# A 4-Week Choice Foot Speed and Choice Reaction Training Program Improves Agility in Previously Non–Agility Trained, but Active Men and Women

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## Abstract

Galpin, AJ, Li, Y, Lohnes, C, and Schilling, BK. A 4-week choice foot speed and reaction training program improves agility in previously non–agility-trained, but active, men and women. *J Strength Cond Res* 22(6): 1901–1907, 2008—Computerized agility training (CAT) products are frequently suggested to improve agility. However, these claims often are made without unbiased scientific support. Therefore, the purpose of this study was (a) to determine the reliability and effectiveness of a 4-week CAT training program on foot speed (FS) and choice reaction (REACT), and (b) to assess whether training on the CAT would facilitate the improvement of a separate change-of-direction (COD) test in non–agility-trained, but active, men and women. Twenty-three participants (15 men, 8 women) pre- and posttested on FS, REACT, and COD drills. Eleven of those participants (7 men, 4 women) engaged in 4 weeks of training on the FS and REACT drills (EX). The remaining 12 (8 men, 4 women) did not participate in the training and served as controls (CON). Coefficients of variation indicate strong precision for FS (6.9%) and REACT (2.6%). Test-retest reliability, as analyzed by intraclass correlations (ICC), were high for both FS and REACT (0.89). Significant test-by-group interactions were observed for all three tests: FS ($p = 0.004$), REACT ($p = 0.011$), and COD ($p = 0.049$). Post hoc analysis indicated that EX increased foot contacts for the FS drill ($p = 0.006$), whereas REACT and COD demonstrated decreases in time to completion ($p = 0.013$ and $0.038$, respectively). The CON group did not improve on any of the tests. This study indicates that the chosen CAT is an accurate and reliable tool for measuring foot speed and reaction time. These data justify the use of this CAT in analyzing foot speed and reaction time. Altogether, 4 weeks of foot speed and reaction training on the chosen CAT produced improvements in overall agility in non–agility-trained, but active, men and women. These data warrant the integration of such a device into the training program of untrained athletes attempting to improve agility.

**Key Words** change of direction, quickness, footwork, reliability, accuracy, precision

## Introduction

The ability to change direction as needed both quickly and accurately is considered by many to be an integral part of athletic performance (14,20,22,28). Factors contributing to an athlete's ability to move quickly and, thus, perform better may include technical footwork (9,26), decision making and accuracy of movement (1–3,7,8), and movement speed (15,16,23). Collectively, this is often termed "agility." However, the context and definition of this term have been without consensus. Sheppard and Young (30) suggest that a more consistent definition of "agility" would describe it as a comprehensive term recognizing physical demands (movement speed and strength), cognitive processing (perception and decision making), and technical skills (footwork and movement technique). Furthermore, Young and Montgomery (36) have proposed that the term "agility" only be used when both change-of-direction (COD) and decision making tasks are involved. Therefore, in the present investigation, "agility" will be operationally defined as movements that comprise three components: quickness (movement speed), choice reaction (perception and reaction), and COD.

Although agility is essential to performance, few data exist regarding the accuracy and reliability of agility testing methodology and even fewer regarding the efficacy of training programs designed to improve agility performance. The majority of these studies have measured closed COD tasks where the individual is not forced to make decisions or react (4,25,32,34,36). Popular examples of such tests are the agility ladder, hexagon test, *t*-test, and shuttle run. All of these tests evaluate the athlete's mobility, foot speed, quickness, and cutting, but they offer no degree of uncertainty or decision making.

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The reliability of such tests may be high, yet the external validity is minimal when we consider that many sport (football, mixed martial arts, hockey, etc.) movements are not a preprogrammed or planned task but a choice reaction to an external stimulus (opponent or puck). It is the ability to choose a correct response and execute the chosen movement quickly and accurately that determines the ultimate performance during competition (33). Furthermore, if a reaction drill is incorporated, it must be random and nonsequential. Otherwise, simple pattern memorization may occur, thus eliminating the decision making process (11). However, if the complexity of the stimulus has a large variance, then the test-retest reliability may be compromised. Thus, determining the reliability of such a test would be mandatory. By incorporating choice reactions into practice, Verkhoshansky (31) claims that movement reaction time can be improved, which, in theory, should allow for better agility. If the goal is to assess agility, the addition of a reliable reaction drill to reliable movement speed and COD drills is warranted.

