

2

4

Effects of a Four-Week “Quick Feet” Training Program on Reaction Time and Agility

6

Andy Galpin, Yuhua Li, Corey Lohnes, and Brian K. Schilling

8

10

Department of Health & Sport Sciences

Human Performance Laboratories

12

The University of Memphis

Memphis, TN, USA 38152

14

16

18

Address correspondence to: Andrew J. Galpin, C.S.C.S.

20

161C Roane Field House

The University of Memphis

22

Memphis, TN 38152

(901) 678-1547 (office)

24

agalpin@memphis.edu

26

28

30

32

34

36

38

40

42

Effects of a Four-Week “Quick Feet” Training Program on Reaction Time and Agility

44

46

48

50

52

54

56

58

60

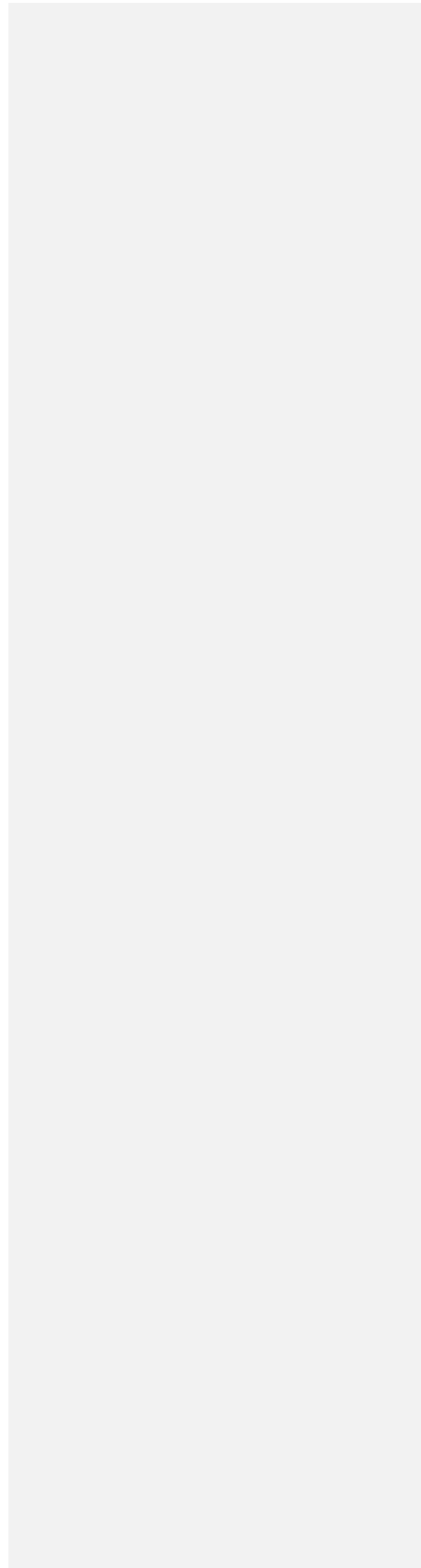
62

64

66

68

70



72
74
76
78
80
82
84
86
88
90
92
94
96

ABSTRACT

Several commercially available computerized agility trainers (CAT) have been developed in an attempt to improve agility. Therefore, the purpose of this study was (a) to determine the reliability of a CAT on measures of foot speed and choice reaction; (b) assess the effects of a 4-week training program using the CAT on foot speed and choice reaction; (c) assess whether training on the CAT would facilitate the improvement of a separate change of direction (COD) test. Twenty-four active men (n=15) and women (n=9) completed a quick feet drill (QF), a choice reaction test (REACT), and a novel agility test (COD). Coefficients of variation (CV) indicate strong precision (6.9% and 2.6%) for QF and REACT, respectfully. Test-retest reliability, as analyzed by intraclass correlations (ICC) was high for both QF and REACT (.89). Statistical analysis revealed that, following training, QF showed an increase in foot contacts in a given time period ($F = 9.22, p = .006$) while REACT and COD demonstrated decreases in time to completion ($F = 7.38, p = .013$ and $F = 4.87, p = .038$ respectively). All tests demonstrated large effect sizes as represented by Cohen's D values of 2.02, 1.12, and 0.9, respectively. This study indicates that the CAT is an accurate and reliable tool for measuring foot speed and reaction time. Moreover, for active college-aged subjects, 4 weeks of foot speed and choice reaction training on the CAT resulted in an improvement in overall agility. However, the external validity of these findings is not clear. Further research should attempt to examine the transferability of these findings to sport performance.

98 **KEY WORDS:** change of direction, quickness, footwork, reliability, accuracy, precision

100 **INTRODUCTION**

102 The ability to change direction quickly is considered by many to be an integral part of
athletic performance (8, 13, 14, 19). Coaches continually emphasize training of various
movements in an attempt to improve foot speed, quickness and movement efficiency (20).
104 Factors contributing to an athlete's ability to move quickly and thus perform better may include
technical footwork (7, 18), decision making and accuracy of movement (1, 2, 3, 5, 6), and
106 movement speed (10, 11, 15).

108 The ability to change direction as needed both quickly and accurately is often referred to
as agility. While the term "agility" is often used, its context and definition has been without
110 consensus. In a recent review on the topic it was noted that agility has traditionally been defined
simply as a rapid change of direction (COD), as well as the ability to change direction both
112 quickly and accurately (20). However, Sheppard and Young (20) suggest that a more consistent
definition of "agility" would describe it as a comprehensive term recognizing physical demands
114 (quickness and strength), cognitive processing (perception and decision making), and technical
skills (footwork and movement technique).

