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REACTIVE AGILITY TESTS FOR TEAM CONTACT SPORTS: A SYSTEMATIC REVIEW

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ABSTRACT

In team sports performance evaluation, reactive agility is one of the important factors that is able to discriminate the performance between elite and amateur athletes from their knowledge and expertise in the sports. Athletes in team sports should be able to adapt the real game situations and quickly plan their movement and action. In this sense, there is a growing number of interests in the factors influencing reactive agility performance due to training strategies and suitable training protocols. Therefore, this systematic literature review was carried out to summarize literature on reactive agility test (RAT) for team contact sports and offer sport coaches the best recommendations to develop and assess the agility quality of their athletes. An electronic database search was conducted to gather literature involving reactive agility tests used for discriminating skilled and less skilled athletes, irrespective of the design protocols. This is because, physical qualities are not the only factors that could differentiate an athlete's skill level, but also cognitive qualities or decision-making ability. After filtration, only 12 articles from over the past decade were found to meet the inclusion criteria for valid RAT. From this study, three RAT designs, namely VRAT (a live-size video projection of an opponent), LSRAT (an in-situ live-size stimulus design), and LIRAT (a light stimulus design) were identified. All the three RAT designs were able to discriminate skilled and less skilled athletes and were more reliable in testing the athletes' agility compared to pre-planned agility tests. Therefore, the athletes' perception and response time could be improved using sport specific reactive agility testing. For future research, more complex and specific environments that challenge the athletes' performance should be considered.

Keywords*:* reactive agility, agility, team sports, skilled players, less skilled players

INTRODUCTION

In sports, agility is divided into two types, namely planned and reactive agility. Planned agility happens when an athlete could predict in advance where and when he should move before making a change of direction, while reactive agility is the opposite. Agility is defined as 'the ability to quickly move the whole body with the changes of direction and speed as a reaction to specific stimuli in a sport' (Sheppard & Young, 2006). Even over a decade, this definition is still applied in some recent studies conducted by Sekulic et al., (2019), Trajkovic et al., (2020), and Krolo et al., (2020). However, experts such as biomechanists and sports scientists have their own perspective in defining agility. As suggested by Sheppard & Young (2006), the biomechanists' point of view on agility is related to mechanical changes, which involves the change in body position. Whereas sports scientists, specifically in the fields of motor learning and sports psychology, define agility in terms of information processing in the forms of visual scanning, decision making, and stimuli response to change direction.

In majority of sports that involve straight sprints with short distances and changes of direction, which are also known as change of direction speed (CODS), agility is dependent on individual physical fitness that can be pre-planned. While reactive agility involves a specific measure of individual physical fitness that is unable to be pre-planned and is focused on sports specific skills such as ball passing and the movement of teammate and the opposition team. In this sense, reactive agility test (RAT) is designed to evaluate the technical, cognitive, and physical qualities of an athlete.

Most studies developed RAT for team sports such as netball (Farrow et al., 2005), rugby (Gabbett et al., 2008; Gabbett and Benton, 2009; Serpell et al., 2010), football (Henry et al., 2011; Henry et al., 2012; Henry et al., 2013; Krolo et al., 2020), soccer (Pojskic et al., 2018; Trecroci et al., 2018; Rauter et al., 2018; Trajkovic et al., 2019), hockey (Morland et al., 2013), basketball (Lockie et al., 2014), and handball (Spasic et al., 2015). It was found that RAT is able to discriminate athletes' skills level of either skilled or less skilled, while a pre-planned agility test is not as capable. Generally, the studies revealed that highly skilled athletes could significantly perform faster than less skilled athletes. Whereas, in the pre-planned agility test, no significant differences were observed between the groups. Therefore, this systematic review aims to summarize the literature on RAT and provide guides with practical advice on the use and application of the test.

MATERIAL & METHODS

Literature review papers play an essential role in the overall diffusion of knowledge in any academic sector. They give the researcher a thorough awareness of the topic and its extent for future research possibilities. Author (Khandelwal et al., 2019) pointed out the literature review process must have a greater level of transparency through comprehensive content analysis of all related articles. This systematic review – and the searches associated with it – were performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) recommendations (Moher et al., 2010).

Data search criteria

An electronic-based data search using Google Scholar, Web of Science, and Scopus databases was employed to gather systematic literature on RAT and other relevant subjects. The keywords used for searching were reactive agility, agility, team sports, skilled players, less skilled players, and issues related to RAT by combining either of the words. The validity of RAT is evaluated based on its capability to discriminate a group of athletes from different skill levels and/or gender. Moreover, a RAT is considered reliable if it can produce similar results through more than one test. Next, the inclusion criteria of RATs that are taken into account for this systematic review include the usage of only English language, dated not more than 10 years (from year 2011 to 2021), involved comparisons of athletes' skill levels and gender, provided the total movement time or decision time, and displayed statistically significant results.

