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REACTIVE (PRE-PLANNED) AND NON-REACTIVE (NON-PLANNED) AGILITY IN DIAGNOSIS OF ATHLETES

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SUMMARY

The aim of the study is to examine the differences between four pre-planned and non-planned agility tests. The movement structure of the tests combined frontal, universal, semi-circular, and lateral agility components. The sample of participants comprised 45 male athletes and 31 female athletes. The time-based parameters for pre-planned and non-planned agility tests were determined using the FitLight Trainer, a wireless training system which is comprised of seven LED-powered lights and controlled via an Android application. The results obtained were then statistically processed using the SPSS software package. Basic descriptive parameters were calculated for all the testing protocols. The differences between the pre-planned and non-planned test versions were evidenced by an independent T-test. A correlation analysis was performed to analyse the relationships between pre-planned and non-planned agility performances in the selected tests, as well as to determine the correlation between the agility performance and the space of linear sprint speed and reactive strength.

The results of the study showed statistically significant differences in selected tests of pre-planned (non-reactive) and non-planned (reactive) agility between both sub-samples. Significant differences were also observed in the reactive and non-reactive agility tests for men as well as women. The difference between male and female athletes was the highest in the non-planned frontal agility test (FRA), followed by the pre-planned frontal agility test (FRA), and pre-planned semi-circular agility test (SCA), whereas the global agility test (GLA) showed the lowest difference. In the sub-sample of male athletes, the difference between the known and unknown movement routines was highest in the global agility test (22.3%), while the lowest gap was reported in the relationship between the reactive and non-reactive lateral agility tests (13.5%).

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The differences between the pre-planned and non-planned agility tests in females were also statistically significant.

Key words: biomotorics, agility, reactive, non-reactive, FitLight

INTRODUCTION

There are a great many definitions of agility based on various criteria. Currently in sports practice and theory there is no universal definition of this ability (Sheppard, Young, 2006). The contemporary paradigm of speed is no longer based on the starting speed, maximum speed and speed endurance, the important factor is the change in direction of that speed (Oliver, Mayers, 2009). According to Bloomfield, Ackland in Elliot (1994) agility is the ability to more quickly and with more coordination perform changes in speed of movement in space. The most recent definitions take into consideration starting reaction, control of movement, dynamic flexibility, reactive power and balance in rapid changes in movement (Little,Williams, 2005; Cronin, Hansen 2005; Sheppard, Young, 2006; Marković et al. 2007; Sporis et al., 2010, Dolan, 2013). The realization of rapid changes in movement does not depend solely on biometric abilities, it also depends to a great extent on cognitive factors, as was determined in the studies of various authors (Cox, 2002; Young et al., 2002; Sheppard, Young, 2006; Hodges et al., 2006). The greatest connection between the space of cognitive factors and agility is achieved by the speed of visual perception, sensory memory, selective attention, kinesthetic scanning of space and anticipation (Abernethy et al., 1999; Cox, 2002; Little et al., 2005; Sheppard, Young, 2006, Spasic, 2013, Laessoe et al., 2016).

The key predictors of agility are the speed of individual movement, speed of acceleration and deacceleration, explosive power, coordination and balance (Miller et al., 2006; Nimphius et al., 2010; Salaj, Marković, 2011; Sekulic et al., 2013; Spasic et al., 2013; Laessoe et al., 2016). Maintaining balance under conditions of rapid changes in speed and changes in direction of movement is related to postural control and proprioceptive mechanisms in the ankle joint, knee joint and hip joint, under conditions of inertia of the body as physical value (Verhagen et al., 2004; Little, Williams, 2005; Salaj et al., 2007; Spasić, 2013). The moment of inertia of the body depends on the distribution of body mass, the axis of rotation and the morphological somatotype of athletes. Reactive power, which is manifested especially in deep – plyometric jumps (drop jumps) is an exceptionally strong predictor of agility (Cronin, Hansen, 2005; Haj-Sassi et al., 2011). Rapid changes in direction and speed of movement depend especially on

contact time with the surface (Sheppard, 2003; Haj-Sassi et al., 2011; Cochrane et al., 2013). Furthermore, certain research has not confirmed the predictor values of speed and explosive power in the space of agility (Marković et al., 2007; Nimphius et al., 2010). Agility must undoubtedly be treated along with coordination and movement technique. Both components define the optimum »agility sample« of movement (Sekulić et al., 2013). In the case of athletes with high levels of motor abilities, effective movement transfer and the integration of these abilities with cognitive functions, we can expect a high level of realization of agility (Young et al., 2001; Young et al., 2002; Enoka, 2002).