116
Much like the term agility, a definition for the term "quickness," may be even more
118 fleeting. This frequently used term often encompasses a wide variety of skills which may or may
not be included in definitions of agility. Moreno (15) suggests that quickness is "a multi-planar
120 or multi-directional skill that combines acceleration, explosiveness, and reactivity". Due to
much discrepancy in the literature in regard to this term, "quickness" will be defined simply as
122 the ability to perform a series of gross motor tasks, including both whole body and limb
movements, rapidly, efficiently, and accurately.

124

Hick's law states that average reaction time is a function of the possible number of
126 choices an individual is exposed to (12). As the number of choices increase, so does the reaction
time. However, agility is often measured during a closed task where the individual is not forced
128 to make decisions or react (17, 22, 23, 24). 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, quickness,
130 and cutting, but offer no degree of uncertainty or decision making. The external validity of such
tests is minimal when we consider that many sports involve open skills with some degree of
132 uncertainty.

134 In those sports, (football, MMA, hockey etc.) movement is not a preprogrammed and
planned task but a choice reaction to an external stimulus (opponent or puck). It is the ability to
136 choose a correct response and execute the chosen movement quickly and accurately that
determines the ultimate performance during competition. By incorporating choice reactions into
138 practice, Verkhoshansky (21) claims that movement reaction time can be improved, which in
theory should allow for better agility. In addition, a recent review of agility concluded that
140 improvements on reaction drills may reduce the risk of injury as well as enhance performance
(25).

142
As Sheppard and Young note, defining agility may also be related to the individual's
144 theoretical background (20). While many strength and conditioning coaches and biomechanical
researchers may define agility in terms of the physical demands and/or technical skills, a motor
146 learning scientist may be more interested in defining agility in terms of the cognitive processing
and learning that takes place during a motor skill. In an attempt to clarify this, Young and
148 Montgomery (24), proposed that the term agility only be used when both COD *and* decision

making tasks are involved. In support, others have suggested a model of agility that places COD
150 and reaction drills in two separate categories of overall agility (20). Therefore, a generally
holistic definition of agility that includes movement speed (or quickness), choice reaction
152 (perception and reaction), and COD will be used in the present investigation.

154 Numerous computerized agility training (CAT) products are commercially available to
the public. One particular device has been proposed to be able to both test and train quickness
156 and choice reaction and was the focus of this study. Therefore, the purpose of this study was (a)
to determine the reliability of the CAT on measures of foot speed and choice reaction; (b) to
158 assess the effects of a 4-week training program on the CAT for foot speed and choice reaction;
(c) to assess whether or not training on the CAT facilitated the improvement of a separate COD
160 test. Because the subjects only trained on the foot speed and choice reaction drills, any
improvements seen in the COD drill would indicate a transfer of training effect. Furthermore, if
162 subjects showed an improvement in all three tests, it can be attributed to the CAT training
program.

164

METHODS

166

Experimental Approach to the Problem

168

Agility, in this case incorporating the ability to change direction, foot speed, and reaction time,
170 is an integral part of many athletic activities. Our pilot data have shown that the CAT is a
reliable testing tool for foot speed and reaction time. However, the training effect has never
172 been tested. Therefore, the primary purpose of this study was to assess the changes in agility of
young, active college students after a 4-week training program on the CAT. Moreover, since
174 three separate measures 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

176 randomized-experimental training design was used involving measurement of COD, foot speed,
and reaction performance before and after a 4-week training program. Those subjects who were
178 randomly assigned into a control group were pre-tested in all three markers, waited 4-weeks,
and then post-tested in the same markers. The order of testing was counterbalanced to decrease
180 potential error associated with testing order.

182 **Subjects**

Thirty-four healthy young men (n=20) and women (n=14) between the ages of 18 and 35
184 volunteered to participate in this study (table 1). All subjects were in good health and free from
musculoskeletal, orthopaedic, cardiovascular and psychological illness and/or disorder as
186 determined by a medical history questionnaire. In order to be considered for this study, all
subjects must have been at a minimum moderately active (subjects must have been engaging in
188 physical activity for at least 5 hours a week and a minimum frequency of 3 times per week).
Upon being accepted to the study, subjects were randomly divided into either the training group
190 (EX) (n= 18, 11m, 7f) or the control group (CON) (n=16, 9m, 7f). Subjects were required to
make a minimum of 10 of the 12 training session (83%) and all testing sessions or were dropped
192 from the study (n=11, 5m, 6f) . 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
194 informed consent, in accordance with the guidelines of the University of Memphis Institutional
Review Board for use in human subjects in research, in order to participate in the study.

196

Equipment

198 The device used for this study is the Quick Feet board, developed by The Quick Board,
L.L.C (figure 1). The board consists of a rubber mat positioned on the ground with sensor pads in
200 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
202 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.

204

The COD was performed as described by Barnes et al., (4) (figure 2). However, in
206 substitute for 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
208 produces an infrared beam. When the subject removed his/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
210 course. The data were then recorded and displayed on the system panel (16).