Many authors have tried to explain the role of other performance markers such as sprinting speed (35) and leg extensor strength (27) and power (21) on agility performance. Others have assessed the effect of chronic training on COD performance by infusing a variety of training modalities such as COD drills (35), unstable surface training (12), general strength training (10), and jump squat training (19) into the training program of current athletes. However, to the authors' knowledge, no data are presently available that exam the role of agility-specific training (as defined here) on agility performance. Young et al. (35) found that 12 COD training sessions in 6 weeks were sufficient to produce significant improvements in a variety of COD drills in noncompetitive, recreationally trained subjects. In addition, Dean et al. (13) found that 4 weeks of a preseason, non–sport-specific COD training program resulted in an improvement of several COD drills in subjects that were casually involved in sporting activities. However, neither of these studies incorporated choice reaction and, thus, fail to meet our definition of true agility. Therefore, it would seem necessary to analyze the efficacy of an agility training program that encompasses movement speed, reaction time, and COD training.

Currently, numerous computerized agility training (CAT) products have become commercially available that claim to have agility-improving capabilities. One particular device has been proposed to be able to both test and train movement speed and choice reaction and was the focus of this study. However, this particular device does not address the COD component of agility. Therefore, the purpose of this study was (a) to assess the effects of a 4-week training program on the CAT for foot speed and choice reaction, (b) to assess whether training on the CAT facilitated the improvement of a COD test, and (c) to determine the reliability of the CAT on measures of foot speed (FS) and choice reaction (REACT). If advancements were made in movement speed, reaction time, and COD time, the claim that agility improved would be justified. Because the subjects only trained on the FS and REACT drills, any improvements seen in the COD drill would indicate a transfer of training effect and, thus, may facilitate potential improvements in sport performance.

## Methods

### Experimental Approach to the Problem

Agility, in this case the incorporation of reaction time, foot speed, and COD ability, is an integral part of many athletic activities. Countless commercial products claim to have the ability to improve agility performance. However, data regarding the training effect, reliability, and accuracy of these devices are often not available. Therefore, the primary purpose of this study was to assess the changes in agility of young, active, non–agility-trained men and women after a 4-week training program on the CAT. Moreover, because three separate components of agility were incorporated into the study design, potential results may have an increased external validity and, thus, be more applicable to the coach/practitioner. A secondary purpose of this investigation was to evaluate the accuracy and reliability of the particular CAT. A randomized-experimental training design was used involving measurement of foot speed, reaction time, and COD performance before and after a 4-week training program. Subjects were randomly divided into either a control group or a training group. Subjects placed in the training group completed pretests in all three markers, trained for 4 weeks on the FS and REACT drills, and then posttested on all three markers. Those subjects who were assigned into a control group were pretested in all three markers, continued normal physical activity for 4 weeks, and then posttested in the same markers. The order of testing was counterbalanced at pretesting to decrease potential testing order effects, and the same order was repeated at posttesting.

### Subjects

Twenty-three men ($n = 15$) and women ($n = 8$) between the ages of 18 and 35 completed this study (Table 1). Initially, 34 subjects volunteered; however, 11 (5 men, 6 women) were removed during the course of the study because they failed to make a minimum of 10 of the 12 (83%) training sessions. No removals were attributable to adverse study effects. All subjects were in good health and free from musculoskeletal, orthopedic, cardiovascular, and psychological illness and/or

**Table 1.** Subject characteristics.

| | EX ($n = 11$) | CON ($n = 12$) |
|---|---|---|
| Age (y) | 26 ± 4 | 25 ± 2 |
| Height (cm) | 169 ± 11 | 172 ± 8 |
| Weight (kg) | 71.2 ± 12.0 | 80.2 ± 24.8 |

EX = training group; CON = control group.