Many situations in sport are related to changes in speed and the direction of movement triggered by an outside signal (stop'n'go). Agility can be manifested through open skill, where movement is unknown – non-planned or through a closed loop (closed skill) where the movement is known beforehand or pre-planned (Sheppard, Young, 2006; Young, Willey, 2010). Movement structures which are not planned beforehand, we define as reactive agility. Movement situations which are known beforehand (pre-planned agility, change of direction speed, CODS), are non-reactive agility (Sheppard et al., 2006; Sheppard, Young, 2006; Serpell et al., 2010). That is why Sheppard and Young (2006) suggest the following definition of agility: "Agility is the change in speed and direction of body movement in space and time as a response to specific stimulus."

In sports theory and practice there is great interest for the development of adequate diagnostic tests of agility and specific training methods through which this agility could be developed. The basic aims of this study were to develop a technological basis, measurement protocols for programmed or non-programmed agility, and to determine the relations between agility with some specific motor abilities. Accordingly, we structured a battery of four tests to determine the differences between programmed (non-reactive) and non-programmed (reactive) agility on a sample of active athletes of both genders. Until now a relatively small number of these types of studies have been realized due to a lack of adequate technologies. A new technology, "FitLight Trainer", enables us to test the agility of programmed and non-programmed movement situations and their direct comparison. In addition, this technology can be an effective means of training specific agility for certain branches of sport.

THE METHOD

The sample of participants

The research included 45 male and 31 female second-year students at the Faculty of Sport, University of Ljubljana. The participants were actively participating in various types of sport. The average height of the men was 181,6

cm (± 8.31 cm), weight 78.9 kg (± 11.33 kg), the height of the women was 167.7 (± 5.03 cm), weight 63.3 (± 8.65 kg). The male participants were aged 21.2 years(±1,78), the female participants 20,6 (± 1,27).

The measurement procedure

The research included an optical system of sensors, "FitLight Trainer", produced by the Sport Corp. Ontario, Canada. The measurement system consisted of 7 system LED electrodes which are managed via an android application. The system can be programmed by sequential light activation or the interruption of the sensors through mechanic contact. Time is registered on the display for each sensor unit individually. The internal program equipment enables 6 accidental combinations of activation of the set of LED electrodes.

The measurement process was carried out in the sports gymnasium of the Faculty of Sport in Ljubljana. The surface was tartan, which enabled the optimal performance of the tests of agility. Each test was performed by the participants twice. The rest between the repetitions of tests was 5 minutes. The best time was taken for statistical analysis. The performance of non-programmed – reactive agility was accidental in accordance with one of the six possible combinations.

The sample of variables

The tests of programmed and non-programmed agility include:

1. a test of frontal agility - *programmed/non-programmed*
2. a test of universal agility - *programmed/non-programmed*
3. a test of semi-circular agility - *programmed/non-programmed*
4. a test of lateral agility - *programmed/non-programmed*

Specific motor variables:

S 15 m – sprint starting speed (15 m sprint with a high start)

L15 m - maximum speed (15 m sprint with a flying start)

SK10 m - horizontal jumps (dominant single-leg jumps at 10m)

The data were statistically analyzed using the SPSS1 computer package. The basic descriptive parameters were calculated for all the tests. The differences between programmed and non-programmed agility were determined based on the T-test for independent samples. The correlation analysis was used to determine the connection between the tests of agility and reactive power, starting and maximum speed.

