Materials : Fitness and Conditioning

Agility test for rugby using sidestep

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The purpose of this study was to develop a method to evaluate the agility of rugby players by change of direction using the sidestep while running, and clarify the characteristics of the movement. Subjects were 38 university rugby players (FW: 20, BK: 18, height: 175.2±5.4 cm, weight: 84.8 kg, age: 20.4±0.9 years old). In the agility test employed, the subject stops with both legs after a 5m sprint, and moves 1m sideways using a sidestep to change direction of movement, and then repeats the sprint and sidestep. Measurement times were reproducible (P<0.01), and there was a significant difference in the section where sidestepping took place and in the deceleration section directly before the sidestepping action between the FW and BK groups (P<0.01). Running speed of the FW group was significantly slower than that of the BK group in the sidestepping section (P<0.01). In this study, the running direction was changed by sidestepping instead of making a 180-degree turn. This method was considered useful in evaluating the agility of rugby players, including their skill to evade opponents.

Keywords: Side step, Agility, Rugby

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1. Introduction

Among the team sports, rugby requires both sprinting and running according to the situation on the field. Players on the offense advance the ball by evading players on the defense, and players on the defense attempt to stop the movement of players on the offense who are trying to evade them. These movements require different responses to opponent movement according to position. Young et al. (2002) reported that individual player agility has a significant impact on running in response to an opponents' movements. They also argued that agility consists of two factors; namely, perception and decision-making, and change of direction speed (CODS).

Rugby players not only often accelerate or decelerate to adjust their running speed, but also quickly decelerate to change direction of movement while running. To date, investigators have employed a wide range of measuring methods to evaluate the agility associated with running in such players. These include Illinois Agility Test (Caldwell, 2009; Cureton, 1951; Roozen, 2008; Wilkinson, 2009), L-Run (Reiman, 2009), the Pro-Agility Test (Harman, 2000), the T-test (Miller, 2006; Semenick, 1994), and the 505 Agility Test (Draper, 1985). Stewart et al. (2012) examined and reported correlations among tests. A commonality among these tests is the performance of a 180-degree turn. Hewit et al. (2012) reported that the ability to make a 180-degree turn is influenced by muscle strength, power, adjustment ability, and pattern of movement.

Movement is often employed in rugby games to evade opponants, and a wide range of evasive running patterns, such as 180-degree turns and slight changes in direction, are available. For example, when a player escapes from the ruck or maul, he might stop quickly, change direction slightly by sidestepping, and move forward. This movement requires stepping ability to evade opponents, and this is often performed in combination with faints. However, there is no method of evaluating player agility in changing direction sideways while running.

Therefore, this study was conducted to develop a method of evaluating rugby player agility in changing direction while running by sidestepping, and to clarify the characteristics of such movement.

2. Method

2.1. Subjects

Subjects of this study were 38 healthy rugby players enrolled at University A (height: 175.2±5.4

cm, weight: 84.8 kg, age: 20.4±0.9 years). There were 20 forwards (FW) and 18 backs (BK).The team was ranked among the top teams in the Kansai University A League (past three years). We explained measurement items and risks to subjects, and obtained informed consent prior to participation in the study.

2.2. Measurement Method

In this study, subjects sprinted 15 m with intermittent sidesteps, as shown in **Figure 1**. Subjects dashed from the start line, passed through an area surrounded by cones (shown as ▲) sidestepping toward the right, dashed and passed through another area surrounded by cones (shown as ▲) sidestepping toward the left, and finished running at an end line. We explained to subjects that this is a Stop & Sidestep Test (SST), and asked them to stop with both legs after sprinting, and run through the cone areas repeatedly using intermittent sidestep. Measurements were conducted on the artificial turf where they