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disorder as determined by a medical history questionnaire. To be considered for this study, all subjects must have been at a minimum moderately active (subjects must have been engaging in physical activity, but not agility oriented, for at least 5 h·wk$^{-1}$ and a minimum frequency of three times per week). Subjects that were involved in some form of agility training outside of the study were not allowed to participate. On being accepted into the study, subjects were randomly divided into either the training group (EX) ($n = 11$; 7 men, 4 women) or the control group (CON) ($n = 12$; 8 men, 4 women). Each subject was carefully informed about the design of the study as well as the potential risks and benefits. Participants were also required to give signed informed consent, in accordance with the guidelines of the University of Memphis institutional review board for use in human subjects in research, to participate in the study. Participants in both EX and CON were instructed to resume normal daily physical activity throughout the duration of the study.

### Equipment

The device used for this study was the Quick Feet board, developed by The Quick Board, LLC (Figure 1). The board consists of a rubber mat positioned on the ground with sensor pads in five locations (upper right and left, lower right and left, and center). This mat is connected to a power cord and run to a control device that provides visual stimulus (i.e., five bright lights that correspond to the five foot pads) and feedback information about the results of the movement responses. The control pad also allows for the command of all sequences and drills.

The COD was performed as described by Barnes et al. (6) (Figure 2). However, instead of a force platform, an electronic timing system (SOLO Time) was used for the testing. Specifically, time was kept using a timing pad connected to a device that keeps time and produces an infrared beam.

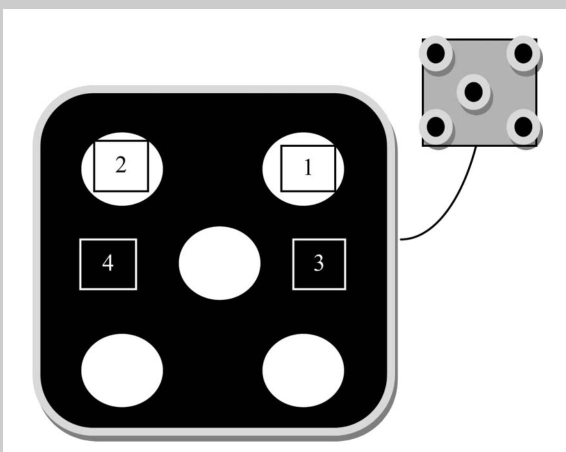


**Figure 1.** Order of foot placements during the foot speed (FS) drill. Subjects repeated the above sequence as fast as possible with the right foot hitting 1 and 3 while the left foot hit 2 and 4.

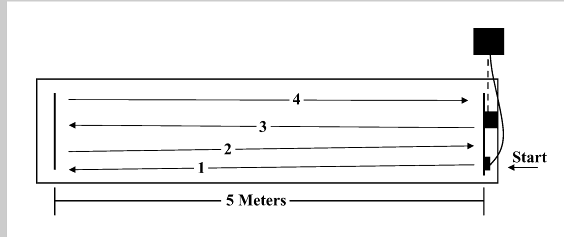


**Figure 2.** Order of directional changes for the change-of-direction (COD) drill. Subjects completed the sequence as fast as possible while facing the same direction at all times and touching each line with their foot.

When the subject removed his or her foot from the starting pad, the time started. The time stopped once the subject crossed the infrared beam located at the end of the course. The data were then recorded and displayed on the system panel (24).

### Procedure

At the initial visit and after consenting to participate, subjects were screened for physical activity requirements, asked to fill out a medical history questionnaire, and randomly divided into EX or CON. All subjects completed a familiarization session in which they were instructed to practice all three drills at maximum effort for a minimum of three trials each. More trials were allowed if a subject did not feel comfortable with the drill or displayed a large variance in scores. Specifically, the FS drill, which included a maximum number of foot touches during a 10-second interval, was performed three times separated by 90 seconds (Figure 1). The REACT drill, which includes 10 foot touches, was performed three times, separated by 60 seconds. The COD drill, which includes a maximum-effort sprint of 5 m with three CODs on a predetermined course totaling 20 m (Figure 2), was performed three times, separated by 150 seconds. Subjects then returned on a separate, nonconsecutive day for the pretesting session. The order of testing was counterbalanced to ensure internal validity. Each subject was given three attempts at each drill (separated by either 60, 90, or 150 seconds of rest), and the best score from each test was used for analysis. Before each session (testing or training), all subjects were instructed to cycle at a low-moderate intensity for 5 minutes to standardize the warm-up.

