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Agility Characteristics of Various Athletes Based on a Successive Choice-reaction Test

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Abstract In competitive sports of an open-skill system, rapid information-processing ability and adequate movement ability corresponding to rapidly changing information and stimuli are demanded athletes. This study examined the agility characteristics of athletes by using a successive choice reaction test. The subjects included 80 male university athletes, with 10 athletes randomly selected per competitive event for a total of eight competitive events. A successive choice-reaction test comprising five step patterns was used. A cell placement similar to step sheet placement was presented to the subjects on a personal computer display. The cell (sheet) for the athletes to step into was continuously and randomly indicated. The athletes quickly stepped onto eight sheets that corresponded to each cell shown on the display in each pattern. The entire process for achieving each pattern required eight steps (between stimulation presentation and step landing). From among the five patterns, the patterns with the minimum and maximum times were excluded. A mean of the total time for three patterns was used as an evaluation variable. Results of the statistical analysis including a one-way ANOVA indicated that the reaction time was significantly shorter in open-skill sports athletes than in closed-skill sports athletes. In conclusion, athletes in open-skill sports have superior successive choice reaction ability when compared with the athletes in closed-skill sports.

Keywords: *reaction test, athletes, open-skill sports, closed-skill sports*

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1. Introduction

In competitive sports, particularly in sports that use a ball, the ability to rapidly process various types of changing information and to quickly react to different stimuli is extremely important for athletes. The concept [1] of agility very widely differs, and there are considerable differences in the type of agility required for each competitive sport. Competitive sports are largely divided into two types, namely open-skill sports and closed-skill sports. Until recently, there was no test to adequately evaluate the agility of open-skill sports athletes. Hence, for convenience, tests developed for evaluating the agility of closed-skill sports athletes were used to evaluate the agility of open-skill sports athletes. For example, representative tests include a jumping reaction time test that involves quickly reacting to stimulation (light or sound) and a side steps test that entails quickly repeating decided movements for a short period of time [2-7].

Sakamaki et al. [8] cited factors determining the superiority or inferiority of agility which included the reaction time from a stimulus to the start of the action, the speed of the action itself and the change speed between actions. Furthermore, Sheppard et al. [9] and Semenick [10] reported that speed of reaction to stimuli, in addition to the speed of simple direction change, are frequently included in the concept of agility.

Interpersonal sports and group sports are regarded as open-skill sports. In these sports, the positions of opponents, friends or the ball markedly change with time. Hence, athletes need to predict suitable movements and take adequate subsequent actions while coping with their movements.

In summary, the agility necessary for athletes in open-skill sports differs from the agility necessary for athletes in closed-skill sports. Therefore, conventional agility tests designed for closed-skill sports are inadequate for open-skill sports.

As there are marked changes in the positions of opponents, friends or the ball in open-skill sports, it is important that the agility test for athletes in open-skill sports adequately evaluates the athlete’s ability to predict their next movements and to quickly act while coping with their movements. Demura et al. [11] and Uchida et al. [12] developed a new successive choice-reaction test which evaluates the agility required by open-skilled athletes. The test displays a high reliability when compared with conventional tests. However, the validity of this test was not sufficiently examined. The validity of the test is desirable in examining various viewpoints such as discrimination validity and criterion-related validity.

In this study, we have hypothesized that athletes in open-skill sports are superior in a successive choice-reaction test in terms of competitive properties when compared to athletes in closed-skill sports. Proving this hypothesis will support the validity of a successive choice reaction test from viewpoints of discrimination or difference validity. The aim of the study included demonstrating the superiority of open-skill sports athletes when compared to closed-skill sports athletes in a successive choice-reaction test.

2. Method

2.1. Subjects

In this study, the open-skill sports system comprised three events, namely kendo, badminton and table tennis, that were selected from interpersonal competitive sports and two events, namely soccer and basketball that were selected from group competitive sports. In kendo, competitors quickly strike a companion with a shinai within a short distance [13]. In table tennis, players hit the ball while quickly moving in the right and left directions [14].

In badminton, players hit a shuttle across the net while quickly moving in various directions [15]. In soccer, players manoeuvre a ball from each other with their legs and must quickly react while coping with the movements of partners or a ball in a large sports stadium [16]. In basketball, players handle a ball from each other with their hands and legs and continuously perform movements such as jumping, running and throwing while coping with the movements of opponents, friends or the ball [17].

Gymnastics, track and field and swimming were selected as closed-skill sports.

These are personal events and athletes repeat either pre-decided or the same movements. All subjects were male university students with more than five years of athletic experience. They also practised the specific sport more than three times a week.

