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THE ABILITY TO MAINTAIN STATIC BALANCE IN COMPETITORS OF CYCLIC SPORTS AT THE STAGE OF DIRECTED TRAINING

Key words: static balance, training, cyclic sports, postural control.

ABSTRACT

The aim of the research was to determine the level of ability to maintain static balance in young competitors of cyclic sports as well as to reveal the influence of gender and body mass on the ability's features. The study attempted to determine the range and direction of the ability to maintain static balance depending on the practiced sport. The study sample consisted of 114 kayakers, rowers, swimmers, cyclists and triathletes (28 girls and 86 boys) at the age of 16.0 ± 1.4. The ability to maintain static balance was determined by means of posturography in an erect position with eyes open. It was established that gender and body mass did not have a significant influence on the basic features of the ability to maintain static balance. Lack of statistically significant differences in the relationship between the ability to maintain static balance and the practiced sport was also found. Junior subjects manifested features of the ability to maintain static balance comparable to those of tennis players, whose game is dominated by acyclic and higher movements, as distinct from non-training subjects.

INTRODUCTION

The ability to maintain balance constitutes one of key coordination abilities. It is indispensable during daily activities as well as in sport competition. One of the aims of exercise is to improve neural-muscular coordination ability, which influences the ability to effectively maintain the centre of gravity in a stable position when static as well as during performance of locomotive movements. In pursuit of this task one is forced to generate appropriate reactions crucial to control body posture [1, 13, 14]. Due to the significance of the manifestation of the ability to maintain static balance research has been undertaken on various training and non-training groups which differ in terms of sex, age, type of practiced exercise and the level of sport achievement.

A high level of the ability to maintain static balance is indispensable for the proper functioning in daily life as well as in sport competition, which often requires a balanced body posture [3, 11, 12]. In view of these considerations, the present study aimed to:

1. Determine the ability to manifest static balance in young competitors of cyclic sports;
2. Determine the influence of gender and body mass on the features of the ability to maintain static balance;
3. Establish the range and direction of changes of the relationship between the ability to maintain static balance and the practiced sport.

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The following research hypotheses were formulated:

1. Competitors practicing cyclic sports at the stage of directed training are characterized by a high level of the ability to maintain static balance, which is essential to keep a stable body posture.
2. Sex and body mass of junior subjects significantly influence the level of the ability to maintain static balance.
3. Athletic training in cyclic sports as early as in its directed stage results in changes in the ability to maintain static balance, whose direction and range is conditioned by the specificity of the practiced sport.

METHODS

The research sample comprised 114 athletes (28 girls and 86 boys), members of sports teams from the Polish provinces of Lubuskie and Wielkopolska. The subjects were approximately 16.0 ± 1.4 years old. They had been trained kayaking, rowing, swimming, cycling and triathlon. Their sport achievement levels were determined by sport class standards: championship, first and second (Tab. 1).

In the study the measurements of the ability to maintain static balance in an erect position with eyes open were made by means of posturography [4, 7]. The posturograph (Olton, Poland) consisted of a platform (400 x 400 x 55 mm) equipped with tensometric detectors, enabling registering the position of the vertical projection of the center of mass (COM), i.e. the center of foot pressure (COP).

The following features were utilized for analysis: center of foot pressure area COP – COPA [mm^2]; number of COP deflections in the frontal plane – NIFP [n] and number of COP deflections in the sagittal plane – NISP; length of deflections in the frontal plane – LIFP [mm] length of deflections in the sagittal plane – LISP [mm]; and the percent of time the COP remained in particular parts on the posturograph platform divided into four parts: front-left [FL], front-right [FR], back-left [BL], back-right [BR].

The obtained results were subject to statistical analysis carried out with the use of Statistica 8 software package (Statsoft, Inc. USA). Arithmetical means, standard deviations and the level of significance of differences between studied parameters were determined. Depending on the nature of data distribution U Mann-Whitney's test as well as t-test were applied. The Bioethical Commission collaborating with the Adam Mickiewicz University in Poznań gave their assent to conduct the research.

