The ability to maintain static balance depending on the engagement of visual receptors among the elite sumo wrestlers

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Abstract

Background and Study Aim: Since the ability to maintain balance is significant to efficient fighting, research was carried out in order to determine the level of the ability to maintain static balance among the Polish elite of sumo sportsmen depending on the engagement of visual receptors.

Material/Methods: Research group comprised 41 best Polish male and female sumo wrestlers. To evaluate the ability to maintain static balance the posturographical method was employed. The following measurements were made: with eyes open (EO), with eyes closed (EC) and in conditions of feedback (FB).

Results: The closing of the eyes resulted in the increase of ACOP. The introduction of feedback had an effect on the obtainment of ACOP lowest values. The differences were not statistically significant.

The change in the value of ACOP results from a modified number of deflections as well as their varied range. The changes in the number of deflections in the frontal and the midline plane were subject to analysis for they are considered to be the basic factors accounting for the reaction of the subjects to the change in the engagement of visual receptors. It was claimed that both the visual analyzers switch-off and the introduction of feedback had an effect on the increase in the number of deflections. The value of NDAP rose more significantly than the value of NDFP.

Conclusions: The elimination of the engagement of visual receptors in the maintenance of static balance among the best Polish sumo sportsmen has a detrimental effect on the basic characteristics of COP. Increased is the value of ACOP and NDFP, especially that of NDAP. The introduction of FB during the measurement of the ability to maintain static balance enables the limitation of ACOP. Its lesser value is achieved due to an increase in the number of COP oscillations, particularly in the midline plane. The ability to take advantage of FB in the maintenance of static balance proves its high developmental level. In comparison with competitors of other sports as well as those not training, sumo sportsmen achieved lower values of ACOP in the majority of cases.

Key words: feedback • maintain balance • posturography • center of gravity • sumo wrestlers

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Background

Sumo as a sport derives from Japanese national sport, and in its precise meaning the word "sumo" stands for swift counteraction to the punches of your opponent. The fight is an attempt to throw the opponent out of the mat or to knock him down by appropriate throws, pushes or body hits [1].

To lead a sports fight efficiently a high level of the ability to maintain balance is required. It allows sustaining

Feedback – the reaction of the system's end-status parameters to the initial characteristics. It relies on the gathering of information concerning own actions and adjusting reactions on their basis.

Balance – the ability to keep the position of the body in a dynamic, reflex-conditioned process.

Posturography – a method facilitating the assessment of the level of the ability to maintain static balance. It enables the registration of the configuration of the vertical projection of the general centre of gravity (COG) upon the determination of the pressure center of the feet on the platform (COP).

The centre of gravity (COG) – a point to which the resultant of the forces of gravity affecting the elements of the body mass is applied.

stable body posture, or in case of its loss, enhances the ability to regain it quickly [2]. The ability to maintain balance is one of the essential coordination abilities and plays a significant part in daily activities as well as under conditions of sports fight, which demands that a balanced body posture be sustained [3–5]. In an attempt to realize the very task a man is forced to generate appropriate reactions indispensable to control body posture [6–8].

The ability to maintain balance was subject to research in various groups of non-training individuals as well as sportsmen, which differed in terms of age, sex and sports level [2,5,9–11]. In the literature available, however, there is no trace of research results treating the issue of the level of the ability to maintain balance in sumo competitors.

Since the ability to maintain balance is significant to efficient fighting research was carried out in order to determine the level of manifestation of the ability to maintain static balance among the Polish elite of sumo sportsmen depending on the level of engagement of visual receptors. Before conducting the research it was hypothesized that elite sumo competitors are characterized by a high level of the ability to maintain static balance, which is essential to sustain stable posture during a fight, and the change in the engagement of visual receptors considerably affects its level.

Material and Methods

Research group comprised 41 best Polish male and female sumo competitors, including 15 women aged 22.9±4.5 years and 26 men aged 23.0±6.6 years. Their body mass oscillated around 78.7±27.4 kg and 99.7±25.7 kg among women and men respectively. The height of the female subjects eight equalled 165±7.5 cm, whilst that of males amounted to 179±9.2 cm.

The subjects boasted a high level of sport achievement (Table 1). There were medallists from world and European championships as well as Polish championships. The participants represented all weight categories, according to sumo rules and regulations. The majority of subjects used to practice various sports in the past (Table 1).

To evaluate the ability to maintain static balance the posturographical method was employed in the tests [4,9]. The following measurements were made: with eyes open (EO), with eyes closed (EC) and in conditions of feedback (FB). A posturograph manufactured by Olton (Poland) consisted of a 400×400×55 mm platform equipped with tensmetric transducers, which enabled the registration of the vertical projection of the centre of gravity (COG) by determining the pressure centre of the feet on the platform (COP) [5]. The location of COP during measurements was recorded by means of temporary values of COP swings in the x and y axis. The competitors subject to the experiment performed three test tasks, each lasting 32 seconds. Every task was carried out in an erect posture, in various conditions of maintaining static balance with the use of visual analyser. The following measurements were taken: with eyes open (EO), and subsequently with eyes closed (EC) and in conditions of feedback (FB). In the last experimental situation the subjects followed the picture of COP on the monitor as a light source and attempted to keep it within the square visible in the central part of the screen.