Before the randomization and the 4-week training protocol, eight subjects (4 men, 4 women) performed the FS and REACT drills in duplicate to determine the reliability and accuracy of the drills and the device itself. Subjects were allowed a familiarization session and then performed three sets of both drills with 1 minute separating each set. Subjects were asked to return 24–48 hours later to repeat the same testing procedure. The test-retest results for each subject were pooled to develop coefficients of variation (CVs) as well as intraclass correlations (ICCs). After these sessions, subjects were randomized into either EX or CON.



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Participants randomized to EX attended an initial familiarization session, pretesting session, 12 supervised training sessions during the next 30 days (three times a week for 4 weeks), and a final posttesting session. Training sessions were approximately 20 minutes in length and consisted of three sets of the quick feet drill lasting 10 seconds each (90 seconds of rest), three sets of 10 reaction touches (60 seconds of rest), three sets of the quick feet drill lasting 5 seconds each (90 seconds of rest), and, finally, three sets of reaction touches lasting 5 seconds each (60 seconds of rest) (Figure 3). It should be noted that subjects did not train on the COD drill. Once the four training weeks concluded, subjects were then posttested in a similar protocol as the pretest.

Control subjects performed the same protocol for the pretest, yet they were not involved in the 4 weeks of training. Once 4 weeks had elapsed, control subjects were brought in for one more familiarization session and then a posttest session (Figure 3). Similar to the training group, the order of testing was counterbalanced.

*Foot Speed Drill.* During the FS drill, subjects began with both feet placed in neutral position (not touching any of the sensors). A 5-second countdown, displayed by the visual output box, preceded the task. Near the end of the countdown, subjects began the task by placing their right foot in the top corner of the pad. Once the right foot touched, the left foot moved rapidly to touch the left pad. Once completed, the right foot returned to the neutral position. The left foot would also return to the neutral position on return of the right foot (without jumping). Once both feet were back to the neutral position, the right foot would start over again (Figure 1). Subjects were encouraged to move as quickly as possible from the end of the countdown through the end of the task. The number of foot touches completed in 10 seconds was recorded by the CAT software.

*Reaction Drill.* Subjects stood on the CAT with both feet in the neutral position (where no feet are touching any of the sensors). After a 5-second countdown, each subject watched the control box (which has five separate red lights that correspond to the pads on the mat) for visual instruction as to which sensor to touch. Once a light turned on, the subject attempted to touch the corresponding pad as rapidly as possible. Once completed, the subject returned the foot back to the neutral position. The subjects attempted to get 10 accurate touches as quickly as possible. The pattern of activation was randomized between each repetition by the CAT software, and, therefore, subjects would not have been able to memorize the sequence.

*Change-of-Direction Drill.* In the COD drill, subjects began the test by pivoting on the left foot and sprinting 5 m. A sensor pad placed underneath the right foot started the timer once the right foot left contact with the pad. After sprinting 5 m, the subject then planted his or her left foot, turned 180° to the right, and sprinted back to the start. The subject then planted the right foot, turned 180° to the left, and sprinted back 5 m. Lastly, after planting his or her left foot and turning 180° to the right, the subject finished the test by sprinting 5 m back to the start, thus completing the test (Figure 2). On crossing the finish line, a beam was tripped and the timer was stopped.