212 **Procedure**

Testing. Upon the initial visit and after consenting to participate, subjects were screened for
214 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
216 instructed to practice all three testing drills. Specifically, the quick feet drill (QF), which
included a maximum number of foot touches over a 10 second interval, was performed three
218 times separated by 90 seconds (figure 1). The choice reaction drill (REACT), which includes 10
foot touches, was performed three times, separated by 60 seconds. The change of direction
220 (COD) drill, which includes a maximum effort sprint of five meters with three changes of
direction on a pre-determined course totaling 20 m (figure 2) was performed three times
222 separated by 150 seconds. Subjects then returned on a separate, non-consecutive day for the pre-
testing session. The order of testing was counterbalanced to ensure internal validity. Each subject
224 was given 3 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

226 were instructed to cycle at a low-moderate intensity for 5 minutes in order to standardize the
warm-up.

228

Participants in EX attended an initial familiarization session, pre testing session, 12
230 supervised training sessions over the next 30 days (three times a week for four weeks) and a final
post testing session. Training sessions were approximately 20 minutes in length and consisted of
232 three sets of the quick feet drill lasting 10 seconds each (90 seconds rest), three sets of 10
reaction touches (60 seconds rest), three sets of the quick feet drill lasting five seconds each (90
234 seconds rest), and finally three sets of reaction touches lasting five seconds each (60 seconds
rest) (figure 3). It should be noted that subjects did not train on the COD drill. Once the four
236 training weeks concluded, subjects were then post tested in a similar protocol as the pre test.

238 Control subjects performed the same protocol for the pre test, yet they were not involved
in the 4 weeks of training. Once 4 weeks had elapsed, control subjects were brought in for one
240 more familiarization session and then a post test session (figure 3). Similar to the training group,
the order of testing was counterbalanced. All subjects were asked to maintain normal physical
242 activity outside of the study.

244 *Quick Feet Drill (QF)*. During the “quick feet” drill, subjects began with both feet placed
in neutral position (not touching any of the sensors). A five second countdown, displayed by the
246 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
248 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 upon return of the right foot

250 (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
252 the countdown through the end of the task. The number of foot touches completed in 10 seconds
was recorded by the CAT software.

254

Reaction Drill (REACT). Subjects stood on the CAT with both feet in the neutral position
256 (where no feet are touching any of the sensors). After a five second countdown, the subject
watched the control box (which has 5 separate red lights that correspond to the pads on the mat)
258 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
260 back to the neutral position. The subjects attempted to get 10 accurate touches as quickly as
possible.

262

Change of Direction Drill (COD). In the COD drill, subjects began the test by pivoting
264 on the left foot and sprinting five meters. A sensor pad placed underneath the right foot started
the timer once the right foot left contact with the pad. After sprinting five meters, the subject
266 then planted their 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 five meters. Lastly, after
268 planting their 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). Upon crossing the finish line, a beam was
270 tripped and the timer was stopped.

272

Statistical Analyses

274 The pre and post testing measures were analyzed to determine any changes in performances on

the three tests for both the training and control group. A 2 x 2 ANOVA (time) was performed on
276 all dependent variables. When appropriate, follow-up analyses via three separate dependent t-
tests were performed. Standard statistical methods were used to determine mean, standard
278 deviation (SD), standard error (SE), coefficients of variation (< 15%), intraclass correlations
(>.7), Pearson product-moment correlation (>.7), and Cohen's D (ES). Statistical significance
280 was set at $p < 0.05$.

282 **RESULTS**

Measures of precision (CV) and reliability (ICC) were derived from pilot data. Results indicated
284 a CV = 6.9% and 2.6% for QF and REACT respectively, while ICC = .89 for both tests. For data
regarding COD, see Barnes et al., (4). Means \pm SD as well as significance values can be seen in
286 table 2 for all groups. Average compliance for EX was 96% and any subject that fell below 83%
was removed from the study ($n = 6$). Final data analysis were based on 24 subjects (EX $m = 7$, f
288 $= 5$ CON $m = 8$ $f = 4$). A bivariate correlation matrix revealed that the COD drill was only able
to explain 8.7% ($p = .161$) of the shared variance in the QF drill while the REACT was able to
290 explain 37% ($p = .002$). Furthermore, COD was only able to explain 18% ($p = .041$) of the
shared variance for REACT. Although 18% and 37% are statistically significant, they may not be
292 practically significant as the Pearson product-moment falls below the preset criteria of 0.71
(~50%). The 2 x 2 mixed factor analysis revealed significant test by group interactions for all
294 three tests; QF ($F = 9.22$, $p = .006$), REACT ($F = 7.38$, $p = .013$), and COD ($F = 4.87$, $p = .038$)
(see table 2 and figure 4). Follow-up analysis showed the following results.

296

298 **Quick Feet**

The mean (\pm SD) change for QF was $+2.25 \pm 4.99$ touches ($p = .147$) for CON and $+9.99 \pm 7.28$

300 touches ($p = .001$) for EX. These data were used to calculate a Cohen's D and revealed a large
effect size of 2.02. Pilot data was used to calculate precision, reliability, and test-retest
302 correlations. As evidenced by the data, the QF drill was shown to be precise (CV = 6.9%) and
reliable (ICC = .89).

