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Research article

Reactive-Agility in Touch Plays an Important Role in Elite Playing Level: Reliability and Validity of a Newly Developed Repeated Up-and-Down Agility Test

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Abstract

Successful athletes are better at performing efficiently than the inferior in particular sports scenarios, while most existing performance tests in the field do not cover the sport-specific context fully. There were two purposes in this study: 1) to evaluate the reliability and validity of a novel Sector Reactive Agility Test (SRAT) which mimicked a reactive-agility defensive scenario in Touch, and 2) to determine the relationships between Touch players' agility and sprint performance. Twenty male Touch players from the elite division and another 20 from the amateur division were invited to participate in this study. They performed SRAT and a 20-m sprint test in two days. Excellent reliability and high precision were found in SRAT (intraclass correlation coefficient [ICC] = 0.97) and 20-m sprint test (ICC = 0.91). The time of completion in SRAT of the elite Touch players (23.93 s) was 2.95 s significantly shorter than that of the amateur players with a large effect size. Elite Touch players also demonstrated moderately faster (0.11 s) than the amateur Touch players in the 20-m sprint test. SRAT demonstrated high test-retest reliability and accuracy in measuring reactive-agility performance in Touch. The minimal detectable changes in SRAT and 20-m sprint test were 1.04 s and 0.13 s respectively. Furthermore, the speed of the 20-m sprint test and playing experience were associated with the time of completion of SRAT, explaining 56% of its variance ($p < 0.001$). Other factors, such as cognition and the ability to control own central gravity, are deemed possible to influence Touch players' agility. Therefore, SRAT should be adopted in Touch player selection and training monitoring.

Key words: Rugby, field testing, external stimuli, reaction, change of direction.

Introduction

Successful athletes possess the ability to solve sport-specific problems and coordinate their bodies efficiently in specialised contexts. Match-play performance, such as on-field attacking ability in rugby league, was demonstrated to associate with physiological and anthropometric qualities, and technical and perceptual skills (Gabbett et al., 2011). Various game analyses in the rugby variations had outlined the game patterns (Chow, 2020; Higham et al., 2012), the key elements of a successful team (Hulin et al., 2015; Ross et al., 2015) and the game performance throughout a tournament (Peeters et al., 2019). To maximise sports performance, sports training should aim to develop context-specific movement, that is to enhance the speciality of the athletes.

Agility has been identified as one of the essential components of the performance of athletes interacting with one or more stimuli. Its definition was revised by Sheppard and Young (2006), from quickness and change of direction (COD) to "a rapid whole-body movement with change of velocity or direction in response to a stimulus." After a decade, they proposed an agility model for invasion sports, highlighting three major components: cognition, physicality and techniques. Young et al. (2021) emphasised that COD was a unique skill that could be reflected by a preplanned movement test, while an agility test was suggested to evaluate the quality of response reacting to a stimulus, often presented by opponents' movement.

A review found that agility test research generally adopted reliable (intraclass correlation coefficient [ICC] > 0.80) methods to assess the components of agility in team sports (Paul et al., 2016). However, reliable agility tests do not necessarily reflect every match-play situation. Varieties of Y-shaped agility test are mostly used to assess athletes' reactive-agility. Sheppard et al. (2006) developed the first version of the reactive-agility test, which required a tester to initiate a movement that served as an external cue for athletes to react and respond. Subsequent versions of Y-shaped agility test maintained its fundaments but varied the distance travelled, the cutting angle, and the source of external cue (e.g., light, or live cue). High reliability was often shown (Gabbett et al., 2008a; Green et al., 2011). Compared with the real-world situation in sports where athletes are usually required to select and react to multiple relevant cues, these derivatives of Y-shaped agility test regulated the athletes to respond to one external cue with distinct movements. Different approaches and assessments to measure specific game-related agility are demanded (Paul et al., 2016; Young et al., 2021). For example, Sekulic et al. (2014) developed a unique and reliable reactive-agility test, “stop’n’go”, (ICC = 0.81–0.86) specifically for the stop-and-go agility scenario. Its modified version was applicable to differentiate football players of various ages and playing experience (Pojskic et al., 2018).

