RELATIVE AND ABSOLUTE RELIABILITY OF A MODIFIED AGILITY T-TEST AND ITS RELATIONSHIP WITH VERTICAL JUMP AND STRAIGHT SPRINT

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ABSTRACT

Sassi, RH, Dardouri, W, Yahmed, MH, Gmada, N, Mahfoudhi, ME, and Gharbi, Z. Relative and absolute reliability of a modified agility t-test and its relationship with vertical jump and straight sprint. *J Strength Cond Res* 23(6): 1644–1651, 2009—The aims of this study were to evaluate the reliability of a modified agility T-test (MAT) and to examine its relationship to the free countermovement jump (FCMJ) and the 10-m straight sprint (10mSS). In this new version, we preserved the same nature of displacement of the T-test but we reduced the total distance to cover. A total of 86 subjects (34 women: age = 22.6 ± 1.4 years; weight = 63.7 ± 10.2 kg; height = 1.65 ± 0.05 m; body mass index = 23.3 ± 3.3 kg·m^{-2} and 52 men: age = 22.4 ± 1.5 years; weight = 68.7 ± 8.0 kg; height = 1.77 ± 0.06 m; body mass index = 22.0 ± 2.0 kg·m^{-2}) performed MAT, T-test, FCMJ, and 10mSS. Our results showed no difference between test–retest MAT scores. Intraclass reliability of the MAT was greater than 0.90 across the trials (0.92 and 0.95 for women and men, respectively). The mean difference (bias) ± the 95% limits of agreement was 0.03 ± 0.37 seconds for women and 0.03 ± 0.33 seconds for men. MAT was correlated to the T-test ($r = 0.79$, $p < 0.001$ and $r = 0.75$, $p < 0.001$ for women and men, respectively). Significant correlations were found between both MAT and FCMJ, and MAT and 10mSS for women ($r = -0.47$, $p < 0.01$ and $r = 0.34$, $p < 0.05$, respectively). No significant correlations were found between MAT and all other tests for men. These results indicate that MAT is a reliable test to assess agility. The weak relationship between MAT and strength and straight speed suggests that agility requires other determinants of performance as coordination. Considering that field sports generally include sprints with change direction over short distance, MAT seems to be more specific than the T-test when assessing agility.

KEY WORDS agility, field-testing, speed, change direction

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INTRODUCTION

The basic movement pattern of many field and court sports such as soccer, handball, basketball, rugby, and tennis require the player to perform many diverse activities such as jogging, sprinting, and jumping. In this type of sport, players are required to accelerate, decelerate, and change direction throughout the game in response to a stimulus, such as an opposing player's movements or the movement of the ball (28). Team game players need thus to be exceptional movers in forward, lateral, back, and multidirectional movements in a very reduced area (4). Most research (5,13,23) has applied the term "agility" to describe any dynamic sporting action that involves change in body position or change of direction speed. Baker (1) and Keogh et al. (16) reported that speed in changing direction is a clear determinant of sport performance in field sports. In fact, Wither et al. (34) have shown that Australian soccer players make an average of 50 turns per game. Recently, Bloomfield et al. (4) have reported that frequency of turning and swerving within a match performed by English soccer players was 727. Deutsch et al. (12) have reported that the number of directional changes in an average point in tennis was 4.

A great interest exists for developing field tests and specific training programs that can effectively measure and improve agility. The majority of tests supported to assess agility are tests based on change of direction speed [e.g., the T-test (25), the Illinois agility test (11,15), the 505 test (13), the L-run test (20), and the zigzag test (19)]. The most used test to assess agility was the T-test (14,21,22,25,26). It is well accepted as a standard test of agility. It is simple to administer and requires minimal equipment and preparation. The T-test involves speed with four directional changes. The T-test is moderately correlated with the 40-yard dash and the vertical jump (counter movement jump). However, the generic cues involved in the T-test did not reproduce the movement pattern of field and court sports. For example, the application of the T-test in sports such as volleyball (14,21) seems to be inappropriate because the total sprinting distance covered is approximately 40 m. In fact, it is well documented that the mean distance and duration of sprints during field and court sports to be between 10 and 20 m and 2 and 3 seconds, respectively (2,17,30). To address the need for a more specific agility test with change of direction speed, we propose a modified version of the agility T-test (MAT). In this new version, we maintained the same nature of displacement but we reduced the total distance covered (20 m).