Table 1 shows the physical characteristics and athletic careers of the subjects. The purpose of this study was explained to the subjects in detail. The informed consent of the athletes was obtained. Additionally, approval was received from the Ethics Committee of the Japanese Society of Test and Measurement in Health and Physical Education (approval number 2013-001).

Table 1. Physical characteristics of the subjects

Sports	n	Age	Height	Weight	Career
		(yts.)	(cm)	(kg)	(yts.)
kendo	10	20.9±1.04	173.6±5.97	65.3±8.12	11.7±2.49
soccer	10	20.4±1.17	172.1±3.44	66.0±4.32	13.1±2.60
basketball	10	18.6±0.49	172.9±6.37	66.9±7.41	7.5±2.06
badminton	10	19.9±0.70	171.0±4.13	60.8±4.35	6.9±1.70
table tennis	10	20.2±1.54	171.5±5.58	61.8±7.60	7.1±1.45
gymnastics	10	19.7±0.90	169.5±5.22	59.4±6.36	7.7±3.55
track and field	10	20.2±1.54	173.1±4.61	63.9±7.27	8.6±2.62
swimming	10	20.9±0.54	174.0±4.11	66.5±4.78	10.3±3.35

2.2. Successive Choice-Reaction Test

Experiment device:

The successive choice-reaction test was performed using Takei Scientific Instruments Co.'s Step Evaluation System devised by Demura S [12]. The device sent and recorded the information from the laptop as a digital signal when the subject's feet touched and left the ground.

Nine sheets (30 cm^2) were set, as shown in Figure 1. The distance from the centre of the middle sheet to the centre of the surrounding sheets was 60 cm. Also, the same nine array cells as that shown in Figure 1 were displayed on the laptop (Figure 2). The nine array cells on the screen matched with the nine sheets on the floor. The laptop is a stimulus presentation device and a moving stimulus (movement direction was indicated when the frame colour changed from white to red) was successively displayed with a constant tempo.

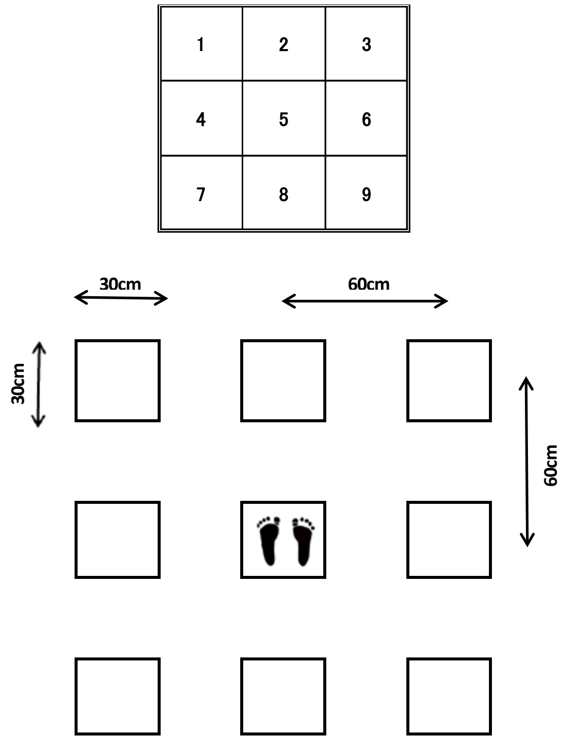

Figure 1. Schematic of the Succession Choice-Reaction Time Measuring Device

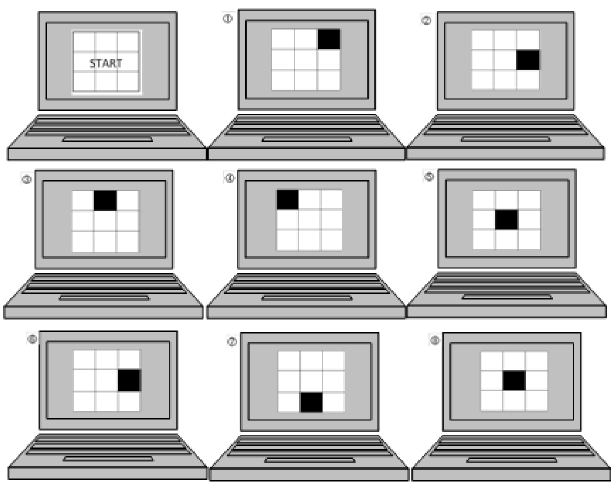

Figure 2. Display Screen

Stimulus presentation pattern: Five kinds of step patterns (Table 2) were chosen such that the subjects could not predict the reaction direction in advance. The subjects randomly selected one of five patterns with different enforcement orders.