Touch, as known as Touch-rugby and Touch Football in different regions of the world, is a variation of contact rugby and has been expanded globally. Its physical demand of the change in running velocity, especially on rapid deceleration (> 3 $m \cdot s^{-2}$), was reported in previous studies (Beaven et al., 2014; Chow, 2020). High-speed running is a common movement variable to determine playing level in Touch. Beaven et al. (2014) showed that international players were more likely to achieve higher running speed than regional players with a moderate effect size (39.3 $m \cdot min^{-1}$ vs 26.0 $m \cdot min^{-1}$). However, in a match, after a defending player makes a "touch" with the ball carrier, all on-

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field defending players have to retire to not less than 7 m from the mark quickly (Federation of International Touch, 2020). It stresses heavily the players' agility to identify the ball carrier, chase forward to make a touch, and retire quickly. This defensive sequence can be repeated up to six times. Athletes playing other sports who need to react to external cues, e.g. badminton, tennis and handball, are also expected to be capable of repeatedly sprinting and reacting simultaneously. Obviously, the previously validated reactive-agility tests could not fully represent the scenario of repeated up-and-down agility in Touch. Therefore, this study aimed to 1) investigate the reliability and validity of a newly developed reactive-agility test for Touch, and 2) to determine the relationships between agility and sprint performance in Touch players. It was hypothesised that elite Touch players outperformed in a sport-specific reactive agility test, namely Sector Reactive Agility Test (SRAT), compared with the amateur Touch players and the elite athletes from other sports. It was also hypothesised that the performance of SRAT was positively related to that of a 20-sprint test.

Methods

Experimental approach to the problem

This study used a cross-sectional observational study design where participants performed SRAT and a 20-m sprint test in the same outdoor playground during their pre-season period. SRAT was designed to simulate the "touch" defensive scenario in Touch considering its ecological validity. The reliability of SRAT was ascertained by test-retest trials separated by two training days (i.e. seven days). To evaluate the relationship between SRAT and high-speed running performance, a 20-m sprint test was selected.

Participants

Forty male participants volunteered to take part in this study (Table 1). The inclusion criteria included: 1) aged 18 to 30, 2) male and 3) injury and illness-free one month prior to the testing day. In addition, Touch players were recruited if they 3) had a minimum of 1 year of Touch training experience and 4) were officially registered players in the Hong Kong Touch Association in 2019/20 and 2020/21. According to their registrations in the Hong Kong Touch Association in 2019/20, the Touch participants were divided into two groups: elite (n = 20; M ± SD: age 23.40 ± 2.60 years; body mass index [BMI] 22.65 ± 2.28; body fat% 18.01 ± 3.02%) and amateur (n = 20; age 25.50 ± 2.57 years; BMI 23.65 ± 1.97; body fat% 17.89 ± 4.36%). Voluntary written informed consent, with explanations of potential benefits and risks, was obtained before data collection. Ethical approval for this research was granted by the Human Research Ethics Committee at The Education University of Hong Kong (Ref. no. 2020-2021-0367).

Procedures

This study was conducted during the season break within a competitive season. Participants received orientation and familiarisation trials before the commencement of the tests. Anthropometric measurements (i.e. height, weight and body fat%) and other demographic data (i.e. age and playing experience in Touch) were collected in the orientation session. All tests were completed within two weeks. Each participant performed SRAT and 20-m sprint test twice on the two separate days. Reactive-agility was assessed after the 20-m sprint test with a 5-minute rest in between.