The purpose of this study was therefore to evaluate the reliability of the MAT and to examine its relationship with 10-m straight sprint and vertical jump as components of leg power and leg speed. We hypothesised that the MAT, like the T-test, would provide stable test–retest scores, and it would have a stronger relationship with strength and speed.

Methods

Experimental Approach to the Problem

Speed in changing directions is considered an important component of most team sports (1,16) because it is believed that game player needs to be exceptional mover in multidirectional movement in very reduced area. Considering that field and court sports generally include speed with change direction over short distance, it seems important to provide testing that mimics this demand to increase specificity. In addition, as suggested by Sheppard (28), the long distance covered in agility tests could account for the weaker relationship with strength and power quality. Decrease in total distance covered in change of direction speed may result in a stronger relationship with strength and straight speed. Thus, we have used relative and absolute reliability to evaluate the MAT reliability. Each subject performed four test trials. The two first trials were for familiarization; only the two last trials were used in the statistical analyses. To study the relationship between the MAT and leg strength and leg speed, subjects performed the T-test, free countermovement jump (FCMJ), and the 10-m straight sprint (10mSS). Subjects were asked to maintain their normal diet and to stop exercise and rest 24 hours before the testing session.

Subjects

A total of 86 subjects who are physical education students of our university took part in this study (52 men and 34 women); they are licensed in various team sports (football, basketball, volleyball, and handball). The mean ± *SD* of age, height, body mass, and body mass index (BMI) are presented in Table 1. Written informed consents were obtained after the explanation of the nature of the research from all subjects before beginning the study. Subjects were selected from their team sport experience. To be eligible for participation, students were required to belong to a sport team for at least 2 years. None was a highly trained competitive athlete; their physical activity practice volume was approximately 16 hours per week.

Procedure

All tests were performed indoors on a synthetic pitch at the sport university gymnasium. Before testing, subjects completed a 15-minute warm-up, including jogging, lateral displacements, dynamic stretching, and jumping. All subjects performed each test with at least 3 minutes of rest between all trials and 5 minutes between tests to ensure adequate recovery. All tests were conducted at a random order and on a single day for each test subject.

T-test, MAT, and 10mSS performances were recorded using an electronic timing system (Globus, Microgate; SARL, Italy). For T-test and MAT, one pair of the electronic timing system sensors mounted on tripods was set approximately 0.75 m above the floor and was positioned 3 m apart facing each other on either side of the starting line. For 10mSS, two pairs of the electronic timing system sensors were placed at the starting and finish lines. Vertical jump performance (peak height) was measured by using the Opto-jump system (Microgate SARL, Italy).

Agility T-test

The T-test (Figure 1) was used to determine speed with directional changes such as forward sprinting, left and right shuffling, and backpedalling. Based on the protocol outlined by Pauole et al. (25), subjects began with both feet behind the starting line A. At his or her own discretion, each subject sprinted forward to cone B and touch the base of it with the right hand. Facing forward and without crossing feet, they shuffled to the left to cone C and touch its base with the left

Table 1. Physical characteristics for women, men, and combined group.*

	Women ($n = 34$)	Men ($n = 52$)	Combined ($n = 86$)
Age (year)	22.6 ± 1.4	22.4 ± 1.5	22.5 ± 1.5
Height (m)	1.65 ± 0.05	1.77 ± 0.06‡	1.72 ± 0.08
Body mass (kg)	63.7 ± 10.2	68.7 ± 8.0†	63.7 ± 9.2
Body mass index	23.3 ± 3.3	22.0 ± 2.0†	22.5 ± 2.6