RESULTS AND DISCUSSION

Based on the statistical results (Table 1) and the t-test, we can determine that the sub-samples of participants differ on all the selected tests, except for one. The test of frontal agility is on the border of statistical significance between programmed and non-programmed agility SMR (sig =0.075). On average, better results are achieved by the male participants. The greatest difference between the sub-samples was for the test of frontal agility -SMR – the non-programmed solution (D= 2.82 sec - 15.8 %), followed by the test of frontal agility SMR – the programmed solution (D=2.43 sec - 15.6 %) and what follows in the end is the test of the semi-circular agility - PAH, the programmed solution (D= 2.10 sec – 13.4 %). Relatively small differences and statistical significance among the sub-samples were determined for the test of lateral programmed and non-programmed agility - YTE (D= 1.55 sec – 12.9 %, D= 1.32 sec – 9.7 %). The smallest difference between the genders was noted for the test of universal agility - ZVE (D= 0.50 sec – 3.9 %).

Table 1. The descriptive statistics of the tests of programmed and non-programmed agility (mean, standard dev.) T - test of agility (F, sig.) between the sub-samples of male and female participants

		N	Mean	Std. Deviation	F	Sig.
SMR PRO	MALE	49	15,59	1,48	54,555	0,000
	FEMALE	31	18,02	1,35		
SMR NEP	MALE	47	17,77	1,38	56,642	0,000
	FEMALE	31	20,59	1,19		
ZVE PRO	MALE	42	12,61	1,08	3,275	0,075
	FEMALE	28	13,11	1,21		
ZVE NEP	MALE	42	15,43	0,99	30,563	0,000
	FEMALE	28	17,15	1,62		
PAH PRO	MALE	39	15,70	1,08	59,027	0,000
	FEMALE	27	17,80	1,11		
PAH NEP	MALE	36	18,22	1,51	13,420	0,001
	FEMALE	25	19,56	1,25		
YLA PRO	MALE	32	12,00	1,33	16,564	0,000
	FEMALE	19	13,56	1,30		
YLA NEP	MALE	31	13,60	1,39	13,265	0,001
	FEMALE	18	14,93	0,87		

Legend: SMR PRO- programmed frontal agility, SMR NEP-non-programmed frontal agility, ZVE PRO- programmed universal agility, ZVE NEP-non-programmed universal agility, PAH PRO-programmed semi-circular agility, PAH NEP-non-programmed semi-circular agility, YLA PRO-programmed lateral agility, YLE NEP-non-programmed lateral agility.

The influence of speed and power on agility is quite often the subject matter of various research (Little, Williams, 2005; Cronin, Hansen, 2005; Marković et al., 2007; Nimphius et al., 2010; Haj-Sassi et al., 2011). Like these authors, we too have determined a low to medium high correlation between starting speed (the 15 m sprint with a high start), maximum speed (the 15 m sprint with a flying start) and reactive power (horizontal jumps on the dominant leg) and programmed and non-programmed agility (Table 2 and 3) for both gender sub-samples. From the aspect of biomechanics, sprint differs from the biomechanics of movement under conditions of rapid changes in movement in time and space. Optimization in acceleration and deceleration requires a controlled speed related to stability, coordination, dynamic balance, visual scanning of space and anticipation of the situation. The step frequency is greater, and the length of the step smaller in rapid changes of movement in the case of agility of motor skills (Young et al., 2001, Little, Williams 2005). The starting speed has the greatest correlation with semi-circular agility (PAH PRO, r= 0.62; PAH NEP, r=0.60) and lateral agility (YLE PRO, r =0.54, YLE NEP, r=0.58). What is unexpected is the correlation between starting speed and lateral agility, since the structure of movement in these situations is quite different. Furthermore, maximum speed has a high correlation with semi-circular agility of the programmed and non-programmed type (PAH NEP, r=0.64; PAH PRO, r=0.62). For the sub-sample of women, the space of agility and linear speed is significantly less related (Table 3). There is a significant correlation between maximum speed and non-programmed universal agility (ZVE NEP, r = 0.51) and starting speed and programmed semi-circular agility (PAH PRO, r = 0.47).

Reactive jumping power (SK10m – horizontal jumps on the dominant leg at 10 m) has a weak correlation with the tests of programmed and non-programmed agility. The surprisingly low connection between the space of agility and reactive power was found for both sub-samples. It was possible to predict a stronger connection since agility is based on the principle of eccentric-concentric muscle contractions and short contact times. Horizontal jumps on the dominant leg at 10 m consist of precisely these biochemical parameters. In addition to that, horizontal jumps are similar from the aspect of movement structures to some elements of the agility technique.