Extraction of data

A preliminary electronic search on the databases from Google Scholar, Web of Science, and Scopus have resulted in 55 articles. After exclusion of 6 duplicates, 49 articles remained for further validation. Subsequently, all articles that did not meet the specified criteria were excluded. Finally, as shown in Figure 1, the remaining 12 articles that meet all the inclusion criteria were used in the proposed systematic review.

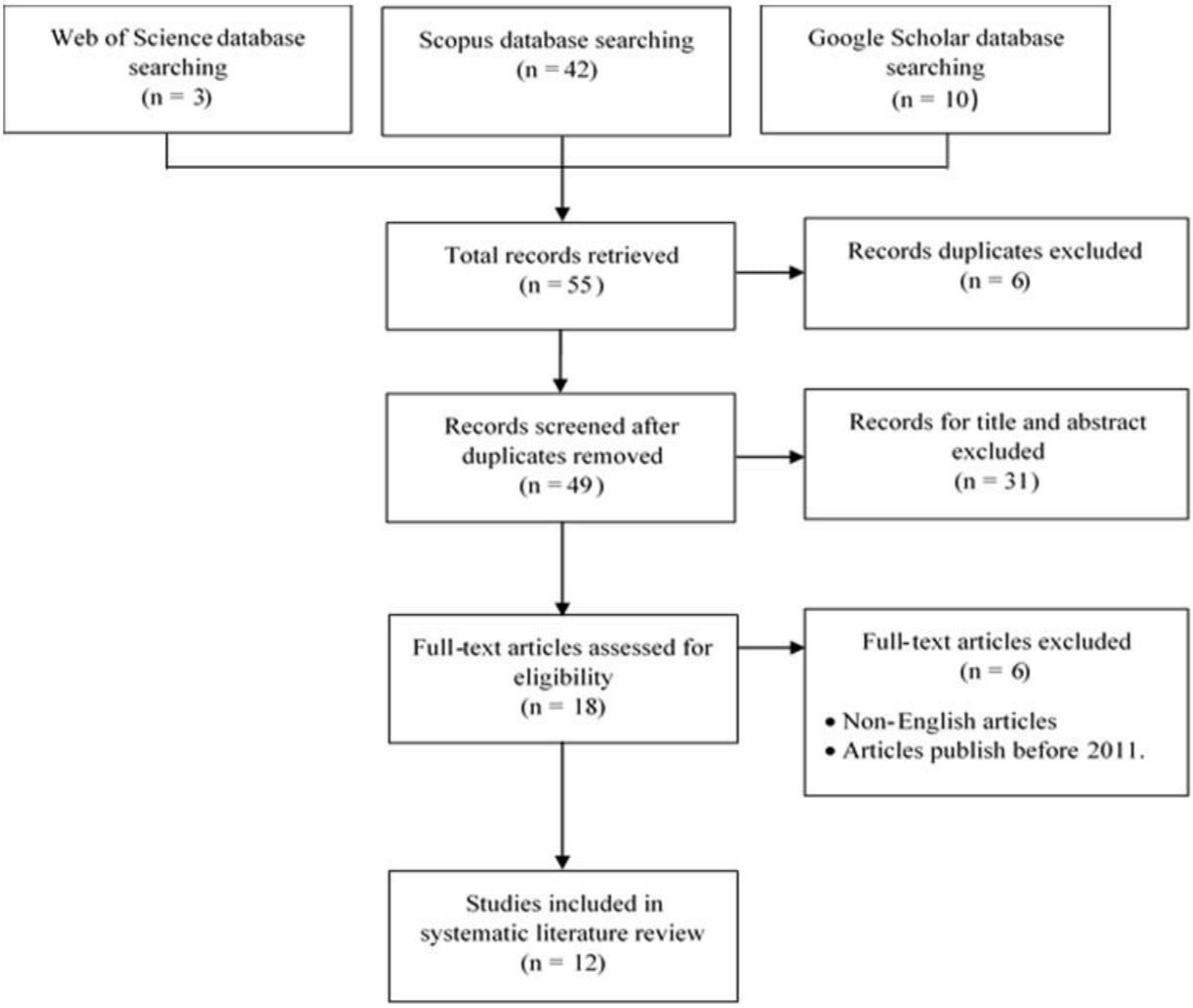

Figure 1. Modified process flowchart of systematic review

RESULTS

Summary of reactive agility test designs

Table 1 lists details on the 12 selected articles applied for this systematic review, including authors and year of publication, research title, journal, and impact factor (IF). In addition, the analysis results of these 12 articles are summarized in Table 2, where three different RAT designs for team contact sports are displayed; video stimulus RAT (VRAT), live-size stimulus RAT (LSRAT), and light stimulus RAT (LIRAT). VRAT involves a live-size video projection of an opponent, whereas in LSRAT, the tester acts as an opponent which provides a stimulus for response. On the other hand, LIRAT involves the lit of light as the stimulus for response.