Table 1. Subjects' profile (n = 114)

Sport	Age (years)	Sex and number of competitors (n)	Height (cm)	Weight (kg)	BMI	Sport experience (years)	Sport class level (n)
Kayaking	15.7±1.0	W (n = 14)	167.2±7.1	61.4±8.8	21.9±2.1	4.8±2.4	M-1; I-9; II-4
	15.7±1.4	M (n = 40)	180.6±6.6	73.7±9.0	22.5±2.0	5.1±1.3	M-2; I-33; II-5
Rowing	16.5±0.6	W (n = 4)	177.3±8.9	70.7±10.4	22.4±2.0	2.5±1.0	M-2; II-2
	16.3±1.6	M (n = 13)	186.8±4.6	83.2±9.5	23.8±2.2	3.3±1.4	M-4; I-4; II-5
Swimming	16.7±1.0	W (n = 6)	170.0±5.4	64.5±5.9	22.4±1.2	10.5±1.8	I-1; II-4
	17.0±0.8	M (n = 4)	182.2±2.5	73.5±1.8	22.3±1.8	10.2±2.2	II-4
Triathlon	16.5±0.6	W (n = 4)	164.0±7.4	54±5.4	20.1±1.3	3.7±1.5	I-1; II-3
	17.2±1.1	M (n = 5)	181.0±6.0	71.2±6.4	21.8±2.2	3.5±1.3	I-3; II-2
Cycling	15.7±1.2	M (n = 24)	176.7±5.9	69.4±6.11	22.2±1.6	3.4±1.5	I-11; II-13

RESULTS

The obtained results point to a differentiation in body built between girls and boys. The practitioners of various sports were characterized by higher values of body mass and body height. The differences between boys and girls in terms of the number and length of deflections in the sagittal plane were noted (Tab. 2). No significant gender-related differences were, however, acknowledged in body built among athletes practicing one type of sport. Gender-related differences with reference to the time the COP remained in particular parts of the posturograph platform were not found either. In the case of both girls and boys the COP remained for the longest time in the back-right part of the platform (Tab. 2).

Table 2. Significance of differences between particular parameters of static balance in relation to gender (n = 114)

	Women M ± SD (n = 28)	Men M ± SD (n = 86)	Significance $p < 0.05$
Weight (kg)	62.8 ± 10.1	73.5 ± 9.0	0.000
Height (cm)	167.2 ± 7.1	180.6 ± 6.6	0.000
BMI	21.9 ± 2.1	22.5 ± 2.0	–
COPA (mm^2)	806.0 ± 524.6	949.1 ± 58.2	–
NISP (n)	22.4 ± 5.9	27.5 ± 7.9	0.005
NIFP (n)	26.2 ± 7.1	26.8 ± 7.5	–
LISP (mm)	156.7 ± 48.7	202.2 ± 68.3	0.001
LIFP (mm)	144.4 ± 43.2	173.0 ± 68.6	–
% FL	13.8	28.3	–
% FR	21.2	17.4	–
% BL	21.6	24.4	–
% BR	43.4	29.9	–

BMI – body mass index; COPA – area developed by vertical projection of COP; NISP – number of deflections in the sagittal plane; NIFP – number of deflections in the frontal plane; LISP – length of deflections in the sagittal plane; LIFP – length of deflections in the frontal plane; % FL – % distribution of the time spent in front/left direction; % FR – % distribution of the time spent in front/right direction; % BL – % distribution of the time spent in back/left direction; % BR – % distribution of the time spent in back/right direction.

In the case of girls and boys no statistically significant differences were observed in terms of the basic features of the ability to maintain static balance, depending on the kind of sport practiced, among boys and girls alike. The most favorable values of the analyzed features of static balance among female athletes were obtained by rowers M = 698.3 ± 402.5 mm^2 and kayakers M = 708.4 ± 350.5 mm^2, whilst the highest values were typical of female triathletes M = 1135.3 ± 1216.0 mm^2 (Tab. 3). These differences were, however, statistically non-significant. The percent distribution of the position of the centre of gravity on the posturograph in girls indicated a longer lasting deflection of the COP to the back – both to the left and to the right. On the basis of these results one may infer that athletic training in its directed stage in most competitors of various sports did not result in a considerable improvement in their ability to maintain static balance (Fig. 1).