In the existing research, authors used vertical and depth jumps as predictors of jumping agility – drop jumps (Cronin, Hansen, 2005; Jason et al., 2008; Haj-Sassi et al., 2011; Salaj, Marković, 2011) and determined medium high correlations with agility.

Table 2. The correlations between the test of programmed and non-programmed agility and reactive power (SK10m), maximum speed (L15m) and starting speed (S15m) – males.

		SMR PRO	SMR NEP	ZVE PRO	ZVE NEP	PAH PRO	PAH NEP	YLA PRO	YLA NEP
SK10 m	PeaCorr	,206	,333*	,055	,313	,465**	,610**	,211	,417*
	Sig.	,221	,044	,751	,063	,004	,000	,323	,048
	N	37	37	36	36	37	34	24	23
L 15m	PeaCorr	,114	,340*	,205	,350*	,583**	,639**	,334	,442*
	Sig.	,490	,034	,211	,029	,000	,000	,103	,031
	N	39	39	39	39	34	31	25	24
S 15m	PeaCorr	,123	,349*	-,059	,268	,615**	,599**	,535**	,584**
	Sig.	,455	,029	,721	,099	,000	,000	,006	,003
	N	39	39	39	39	34	31	25	24
*. Correlation is significant at the 0.05 level (2-tailed).									
**. Correlation is significant at the 0.01 level (2-tailed).									

Table 3. The correlations between the tests of programmed and non-programmed agility and reactive power (SK10m), maximum speed (L15m) and starting speed (S15m) – women.

		SMR PRO	SMR NEP	ZVEZ PRO	ZVE NEP	PAH PRO	PAH NEP	YLA PRO	YLA NEP
SK 10m	PeaCorr	,166	,110	,573**	,268	,255	,507*	,174	,010
	Sig.	,438	,609	,004	,217	,229	,016	,504	,970
	N	24	24	23	23	24	22	17	16
L 15m	PeaCorr	,168	,361	-,002	,506**	,378	,495*	,339	,160
	Sig.	,411	,070	,994	,007	,076	,023	,169	,539
	N	26	26	27	27	23	21	18	17
S 15m	PeaCorr	,348	,308	,044	,349	,477*	,403	,333	,415
	Sig.	,081	,126	,828	,074	,021	,070	,177	,098
	N	26	26	27	27	23	21	18	17
*. Correlation is significant at the 0.05 level (2-tailed).									
**. Correlation is significant at the 0.01 level (2-tailed).									

The greatest connection was established between horizontal jumps and semi-circular programmed and non-programmed agility (PAH PRO, r = 0.58 and PAH NEP, r = 0.64). In the case of the women, reactive power has the strongest connection with programmed universal agility (ZVE PRO, r=0.57) and non-programmed semi-circular agility (PAH NEP, r = 0.51). The results of this study indicate that agility as an ability is a complex area, which depends on numerous factors of man's psycho-motor skills and their interactions. Optimization under conditions of rapid changes in movement of the human body in space and time clearly does not only depend on motor skills, but also on the ability to control movement, optimum technique, morphological constitution, and cognitive factors.

CONCLUSION

The results of this study have indicated statistically significant differences between two types of agility among the sub-samples of male and female athletes. The more complex the movement structure, the greater the difference between reactive and nonreactive agility. Between the space of agility, linear speed and reactive power there are no high correlations. It is clear that agility is a multi-dimensional ability which depends on the optimal combinations of speed, power, coordination, dynamic balance, movement technique, visual scanning, reaction speed, anticipation, and the higher cognitive abilities of athletes. In upcoming research in this field, it would be necessary to include cognitive and sensory-motor variables, expand the sample of athletes to include various branches of sport, and include additional tests of programmed and non-programmed agility.