Participants were advised to wear jerseys, shorts, and sneakers, and consumed their main meals not less than 3 hours before testing. A 10-minute standardised Raise, Activate, Mobilize, Potentiate warm-up was provided (Jeffreys, 2007). It included 2 minutes of jogging at a self-selected pace, 4 minutes of activation and mobilisation exercises of the lower limbs and 4 minutes of progressive forward and backward with and without COD runs, at 60%, 80% and 100% of perceived maximum. To avoid the risk of diurnal variation to performance, all tests were completed at the same time of day (i.e. 18:30 to 21:30) and under similar environmental conditions (temperature: 19.2 °C to 24.6 °C and humidity: 70% to 94%). All the measurements were administrated by the same researcher.

20-m Sprint Test

The maximum running speed was measured by Brower Timing System (TCi-System, Draper, UT, USA) which was positioned 0.4 m above the ground. Participants used a standing start 0.5 m behind the starting line to avoid accidentally activating the first timing gate. They were instructed to sprint with maximal effort when the participant was ready. Two trials were provided to each participant with a five-minute rest in between. The time for each trial was recorded to the nearest 0.01 s, and the fastest time of completion was analysed. Excellent test-retest reliability (ICC > 0.90) and very small variability (coefficient of variation [CV] < 3.0%) were reported in 20-m sprint test (Lockie et al., 2013; Shalfawi et al., 2012).

Sector Reactive Agility Test (SRAT)

SRAT was a light-based reactive-agility test and was modified according to "fivefold run to the gates" (Popowczak et al., 2015; Popowczak et al., 2016). BlazePod™ (Play Coyotta Ltd, Tel Aviv, Israel), a recent visual-cognitive technology, connected with a mobile phone was used to record players' response time. BlazePod™ demonstrated good reliability (ICC, 95% CI = 0.82, 0.59–0.82) and

Table 1. Comparison of the demographics of the participants (n = 40). Data are means ± SD.

	Elite (n = 20)	Amateur (n = 20)	*p*-value
Age (year)	23.40 ± 2.60	25.50 ± 2.57	0.014*
Height (m)	1.73 ± 0.06	1.73 ± 0.06	0.732
Weight (kg)	67.73 ± 9.77	70.90 ± 6.09	0.23
BMI	22.65 ± 2.28	23.65 ± 1.97	0.334
Body fat (%)	18.01 ± 3.02	17.89 ± 4.36	0.917
Playing experience in Touch (year)	5.43 ± 3.01	1.98 ± 1.02	<0.001*

BMI = body mass index; * Significant different between groups (p < 0.05)

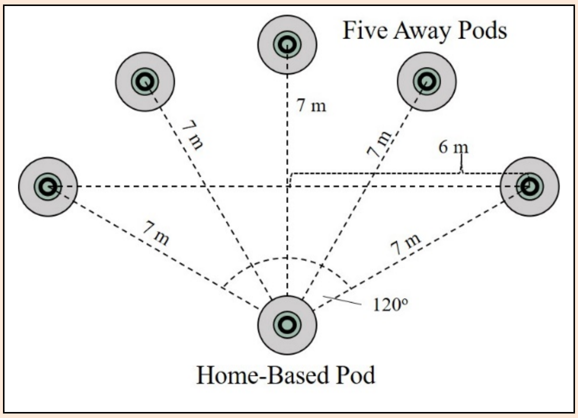

Figure 1. **The setup of SRAT in the present study.**

highly acceptable variability (CV, 95% CI = 3%, 2%–4%) in the response time (ms; de-Oliveira et al., 2021).

SRAT, requiring six back and forth travels, was designed to simulate the "touch" defensive scenario in Touch. Figure 1 illustrated the setup of BlazePod^{TM}, originally developed for this study. SRAT consisted of six light pods on the ground, one home-based pod and five away pods. The light pods created visual stimuli. To begin the test, the participants stood next to the home-based pod and tap it to start. Following a beep from the home-based pod, one of the away pods then randomly lit up in red. The participants were required to run to and tap it using either hand. At this point, the home-based pod lit up in green without delay, participants then retired and tap it. The home-based and away pods lit up 11 times in total (i.e. 6 aways and 5 homes) and the participants had to tap every light. Each participant's time of completion (in s) was automatically recorded on the mobile phone through a Bluetooth signal. In this study, the participants performed SRAT twice with a five-minute rest interval on each day, and the faster ones in each visit were analysed.