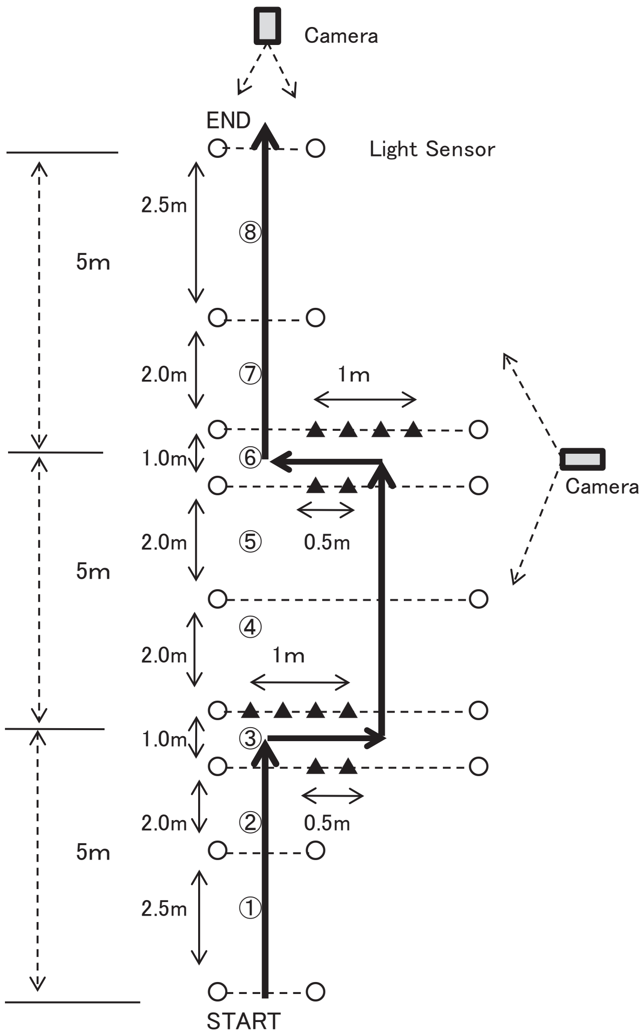

Figure 1 The Stop & Sidestep Test (SST)

exercise on a daily basis.

It was the first time for subjects to undergo this measurement. Therefore, they ran twice to warm up and familiarize themselves with the procedure. We measured running time twice and used the mean values for each subject. Both measurements were used to examine the reproducibility of the measurement times.

We placed a photoelectric tube and measured section times to understand the characteristics of each subject's movements. Furthermore, we placed two high-speed cameras (High Speed Exilim EX-GZ, CASIO, with 240fps photography speed and 1/1000 sec shutter speed) at 1.2 m to observe the sidestepping of each subject before the end line. Twenty-five measurement points were set on subject bodies based on their individual VTR images, and their movements were analyzed by three-dimensional motion analysis utilizing a motion analysis system (FrameDIAS IV, DKH). In addition, we determined optimum high cut-off frequency (2.4 0 8.4 Hz), obtained smoothened coordinate data utilizing the Butterworth digital filter, and calculated subject movement speed.

We further calculated center of gravity coordinates for each subject based on the smoothened coordinate data of the body points to be analyzed utilizing Ae's Body Segment Inertia Parameters (1996). We differentiated coordinates of the center of gravity to obtain the velocity of the center of gravity.

2.3. Questionnaire Survey for Coaches

Next, we delivered a questionnaire to two team coaches to compare their evaluation of player agility with the results obtained in this study. The evaluation was scored according to a five-point scale. The questionnaire items were as shown below.

[Questionnaire to Coaches: 5-point evaluation (1. Poor – 5. Excellent)]

A. How would you rate this subject's agility?
B. How would you rate this subject's ability to evade opponents in games?
C. How would you rate this subject's ability to quickly decelerate or stop?
D. How would you rate this subject's ability to take one step forward?
E. How would you rate this subject's ability to sprint?

The scale of evaluation was from 1 to 5, with 1 being "poor" and 5 being "excellent." The questionnaire environment prevented opinion exchange. The mean value of the evaluations in the questionnaire was considered as the evaluation of each subject.

2.4. Statistics

Measurements were shown as mean±stanadrd deviation. Reproducibility of results was examined by paired t-test for two measurements, and Pearson's product-moment correlation coefficient was used to clarify reproducibility. A paired t-test was used to compare the mean values between FW and BK. We set significance at less than 5% for both tests.

3. Results

SST test was classified into the eight sections and running times shown in **Table 1** to indicate the reproducibiity of the 1st and 2nd measurement results. Total running time in the 1st measurement was 4.16±0.28 seconds and 4.14±0.22 seconds in the 2nd measurement, which revealed a correlation between the two tests (r=0.877, p<0.01). All running times in the eight sections revealed a correlation (p<0.01).

Table 2 shows the running time for FW and BK in each section. The total running time of subjects was 4.14±0.25 seconds (FW: 4.33±0.28 seconds, BK: 3.94±0.14 seconds), which revealed a significant difference between the two groups (p<0.05). BK was significantly faster than FW (p<0.05) in sections (3) and (6), for direction change, and sections (2) and (5), for deceleration, as shown in **Figure 1**.