The running pattern performed by an athlete can either be in Y-shaped, T-shaped, or universal direction. Out of the 12 articles, only Spasic et al., (2015) investigated T-shaped running pattern, while Rauter et al., (2018) and Pojskic et al., (2018) performed investigation on the universal direction running pattern. The other articles, on the other hand, studied the Y-shaped running pattern. Moreover, it was found that all the studies in these 12 RAT articles were effective and reliable in testing the reactive agility of athletes from team contact sports i.e. football, soccer, futsal, hockey, basketball, and handball. The outcome measure for all RATs included in this systematic review is mostly the total time recorded to complete the tests.

Table 1 – Author and year of publication, research title, journal, and impact factor (IF) of the selected journals

Author and Year of Publication	Research Title	Journal	Impact Factor (IF)
Henry et al., (2011)	Validity of reactive agility test for Australian football.	International Journal of Sports Physiology and Performance.	1.980
Henry et al., (2012)	Effects of a feint on reactive agility performance	Journal of Sport Science	2.504
Morland et al., (2013)	Can change of direction speed and reactive agility differentiate female hockey players?	International Journal of Performance Analysis in Sport	1.188
Henry et al., (2013)	Decision-making accuracy in reactive agility: quantifying the cost of poor decisions.	Journal of Strength and Conditioning Research	2.188
Lockie et al., (2013)	Planned and reactive agility performance in semi-professional and amateur basketball players.	International Journal of Sports Physiology and Performance	3.433
Spasic et al., (2015)	Reactive agility performance in handball: development and evaluation of a sport-specific measurement protocol.	Journal of Sport Science and Medicine	1.708
Pojskic et al., (2018)	Importance of reactive agility and change of direction speed in differentiating performance levels in junior soccer players: reliability and validity of newly developed soccer-specific tests.	Frontiers in Physiology	3.289
Rauter et al., (2018)	Analysis of reactive agility and change-of-direction speed between soccer players and physical education students.	Human Movement	0.44
Trecroci et al., (2018)	Field-based physical performance of elite and sub-elite middle-adolescent soccer players	Research in Sports Medicine	2.667
Sekulic et al., (2019)	Importance of agility performance in professional futsal players; reliability and applicability of newly developed testing protocols.	International Journal of Environmental Research and Public Health.	3.180
Trajkovic et al., (2020)	The importance of reactive agility tests in differentiating adolescent soccer players.	International Journal of Environmental Research and Public Health.	2.849
Krolo et al., (2020)	Agility testing in youth football (soccer) players; evaluating reliability, validity, and correlates of newly developed testing protocols.	International Journal of Environmental Research and Public Health	2.849

Table 2 – Summary of reactive agility test (RAT) studies

Study	RAT Design	Participants Group	Participants Number	Objective	Study Outcomes	Results
Henry et al., (2011)	Video and light stimuli in Y-shaped pattern	Male football players and non-football players	N=42 n=15 (Top AFL U19 team – highly skilled) n=15 (Lower grade AFL – moderately skilled) n=12 (Non-football athletes – less skilled)	To evaluate the reliability and validity of RAT under two conditions (video stimulus of an opponent and light stimulus) and CODS in discriminating different skill levels.	3m time Decision time Total time Agility time Movement time	VRAT: Able to discriminate players' skill levels better than LIRAT. LIRAT: Highly skilled players performed better than moderately and less skilled players in decision time. CODS: No significant difference observed between group players.
Henry et al., (2012)	Video stimulus in Y-shaped pattern	Male football players	N=28 n=14 (semi-pro AFL players – highly skilled) n=14 (amateur AFL players – less skilled)	To evaluate the reliability and validity of RAT using video stimulus under two conditions (with feint and without feint) in discriminating different skill levels.	Decision time 1 (non-feint trials or first feint trial) Decision time 2 (for feint trial) 3m time Total time Agility time Movement time	VRAT: Highly skilled players performed better than less skilled players in feint and non-feint agility time, decision time 1, and feint movement time. Able to discriminate different skill levels.

Study	RAT Design	Participants Group	Participants Number	Objective	Study Outcomes	Results
Morland et al., (2013)	Live-size and light stimuli in Y-shaped pattern	Female hockey players	N=20 n=10 (state players – highly skilled) n=10 (school players – less skilled)	To evaluate the reliability and validity of RAT under two conditions (live-size stimulus and light stimulus) and CODS in discriminating different skill levels.	Total time	LSRAT: Higher skilled players were more agile than less skilled players. CODS and LIRAT: No differences observed in total time between highly skilled and less skilled players.
Henry et al., (2013)	Video stimulus in Y-shaped pattern	Male football players	N=28 n=14 (semi-pro AFL players – highly skilled) n=14 (amateur AFL player – less skilled)	To evaluate the reliability and validity of RAT using video stimulus under two conditions (with feint and without feint) in discriminating different skill levels. To compare the accuracy of decision-making and the time cost of error responses between higher and less skilled group players.	**Decision accuracy** Correct and incorrect direction: Decision time 1 (non-feint trials or first feint trial) Decision time 2 (for feint trial) Total time Agility time Movement time	VRAT: Decision accuracy was similar between group players at decision time 1, while highly skilled players performed better in decision time 2 than less skill players. Skill group pooled: For feint and non-feint correct direction; decision time 1, decision time 2, and agility times were longer, but movement time was similar, while for non-feint and feint group, all outcomes were shorter. Able to discriminate players' skill levels.

