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The ability to maintain postural balance by water polo players during supervised training of Polish junior national team members

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ABSTRACT

Introduction. The ability to maintain one's balance depends on a variety of coordination skills and is necessary both for performing sports and everyday activities.
Aim of Study. 1. To determine the ability of water polo players from the Polish junior national team to maintain static body balance; 2. To analyze the effects of body mass on the basic ability to maintain postural balance. Hypotheses: 1. Water polo players during supervised training are characterized by a high ability to maintain postural balance; 2. The body mass of junior athletes significantly influences their ability to maintain static body balance.
Material and Methods. A group of water polo players performed three tasks: a) standard – with their eyes open; b) with their eyes closed; c) with feedback.
Results and Conclusions. Using visual control allowed water polo players to achieve optimal characteristics in their ability to maintain postural balance. Significant differences were observed between the center of pressure distribution area [COPA, mm^2]; results of trials with open and closed eyes, as well as between the closed eyes trial and feedback trial. A significant relationship between the ability to maintain postural balance and body mass was noted during the open eyes trial. Players with a greater body mass achieved less favorable COPA characteristics during this trial.

KEY WORDS postural balance, water polo, training.

Introduction

The ability to maintain postural balance depends on a variety of coordination skills and is necessary both for performing sports and everyday activities. Striving for balance in the vertical position is determined by stability [1]. Maintaining a stable body posture requires coordination between the activity of the visual organ as well as the vestibular and proprioceptive systems [2, 3]. Numerous stimuli of various types inform the body of its positions and modulate the maintenance of body balance. These stimuli provide the central nervous system with information on dislocations of the center of gravity. The nervous system activates the motor system to perform certain tasks, e.g., to limit body sway in order to keep the vertical projection of the center of gravity within the anatomical surface of support [1, 4, 5].

Disturbances in body balance may lead to falls with consequent injuries and contusions. Measuring stimuli affecting the imbalance necessitates corrections as integral components of the executive motor program [6]. The area in which there is the possibility to determine the effective correction of the safety margin makes it impossible to recover the excess balance [7]. Numerous studies have been undertaken regarding the role of body balance, which involved training and non-training individuals of both genders, different age, types of motor activity, and attended sport classes [8-10].

Water polo is a discipline that requires complex coordinated movements. In order to be competitive in this sport, players are required to maintain body balance in specific water conditions in various situations: during changes of their movement direction, throwing the ball towards the goal, serving the ball, or defending against throws. We have not found any studies in the available literature on the ability of water polo players to maintain their body balance. Previous studies involving water polo players dealt with their anthropometric characteristics as well as with the analysis of tactics and game effectiveness [11-14].

Aim of Study

This study was undertaken because of the significant role body balance maintenance during water polo competitions. The aim of this research was:

1. To determine the ability of water polo players from the Polish junior national team to maintain static body balance.
2. To analyze the effects of body mass on the basic ability to maintain postural balance.

This study was based on the following initial hypotheses:

1. Water polo players during supervised training are characterized by a high ability to maintain postural balance.
2. The body mass of junior players significantly influences their ability to maintain static body balance.

Material and Methods

The study sample consisted of 12 water polo players from the Polish junior national team taking part in a training camp. The mean age of the study participants was 16.7 ± 0.7 years, and their body mass and body height amounted to 74.8 ± 11.2 kg and 179.9 ± 6.7 cm, respectively. The players' training experience was 4.6 ± 1.2 years (Table I).

Table I. Biometric characteristics of water polo players (n = 12)

Parameter	Mean [M]	Min.	Max	[SD]
Age [years]	16.7	15	17	0.7
Body mass [kg]	74.8	57	95	11.2
Body height [cm]	179.9	167	190	6.7
Training experience [years]	4.6	3	8	1.2

Posturographic measurements were made using an Olton posturograph (Poland). The measuring unit comprised a 400 x 400 x 55 mm force plate with tensometric converters enabling determination of the vertical projection of the center of pressure (COP) [15, 16].

The subjects performed three tasks, each lasting 32 seconds. Each task required maintaining body balance in a standing position but under different conditions: a) with the eyes open; b) with the eyes closed; c) with feedback. During the last task, subjects would watch their own center of pressure on the screen represented as a light spot and were asked to keep it within a square in the middle of the screen.

The following parameters of the ability to maintain body balance were subjected to further analysis: COPA [mm^2] – center of pressure distribution area; NISP [n] – number of COP sways in the sagittal plane; NIFP [n] – number of COP sways in the frontal plane; LISP [mm] – sway length in the sagittal plane; and LIFP [mm] – sway length in the frontal plane. Moreover, the percentage time distribution of the COP in four sectors of the posturographic plane (front-left [FL], front-right [FR], back-left [BL], back-right [BR]) was also determined.

The results were processed using the Statistica 8 software package (Statsoft, Inc. USA). Arithmetic means and standard deviations were calculated for continuous variables. The significance of differences between analyzed parameters was determined with the Mann-Whitney U-test or Student's t-test, depending on variable distribution. All the procedures were approved by the Local Bioethical Committee of the Poznań University of Medical Sciences.