Figure 2 shows the center of gravity for the fastest FW and BK athletes. The horizontal axis shows time, with "0" indicating the time that both feet were placed on the ground in measurement section (6) in **Figure 1**. This revealed that subjects decelerated quickly, maintained a certain center of gravity shift velocity when both feet were placed on the ground, and accelerated in approximately 0.4 seconds. Therefore, we also obtained the peak center of gravity shift velocity immediately before deceleration while running, and the lowest velocity at sidestep after placing both feet on the ground for each subject (**Table 3**). According to peak velocity and velocity at sidestep, the BK group showed significantly higher values than the FW group did (p<0.01).

Then, we asked the two team coaches to evaluate five items regarding the agility of each subject.

Table 1 Relationship between 1st and 2st test results

			t-test		correlation coefficient	
	1st	2nd	t	P	r	P
0～1	0.797±0.064	0.786±0.057	1.961	0.098	0.832	<0.01
1～2	0.575±0.085	0.564±0.062	1.433	0.163	0.849	<0.01
2～3	0.435±0.116	0.444±0.091	−1.198	0.241	0.921	<0.01
3～4	0.548±0.102	0.536±0.091	1.573	0.127	0.894	<0.01
4～5	0.399±0.105	0.406±0.088	−1.087	0.287	0.913	<0.01
5～6	0.508±0.068	0.500±0.044	1.113	0.276	0.813	<0.01
6～7	0.449±0.039	0.455±0.031	−1.268	0.216	0.767	<0.01
7～8	0.447±0.032	0.452±0.024	−1.269	0.215	0.681	<0.01
Total Time	4.159±0.284	4.143±0.216	0.746	0.412	0.877	<0.01

Table 2 SST time

	1 section	2 section	3 section	4 section	5 section	6 section	7 section	8 section	Total Time
ALL	0.79±0.06	0.57±0.07	0.44±0.10	0.54±0.10	0.40±0.10	0.49±0.04	0.45±0.03	0.45±0.03	4.14±0.25
FW	0.81±0.05	0.60±0.06*	0.47±0.10*	0.57±0.10	0.45±0.08*	0.51±0.05*	0.47±0.03*	0.45±0.02	4.33±0.28*
BK	0.77±0.06	0.54±0.05	0.41±0.09	0.52±0.07	0.36±0.09	0.47±0.03	0.43±0.03	0.44±0.03	3.94±0.14

*: P<0.05

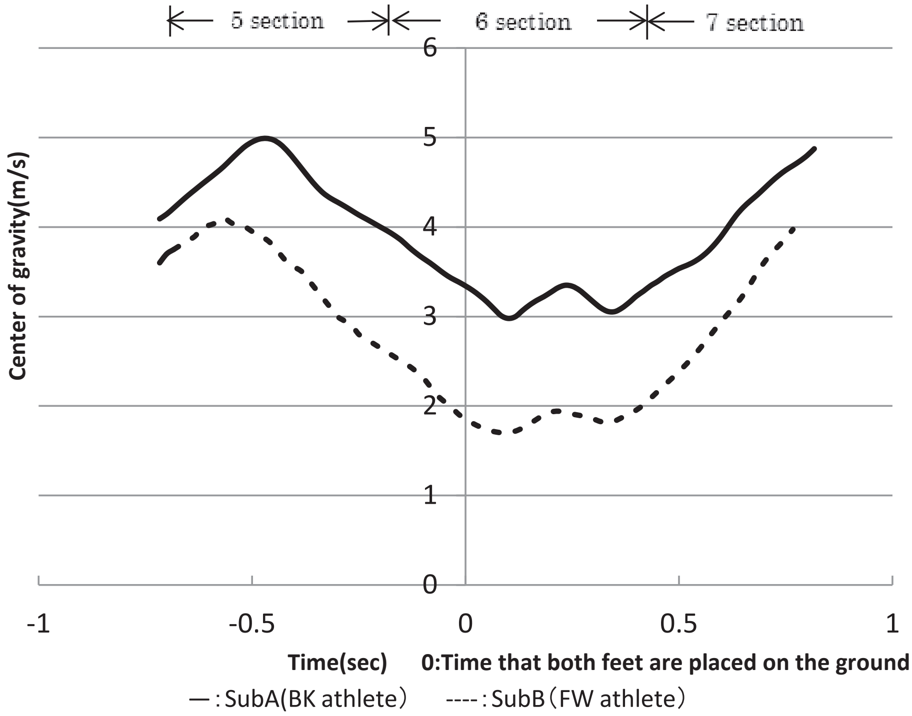

Figure 2 Velocity of center of gravity in sidestep motion section

Table 3 Velocity at sidestep motion

	Peak Velocity (m/s)	Velocity at sidestep motion(m/s)
ALL	4.61±0.45	2.37±0.39
FW	4.25±0.38*	1.89±0.29*
BK	4.92±0.39*	2.98±0.20*