Study	RAT Design	Participants Group	Participants Number	Objective	Study Outcomes	Results
Lockie et al., (2014)	Light stimulus in Y-shaped pattern	Male basketball players	N=20 n=10 (semi-pro in Australian professional league – highly skilled) n=10 (amateur player – less skilled)	To evaluate the reliability and validity of RAT and CODS in discriminating different skill levels.	Total time	LIRAT: Higher skilled group was significantly more agile than the less skilled group. CODS: No significant difference observed between group players.
Spasic et al., (2015)	Light stimulus in T-shaped pattern	Male and female handball players	N=49 (League of the National Championship in 2013-2014 season) n offensive: 14 male players 13 female players n defensive: 12 male players 10 female players	To evaluate the reliability and validity of RAT and CODS on a handball team.	Total time	Reliability: Both male and female players showed satisfactory results in CODS and LIRAT. Validity: Both CODS and LIRAT were valid in defining real game situation performance for both genders.
Rauter et al., (2018)	Light stimulus in universal direction pattern	Male and female soccer players and physical education students	N=36 (Various sports clubs soccer players) n=12 (male players) n=24 (female players) N=58 (physical education students) n=36 (male students) n=22 (female students)	To evaluate the reliability and validity of RAT and CODS discriminating soccer players and physical education students.	Total time	LIRAT: Soccer players were significantly more agile than physical education students and male players were significantly faster than female players. CODS: Soccer players were significantly more agile than physical education students.

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Study	RAT Design	Participants Group	Participants Number	Objective	Study Outcomes	Results
Pojskic et al., (2018)	Light stimulus in universal direction pattern	Youth male soccer players	N=20 n=10 (U19 – highly skilled) n=10 (U17 – less skilled)	To evaluate the reliability and validity of newly developed RAT and CODS in discriminating youth soccer players.	Total time	LIRAT & CODS: Highly skilled players displayed significantly better results than the less skilled players.
Trecroci et al., (2018)	Live-size stimulus in Y-shaped pattern	Male soccer players	N=40 (Youth Italian soccer teams) n=20 (national players – highly skilled) n=20 (regional players – less skilled)	To evaluate the reliability and validity of RAT in discriminating the field-based physical performance of higher and less skilled players.	Total time	LSRAT: Highly skilled players exhibited significantly better performance in field-based physical performance than less skilled players.
Sekulic et al., (2019)	Light stimulus in Y-shaped pattern	Male futsal players	N=32 (Competing at the highest national level in Croatia) n=12 (top-level players – highly skilled) n=20 (team-level players – less skilled)	To evaluate the reliability and validity of newly developed sport specific RAT and CODS with dominant and non-dominant sides in discriminating different skill levels.	Total time	Reliability: Both LIRAT and CODS with dominant side were reliable, but LIRAT with non-dominant side was non-reliable. LIRAT & CODS: Highly skilled players performed significantly better than less skilled players.

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Study	**RAT Design**	**Participants Group**	**Participants Number**	**Objective**	**Study Outcomes**	**Results**
Trajkovic et al., (2020)	Live-size and light stimulus in Y-shaped pattern	Adolescent male soccer players	N=75 n=25 (national players – highly skilled) n=27 (regional players – moderately skilled) n=23 (club level players – less skilled)	To evaluate the reliability and validity of RAT, CODS, and speed in discriminating different skill levels.	Total time Response movement time	LIRAT and LSRAT: Highly skilled players demonstrated significantly superior total time and response movement time than moderate and less skilled players. CODS: Highly and moderately skilled players were significantly more agile than less skilled players.
Krolo et al., (2020)	Light stimulus in Y-shaped pattern	Young male soccer players	N=59 n=29; U13 n=14 (starters – highly skilled) n=15 (non-starters – less skilled) n=30; U15 n=15 (starters – highly skilled) n=15 (non-starters – less skilled)	To evaluate the reliability and validity of newly developed sport specific RAT and CODS in discriminating different skill levels.	Total time	Reliability: Both U13 and U15 showed better reliability in the LIRAT and CODS. LIRAT & CODS: Highly skilled players were significantly more agile than less skilled players for both U13 and U15.