#### Statistical Analyses

The pre- and posttesting measures were analyzed to determine any changes in performance on the three tests for both the training and the control group. A 2 $\times$ 2 ANOVA (time) was performed on all dependent variables. When appropriate, follow-up analyses via separate, dependent *t*-tests were performed. Standard statistical methods were used to determine mean, standard deviation (*SD*), standard error (*SE*), CVs (<15%), ICCs (>0.7), Pearson product-moment correlation (>0.7), and Cohen's D (effect size [ES]). Statistical significance was set at $p \leq 0.05$.

| Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 |
|---|---|---|---|---|---|
| *Experimental* | | | | | |
| 1 Familiarization Session and Pre-Test | Training sessions 1-3 | Training sessions 4-6 | Training sessions 7-9 | Training sessions 10-12 | Post-Test |
| *Control* | | | | | |
| 1 Familiarization Session and Pre-Test | Normal daily living | Normal daily living | Normal daily living | Normal daily living | 1 Familiarization Session and Post-Test |

Training session includes:
1. Subjects arrive in training area, check in, and cycle for 5 minutes
2. 3 x 10 seconds quick feet drill + 90 seconds rest between sets
3. 3 x 10 touches reaction drill + 60 seconds of rest between sets
4. 3 x 5 seconds quick feet drill + 90 seconds of rest between sets
5. 3 x 5 touches reaction drill + 60 seconds of rest between sets
6. Subjects are released

**Figure 3.** A schematic of the experimental design.

## Results

Average compliance for EX was 96% for the subjects who completed the study. Measures of precision (CV) and test-retest reliability (ICC) for FS and REACT indicated CVs of 6.9 and 2.6% for FS and REACT, respectively; ICCs = 0.89 for both tests. Previously reported data from our lab were used to establish accuracy (CV = 1.9%) and reliability (ICC = 0.69) for COD (6). Mean $\pm$ *SD* as well as significance values can be seen in Table 2 for all



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**Table 2.** Mean, *SD*, and *p* values for control (CON) and training (EX) groups.

| | Mean ± *SD* | *p* Value | Cohen's D |
|---|---|---|---|
| FS (touches) | | | |
| Training | | | |
| Pre | 42.08 ± 6.43 | | |
| Post | 52.07 ± 5.20 | 0.001* | 2.02† |
| Control | | | |
| Pre | 41.00 ± 8.19 | | |
| Post | 43.25 ± 8.73 | 0.147 | |
| REACT (seconds) | | | |
| Training | | | |
| Pre | 5.74 ± 1.17 | | |
| Post | 4.40 ± 0.35 | 0.002* | 1.12† |
| Control | | | |
| Pre | 4.94 ± 0.97 | | |
| Post | 4.73 ± 0.74 | 0.411 | |
| COD (seconds) | | | |
| Training | | | |
| Pre | 6.23 ± 0.62 | | |
| Post | 5.78 ± 0.65 | 0.005* | 0.90† |
| Control | | | |
| Pre | 6.12 ± 0.81 | | |
| Post | 5.98 ± 0.85 | 0.052 | |

FS = foot speed; REACT = choice reaction; COD = change-of-direction test.
*Indicates statistical significance.
†Indicates a large effect size.