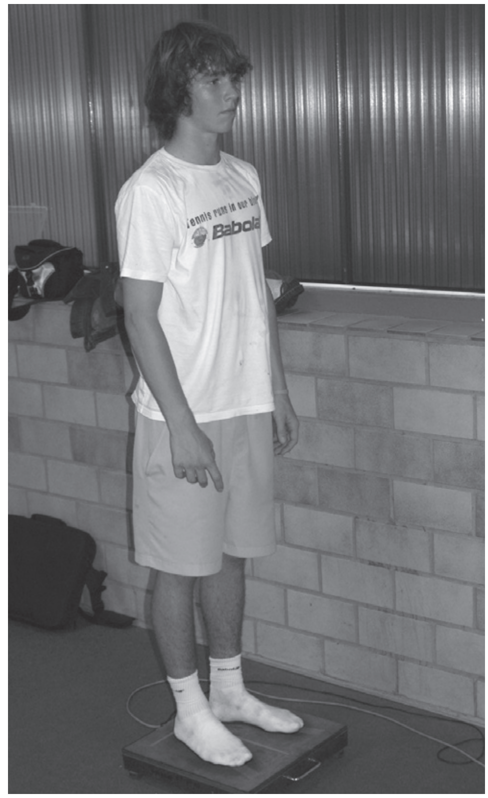

Figure 1. Measuring postural balance maintenance

Results

The best values of the basic characteristics of CoG dislocation were observed during the feedback trial (M = 798.3 ± 339.0 mm^2) or during the open eyes trial (M = 870.1 ± 508.6 mm^2). The elimination of visual control was reflected by a markedly greater COPA in which the mean value reached 1303.1 ± 728.6 mm^2. Significant differences were observed between COPA values during trials with open and closed eyes, as well as between the closed eyes trial and the feedback trial.

No significant differences were observed in the number of sways in the sagittal and frontal plane. The highest stability of these parameters was observed during the open eyes trial. There was a tendency toward more frequent forward and backward body sways. During all trials, a higher number of COPA sways was observed in the sagittal plane – particularly during the trial with closed eyes, i.e. without visual control.

A significant relationship was found between the ability to maintain postural balance and body mass during the trial with open eyes. Players with a greater body mass achieved less favorable COPA characteristics during this trial. These findings suggest that the supervised training of water polo players was not reflected by a relatively better ability to maintain postural balance (Table II, Fig. 2).

The percentage time distribution of the COP location in certain sectors of the posturographic plane revealed longer backward COP sways either to the right or to the left. This phenomenon was observed both during the open and closed eyes trials. During the feedback trial, however, a similar time distribution of COP amongst all posturograph sectors was observed (Table II, Fig. 3).

Table II. Characteristics of the ability to maintain postural balance in studied water polo players (n = 12)

Parameter	OO [eyes open] M ± SD	OZ [eyes closed] M ± SD	SZ [feedback] M ± SD
COPA [mm^2]	870.1 ± 508.6	1303.1 ± 728.6	798.3 ± 339.5
NISP [n]	24.8 ± 6.8	39.3 ± 11.8	38,0 ± 7.9
NIFP [n]	26.9 ± 6.0	30.5 ± 7.8	35,3 ± 7.9
LISP [mm]	176.8 ± 60.5	332.7 ± 90.4	295.4 ± 76.3
LIFP [mm]	156.3 ± 42.6	219.8 ± 73.7	260.6 ± 85.4
% FL	15.6 ± 19.2	22.2 ± 22.9	31.8 ± 10.4
% FR	8.5 ± 11.1	19.6 ± 15.4	22.4 ± 11.8
% BL	25.6 ± 20.6	15.4 ± 18.0	24.4 ± 16.9
% BR	50.3 ± 33.4	43.0 ± 30.2	21.4 ± 12.4

COPA [mm^2] – center of pressure distribution area; NISP – number of sways in sagittal plane; NIFP – number of sways in frontal plane; LISP – sway length in sagittal plane; LIFP – sway length in frontal plane; % FL – percentage distribution of location: front/left; % FR – percentage distribution of location: front/right; % BL – percentage distribution of location: back/left; % BR – percentage distribution of location: back/right.

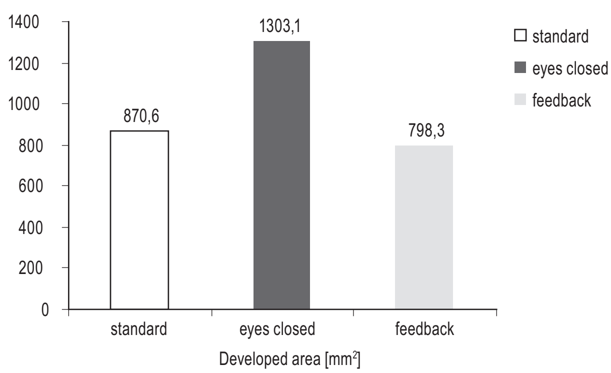

Figure 2. Changes in COPA projection depending on visual receptor involvement in water polo players (n = 12)