Reactive agility test (RAT) procedure

In this systematic review, three design patterns were considered; Y-shaped, T-shaped, and universal direction, which required the tested athletes to primarily understand the overview of running protocol in each design before undergoing the tests. The running protocols for Y-shaped RAT involved athletes to run in a Y-shaped pattern by running forward and reacting to either live-size, video, or light stimuli by making a 45° cut to the right or left and running to the finish line. While in T-shaped RAT, the athletes were required to run forward to the centre then react to the lit light by shuffling to the right or left and back to the centre, before running back to the starting line. For universal direction RAT, the protocols required the athletes to cross the centre, break a base light signal using their preferred hand to ignite one of the six other lights, then react by running as fast as possible toward a cone around the lit light, and finally return to the base light to ignite the next light until all lights are ignited.

Video stimulus reactive agility test (VRAT)

Among the twelve (12) articles included in this systematic review, two (2) studies by Henry et al., (2012) and Henry et al., (2013) employed VRAT solely while one (1) applied a combination of VRAT and LIRAT (Henry et al., 2011). In these studies, RAT was designed to measure the reactive agility of male Australian Rules football players using a similar Y-pattern design. In the first study, Henry at al., (2011) utilized VRAT to test reactive agility, while in the second study, Henry et al., (2012) tested reactive agility under two conditions; with and without feint.

Lastly, apart from reactive agility test, Henry et al., (2011), Henry et al., (2012), and Henry et al., (2013) had also tested the accuracy of decision-making and time cost of responses of the group players. As illustrated in Figure 2, although the distance of the screen from the starting position varies, players are still required to respond in a similar way, which is to run forward and make a 45° cut to the left or right when a stimulus is presented.

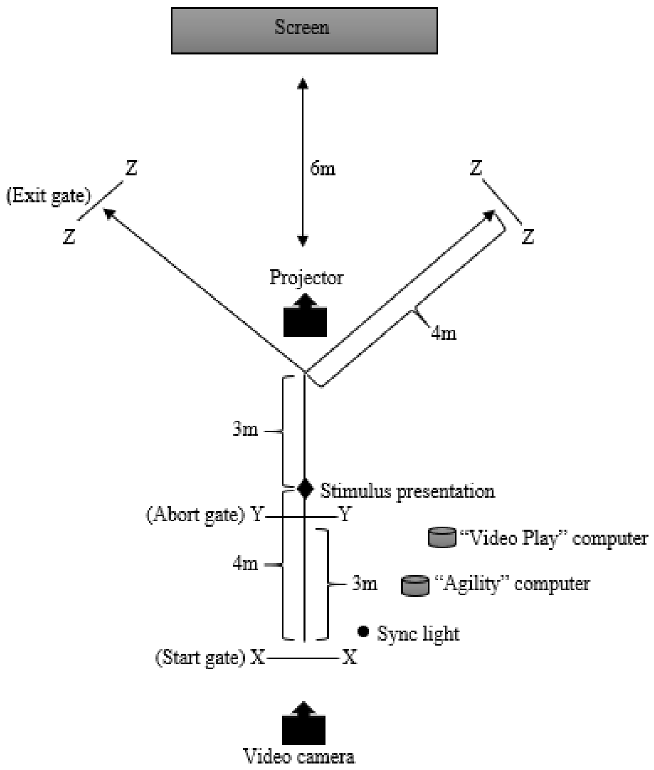

Figure 2. Schematic VRAT design proposed by Henry et al., (2011; 2012; 2013)

Live-size stimulus reactive agility test (LSRAT)

Among the twelve (12) articles included in this systematic review, one (1) study by Trecroci et al., (2018) utilized LSRAT solely while two (2) studies employed a combination of LSRAT and LIRAT. Trecroci et al., (2018) designed LSRAT to measure the reactive agility of elite and sub-elite middle-adolescent soccer players by applying a similar Y-pattern design with no specific sports stimulus, as shown in Figure 3. The tester is located opposite to the players and after an initial sprint, the players need to respond by making a 45° cut to the left or right, in opposition to the tester's movement. On the other hand, Morland et al., (2013) and Trajkovic et al., (2020) employed the combined LSRAT and LIRAT to evaluate the performance of female hockey players with hockey specific stimulus condition and adolescent male soccer players, respectively, using a similar protocol as described by Trecroci et al., (2018).