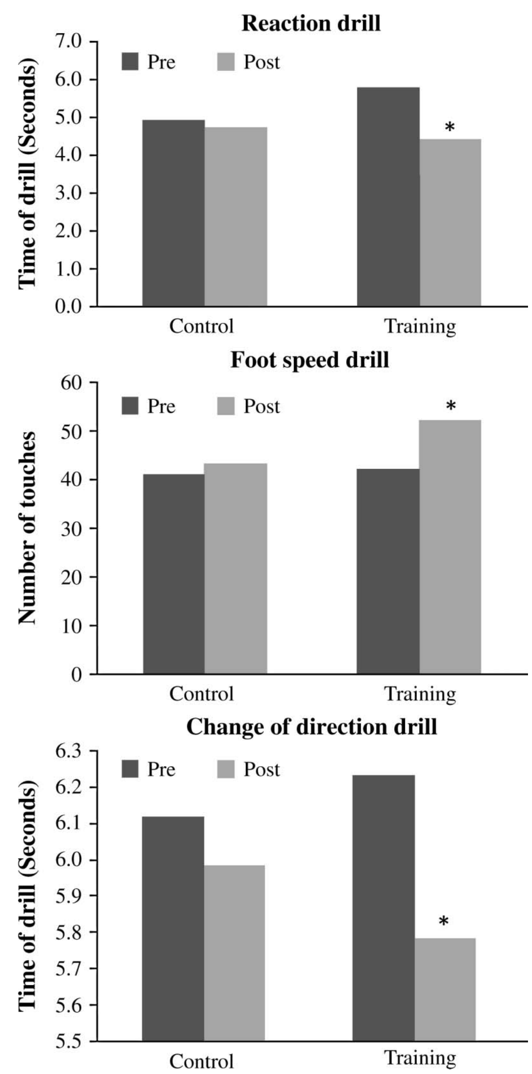


**Figure 4.** Changes in performance of FS, REACT, and COD for EX and CON. *$p < 0.05$. FS = foot speed; REACT = choice reaction; COD = change of direction; EX = training group; CON = control group.

groups. A bivariate correlation matrix revealed that the COD drill was only able to explain 8.7% ($p = 0.161$) of the shared variance in the FS drill, whereas the REACT drill was able to explain 37% ($p = 0.002$) (Table 3). Furthermore, the COD drill was only able to explain 18% ($p = 0.041$) of the shared variance for REACT. The 2 × 2 mixed-factor analysis revealed significant test-by-group interactions for all three tests: FS ($p = 0.004$), REACT ($p = 0.011$), and COD ($p = 0.049$) (see Table 2 and Figure 4). Time-by-gender (FS: $p = 0.737$; REACT: $p = 0.630$; COD: $p = 0.497$) as well as time-by-group-by-gender interactions (FS: $p = 0.766$; REACT: $p = 0.201$; COD: $p = 0.398$) were not significant for any of the tests.

**Table 3.** Pearson product-moment correlation (*r*) values.

| | REACT | FS | COD |
|---|---|---|---|
| FS | 0.61* | – | – |
| COD | 0.42* | 0.29 | – |

REACT = choice reaction; FS = foot speed; COD = change-of-direction test.
*Indicates statistical significance but did not meet the minimum criteria for the study ($r = 0.7$).

### Foot Speed

The mean (± *SD*) change for FS was +2.25 ± 4.99 touches ($p = 0.147$) for CON and +9.99 ± 7.28 touches ($p = 0.001$) for EX. These data were used to calculate a Cohen's D and revealed a large ES of 2.02. Pilot data on a separate but similar group of men were used to calculate precision (CV = 6.9%) test-retest reliability (ICC = 0.89).

### Reaction

The mean (± *SD*) change for REACT was −0.21 ± 0.86 seconds ($p = 0.411$) for CON and −1.33 ± 1.13 seconds



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($p = 0.002$) for EX. Again, a large ES (Cohen's D = 1.12) was calculated. Both precision and reliability were similar to that of Quick Feet (CV = 2.6% and ICC = 0.89). Both precision (CV = 2.6%) and reliability (ICC = 0.89) were obtained from the same subject pool as FS and, again, seemed to be very strong.

#### Change of Direction

The mean (± *SD*) change for the COD drill was −0.14 ± 0.22 seconds ($p = 0.052$) for CON and −0.45 ± 0.44 seconds ($p = 0.005$) for EX. Similar to Quick Feet and REACT, a large ES (Cohen's D = 0.90) was calculated. Previous data from our lab have indicated that the same COD drill was highly precise (CV = 1.9%) but had moderate reliability (ICC = 0.69) (6).

## Discussion

The primary findings of this study are that (a) the Quick Feet board is an accurate and reliable CAT for measures of reaction time and foot speed, (b) the 4-week training program produced significant improvements in both REACT and Quick Feet, and (c) 4 weeks of training in FS and REACT resulted in a significant increase in COD performance. Therefore, it is likely that for previously active, but non–agility-trained men and women, 4 weeks of training on the CAT can increase overall agility as marked by improvements in RS, REACT, and COD drills. It is possible that the improvements seen during the FS and REACT tests were a direct result of practice and familiarization. It would be expected that 4 weeks of practice at a novel task would lead to improvements of that task (5). However, this would not explain the improvements in the COD drill because this was not practiced throughout the training program. Thus, it is likely that the improvements seen by the training group were a reflection of more precise and accurate motor unit firing sequences (29). Regarding gender, the data indicate that there were no differences between men and women, and, thus, it is concluded that non–agility-trained men and women respond in a similar fashion to 4 weeks of FS and REACT training. This is supported in the literature; Dean et al. (13) have reported similar findings in a group of young people after 4 weeks of supervised agility training.