*Values are mean ± *SD*.
†Significantly different ($p < 0.05$) for women vs. men.
‡Significantly different ($p < 0.001$) for women vs. men.

hand. Subjects then shuffled to the right to cone D and touch its base with the right hand. They shuffled back to the left to cone B and touch its base. Finally, subjects ran backward as quickly as possible and return to line A. Any subject who crossed one foot in front of the other, failed to touch the base of the cone, and/or failed to face forward throughout had to repeat the test.

The recorded score for this test was the better of the two last trials. The reliability of the T-test in our study was 0.97 (95% CI: 0.93–0.98) and 0.90 (95% CI: 0.82–0.94) in women and men, respectively. No significant differences between test-retest scores were observed ($p = 0.109$ and 0.459 in women and men, respectively).

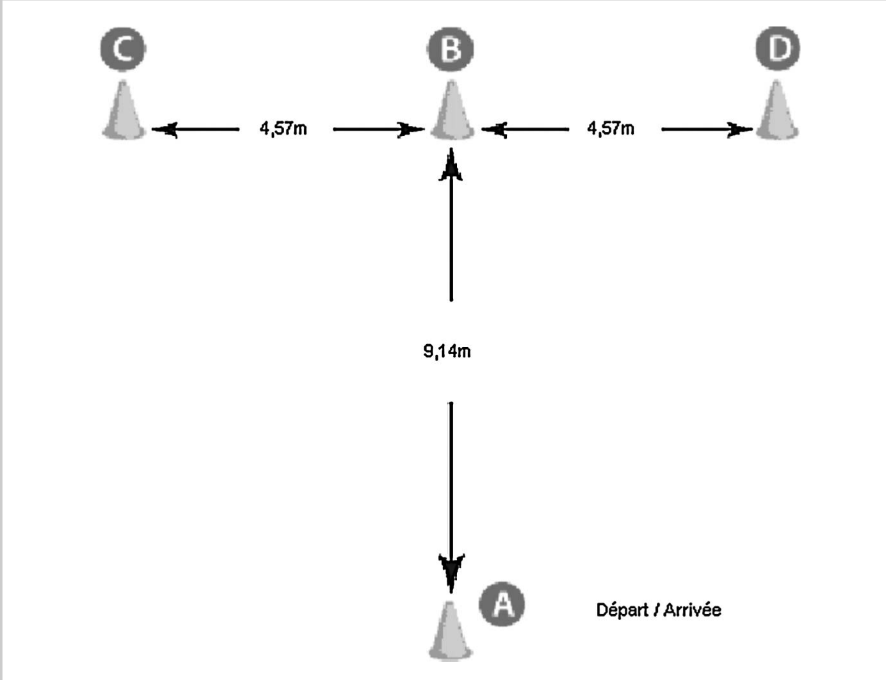

Figure 1. Agility T-test. The athlete runs forward from cone A to cone B, then shuffles to the left (cone C), then shuffles to the right (cone D), then shuffles back to point B, before running backwards to the start position (point A).

Modified Agility T-test

The MAT (Figure 2) was performed using the same directives protocol of the T-test, except that the total distance covered and measures of intercone distance were modified. The number of directional changes were maintained the same. Subjects covered a total distance of 20 m on the modified T-test instead of 36.56 m on the T-test. Criteria for accepted test trials were the same of those used on the T-test. The recorded score for this test was the better of two last trials (test–retest session).