＊: FW VS BK P<0.01

Table 4 shows the reliability of evaluation by the coaches with interclass correlation coefficients. No significant difference was observed among the five items between the two coaches. The correlation between SST time and evaluation by coaches in (A) *comprehensive agility* was r=0,577, in (B) *evading ability was* r=0.629, in (C) *decelerating ability* was r=0.595, and in (D) *accelerating ability* was r=0.413. Significant correlation was observed between each item ($p<0.05$). In addition, correlation was observed between (A) *comprehensive agility* and time in the deceleration section (r=0.481), and between (A) *comprehensive agility* and time in the sidestepping section (r=0.543) ($p<0.05$). Furthermore, the highest correlation was observed between (B) *evading ability* and time in the decelaration section (r=0.498), and between (B) *evading ability* and time in the sidestepping section (r=0.587) ($p<0.05$). However, no significant correlation was observed between (E) *sprinting ability* and time in any section.

4. Discussion

The purpose of this study was to develop a method to evaluate the agility of rugby players by change of direction using sidesteps while running, and clarify the characteristics of the movement.

The sidestep used in this study is a frequently used movement in team sports. Rugby players in particular require agility to advance the ball and run through or evade opponents. Young et al. (2002) reported that change of direction speed (CODS) as agility is composed of four factors: running techniques, straight sprinting ability, leg muscle power, and physical

Table 4 Correlation between measurement time and evaluation by coaches

	subject A		subject B				a coefficient of correlation			
	M	SD	M	SD	ICC	F	SST	Deceleration section	Sidestep section	Acceleration section
(A)Agility ability	3.05	1.01	3.14	1.04	0.92	1.45n.s.	0.577*	0.481*	0.543*	0.193
(B)Evasion ability	3.24	1.02	3.39	0.88	0.88	2.08n.s.	0.629*	0.498*	0.587*	0.208
(C)Deceleration ability	3.09	0.81	3.17	0.87	0.81	2.32n.s.	0.595*	0.445*	0.421*	0.109
(D)Acceleration ability	3.15	0.83	3.26	0.90	0.79	2.55n.s.	0.413*	0.405*	0.357	0.427*
(E)Sprint ability	3.14	0.91	3.24	0.91	0.75	1.39n.s.	0.351	0.248	0.109	0.403*

*:P<0.05

characteristics. Combining these four factors, team sports players can change direction associated with quick deceleration while running, and accelerate again immediately. CODS ability has been evaluated with tests that include making 180-degree turns. These tests include the Illinois Agility Test and the 505 test, and are characterized by an immediate deceleration to zero to make a 180-degree turn. However Lockie et al. (2013) reported that it is possible to evaluate player agility using a zigzag run without 180-degree turns utilizing the change-of-direction and acceleration test (CODAT). Different from the existing evaluation methods, CODAT only requires subjects to change direction within 90 degrees, and shows high correlation with the Illinois Agility Test. The Illinois Agility Test requires 16 to 18 seconds for measurement, which is too long. The 505 test is reported to have high correlation with the Ilinois Agility Test while measurement requires only 2.5 seconds, which allows the movement of 180-degree change of direction to have impact on measurement times. CODAT, developed by Lockie (2013), however, requires 6 to 8 seconds for measurement, which is approximately equal to the average time of a sprint during team games. Therefore, CODAT is considered more useful than other measurement methods.

CODAT, however, is insufficient for the evaluation of sidestep movements such as quick stopping, changing direction by sidestep, and evading opponents. Therefore, we developed a measurement method using sidesteps, which is a stop and sidestep test (SST). According to the results of running times in the eight sections, which was carried out to clarify the SST, SST exhibited reproducibility ($p<0.01$) (**Table 1**). The reason for such high reproducibility may be due to the fact that no errors occurred in measurements because of the predetermined direction of sidesteps in the SST. In addition, only one sidestep was used for changing direction, which made it easier for subjects to exercise leg muscle strength required to move sideways after stopping.