304

Reaction

306 The mean (\pm SD) change for REACT was -0.21 ± 0.86 sec ($p=.411$) for CON and -1.33 ± 1.13
sec ($p = .002$) for EX. Again, a large effect size (Cohen's D = 1.12) was calculated. Both
308 precision and reliability were similar to that of QF (CV = 2.6% and ICC = .89)

Change of direction (COD)

310 The mean (\pm SD) change for the COD drill was -0.14 ± 0.22 sec ($p=.052$) for CON and $-0.45 \pm$
312 $.44$ sec ($p = .005$) for EX. Similar to QF and REACT, a large effects size (Cohen's D = 0.90) was
calculated. Previous data from our lab reported that the same COD drill was highly precise (CV
314 = 1.9%) but had moderate reliability (ICC = .69) (4).

DISCUSSION

The primary findings of this study are that (a) the Quick Feet board is an accurate and reliable
318 CAT for measures of reaction time and foot speed, (b) the four-week training program produced
significant improvements in both REACT and QF, (c) four weeks of training in foot speed and
320 reaction resulted in a significant increase COD performance. Therefore, it is likely that for
previously active men and women, four weeks of training on the CAT can increase overall
322 agility as marked by improvements in foot speed, reaction time, and change of direction drills.

No comparison has been made on gender deference in this investigation due to uneven and small
324 female sample sizes. However, this is likely not an issue as current literature suggests that
adaptations to agility training are not gender specific (9).

326

This investigation was the first to analyze the reliability and accuracy of this particular
328 device in testing human agility. The accuracy for both QF and REACT was exceptionally high
(CV = 6.9% and 2.6%, respectively). Moreover, reliability, as represented by ICC was markedly
330 high as well (.89 for both). Taken together, this would indicate that the device is accurate and
shows little variation from trial to trial when testing foot speed and reaction time in men and
332 women. This further supports the claim that overall agility was improved as a result of the
training since changes in performance were not due to inaccuracies in the testing device.

334

The 4-week training period was shown to be beneficial for both QF and REACT as the
336 EX group displayed an average increase in foot contacts of 9.99 ± 7.28 ($p = .001$) while CON
showed no significant change. In addition, EX improved reaction time by an average of -1.33 sec
338 ± 1.13 sec ($p = .002$) while the control group showed no alterations. Moreover, with Cohen's D
effects sizes of (2.02 and 1.12, respectively) it is likely that the improvements would be
340 practically important. These data would suggest that the training program and not simply
familiarization was responsible for the improvements in performance.

342

The improvements seen in reaction time and foot speed agree with previous literature (1,
344 2, 3, 5, 6, 10, 11, 15). However, the most significant finding of this investigation is that subjects
in the EX group showed an average decrease of -0.45 sec $\pm .44$ sec ($p = .005$) on the COD drill
346 while CON did not improve (-0.14 sec ± 0.22 sec, $p=.052$). Further analysis of CON alone
revealed strong precision (CV = 1.8) and reliability (ICC = .98) between pre and post tests for
348 this drill and therefore familiarization is likely not an issue. Regardless, a large effects size
(Cohen's D = .9) was noted for COD in the training group and therefore it can be concluded that

350 the improvements in COD were a result of the QF and REACT training. Moreover, since EX
showed an improvement in foot speed, reaction time, and change of direction, it can be
352 concluded that overall agility increased.

354 While the data presented in this investigation support the hypotheses that the CAT is
reliable and may improve agility (as defined by an involvement of foot speed, choice reaction,
356 and change of direction), the external validity is not apparent. Further research should attempt to
examine the transferability of these findings to sport performance. Furthermore, these data were
358 obtained from subjects that were not participating in a formalized athletic competition. Further
research should investigate the role of the CAT on athletes currently involved in sport. Another
360 possible avenue for investigation is the dose response of training. It is widely accepted that
physical performance is highly influenced by several training variables such as frequency,
362 duration, volume, and intensity. Therefore, a study that examines various training frequencies,
durations, and volumes is warranted.

364

366 **PRACTICAL APPLICATION**

The reliability and accuracy of CAT devices is of great importance for coaches and practitioners.
368 That is to say, coaches can better monitor their athlete's agility performance with such a device
and be certain that changes in performance are a result of changes in the athlete and not
370 fluctuations seen in the testing device. This is important, as unless otherwise tested, other testing
equipment may not be reliable. Moreover, it appears that training foot speed and reaction time on
372 this specific CAT for as little as 10-15 minutes a day, 3 days a week for 1 month is adequate to
elicit positive adaptations to foot speed, reaction time, and change of direction drills in active
374 college aged men and women.

376

378

ACKNOWLEDGEMENTS

380

Funding and equipment for this study was provided by The Quick Board, LLC (Memphis, TN). The authors would like to thank Dr. Louis Franceschini III for his help with the statistical analysis of data. The results of this study do not constitute endorsement of the product by the authors or the NSCA.