Table 2. Stimuli Display Patterns

	1	2	3	4	5	6	7	8
Pattern A	Digonal - forward right	Backward	Digonal - forward left	Left	Digonal - bagkward raight	Right	Digonal - bagkward left	Forward
Pattern B	Digonal - bagkward left	Forward	Digonal - bagkward raight	Right	Digonal - forward left	Left	Digonal - forward right	Backward
Pattern C	Forward	Digonal - bagkward left	Right	Digonal - forward right	Left	Digonal - bagkward raight	Backward	Digonal - forward left
Pattern D	Backward	Digonal - forward right	Left	Digonal - bagkward left	Right	Digonal - forward left	Forward	Digonal - forward right
Pattern E	Right	Digonal - bagkward left	Forward	Digonal - forward right	Left	Digonal - bagkward raight	Right	Digonal - forward left

The presentation pattern of direction indication comprised different combinations of eight directions (front, back, right, left, right front oblique, right back oblique, left front oblique and left back oblique).

The subjects were required to quickly step on all sheets. For instance, in the case of pattern A, the subjects moved in the following order: centre sell, diagonal forward right sell, backward sell, diagonal forward left sell, left sell, diagonal backward right sell, right sell, diagonal backward left sell and forward sell (Figure 1).

Based on a study by Uchida et al, the tempo of stimulation presentation was set to 40 bpm [12]. After practising a randomly selected pattern, the subjects performed each pattern once. The test was repeated after a break, since the subjects were not allowed to step on a step sheet by the next stimulation presentation continuously more than twice.

2.3. Measurement Procedure

The subjects closely watched a laptop. They stood by equally distributing the weight to both legs in the centre of the step sheet and bending both knees. After the movement indication was presented, they quickly stepped.

From the successive choice reaction times for five patterns, a mean of the total time for three patterns was used as an evaluation variable. The patterns with the minimum and maximum times were excluded.

2.4. Statistical Analysis

A difference among the means of each group in a successive choice-reaction test was tested using a one-way ANOVA. The Bonferroni method was used for multiple comparisons when significant interaction or main effects were found. Additionally, the linear comparison method of Scheffe [18] was used to test the differences among means of group, interpersonal and individual competition events. The significance level was set at $p < 0.05$.

3. Results

Table 3 displays the results of the basic statistics and statistical analysis of the successive choice reaction test of eight competitive events. In the results of multiple comparison tests, the response time was significantly faster in the kendo, soccer, basketball and table tennis group than in the gymnastics, track and field and swimming groups. The response time was also significantly greater in the badminton group than in the track and field and swimming groups. The differences among the responses for the groups of kendo, soccer, basketball, table tennis and badminton which were selected as open-skill sports were insignificant. The differences among the responses for the groups of gymnastics, track and field and swimming, which were selected as closed-skill sports, were also insignificant (Table 3).

Furthermore, the results of a linear comparison of mean response times for interpersonal competition events (kendo, table tennis and badminton), group competition events (soccer and basketball) and individual competition events (gymnastics, track and field and swimming) indicated that there were no significant differences between an interpersonal competition event and a group competition event.

Table 3. A comparison of the reaction times to successive choice reactions for differentsports

	G1 (n=10)	G2 (n=10)	G3 (n=10)	G4 (n=10)	G5 (n=10)	G6 (n=10)	G7 (n=10)	G8 (n=10)	F	η^2	multiple comparison assessment
Mean	0.74	0.75	0.72	0.77	0.75	0.82	0.83	0.84	2.10	0.57	G1,G2,G3,G5 < G6,G7,G8 G4 < G7,G8
SD	0.03	0.03	0.02	0.03	0.05	0.03	0.05	0.06			
Max	0.77	0.78	0.75	0.81	0.83	0.86	0.94	0.89			
Min	0.67	0.71	0.69	0.70	0.65	0.78	0.77	0.71			

G1: kendo, G2: soccer, G3: basketball, G4: badminton, G5: table tennis, G6: gymnastics, G7: track and field, G8: swimming

4. Discussion

Agility refers to the ability to rapidly move the body or parts of the body and/or to swiftly switch directions. To differentiate the agility necessary for each sport, adequately evaluating the agility specific to each sport is important [19].

As the situation in competitive sports in an open-skill system markedly changes with time, it is important for the athletes to quickly judge and move according to the surrounding situations [21]. Hence, athletes need to constantly predict changing movements and to prepare themselves to quickly cope with the situation.

Typically, conventional agility tests (such as side jumping tests or step tests) evaluate quickness by quickly repeating the same movement or by recognizing the simple reaction task without any prediction or with the speed of muscular contraction (jumping reaction time). Hence, these tests are effective for evaluating the agility of sports athletes in a closed-skill system.

However, conventional agility tests cannot adequately evaluate the agility of sports athletes in an open-skill system. This is because the demands on these athletes include predicting the forthcoming movements of opponents, friends and the object (e.g. ball and racket) and quickly and selectively reacting to the movements.

