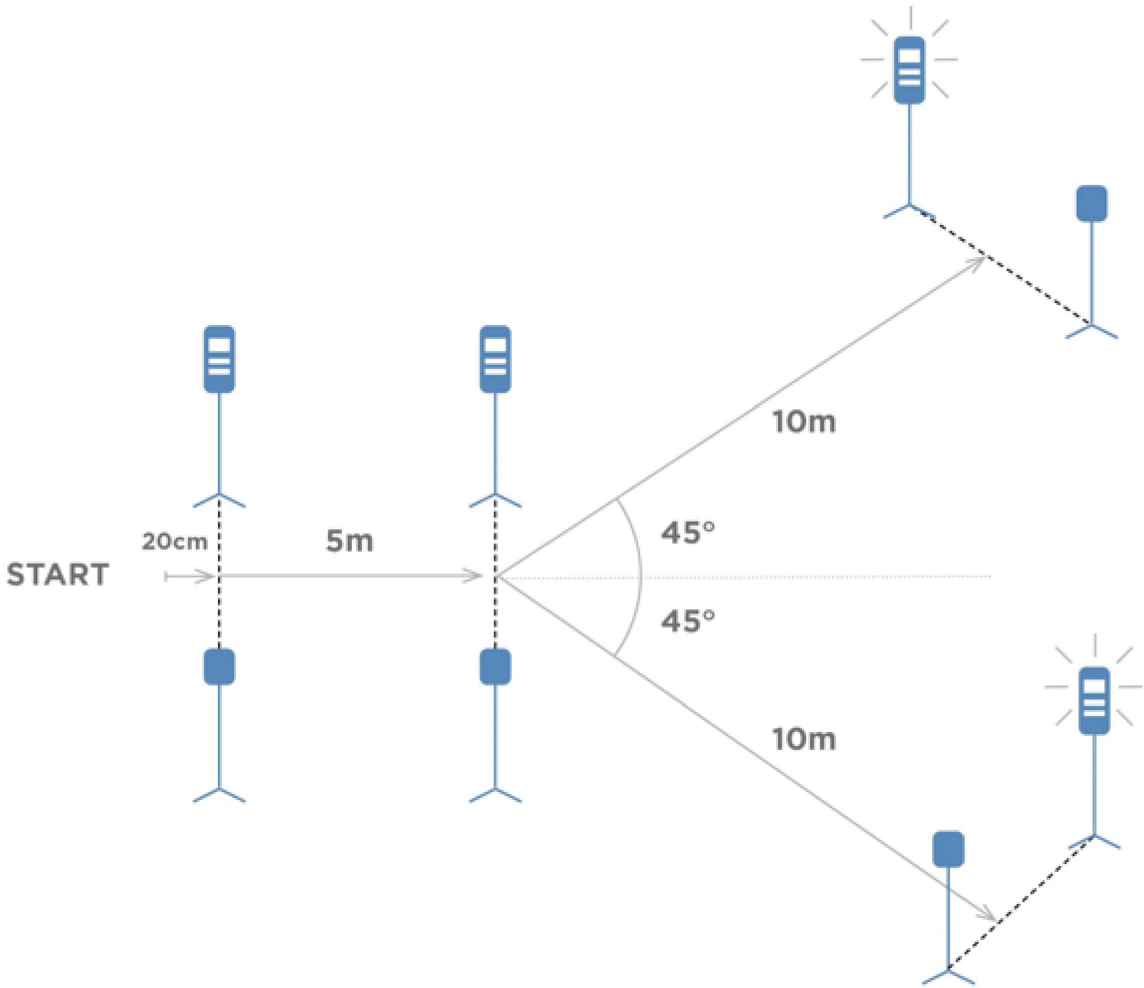

Figure 1. The layout of photocell timing gates and the way of carying out the test task protocol 1-1-2.

Figure 1

See figure for legend.