384

386

388

390

392

394

396

398

400

402

404

406

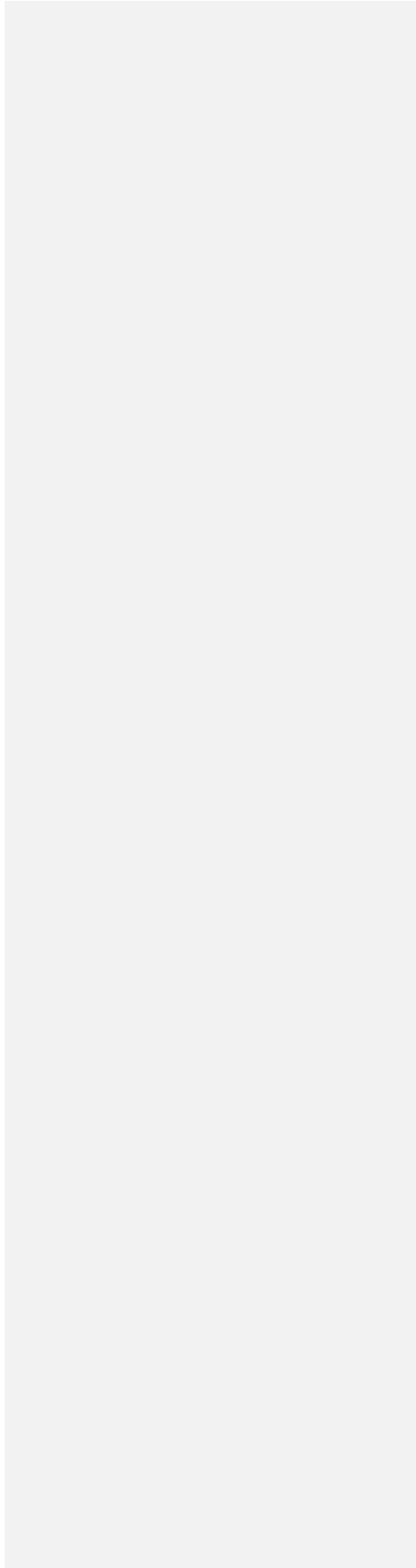
408

410

412

414

416



REFERENCES

- 420 1. ABERNETHY, B. Searching for the minimal essential information for skilled perception
and action. *Psychol.Res.* 55: 2: 131-138, 1993.
- 422 2. ABERNETHY, B. Training the visual-perceptual skills of athletes. Insights from the Study
of Motor Expertise. *Am.J.Sports Med.* 24: 6 Suppl: S89-92, 1996.
- 424 3. ABERNETHY, B., AND J.M. WOOD. Do generalized visual training programmes for sport
really work? An experimental investigation. *J.Sports Sci.* 19: 3: 203-222, 2001.
- 426 4. BARNES, J.L., B.K. SCHILLING, M.J. FALVO, L.W. WEISS, A.K. CREASY, AND A.C. Fry.
Relationship of jumping and agility performance in female volleyball athletes. *J Strength*
428 *Cond. Res.* 2007, (in press).
5. BESIER, T.F., D.G. LLOYD, J.L. COCHRANE, AND T.R. ACKLAND . External loading of the
430 knee joint during running and cutting maneuvers. *Med.Sci.Sports Exerc.* 33: 7: 1168-
1175, 2001.
- 432 6. BESIER, T.F., D.G. LLOYD, T.R. ACKLAND , AND J.L. COCHRANE. Anticipatory effects on
knee joint loading during running and cutting maneuvers. *Med.Sci.Sports Exerc.* 33: 7:
434 1176-1181, 2001.
7. BROWN, T.D. AND J.D. VESCOVI. Efficient arms for efficient agility. *Strength Cond. J.* 25:
436 4: 7-11, 2003.
8. DOCHERTY, D., H. A. WENGER, AND P. NEARY. Time-motion analysis related to the
438 physiological demands of rugby. *J. Hum. Move. Stud.* 14: 269-277, 1988.
9. DEAN, W.P., M. NISHIHARA, J. ROMER, AND K.S. MURPHY. Efficacy of a 4-Week
440 Supervised Training Program in Improving Components of Athletic Performance. *J.*
Strength Cond. Res. 12: 4: 238-242, 1998.

- 442 10. FULTON, KT. Off-season strength training for basketball. *Nat. Strength Cond. J.* 14: 1: 31-
33, 1992.
- 444 11. GAMBETTA, V. How to develop sport-specific speed. *Sports Coach* 19: 3: 22-24, 1996.
12. HICKS, W. On the rate of gain of information. *Quarterly Journal of Experimental*
446 *Psychology* 4: 11-26, 1952.
13. KEOGH, J.W., C.L. WEBER, AND C.T. DALTON. Evaluation of anthropometric,
448 physiological, and skill-related tests for talent identification in female field hockey.
Can.J.Appl.Physiol. 28: 3: 397-409, 2003.
- 450 14. MEIR, R., R.U. NEWTON, E. CURTIS, M. FARDELL, AND B. BUTLER. Physical fitness
qualities of professional rugby league football players: determination of positional
452 differences. *J.Strength Cond Res.* 15: 4: 450-458, 2001.
15. MORENO, E. Developing quickness - part 2. *Strength and Conditioning* 17: 38-39, 1995.
- 454 16. NADEAU, J. L. Balance and agility of soccer players. Unpublished master's thesis. The
University of Memphis, Memphis. 2007.
- 456 17. NEGRETE, R., AND J. BROPHY. The relationship between isokinetic open and closed chain
lower extremity strength and functional performance. *J. Sport Rehab.* 9: 46-61, 2000.
- 458 18. PALMIERI, J. Speed Training for Football. *Nat. Strength Cond. Ass. J.* 15: 6: 12-17, 1993.
19. REILLY, T., A.M. WILLIAMS, A. NEVILL, AND A. FRANKS. A multidisciplinary approach to
460 talent identification in soccer. *J.Sports Sci.* 18: 9: 695-702, 2000.
20. SHEPPARD, J.M., AND W.B. YOUNG. Agility literature review: classifications, training and
462 testing. *J.Sports Sci.* 24: 9: 919-932, 2006.
21. VERKHOSHANSKY, Y.V. Quickness and velocity in sports movements. *New Stud. Athlet.*
464 11: 2-3, 1996.