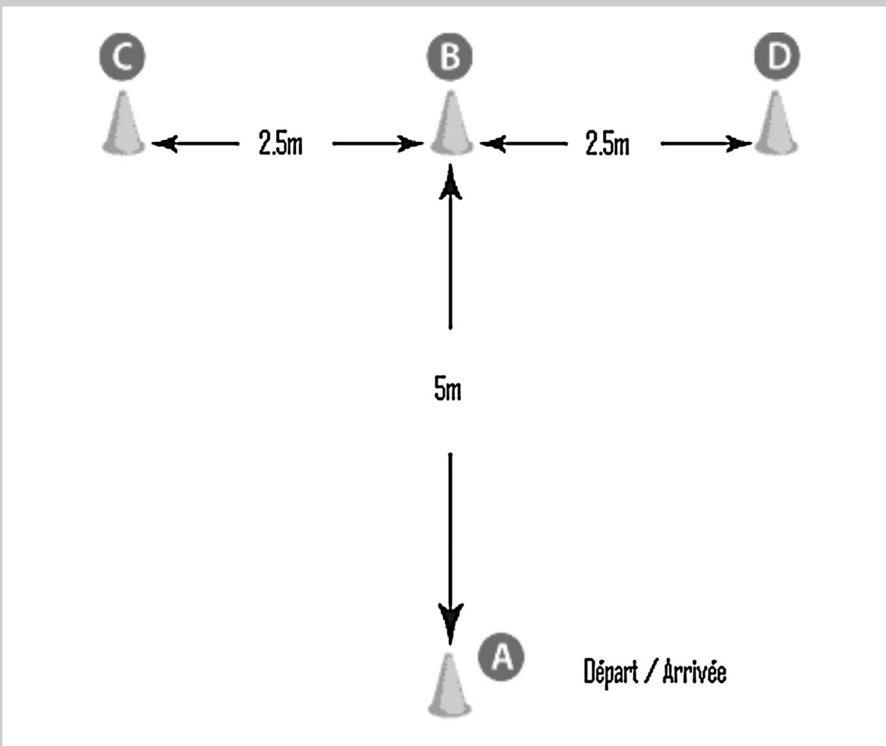

Figure 2. Modified agility T-test (MAT). The protocol of this test is the same that the T-test with modification of the total distance covered and measures of intercone distance.

Straight Sprint (10mSS)

Acceleration was evaluated using a straight sprint test, involving sprinting 10 m as fast as possible from a stationary start position. Subjects were instructed to begin with their preferred foot forward, placed on a line marked on the floor from a standing position. The subjects performed three test trials. The recorded time for this

TABLE 2. Performance characteristics and results of absolute reliability of MAT test for science sport students.*

	Test trial 1 (seconds)	Test trial 2 (seconds)	Mean difference	ICC (95% CI)	95% LOA	CV (%)
Women ($n = 34$)	7.29 ± 0.36	7.26 ± 0.34	0.03 ± 0.19	0.92 (0.84–0.96)	0.33	2.6
Men ($n = 52$)	6.28 ± 0.37	6.25 ± 0.36	0.03 ± 0.18	0.95 (0.91–0.97)	0.37	2.7

*Values are mean ± *SD*. ICC = intraclass coefficient; CV = coefficient of variation; LOA = limit of agreement.

TABLE 3. MAT, T-test, FCMJ, and 10mSS scores for women and men.*

	MAT (seconds)	T-test (seconds)	FCMJ (cm)	10mSS (seconds)
Women ($n = 34$)	7.20 ± 0.32	11.92 ± 0.52	29.49 ± 5.09	2.33 ± 0.10
Men ($n = 52$)	6.19 ± 0.35†	10.08 ± 0.46†	42.16 ± 4.32†	1.93 ± 0.13†

*Values are mean ± *SD*.
†Significantly different ($p < 0.001$) for men vs. women.

test was the better of the two last trials. The reliability of the 10mSS in our study was 0.86 (95% CI: 0.72–0.93) and 0.90 (95% CI: 0.79–0.93) in women and men, respectively. No statistical differences between test–retest scores were observed ($p = 0.599$ and 0.580 in women and men, respectively).