The correlation matrix suggested that performance on COD could not be explained by FS performance, and vice versa (Table 3). However, COD was able to explain 18% of the variance for REACT. Moreover, REACT was able to explain 37% of the variance in FS. Although these were both statistically significant, they may not be practically significant, because the Pearson product-moment correlation falls below the preset criteria of 0.71 (~50%). Together, this would suggest that the three drills were able to provide unique information and that performance on one of the drills did not influence performance on the other two drills.

This investigation was the first to analyze the accuracy and reliability of this particular device in testing human agility. The data indicate that for both FS and REACT, accuracy and reliability were exceptionally high. This suggests that the device is accurate and shows little variation from trial to trial when testing foot speed and reaction time in men and women. This further supports the claim that overall agility was improved as a result of the training because changes in performance were not attributable to inaccuracies in the testing device. The use of this CAT may, therefore, be beneficial to coaches and practitioners who routinely test foot speed and reaction time. Specifically, this device may reduce the potential for human error when multiple coaches are used as timekeepers.

The 4-week training period was shown to be beneficial for both FS and REACT. The EX group displayed an average increase of 26% in foot contacts in the FS drill, whereas the CON group did not change. This would suggest that the ability to produce movement speed in the foot improved as a result of the 4 weeks of training. In addition, EX subjects improved in their time to completion during the REACT drill by an average of 19%, whereas CON subjects showed no alterations. Because the sequence of the REACT drill was randomized throughout both training and testing, these improvements cannot be explained by simple pattern memorization.

The improvements seen here agree with previous literature concerning reaction time and foot speed training (1–3, 7,8,15,16,23). However, the most significant finding of this investigation is that subjects in the EX group showed a significant average decrease of 7% in time to completion for the COD drill, whereas the CON group did not change. Further analysis of the CON group alone revealed strong precision (CV = 1.8) and reliability (ICC = 0.98) between pre- and posttests for this drill, and, therefore, familiarization is likely not an issue. Therefore, it can be concluded that the improvements in COD were a result of the FS and REACT training. To the authors' knowledge, this is the first study to report that FS training, in concert with REACT training, facilitated improvements in a novel COD drill. Moreover, because EX displayed positive development in all three aspects, it can be concluded that overall agility improved.

Although the data presented in this investigation support the hypotheses that the CAT is reliable and may improve agility (as defined by an involvement of FS, REACT, and COD), the external validity is not apparent. Further research should attempt to examine the transferability of these findings to sport performance. Furthermore, these data were obtained from subjects who were not participating in a formalized athletic competition. Thus, the role of the CAT on athletes currently involved in sport would be of interest. Another possible avenue for investigation is the dose response to this mode of training. It is widely accepted that physical performance is highly influenced by several training variables such as frequency, duration, volume, and intensity. Therefore, a study that examines various training frequencies, durations, and volumes is warranted.



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## Practical Applications

The reliability and accuracy of CAT devices is of great importance for coaches and practitioners. That is to say, a coach can better monitor an athlete's agility performance with such a device and be certain that changes in performance are the result of changes in the athlete and not fluctuations seen in the testing device. This is important because, unless otherwise tested, other testing equipment may not be reliable. Moreover, it seems that training foot speed and reaction time on this specific CAT for as little as 10–15 $\text{min}\cdot\text{d}^{-1}$, 3 $\text{d}\cdot\text{wk}^{-1}$, for 1 month, is adequate to elicit positive adaptations to FS, REACT, and COD drills in active, but untrained, college-aged men and women. For these reasons, it may be beneficial to prescribe similar training protocols to athletes during the preseason or general preparation phase of their macrocycle because they may be of a similar activity status as the subjects in this study (moderately active, but not agility trained).

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