22. WEBB, P., AND LANDER, J. An economical fitness testing battery for high school and
466 college rugby teams. *Sports Coach* 7: 3: 44-46, 1983.
23. YOUNG, W.B., M. HAWKEN AND L. McDONALD. Relationship between speed, agility, and
468 strength qualities in Australian rules football. *Strength Cond. Coach* 4: 4: 3-6, 1996.
24. YOUNG, W.B., AND J.R. MONTGOMERY I. Is muscle power related to running speed with
470 changes of direction? *J.Sports Med.Phys.Fitness* 42: 3: 282-288, 2002.
25. YOUNG, W.B., AND D. FARROW. A review of agility: practical applications for strength
472 and conditioning. *Strength Cond. J.* 28: 5: 24-29, 2006.

474

476

478

480

482

484

486

488

490

492

494

496

498

500
502
504
506
508
510
512
514
516
518
520
522
524
526
528
530
532
534
536
538
540
542
544
546

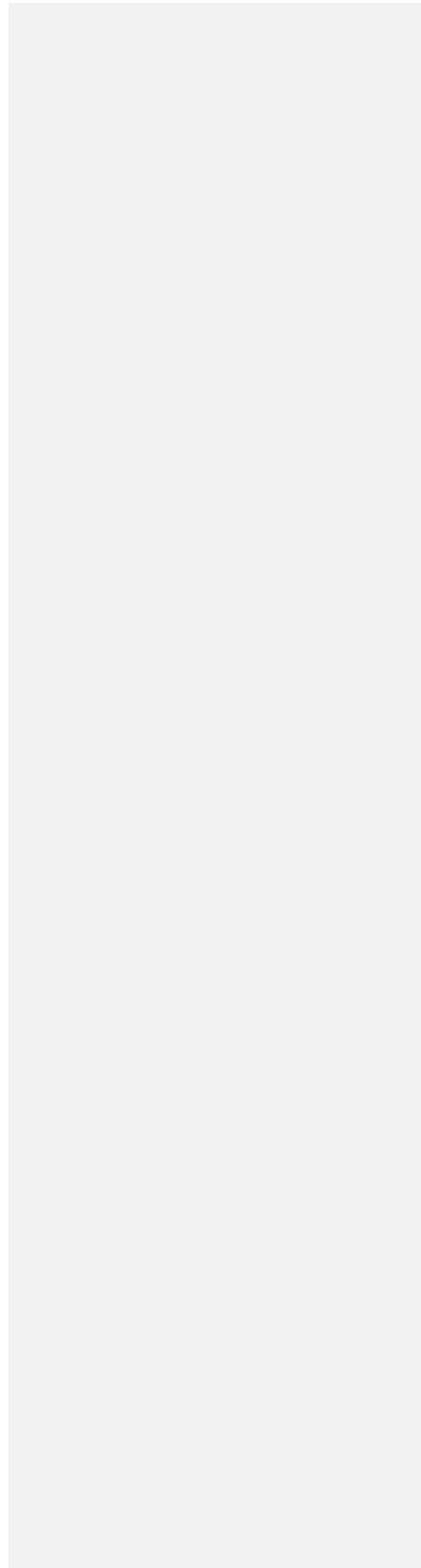
Figure Legends

FIGURE 1. Order of foot placements during QF. 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 COD. Subjects completed the sequence as fast as possible while facing the same direction at all times and touching each line with their foot.

FIGURE 3. A schematic of the experimental design.

FIGURE 4. Changes in performance of QF, REACT, and COD for EX and COD. * $p < .05$.