Statistical analyses

Statistical package SPSS version 27.0 (IBM Corp., Armonk, NY, USA) and Microsoft Excel (Microsoft, Redmond, Washington, United States) were used. Statistical significance was set at 0.05 (two-tailed). Normal data distribution was confirmed by the Shapiro-Wilk test. Multiple independent sample t-tests were used to examine the between-group differences of the demographic continuous variables, the times to completion in SRAT and 20-m sprint test. Effect size (ES) was interpreted using Cohen's d and was categorised as trivial (< 0.2), small (0.2–0.6), moderate (0.6–1.2), and large (1.2–2.0; Hopkins et al., 2009).

Relative reliability of SRAT and 20-m sprint test was determined by calculating ICC reliability analyses, two-way mixed effects, absolute agreement, single measurement ($ICC_{3,1}$) between testing occasions (Koo and Li, 2016). The reliability was classified as fair (0.25–0.50), moderate (0.50–0.75), good (> 0.75) and excellent (> 0.9; Portney, 2020). Absolute reliabilities of SRAT and 20-m sprint test between testing sessions were expressed as CVs, which were also used to determine the magnitude of measurement error. it was classified as good (<5%), moderate (5–10%), and poor (>10%). ICC ≥ 0.75 and CV ≤ 10% were defined as sufficient reliability. The minimal detectable change (MDC) was also calculated through the standard error of measurement (SEM) to highlight the practicality.

To determine if the 20-m sprint test and demographic variables predicted the agility performance, the Pearson correlation coefficient (r) was used to reveal the relationships among the performances of SRAT, the 20-m sprint test, and other demographic variables (i.e. playing experience in Touch, age, height, weight, and body fat%). Next, coefficients of determination (R^2) were used to explain the variance between variables by multiple linear regression analysis. Multicollinearity was checked whether any predictors had a variance inflation factor of > 10 and a tolerance value of < 0.1. The following values were references for the degrees of correlation: low, r = 0.10; moderate, r = 0.30; and high, r = 0.50 (Portney, 2020).

Results

The elite Touch players completed faster than the amateur Touch players in both SRAT (2.71 s; 95%CI: 1.82 s, 3.62 s, p < 0.001; d = 1.93) and the 20-m sprint test (0.11 s; 95%CI: 0.00 s, 0.21 s, p = 0.042; d = 0.67; Table 2). Pearson correlation analysis showed that the time of completion in SRAT was positively associated with that in the 20-m sprint test (r = 0.61, p < 0.001). Meanwhile, greater playing experience in Touch correlated to faster SRAT completion (r = -0.70, p < 0.001). However, no significant association was found between the time of completion in SRAT and the other demographic variables. Therefore, the multiple regression was run to predict the performance of SRAT from that of the 20-m sprint and the playing experience in Touch. The multiple regression model statistically significantly predicted SRAT performance, $F(2, 37) = 23.08$, $p < 0.001$, $R^2 = 0.56$. The two variables added statistically significantly to the prediction, p < 0.001. Regression coefficients were shown in Table 3.

The test-retest reliability of SRAT and the 20-m sprint test was assessed by $ICC_{3,1}$ for the entire sample (see Table 4). Results demonstrated excellent relative and absolute reliability in SRAT ($ICC_{3,1} = 0.97$; CV = 0.34%) and 20-m sprint test ($ICC_{3,1} = 0.91$; CV = 1.03%). The SEM and MDC were also presented for SRAT and the 20-m sprint test in Table 2. If changes in SRAT and the 20-m sprint test performance exceed 1.04 s and 0.13 s, correspondingly, these can be accepted as true changes that occur beyond measurement error.

Table 2. Comparison of the results of SRAT and the 20-m sprint test between Elite Touch players and Amateur Touch players (n = 40). Data are means ± SD.