In general, the ability of BK athletes to evade opponents while running is thought to be higher than the ability of FW athletes. Therefore, we classified measurements into BK (higher group) and FW (lower group) for analysis. As was predicted, the BK group had significantly faster times than the FW group ($p<0.05$). Sections (1), (4), and (7) in **Figure 1** are acceleration sections. Although subjects accerelate in sections (1) and (4), they quickly decelarate in next sections (2) and (5). Therefore, subjects employ different ways of exercising leg muscle strength in section (7) than they do in sections (1) and (4). **Table 2** shows no significant difference between FW and BK groups in sections (1) and (4), which suggested the difficulty in evaluating the agility of subjects in these sections with SST. However, the FW and BK groups showed significant difference ($p<0.05$) in deceleration sections (2) and (5) and stop & sidestep sections (3) and (6). Sections (3) and (6) require the ability to run maintaing as much speed as possible without stopping.

As shown in **Figure 2**, BK athelete speed when both feet were placed on the ground was 3.0 – 3.3 m/sec, and FW athlete speed was 1.8 – 2.0 m/sec. At this point, it is thought that subjects shifted their center of gravity sideways to change direction before their feet were placed on the ground. In other words, these results showed differences in sidestep skills between BK and FW athletes. Examination of the velocity of the center of gravity of subjects in FW and BK groups when both feet were placed on the ground (**Table 3**) revealed a significant difference between the two groups ($p<0.01$). Therefore, it is assumed that the BK group, which exhibits superior sidestep technique for change of direction, is more aware than the FW group is of the need to adjust speed for change of direction during day-to-day practice. In addition, this group quickly decelerates running speed to evade opponents, and lowers center of gravity beforehand for effective sidesteps, which is thought to prevent significant deceleration in running speed while sidestepping (Wheeler et al., 2010).

Running techniques incorporating sidestepping are necessary for team sport players to evade opponents (Sayers 1999). The techniques of change of direction in the sidestepping sections in this study are often used in combination with fainting during rugby games. In this study, we asked subjects to change direction after setting points at which sidestepping was to be employed for the measurement of times. Sheppard et al. (2006), Gabbett et al. (2008), Sperpell et al. (2010), and Henry et al. (2012) developed a measurement method in which the sidestep direction is indicated to subjects when they pass certain points while running. They use human movements and photo-stimulators to indicate the direction and define the method as a reactive agility test (RAT). However, when the indicated direction is different from the direction that the subject predicts, the subject is required to change movements. There is still a need for discussions on how to deal with the time required for the adjustment (Sheppard et al., 2006). In addition, RAT is employed to evaluate one-on-one sidestepping; therefore, it is difficult to evaluate the agility of a player running through a crowd. The SST used in this study and the Illinois and other agility tests ask subjects to use sidestepping to a direction designated in advance. It is necessary to evaluate the agility of team sport players easily, with fewer errors, and to evaluate the ability to adjust speed and sidestepping while running. Therefore, it is difficult to use a measurement method associated with recognition such as RAT to evaluate training. However, RAT is valid for the evaluation of perceptual and decision-making factors (Young , 2002), so it is necessary to further improve it from now.

Many studies conducted to develop new agility tests show their usefulness and correlation with a wide range of measurement methods such as the Illinois Agility Test. In this study, we examined the relationship between SST times and the agility test for players by coaches, and examined usefulness from a different viewpoint from previous studies. We clarified that there is no difference in evaluation between coaches (**Table 4**), and examined the correlation between SST times and coaches' evaluation of five player abilities (A: agility, B: evading, C: decelerating, D: accelerating, E: sprinting). As a result, significant correlation was observed between SST times and A to D among the five above-mentioned abilities ($p<0.05$). A significant correlation between evaluation of A, B, and C in players by coaches, and times in the deceleration and sidestepping sections was observed, proving the validity of the measurement method developed in this study. Coaches evaluate players comrehensively by position considering sprinting, evading, and judgment ability during games, in addition to observing their physial training, to develop new tactics and give directions for games. The SST times and agility test by coaches who can comprehensively observe players' movements during games revealed a correlation, suggesting that the SST developed in this study is appropriate to evaluate the agility of rugbly players associated with running.

5. Conclusion

The purpose of this study was to develop a method to evaluate the agility of rugby players by change of direction using sidesteps while running, and clarify the characteristics of the movement. A significant difference was observed between the running speed and times between FW and BK groups in the sidestepping sections and the immediately preceding sections ($p<0.01$). Running times measured in this study and agility test for players by coaches showed a significant correlation ($p<0.05$). However, there is still a need to examine this method and compare with other tests to determine its stability as an evaluation of rugby player agility. In order to do so, we need to increase number of subjects and create score records.

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