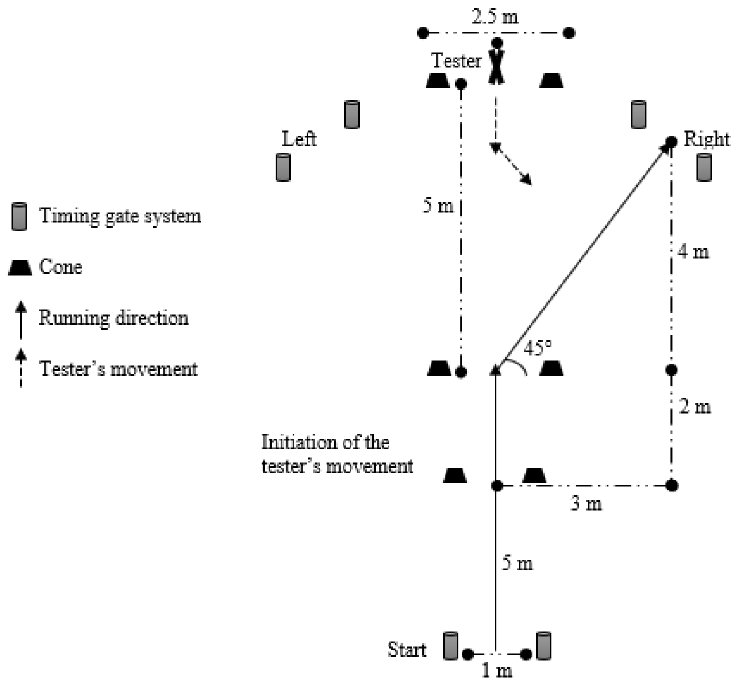

Figure 3. Schematic LSRAT design proposed by Trecroci et al., (2018).

Light stimulus reactive agility tests (LIRAT)

Among the twelve (12) articles included in this systematic review, six (6) employed the LIRAT design solely. The first Y-shaped LIRAT design as shown in Figure 4 was designed by Lockie et al., (2014) to measure the reactive agility of male basketball players. On the other hand, Sekulic et al., (2019) and Krolo et al., (2020) tested the reactive agility of male futsal and soccer players respectively using the same distinctive Y-pattern design. Another LIRAT design was introduced by Spasic et al., (2015) in T-pattern to test the reactive agility of both male and female handball players in offensive and defensive positions in the National Handball League Championship from 2013 until 2014, as shown in Figure 5. Moreover, Rauter et al., (2018) and Pojskic et al., (2018) designed universal direction LIRAT to test the reactive agility of soccer players as shown in Figure 6 and Figure 7, respectively.

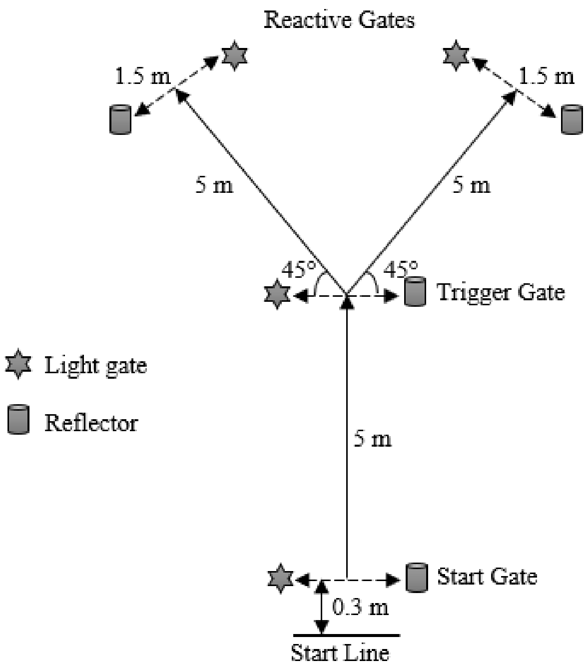

Figure 4. Schematic RAT for LIRAT by Lockie et al., (2014)

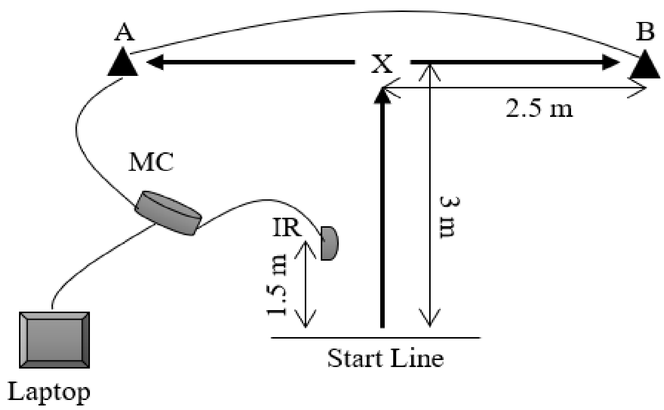

Figure 5. Schematic RAT for LIRAT by Spasic et al., (2015)

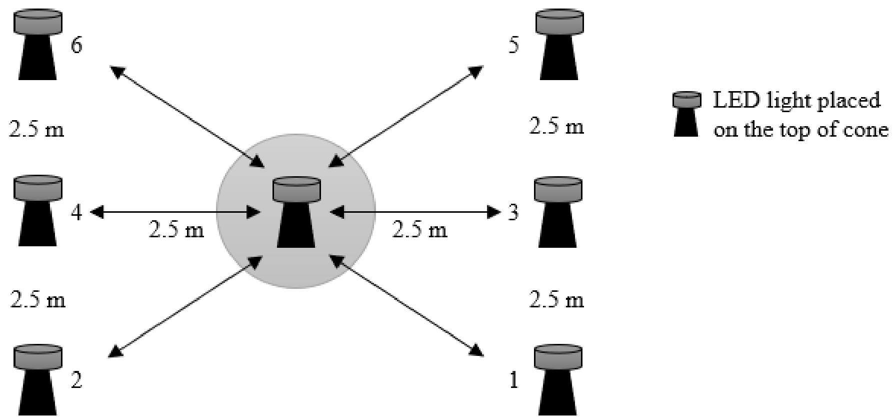

Figure 6. Schematic RAT for LIRAT by Rauter et al., (2018)