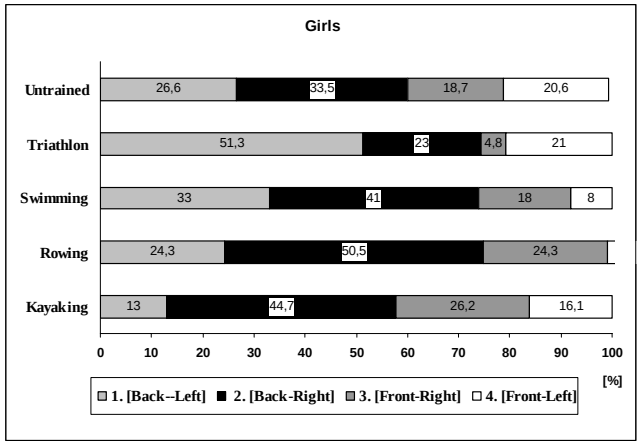

Figure 1. Position of the COP in groups of girls (n = 28)

Among the examined male athletes statistically significant differences in terms of basic features of the ability to maintain static balance were not observed either. The lowest COPA values were obtained by rowers and swimmers, and amounted to M = 671.2 ± 320.7 mm^2 and M = 816.3 ± 337.6 mm^2, respectively; whilst the highest ones were recorded by kayakers – M = 1082.5 ± 614.4 mm^2 (Tab. 4). In the groups of boys a greater "looseness" of the body was recognized than in their girls'. It was typical of kayakers and swimmers to display a long lasting deflection to the back and to the left, whilst in the case of rowers and triathletes the tendency to maintain the COP in the position to the front and to the right was typical (Fig. 2).

Table 3. Sport types and balance in groups of girls (n = 28)

Data	Kayaking (n = 14)	Rowing (n = 4)	Cycling (n = 6)	Triathlon (n = 4)	Non-training (n = 42)
COPA (mm^2)	708.4 ± 350.5	698.3 ± 402.5	837.5 ± 235.1	1135.3 ± 1216.0	713.6 ± 440.6
NISP (n)	22.3 ± 5.2	22.5 ± 3.8	22.2 ± 3.5	26.3 ± 11.2	25.8 ± 7.1
NIFP (n)	24.8 ± 7.1	25.5 ± 4.2	27.2 ± 5.4	30.0 ± 11.6	23.5 ± 7.8
LISP (mm)	153.9 ± 47.7	136.0 ± 24.4	157.2 ± 30.3	185.0 ± 9.0	172.8 ± 63.0
LIFP (mm)	136.5 ± 38.6	123.0 ± 31.4	167.0 ± 37.2	157.0 ± 56.1	123.1 ± 56.4

Table 4. Sport types and balance in groups of boys (n = 86)

Data	Kayaking (n = 40)	Rowing (n = 13)	Swimming (n = 4)	Triathlon (n = 5)	Cycling (n = 24)	Non-training (n = 24)
COPA (mm^2)	1082.5 ± 614.4	671.2 ± 320.7	816.3 ± 337.6	761.2 ± 426.2	938.8 ± 567.1	617.3
NISP (n)	27.3 ± 9.0	26.4 ± 9.1	23.5 ± 7.6	29.8 ± 3.9	27.5 ± 6.5	25.2
NIFP (n)	27.2 ± 7.7	27.0 ± 6.3	34.3 ± 9.6	22.4 ± 6.1	25.8 ± 7.3	26.9
LISP (mm)	212.2 ± 83.3	173.9 ± 48.7	188.3 ± 52.6	203.8 ± 36.0	199.5 ± 54.3	173.9
LIFP (mm)	178.4 ± 77.4	151.4 ± 38.4	218.3 ± 102.4	147.2 ± 72.6	171.3 ± 58.1	136.5

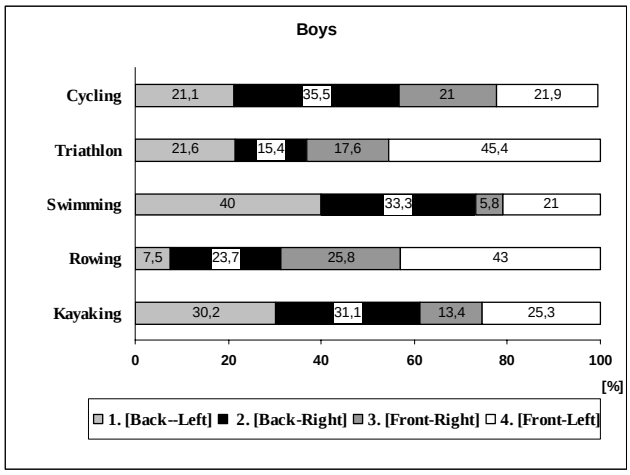

Figure 2. Position of the COP in groups of boys (n = 86).