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РЕАКТИВНЫЕ (ЗАРАНЕЕ СПЛАНИРОВАННЫЕ) И НЕРЕАКТИВНЫЕ (НЕ СПЛАНИРОВАННЫЕ) МАНЕВРЕННЫЕ ДЕЙСТВИЯ В ОПРЕДЕЛЕНИИ УРОВНЯ ПОДГОТОВКИ СПОРТСМЕНОВ

АННОТАЦИЯ

Цель исследования – рассмотреть различия между четырьмя тестами на заранее спланированные и не спланированные маневренные действия спортсменов. В структуре движения испытуемых сочетались компоненты маневренных действий спортсменов в позиции нападающего, универсального игрока, центрового и защитника. В испытаниях участвовали: 45 спортсменов мужского пола и 31 спортсмен женского пола. ВременнЫе параметры для тестов на заранее спланированные и не спланированные маневренные действия были определены с помощью Fitlight Trainer, беспроводной системы обучения, которая состоит из семи светодиодных ламп и управляется с помощью приложения для Android. Полученные результаты были статистически обработаны с помощью программного пакета SPSS. Для всех протоколов тестирования были рассчитаны основные описательные параметры. Различия между версиями тестов на заранее спланированные и не спланированные маневренные действия были подтверждены независимым Т-тестом. Был проведен корреляционный анализ для выявления взаимосвязей между показателями заранее спланированных и не спланированных маневренных действий в выбранных тестах, а также для определения корреляции между показателями маневренности и пространством линейной скорости спринта и взрывной силы.

Результаты исследования выявили статистически значимые различия между двумя выбранными тестами: заранее спланированные (нереактивные) и не спланированные (реактивные) маневренные действия участников. Значительные различия наблюдались также в тестах на реактивные и нереактивные маневренные действия у мужчин и женщин. Разница между спортсменами мужского и женского пола была самой высокой в тесте на незапланированные маневренные действия спортсмена в позиции нападающего (FRA), за которым следовал тест на заранее спланированные маневренные действия спортсмена в позиции нападающего (FRA), и тест на заранее спланированные маневренные действия в движении по траектории полукруга (SCA), в то время как глобальный тест на маневренные действия (GLA) показал самый низкий уровень. В показателях спортсменов-мужчин разница между спланированными и не спланированными маршрутами движениями была самой высокой в глобальном тесте на маневренные действия (22,3%), в то время как самый низкий разрыв был отмечен в отношении между реактивными и нереактивными тестами на маневренные действия спортсмена в позиции защитника (13,5%). Различия между тестами на заранее спланированные и не спланированные маневренные действия у женщин также были статистически значимыми.

Ключевые слова: биомоторика, маневренные действия, реактивный, нереактивный, Фитлайт

ПРОГРАМИРАНА И НЕПРОГРАМИРАНА АГИЛНОСТ У ДИАГНОСТИЦИ СПОРТАША

САЖЕТАК

Циљ овог истраживања је да се испитају разлике између тестова четири унапред планирана и непланирана елемента агилности. Тестови су испитивали комбиновану структуру покрета: предњу, универзалну, полукружну и бочну агилност. Узорак испитаника обухватио је 45 спортиста и 31 спортискињу. Временски одређени параметри за тестове унапред планиране и непланиране елементе окретности одређени су коришћењем ФитЛигхт Траинер-а, бежичног система тренинга који се састоји од седам ЛЕД лампица и који се контролише путем Андроид апликације. Добијени резултати потом су статистички обрађени користећи софтверски пакет СПСС. Основни описни параметри израчунати су за све протоколе тестирања. Разлике између унапред планиране и непланиране верзије теста доказане су независним Т-тестом. Извршена је корелациона анализа да би се анализирала веза између перформанси унапред планираних и непланираних елемената агилности у одабраним тестовима, као и да би се утврдила повезаност између перформанси агилности и простора линеарне брзине спринта и реактивне снаге.

Резултати истраживања показали су статистички значајне разлике у одабраним тестовима унапред планиране (нереактивне) и непланиране (реактивне) агилности између оба подузорка. Значајне разлике примећене су и у тестовима реактивние и нереактивне агилности мушкараца и жена. Разлика између спортиста и спортискиња била је највећа у тесту непланиране фронталне агилности (ФРА), затим следи тест унапред планиране фронталне агилности (ФРА) и тест унапред планиране полукружне агилности (СЦА), док је тест глобалне агилности (ГЛА) показао најмању разлику. У подузорку спортиста разлика између познате и непознате рутине кретања била је највећа у тесту глобалне агилности (22,3%), док је најмања разлика пронадјена на тесту односа између реактивних и нереактивних бочних окретности (13,5%). Разлике на тестовима између унапред планираних и непланираних агилности код жена такође су биле статистички значајне.

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