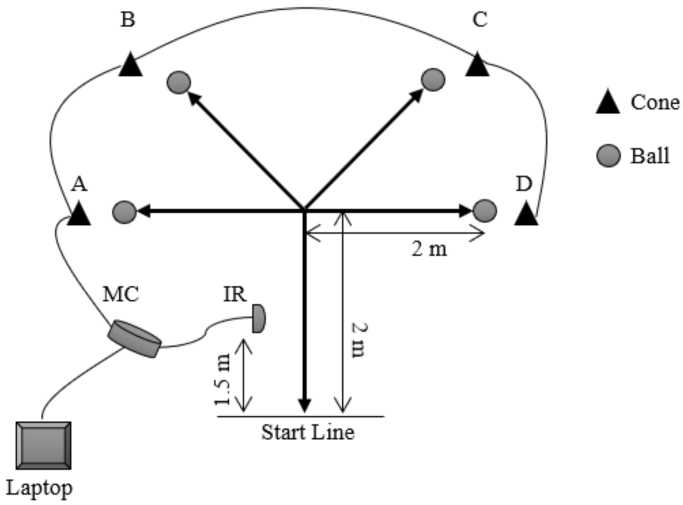

Figure 7. Schematic RAT for LIRAT by Pojskic et al., (2018)

Result indicators for reactive agility test (RAT)
All the twelve RATs included in this systematic review presented total recorded time as one of the result indicators. However, only four studies measured decision/response time and movement time (Henry et al., 2011; Henry et al., 2012; Henry et al., 2013; Trajkovic et al., 2020). Movement time is defined as the total time required to complete a test, which is the time taken from when the tester initiates the test and starts timing, until the participant triggers the timing beam on both sides of the tester (Gabbett & Benton, 2009). Decision/response time, on the other hand, is defined as the time taken for an athlete to react and make the decision to run either to the left or right in response to a stimulus (Clark et al., 2010).

DISCUSSION

All the reviewed studies indicated that RAT is an effective and reliable method for assessing reactive agility based on different skill levels. Henry et al., (2011) disclosed that a VRAT is capable of distinguishing athletes from their skill levels. Similarly, Morland et al., (2013) emphasized that a LSRAT can distinguish hockey players of different skill levels while Lockie et al., (2014) reported that a LIRAT can distinguish male basketball athletes of high and low skill levels. The common finding in these studies is that athletes with higher skill levels were measured to be faster in the RAT either of video-based stimulus, live-size stimulus, or light stimulus. This is because highly skilled athletes have better decision-making ability and pre-determined movement strategies as compared to less skilled athletes.

Moreover, highly skilled athletes are experts and have better knowledge in their field, meaning that they have better perceptual and cognitive skills than less skilled athletes. This was supported by Mann et al., (2007) in their study on meta-analysis of expertise in sports. The authors stated that perceptual and cognitive skills refer to the ability of athletes to recognize and acquire environmental information to integrate with their existing knowledge, so that they can choose and implement appropriate responses. Based on the elements of decision-making ability, knowledge, and expertise of athletes, the hierarchy of agility testing instrument can be drawn as shown in Figure 8. In LSRAT, the reaction of stimulus is unpredictable, so the tested athletes need high ability of decision-making and knowledge to complete the test. Whereas, in VRAT and LIRAT, the tested athletes need intermediate and moderate decision-making ability and knowledge, respectively to complete the tests. Lastly, in CODS, no decision-making ability is needed to perform the test, meaning that not only team sports can undergo this agility test, but also individual sports.