Vertical Jump

Jumping ability was assessed using FCMJ. Subjects performed three test trials. They were allowed to swing their arms freely but were not allowed any preparatory step before jumping. The best performance of the two last trials was recorded. The reliability of the FCMJ in our study was 0.97 (95% CI: 0.95–0.99) and 0.93 (95% CI: 0.88–0.96) in women and men respectively. No significant differences between test–retest scores were observed ($p = 0.491$ and 0.876 in women and men, respectively).

Statistical Analyses

Data analyses were performed using SPSS version 13 for Windows (SPSS Inc., Chicago, IL, USA). Mean and *SD* values were calculated for each variable. The normality of appropriate data sets was checked using the Kolmogorov-Smirnov test. It was considered appropriate therefore to test stated hypotheses using parametric statistical techniques. Comparison of anthropometric variables and test performances between women and men was assessed using independent *t*-test. Since significant differences were found

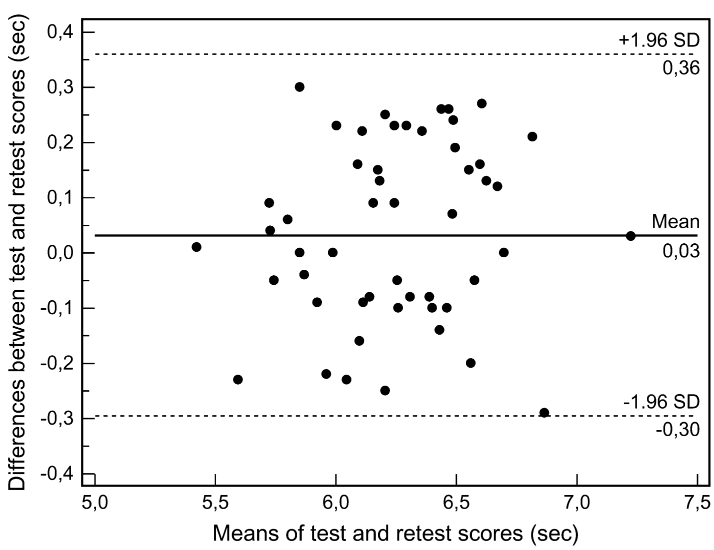

Figure 3. Bland and Altman plots with limit of agreement (dashed line) of test-retest of the MAT for women (a) and for men (a). The differences between test-retest scores (test score 2 minus test score 1) plotted against their mean (dot line) for each subject.

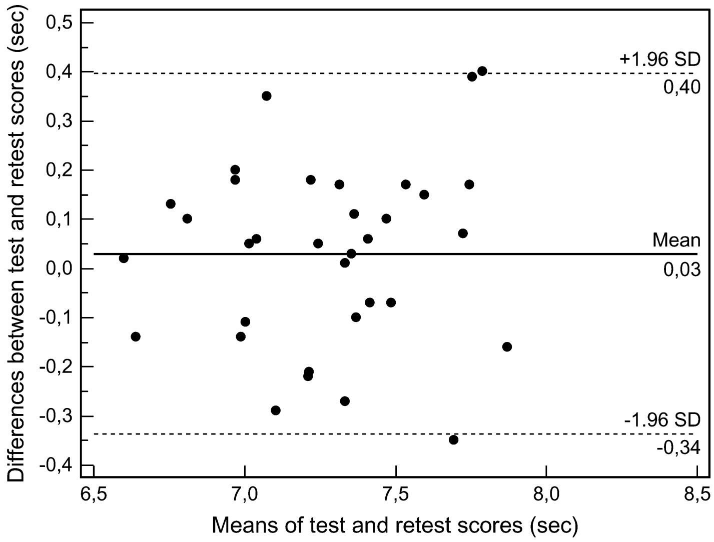

Figure 4. Bland and Altman plot with limit of agreement (LOA) of tests retest MAT for women.