Until recently, the development of a test evaluating the agility of athletes in open-skill sports was difficult, because it is necessary to include the consecutive stimulation which athletes hard predict.

Demura et al. [11] developed a new successive choice reaction test to evaluate the agility of open-skill sports athletes by offering unpredictable stimulations at random on a PC screen. In this test, subjects must acknowledge consecutive stimulations (signal transduction receptors from vision) shown on a PC screen, react (nerve-line-end effector sense of cooperation), move (myofunction) and prepare the posture for the next stimulation. Additionally, this test requires the athletes to predict the direction of the movement, adequately react to stimulation and demonstrate various sensory abilities such as judgment ability and information processing ability.

Guizani et al. [22] reported specificity between simple reaction and choice reaction tasks. A choice reaction task differs from a simple reaction task as it displays a process selecting reaction to the stimulus.

The present new successive choice-reaction test comprises plural simple reaction tasks. Hence, even if subjects have superior ability in the simple reaction task, If they need extended periods of time for process selection of each simple reaction task, the performances of the successive choice reaction task decrease.

Laming [23] suggested that delaying reaction in the choice reaction tasks affects the subsequent task and slows the process by increasing the total time spent to react.

In this study, kendo, soccer, basketball and table tennis were selected as open-skill sports. Gymnastics, track and field and swimming were selected as closed-skill sports. The results of a successive choice-reaction test of athletes representing the above-stated sports events were compared. The reaction time was shorter in the kendo, soccer basketball and table tennis groups when compared to the gymnastics, track and field and swimming groups. Also, the badminton group had a shorter reaction time than the track and field and swimming groups.

Kioumourtzoglou et al. [24] examined various perceptual abilities in basketball, volleyball and water polo players. They reported that there are specificities in the effects wherein respective experience in sports affects perceptual ability. Furthermore, there were no significant differences among the five open-skill sports events and three closed-skill sports events. Generally, the open skill sports except for kendo involve a competition using a locomotor (a ball). Takano [25] reported that kendo competitors displayed superior general selection response when compared with soccer and volleyball players.

Although, unlike kendo, table tennis and badminton are not sports involving physical contact, they are same pair person competitions. Hence, it is necessary for players to predict the position of a returned ball or shuttlecock simultaneously after hitting it to instantly react. Ebashi et al. [26] reported that EMG-reaction time was faster in the table tennis players with higher competition levels. As basketball and soccer are group sports, the players in these sports are required to constantly predict the movements of friends, opponents and the balls and to quickly react. Uchida et al. [1] reported that basketball players were superior when compared with track and field athletes and swimmers in a successive choice-reaction test. Also, the present results supported the results by Maeda et al. and indicated that basketball and soccer players were superior to swimmers [17].

The above discussion suggests that open-skill athletes are superior to closed-skill athletes in terms of the successive choice reaction test. Furthermore, no differences were indicated between athletes in interpersonal sports and athletes in group sports. Both these groups are represented by open-skill sports and have a commonality in factors such as movement of partners and the prediction, continued stimulation and quick reaction with respect to the object (for example, a ball). In short, they are considered to depend on similar demanded agility.

On the contrary, Edo [27] reported that in selective light stimulation and simple light stimulation, regular Kendo competitors showed significantly shorter transition to action time when compared with reserve Kendo competitors. Also, Miyoshi et al. [16] reported that veteran soccer players had better selective response time than immature soccer players and general persons. Thus, from a difference validity viewpoint, comparing the successive choice reactions of athletes with different skills in open-skill sports is also necessary now.

5. Practical Applications

In open-skill sports, unlike in closed-skill sports, surrounding movements (e.g. opponents, friends and ball) change with time. Hence, it is crucial for athletes in these sports to possess the agility to adequately predict surrounding movements and to quickly cope with these movements. The successive choice-reaction test was recently developed to examine the differences in response time among athletes representing various sports events. It was verified that athletes in open-skill sports are superior in successive choice reactions when compared to athletes in closed-skill sports. It was concluded that the successive choice-reaction test can adequately evaluate the agility of athletes in open-skill sports. The athletes can also obtain the concrete and objective index of the agility necessary for open-skill sports by using this test.

Also, the successive choice reaction test is available for an aptitude diagnosis of open-skill sports athletes. To summarize, this test demanded subjects to exert a complete agile ability including the discrimination time to a startup, the speed of the movement and the speed of the change between the movements. The above ability is improved by practice or training. However, qualities of an individual are also indispensable. Hence, it is proposed that children who exhibit a superior performance in this test will also have an aptitude for open-skill sports. Moreover, the test itself or exercises similar to the test will increase the agility necessary for open-skill sports and/or confirm the effect of the skill training.

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