548

550

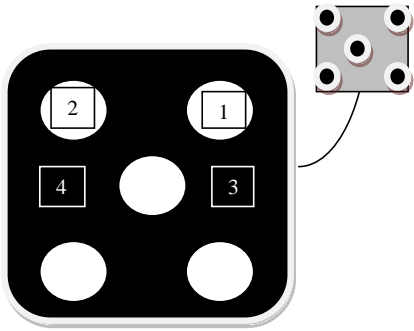
552

554

556

558

560



562

564

566

568

570

572

574

576

578

580

582

584

586

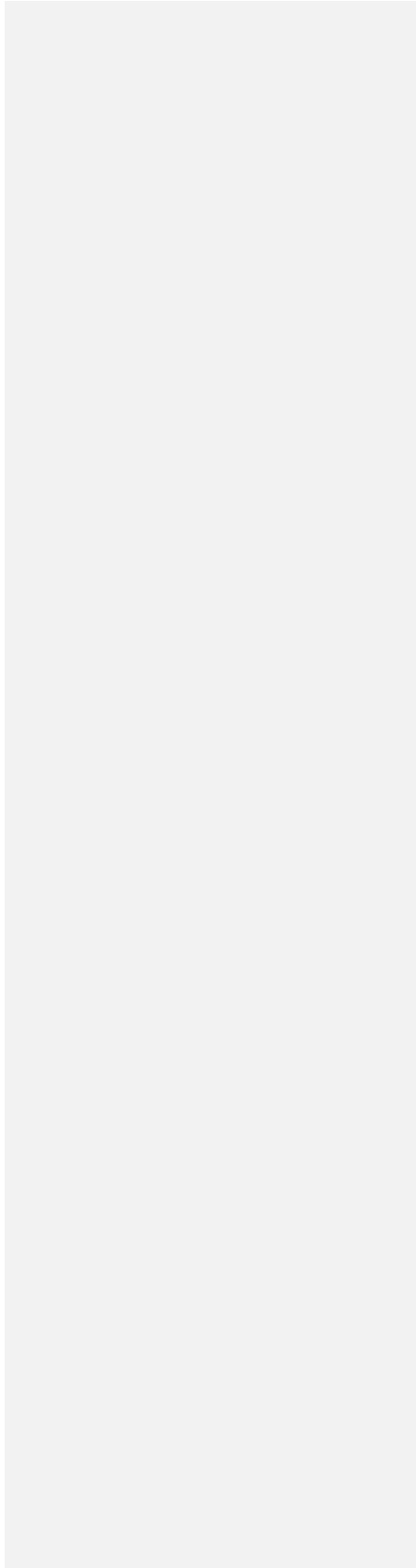
588

590

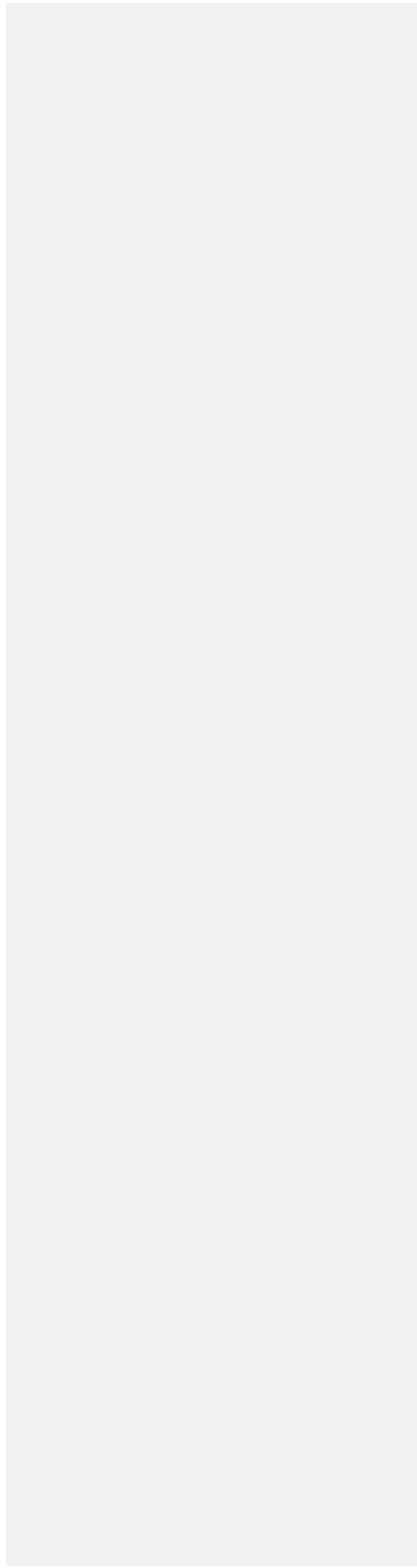
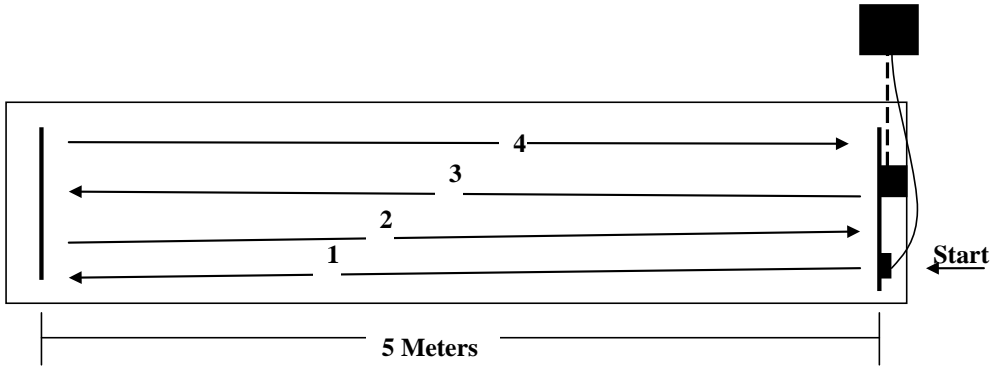
592

594

596



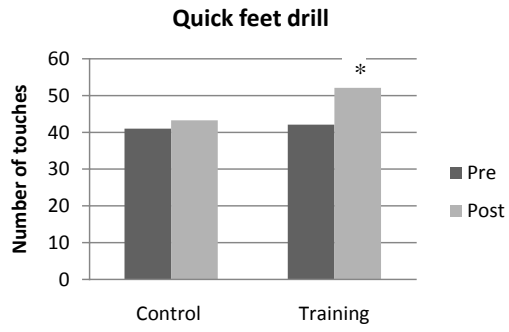
598
600
602
604
606
608
610
612
614
616
618
620
622
624
626
628
630
632
634
636
638
640
642
644