between all of these variables in women and men, the results were analysed in the two groups separately. To determine relative reliability, the intraclass correlation coefficient (ICC) was calculated. To test the absolute reliability of the MAT, the agreement between repeat performances (test-retest) was quantified using the 95% limit of agreement (LOA) method originally described by Bland and Altman (3). To investigate systematic bias, a paired Student's t-test was conducted to test hypothesis of no difference between the sample mean score for the test versus the sample mean score for the retest. Heteroscedasticity was revealed by calculating a correlation coefficient between the absolute difference and the average of the test trials. Heteroscedasticity was addressed for each Bland-Altman calculation. Since heteroscedasticity was found in the present data (24), a log transformation and antilog (back transformation) were applied giving values that can be interpreted in relation to the original scale. A Pearson product moment correlation was computed between the MAT and with each of other tests. Statistical significance was set at $p \leq 0.05$.

Results

Mean performance scores ± *SD* at different tests for women and men are given in Table 2. Significant differences were found between women and men for MAT, T-test, FCMJ, and 10mSS (Table 3). Mean scores (*SD*) of the MAT for the first and the second test session, mean difference ± SD_{diff}, ICC values, 95% LOA, and coefficient of variance (CV) between test and retest for women and men are given in Table 2. There were no differences between test sessions scores in the two groups. ICC values to assess the relative reliability of the MAT were 0.92 (95% CI: 0.84–0.96) for women and 0.95 (95% CI: 0.91–0.97) for men.

Bland-Altman plots of first versus second test scores are shown in Figures 3 and 4 for women and for men, respectively. The residual errors between scores on the test and the retest for women and men were normally distributed ($p = 0.831$ and 0.807, respectively) and the heteroscedasticity coefficients were $r = 0.291$ ($p = 0.094$) for women and $r = 0.222$ ($p = 0.114$) for men. The mean difference (bias) ± the 95% limits of agreement was 0.03 ± 0.37 seconds for women and 0.03 ± 0.33 seconds for men.

Log transformation of the test and retest data reduce the heteroscedasticity to $r = 0.243$ ($p = 0.167$) in women and to $r = 0.15$ ($p = 0.287$) in men. There is no significant bias between log-transformed mean scores for the two trial tests in both women and men. The residual errors between scores on the test and the retest log transformed data were normally distributed ($p = 0.669$ for women and $p = 0.816$ for men). The mean difference (bias) ± the 95% limits of agreement was

Table 4. Pearson product moment correlations (95% confidence interval).

MAT	T-test	FCMJ	10mSS
Women ($n = 34$)	0.79 (0.61–0.89)*	−0.47 (−0.70 to −0.16)†	0.34 (0.00–0.61)‡
Men ($n = 52$)	0.75 (0.59 – 0.85)*	−0.07 (NS)	0.22 (NS)

*$p < 0.001$.
†$p < 0.01$.
‡$p < 0.05$.