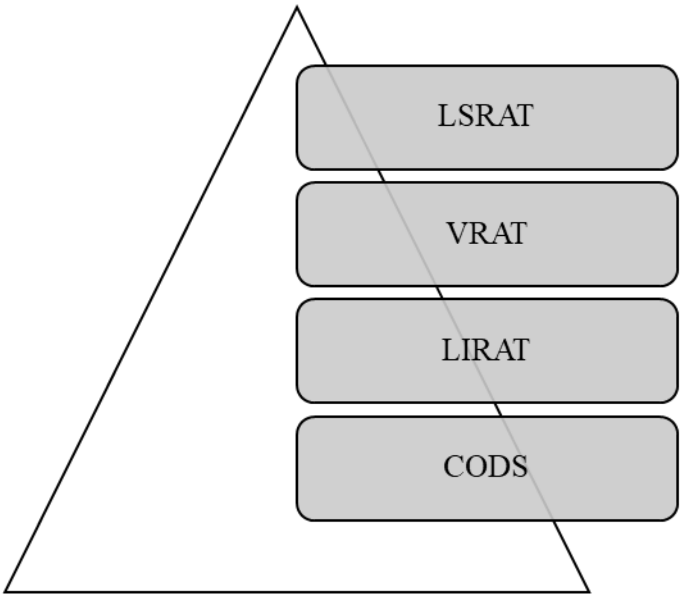

Figure 8. Hierarchy of agility testing instrument

Besides, Trajkovic et al., (2020) had proven that a LSRAT could successfully distinguish adolescent male soccer players from three different skill levels. However, the key difference lies in the response movement time factor. Once again, highly skilled players performed much better in RAT, which may be attributed to their excellent response movement ability. It is worth noting from the study that highly skilled athletes (elites) demonstrated better reaction time than moderately skilled athletes (sub-elites) and less skilled athletes (amateurs) due to their ability to predict the direction of movement expected by their opponents, and the ability to predict their change of direction to complete the sprint part of the test at a faster speed.

It is consistent that the RAT results in this systematic literature review can distinguish athletes of different skill levels, but it is more important to evaluate the reliability and validity of RAT for distinguishing different genders. This is emphasized by Spasic et al., (2015) whom examined the reliability and validity of RAT for evaluating male and female handball players. They revealed that both genders showed satisfactory and valid RAT results in defining real game situation performance. Furthermore, the results were supported by Rauter et al., (2018) in their study on male and female soccer players, where the reactive agility of male soccer players was significantly faster than female soccer players. They found that male athletes have a higher natural motor potential than female athletes, especially in terms of power, reactive strength, and speed (acceleration and deceleration).

Strength and limitations

The primary aim of this systematic literature review (SLR) is to investigate the reactive agility difference between highly skilled and less skilled athletes of team contact sports. Among the 12 studies included in the SLR, 17%, 8%, 50%, and 25% of them utilized VRAT, LSRAT, LIRAT, and a combination between two of the three stimuli, respectively. When designing RAT, the advantages and disadvantages of each method should be simultaneously considered. It was proven that in designing RAT, sport-specific stimuli should be applied in order to discriminate players' skill levels as stated by Trajkovic et al., (2020), which was also supported by Rauter et al., (2018) in their study.

The major limitation of the three RAT designs is limited output indicator of only total time. Moreover, a few studies did not take into account decision/response time and movement time as the indicators (Morland et al., 2013; Lockie et al., 2014; Spasic et al., 2015; Rauter et al., 2018; Pojskic et al., 2018; Trecroci et al., 2018; Sekulic et al., 2019; Krolo et al., 2020). The evaluation of decision/response time is deemed crucial in comprehending the rationality of the current findings due to anticipatory skills exhibited by different players, and this was supported by Trecroci et al., (2018) in their study.

In addition, Spasic et al., (2015) elucidated satisfactory and valid RAT results for defining real game situation performance of both male and female athletes. However, in this systematic review, only one study conducted by Rauter et al., (2018) had included gender difference in evaluating the reactive agility of athletes. Nevertheless, the hypothesis for this evaluation was not concrete.

CONCLUSIONS AND FUTURE WORK RECOMMENDATION

The systematic literature review revealed that RAT is a reliable and valid method for assessing athletes' agility. From the study, all the three RAT designs; VRAT, LSRAT, and LIRAT exhibited their own advantages and disadvantages. However, to ensure the most accurate test results are obtained, the design and implementation of RAT need to be carefully considered. From coaches' and sport scientists' point of view, reactive agility training and testing, especially for team sports, should not be limited to pure CODS tasks, but should involve sport specific scenarios with full-spaces configurations including decision-making tasks. Additionally, future work should also measure the perception and response time as well as movement time, not only to distinguish the skill level of athletes, but also to determine their strength and weaknesses (Safaric & Bird, 2011).

In terms of test design, majority of the literature reported Y-shaped test configuration through which the participants are required to perform a common 45° cut. An alternative methodological design is necessary, and if it is based on observational research to achieve ecological effectiveness, greater credibility may be obtained. It seems necessary to consider the risks from the current Y-shaped test design and investigate alternative methods. Finally, future studies should take into account gender difference when designing RAT in in order to evaluate the performance of both genders athletes in real game situation and also for talent identification (TID).

From a practical point of view of all three RAT designs, LSRAT and LIRAT provide field and laboratory test and training tool for strength and conditioning coaches even though LSRAT is less recommended to use as a training tool. While VRAT is preferred for laboratory test and this was supported by Paul et al., (2016) in their study. On the other hand, from the coaches' point of view, RAT should not only target the scenarios such as stepping left and right, but also as much sport specific as possible e.g. passing, jumping, kicking, and ball handling to challenge the athletes. On top of that, the confidence level of athletes should also be included and measured in RAT to avoid invalid results for coaches' reference.

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