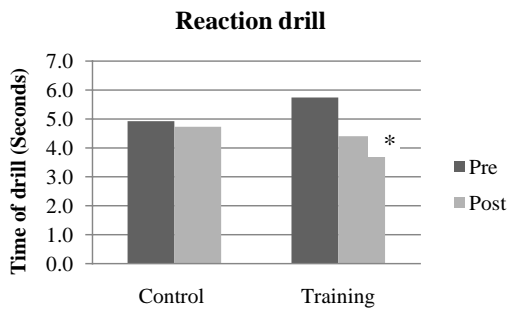
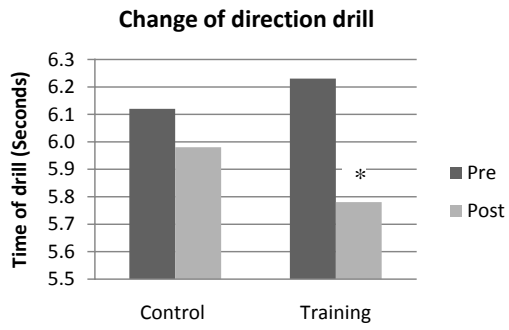
Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
<i>Experimental</i>					
1 Familiarization Session and Pre-Test	Training sessions 1-3	Training sessions 4-6	Training sessions 7-9	Training sessions 10-12	Post-Test
<i>Control</i>					
1 Familiarization Session and Pre-Test	Normal daily living	Normal daily living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

648 Training session includes:

1. Subjects arrive in training area, check in, and cycle for 5 minutes
- 650 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
- 652 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
- 654 6. Subjects are released



656



658

660

662

664

666

TABLES

668 **TABLE 1.** Subject characteristics

	<u>EX (n = 11)</u>	<u>CON (n = 12)</u>
670 Age (y)	26 ± 4	25 ± 2
Height (cm)	169 ± 11	172 ± 8
672 <u>Weight (kg)</u>	<u>71.2 ± 12.0</u>	<u>80.2 ± 24.8</u>

674

676

678

680

682

684

686

688

690

692

694

696

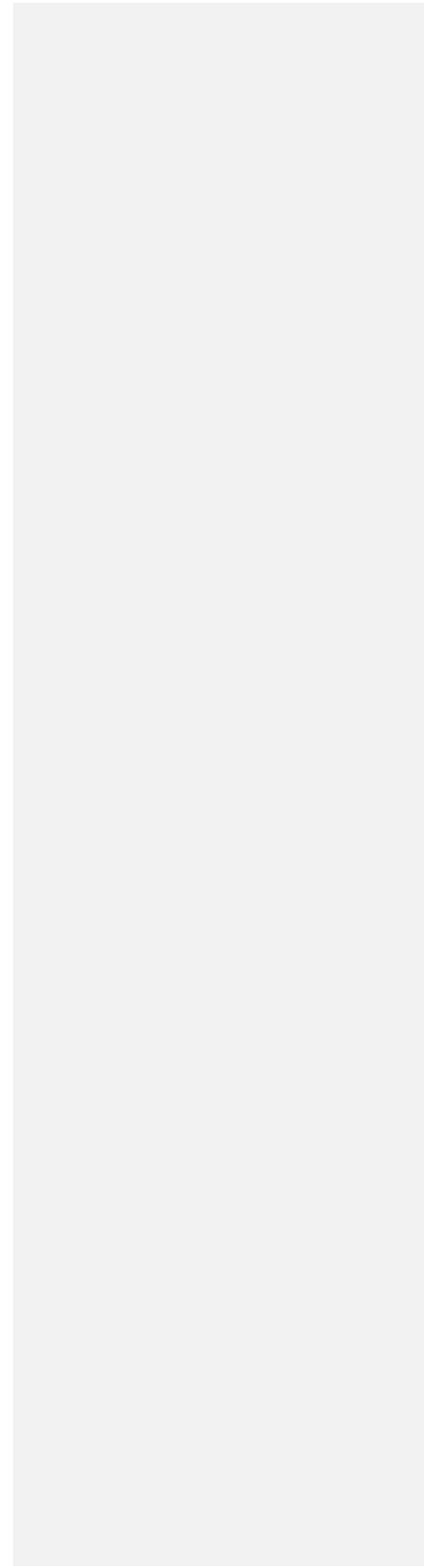
698

700

702

704

706



708

TABLE 2. Mean, SD, and p-value for CON and EX group.

Formatted: Font: (Default) Times New Roman

Formatted: Font: (Default) Times New Roman

710 Variable Mean ± SD p-value Cohen's D

QF

712 Training

Pre 42.08 ± 6.43

714 *Post* 52.07 ± 5.20 .005* 2.02**

Control

716 *Pre* 41.00 ± 8.19

Post 43.25 ± 8.73 .147

718 REACT

Training

720 *Pre* 5.74 ± 1.17

Post 4.40 ± 0.35 .001* 1.12**

722 Control

Pre 4.94 ± 0.97

724 *Post* 4.73 ± 0.74 .411

COD

726 Training

Pre 6.23 ± 0.62

728 *Post* 5.78 ± 0.65 .002* 0.90**

Control

730 *Pre* 6.12 ± 0.81

Post 5.98 ± 0.85 .052

732 * Indicates statistical significance. ** Indicates a large effects size