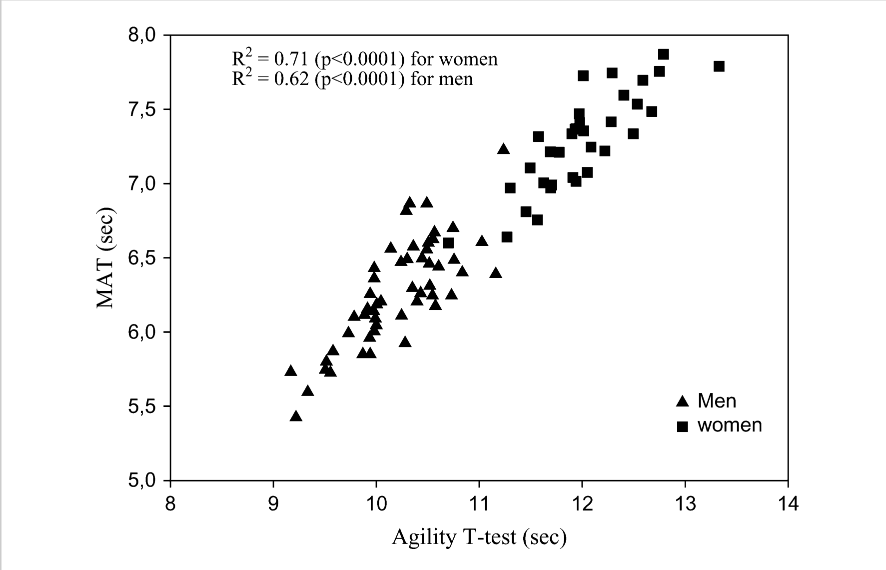

Figure 5. Correlation between MAT and Agility T-test for women and men.

To identify the stability reliability of the MAT, we evaluated the absolute reliability by calculating the 95% LOA originally described by Bland and Altman (3). In the test–retest data, bias ± the 95% LOA of the repeatability of the MAT were given as 0.03 ± 0.37 seconds for women and 0.03 ± 0.33 seconds for men. Moreover, Nevill (24) stated that any two tests would differ due to measurement error by no more than 5% in a positive or negative direction. In our study, difference between the two test trials due to measurement error (coefficient of variation) was 2.6% and 2.7% for women and men, respectively. Likewise, log transformed data reduced heteroscedasticity coefficient and gave a mean bias ± 95% LOA of 0.0018 ± 0.0216 for women and 0.002 ± 0.023 for men. When antilog of these values was taken, the results could be expressed as the mean bias ×/÷ 95% of agreement component (1.002 ×/÷ 1.022 for women and 1.002 ×/÷ 1.023 for men). Consequently, 95% of the ratios for the sample (log-transformed test score divided by log transformed retest score) should be contained between the values 0.980 (1.002 ÷ 1.022) and 1.024 (1.002 × 1.022) for women and 0.979 (1.002 ÷ 1.023) and 1.025 (1.002 × 1.023) for men. To put these results in a practical context (9), if a woman from the study population performed 7 seconds on the first application of the MAT, suggests that she could performed on the second trials a score as high as 7 × 1.024 = 7.17 seconds, or as low as 7 × 0.98 = 6.86 seconds. For a male subject with a performance on the test of 5.5 seconds, for example, there is a 95% probability that the second trial performance might be as high as 5.5 × 1.025 = 5.64 seconds or as low as 5.5 × 0.979 = 5.39 seconds. We could consider these LOA acceptable.

0.0018 ± 0.0216 for women and 0.002 ± 0.023 for men. Taking antilog of these values gave a mean bias of 1.0018 with an agreement component of ×/÷ 1.0218 for women and 1.002 ×/÷ 1.0233 for men.

Pearson product moment correlation between all tests for both women and men is presented in Table 4. The MAT is significantly correlated to agility T-test for both women and men (Figure 5). A low correlation was found between MAT and FCMJ, MAT, and 10mSS tests in women, and it was not significantly correlated with these tests in men.

Discussion

The main finding of this study is that the reliability of the MAT was high across the two measurement trials. Most recent research (6,9,10,18) investigating reliability of field-testing has used the ICC values and the 95% LOA method (3). These studies considered the two methods as the most appropriate and objective to assess reliability. ICC across the two trials in our study were 0.92 and 0.95 for women and men, respectively. These values were comparable to relative reliability of other agility tests. Pauole et al. (25) reported an ICC of 0.98 across three agility T-test trials in college-aged men and women. Sheppard et al. (28) found an ICC of 0.87 across two reactive agility test trials in 38 Australian football players. As general rule, an ICC over 0.90 is considered high, between 0.80 and 0.90 is moderate, and less than 0.80 is insufficient for physiological field tests (32). Thus, our results demonstrated a high reliability. It is well documented that reliability of field-testing is very influenced by the subject's age or gender, heterogeneity, and motivation to do well. The test-retest ICC in our data is high, despite the fact that statistical analyses were assessed separately in women and men.