	Elite (n = 20)	Amateur (n = 20)	*p*-value	Effect size
20-m sprint (s)	2.69 ± 1.56	2.80 ± 0.16	0.042*	*d* = 0.67
SRAT (s)	23.93 ± 1.65	26.65 ± 1.12	<0.001*	*d* = 1.93

SRAT = Sector Reactive Agility Test. *Significant different between groups ($p < 0.05$)

Table 3. Multiple regression results for SRAT among Touch players (n = 40).

SRAT	Unstandardized regression coefficient (B)	95% Confidence interval for B	Standardized coefficient (β)	R^2	adjusted R^2	*p* value
Model				0.56	0.53	
Constant	9.37	1.87, 16.86				0.016
20-m Sprint Test	6.21	3.53, 8.89	0.53			< 0.001
Playing experience in Touch	-0.30	-0.46, -0.15	-0.44			< 0.001

Model = "Enter" method i

Table 4. Reliability statistics for SRAT and the 20-m sprint test within Touch players (n = 40). Data are means ± SD.

	Trial 1 (s)	Trial 2 (s)	$ICC_{3,1}$	95% CIs	SEM	MDC (s)
20-m sprint test	2.76 ± 0.15	2.76 ± 0.17	0.91	0.84, 0.95	0.05	0.13
SRAT	25.44 ± 2.15	25.32 ± 1.96	0.97	0.94, 0.98	0.37	1.04

ICC = intraclass correlation coefficient; CI = confidence interval; SEM = standard error of measurement; MDC = minimal detectable change; SRAT = Sector Reactive Agility Test.

Discussion

This study was the first to examine the practicality of SRAT, a novel reactive-agility test in Touch. We discovered that SRAT was a highly reliable performance test to differentiate the elite Touch players from their amateur counterparts. The results particularly highlighted the physical advantages of elite Touch players due to the well faster time of completion in both SRAT and the 20-m sprint test (SRAT effect size: 1.93 [very large]; 20-m sprint effect size: 0.67 [moderate]). The minimal amount of measured changes (i.e. MDC) provided evidence and information for player selection and training monitoring, and determine true changes that occur beyond measurement error.

Strong reliability of SRAT was demonstrated in the entire sample in the present study, implying that this original testing protocol was highly reproductive. The $ICC_{3,1}$ established in this study was higher than those of Y-shaped agility test (ICC = 0.87–0.92; Gabbett et al., 2008a; Green et al., 2011; Sheppard et al., 2006) and "stop'n'go" reactive-agility test (ICC = 0.81–0.86; Sattler et al., 2015; Sekulic et al., 2014). It was also higher than that in the technical report of the BlazePod™ technology (ICC = 0.82; de-Oliveira et al., 2021). The reliability of "fivefold run to the gates" was not reported by Popowczak and his colleagues (2015, 2016). Notably, the familiarisation of the tests and the standardisation of the warm-up led to a promising assessment, given that the nature (open skill vs closed skill) of warm-up did not seem to compromise on reactive-agility performance (Gabbett et al., 2008b).

The elite Touch players considerably outperformed the amateur players in SRAT, shown by the very large effect size. This finding echoed the high discriminant validity in reactive-agility tests regardless of the types of stimulus (Morral-Yepes et al., 2022) and was similar to other studies examining levels of playing on sport-specific reactive-agility performance (Pojskic et al., 2018; Sekulic et al., 2017).