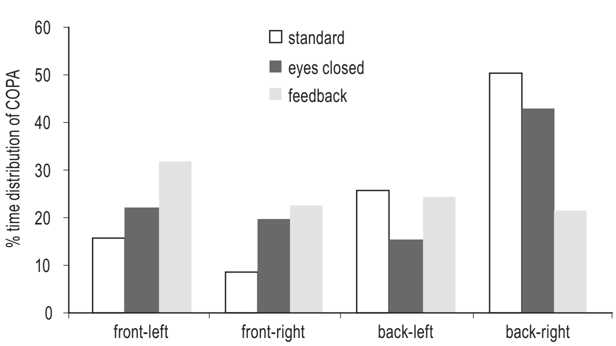

Figure 3. COPA percentage time distribution on the posturographic plane

Discussion

The posturographic method implemented in this study enables a complex and efficient evaluation of the systems involved in maintaining postural balance. The possibility of recording and analyzing the reactions of the plate to changes in the COPA location allows us to determine the so-called postural strategies such as "tarsal joint strategy", "hip joint strategy" or "step strategy" [17-19]. The mechanisms allowing ones to keep their body balance are based on these strategies [15]. The study on the ability level of the Polish junior water polo team to maintain postural balance was undertaken in view of the significant role played by this coordination skill during sports competition.

The study revealed that the most favorable characteristics of COPA dislocation were observed during the feedback trial and open eyes trial. Implementation of feedback allowed participants additional corrections in the COPA location by activating their visual receptors. Visual information may be utilized to evaluate body position in the water and allows for constant corrections, e.g. while observing movements of the opposite team players and watching rapid changes in the game.

The lack visual stimulation in the trials with eyes closed, negatively affected the participants' ability to maintain stable body balance as reflected by an increased center of pressure distribution area. Significant differences in COPA values were observed between the open and closed eyes trials with more favorable results recorded during the former. A similar relationship was observed between the results of the closed eyes trial and feedback trial with more favorable values in the latter.

A significant inverse correlation was observed between the level of ability to maintain postural balance and the body mass of participants subjected to the open eyes trial. Players with greater body mass achieved less favorable COPA characteristics during this trial. Interestingly, the effects of body mass on the CoG location of were not observed in other studies of athletes of different disciplines but of similar age [20]. According to Collins et al. [1993], improvements in postural stability appear along with increasing body mass and higher body inertia. The aforementioned studies revealed that increasing body mass in participants of different ages was reflected by an increasing support area, which in turn positively influenced their ability to maintain postural balance. These findings were supported by other authors who observed that higher body mass reduced body sway and consequently enabled the maintenance of a more stable posture [21, 22]. Collins et al. [1993] suggested that the level of body balance may be negatively affected by increases in body height, but this theory has not been confirmed in our study of water polo players.

In this study, no significant differences were observed in the number of sways (either in the sagittal or frontal plane). The influence of visual control in the open eyes trial was reflected by the highest levels of stability. In this trial, the tendency toward more frequent forward and backward sways was observed.

During all trials, a higher range of COPA sways was observed in the sagittal plane, particularly during the closed eyes trial, i.e. without visual control. Plausibly, the lack of visual stimulation was reflected by better stabilization of body posture in the frontal plane. A crucial role in body balance regulation was played by sagittal COPA dislocations. This solution is probably more effective since it permits the use of other strategies of balance maintenance, including the "step strategy" and "hip joint strategy". Their choice depends on the ability to properly analyze a variety of information about the current state of the body and the support surface [23, 24]. The possibility of ad hoc correcting the body position results in an improved symmetry in the sagittal plane with a subsequent forward dislocation of the body [15].

This study revealed that supervised training of young water polo players did not result in a marked improvement in their ability to maintain postural balance. It should be noted, however, that the participants' training experience was relatively short, while the basic characteristics of COPA dislocation became more favorable along with training experience. The values observed in this study were similar in subjects of similar age characterized with different levels of sport activity, e.g. canoeists, swimmers and cyclists [10, 20, 22]. Additionally, we did not observe a significant influence of body mass on the basic characteristics of maintaining postural balance.

The percentage time distribution of COPA among certain sectors of the posturographic plane suggested a longer backward sway of the body – either to the right or to the left. This was observed both during the open and closed eyes trials. During the feedback trial, however, the time distribution of the COPA was similar in all posturograph sectors. This finding probably resulted from the participants' attempts to place the light spot in the middle of the screen, and therefore avoid a relatively similar COP dislocation in all directions.

Conclusions

Using visual controls allowed water polo players to achieve optimal characteristics in their ability to maintain postural balance. Significant differences were observed between COPA values recorded in open and closed eyes trials, as well as between the closed eyes trial and feedback trial.

A significant relationship was observed between the ability level to maintain postural balance and the body mass of participants subjected to the standard (open eyes) trial. During this trial, participants with greater body mass achieved less favorable COPA values.

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