Pearson product moment correlations were calculated independently between all tests for women and men (Table 4). The MAT was significantly correlated to the T-test in both women and men. The coefficients of determination (r^2) showed that MAT and T-test share 62% and 56% common variance in women and men, respectively. These results indicate that the MAT, as the T-test, could be used to evaluate change of direction speed, and thus agility. The MAT was not correlated to FCMJ and 10mSS in men. However, MAT was significantly correlated to FCMJ and 10mSS in women. It is generally accepted that correlation between tests are highly influenced by heterogeneity of subjects. Therefore, relative heterogeneity of the women could contribute to the relationship found between different performance tests. For the men, we supposed that there was not enough variance within the data of tests to accurately detect a correlation between variables. This homogeneity of subjects could not be anticipated prior to the beginning of the study. On the other hand, when we increased heterogeneity by combining all subjects (women and men), we found increased correlation coefficients between tests ($r = 0.93$ between MAT and T-test; $r = -0.74$ between MAT and FCMJ; $r = 0.78$ between MAT and 10mSS).

Our results were comparable with other studies that examined the relationship between agility tests (change of direction speed tests) and vertical jump and straight sprint tests (19,25,26,33,35). Peterson et al. (26) reported a significant correlation between T-test and vertical jump (CMJ) in women but not in men. They also reported a low correlation between T-test and acceleration (20-yard as split time of 40-yard) and sprint velocity (40-yard). Similarly, Pauole et al. (25) reported low to moderate significant correlations ($p < 0.05$) between T-test for change of direction speed and a 40-yard sprint ($r = 0.73$ for women and $r = 0.55$ for men) and a vertical jump ($r = -0.55$ for women and $r = -0.49$ for men). Likewise, Little and Williams (19) reported a low significant correlation between agility (zigzag test, 20 m) and acceleration (10 m) and maximum speed (20 m). Young et al. (35) found low and nonsignificant correlation between CMJ and 20-m change of direction test. Similarly, Webb and Lander (33) reported a low and nonsignificant correlation between the "L" run test for change of direction speed and vertical jump. In the women's group, the common variances found between both MAT and FCMJ, and MAT and 10mSS, were 25% and 14%, respectively. Nevertheless, Thomas and Nelson (31) stated, "When common variance between the two variables is less than 50%, it indicates that they are specific or somewhat independent in nature." Based on these results, it seems that change of direction speed and straight sprint were two specific determinant qualities on performance.

Agility is a very complex concept that requires interactions of physiological and biomechanical components. In fact, the complex control motor and coordination of several muscle groups could contribute considerably to the change of direction speed performance (35). Cazorla et al. (7) reported that relative maximum force and the mean body mass explained 44% of 20-m sprint with change of direction performance; they suggested that coordination could represent the 50% of unexplained performance.

In conclusion, our findings indicate that this new version of T-test (MAT) obtained by reducing the total distance to cover presents a good relative and absolute reliability for both women and men. The nature of displacements in sports such as volleyball, basketball, and tennis cannot be replicate by using the standard T-test because they are based on very short repeated displacements. The MAT will provide a more specific measurement of agility for these sports. However, for activities practiced in big courts or fields such as football and rugby, the use of the T-test would be more adequate and recommended. Further research is essential to investigate other factors that will contribute to the change of direction speed performance, and also to assess contribution of coordination quality in agility performance.

Practical Applications

The findings of this research indicate that MAT, as the T-test, is a reliable test for assessing agility. However, coaches and trainers were challenged to select the most appropriate and specific test to assess agility of their players or athletes. However, the speed and the lower limb strength may explain, in part, only a small percentage of sprints with change-direction performance. Coaches and trainers are advised to implement specific agility drills, such as coordination, to develop this quality.

Acknowledgments

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