It was affirmed that the examined female and male competitors at the directed stage of their athletic training obtained COPA values close to or higher than those of non-training subjects (Tab. 3 and 4).

DISCUSSION

The posturographical method employed in the research allowed a comprehensive evaluation of the system responsible for the maintenance of static balance. Registration and analysis of reactions to the change in the COP position enables us to determine indirectly the so-called postural strategies: ankle strategy, hip strategy and step strategy used for sustaining the body in static balance [4].

It was established that both gender and body mass did not differentiate the subjects in a significant way with regard to the basic features of the ability to maintain static balance. Sports practiced by the examined athletes are characterized by cyclic movements, which are performed with due frequency. It seems that this kind of exercise requires development of a specific ability to maintain balance, manifesting itself in an activity typical of particular sports (rowing, swimming, running, cycling).

The obtained results show that athletic training at its directed stage among the representatives of examined sports did not result in a marked improvement in their manifestations of the ability to maintain static balance. No statistically significant differences were observed in terms of basic features of the ability to maintain static balance in relation to the type of practiced sport. Therefore, the third hypothesis should be rejected. It seems, however, that longer periods of training may lead to an occurrence of such changes.

A considerable individual differentiation of the results of static balance measurements was found, which justifies the need for individualization

in the development of this ability, necessary to maintain stability in varied conditions of sport competition.

It was stated that female and male competitors at their directed stage of athletic training obtained COPA values close to or lower than those of tennis players at a similar age, whose result equaled M = 1,013.1 mm^2 . The male subjects obtained COPA values similar to those of non-training subjects. The girls' results were juxtaposed with values typical of women aged 52-69 years, regularly attending gymnastics classes with static balance exercises. The juniors' results were compared with results typical of students of the University School of Physical Education aged 19-23, whose involvement in sports resulted from participation in classes being part of the physical education curriculum [12]. It appears that the ability to maintain static balance is characterized by substantial stability, relatively independent of the subjects' age.

In the majority of examined groups it was noticed that maintaining the vertical position is a manifestation of the tendency for more frequent COP deviations to the back. It can be indicative of supplementation of the ankle joint strategy with hip joint strategy [1]. Results of other studies on the ability to maintain static balance show that the choice of the strategy to maintain balance is conditioned by the size of the base area and the angle of COP deflection within the bounds of stability as well as by the angular speed of these deflections. Should the former two strategies (or their combinations) fail, there is a possibility to implement the "step" strategy. It is employed in extreme conditions when the force and the speed of COP deflection debilitates the effectiveness of the former two. The "step" strategy may be applied in conditions of considerable COP deflections, beyond the bounds of stability. This strategy prevents falls since it increases the body's supporting area, as a result of taking a step and spreading the feet apart [5, 8, 9]. In studies on the mechanism of body sway, the regulation of body balance is treated as a process of the so-called multi-segmental reverse pendulum. In this interpretation, the basic adjusted variable is the position of COP within its supporting area [2, 7, 10].

A considerable individual differentiation of the results in terms of the basic features of the ability to maintain static balance should constitute the fundamentals for introducing appropriate exercises to stimulate the improvement of the level of the ability to maintain balance as well as to increase its stability. The obtained results enabled the formulation of the following conclusions:

1. Gender and body mass did not influence significantly the basic features of the ability to maintain static balance.
2. The type of practiced cyclic sport does not influence significantly the level of the ability to maintain static balance. It appears that far longer training experience is required for these significant changes to occur. A considerable individual differentiation of the results suggests the need for individualization in the development of the ability to maintain balance.
3. In terms of the basic features of the ability to maintain static balance junior practitioners of various cyclic sports obtained values comparable to those of tennis players, whose movements are predominantly acyclic. Values typical of athletes were higher than those of non-training subjects.

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