Subsequent correlation analysis showed that result of SRAT was positively associated with forward sprinting performance (i.e. 20-m sprint test) in this study. Besides, participants with more experience in Touch completed SRAT faster. Indeed, the length (years) of Touch training and 20-m sprinting performance could only explain 56% of the variance of SRAT results. These suggested that a substantial part of SRAT performance was not explained by physical qualities. Such a relationship was similar to the investigations of basketball, handball, and rugby variations (r = 0.33–0.78; Gabbett et al., 2008a; Horníková et al., 2021; Sheppard et al., 2006). The discrepancy might be due to the different kinds of sports and designs of the reactive-agility tests adopted. Specifically, Scanlan et al. (2016) recently supported that reactive-agility was the function of physical and cognitive components. Consistently, Horníková et al. (2021) reported that the contributions of sensory and motor components depended on the design of the reactive-agility test. They found that Y-shaped agility test, which involved a two-choice reaction (i.e. left and right), relied more on sprinting, COD and relative muscle strength, while a modified "stop'n'go" reactive-agility test, which reacted to four stimuli 20 times randomly, tended to demand more strength, speed and visual reaction time. Consequently, there was a tendency for the elite Touch players to possess better visual-motor reactions than their lower-level counterparts. However, cognitive involvement was not measured directly in this study and is warranted in the future.

In addition to forward and backward sprinting, two major components contributed to the performance of SRAT: i) response time to the light pods, and ii) postural control after receiving stimuli. In the present study, the sector setup of the light pods provided a 120° vision and created a high demand for visual scanning and cognitive loading in SRAT (Popowczak et al., 2015; Popowczak et al., 2020). SRAT requires participants to identify the lit pod before every forward movement. The five away pods created unpredicted multiple visual stimuli which forced athletes to select the relevant information from five possible sources, probably highly stressing cognitive loading (Hoffman, 2020). The use of LED lighting devices was shown to allow athletes to react to multiple visual stimuli appearing in different areas of the visual field (Arede et al., 2021). It was relevant to the level of spatial orientation of the participants. Reactive response to stimuli is a crucial component in unplanned agility performance (Trajkovic et al., 2020). When responding to external stimuli during multi-directional sprints, athletes who rely less on visual input to balance may have better visual perceptual skills for game reading and tactical executions (Chow et al., 2017).

The ability to manipulate body segments and accelerate to the correct away pod rapidly after receiving stimuli was also associated with the performance of SRAT. In this study, SRAT results could be predicted by playing experience in Touch (year). Constantly, better developed physical and skill qualities, and playing performance appeared to relate to greater playing experience in rugby league (Gabbett et al., 2011). Similarly, experienced Touch players are deemed to cope with the game demands better. A previous match-play analysis of an international Touch tournament highlighted the uniqueness of the game patterns: a high frequency of change of running velocity and a heavy reliance on deceleration capacity (Chow, 2020). Hence, in the current study, it was possible that the athletes not only could decelerate, stop, turn, and reaccelerate, when appropriate, but also favourably react to external stimuli during the repeated up-and-down sprints. This sport-specific quality could be reflected by the elite Touch players' superior performance in SRAT.

There were two limitations in this study. First, although SRAT adopted visual stimulus, which challenged participants' visual-motor coordination, the cognitive factors during the test were not directly measured; therefore, those contributions in this original developed SRAT remained uncovered. Second, although the relationships among the variables were evidenced in this cross-sectional study, there is no evidence of the causal relationship between the exposures to sprinting and playing experience and the outcome of reactive agility.

Conclusion

This study established the high reliability of the newly developed repeated up-and-down agility test, SRAT, and demonstrated its discriminant validity to differentiate elite Touch players from amateur players. The findings also illuminated the practical utility of SRAT for assessing Touch players' agility in a sports-specific scenario and raised questions about team selections without assessing related components. The more superior SRAT performance of the elite Touch players, compared with their lower counterparts, identifying the tendency for better visual-motor performance. Moreover, agility training and tests should mimic real-world situations, usually involving various and multiple stimuli. It is hoped that this study mobilises future studies on the reliability and validity of this original SRAT which simulates the sport-specific up-and-down agility scenario in Touch.

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Key points

- The newly developed reactive-agility test, SRAT, was shown to be a reliable and valid tool for agility assessment.
- Sensory components (i.e. visual-motor coordination) of agility could be assessed by handy and portable lighting devices.
- SRAT performance can possibly predict visual-motor performance.
- SRAT result was associated with sprint performance and playing experience in Touch.

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