For the analysis to be completed, the following features were applied: the area developed by COP – ACOP; as well as the number of COP deflections in the frontal plane and in the midline plane – marked as NDFP and NDAP, respectively. The test results were compiled by the application of statistical software Statistica 8 (Statsoft, Inc. USA).

Results

The tested sumo sportsmen were characterized by a great diversity in terms of body structure. However, since the size of the tested group was relatively small, particularly in the heaviest weight categories, the analysis of results in separate categories was abandoned. No statistically important correlation coefficients between height, body mass, BMI and ACOP were observed in tested women and men.

The closing of the eyes contributed to achieving higher values of ACOP (Table 2). The introduction of feedback was instrumental for those tested persons who achieved the lowest ACOP values in that test situation. Nevertheless, the differences which occurred were not statistically significant.

The change in the value of ACOP results from the modified number of deflections as well as their varied range. The experiment looked into the changes in the number of deflections in the frontal and the midline since it was assumed that they form a basic factor accounting for the reaction of the subjects to the change in the engagement of visual receptors. It was affirmed that both the visual analysers switch-off and the introduction of feedback had an effect on the increase in the number of deflections (Table 2). The value of deflections in the midline plane (NDAP) rose more significantly than that in the frontal plane (NDFP).

Table 1. Subjects profile (n=41).

Data	Women (n=15)			Men (n=26)		
Weight category (n)	≤65 kg (10)	≥65 kg (5)		≤85 kg (11)	≤115 kg (11)	≥115 kg (4)
Sport class(n)	MM (8)	MK (5)	I (2)	MM (8)	MK (14)	I (5)
Previously sports disciplines (n)	Wrestling (9)	Combat sports (3)	Others (3)	Wrestling (17)	Combat sports (1)	Others (8)

MM – international champion class; MK – national champion class; I – regional sports class.

Table 2. The profile ability of maintain balance at sumo wrestlers (n=41).

	Men (n = 26)		Women (n = 15)	
	M	SD	M	SD
ACOP-EO [mm^2]	458.6	258.4	567.8	389.0
ACOP-EC [mm^2]	677.5	402.2	783.5	523.6
ACOP-FB [mm^2]	334.0	176.7	467.7	230.9
NDFP-EO [n]	21.6	9.8	24.7	9.9.
NDFP-EC [n]	27.1	11.0	25.9	10.3
NDFP-FB [n]	24.5	8.5	29.3	8.3
NDAP-EO [n]	23.5	5.5	23.3	8.6
NDAP-EC [n]	35.2	9.7	32.7	9.6
NDAP-FB [n]	31.9	7.5	31.7	8.1

Sumo – a kind of martial arts which derives from Japanese national sport. It indicates a swift counteraction to the opponent's punches. The fight is an attempt to throw the opponent out of the mat or to knock him down by appropriate throws, pushes or body hits [1].

Feedback – a mechanism which relies on the mutual synergy of effectors and receptors in a human body. Information about the effects of their actions accounts for the basis of further reactions readjustment. During the performance of movement it is a continuous process, which is fundamental to the steering of their course.

Static balance – the ability to maintain body posture without shifting the whole body or its parts. It is determined by registering and analyzing the course of reactions to the changes in the position of the general center of gravity (COG), measured most often in an erect posture.

Discussion

The posturographical method applied in the test permits a comprehensive assessment of the efficiency to maintain static balance by means of registration and analysis of the course of reaction to the change in the location of the general centre of gravity (COG). ACOP is defined as a measurement of the overall body's dynamics, which comprises the resultant effect of the various nervous-muscular components in the joints. Their features are mainly dependent on the principal input signals from the system of balance – visual, auricular and proprioceptive [4]. In an indirect manner, the posturographical method assists the determination of the ways to pursue the most stable body posture that is the so-called postural strategies. Mechanisms maintaining the body in static balance function on the strength of these strategies [3].

The tested male sumo competitors achieved varied results of ACOP. They were more favourable than those obtained by female ones (Table 2). This trend concerned all three test situations, which differed in terms of the engagement of the visual analyser (EO, EC, FB). Interestingly enough, the best results when it comes to the ability to maintain static balance were obtained by males, who boasted a considerably higher level of BMI (M=30.5) than females (M=26.7). A similar dependence was also seen in other tests. It was determined that the improvement of the so-called postural stability occurs alongside the weight gain and, simultaneously, the higher moment of inertia [10]. Weight gain also results in the growth of the supporting plane, which is beneficial for the ability to maintain static balance. Detrimental, on the other hand, may be the effect of the increase in body height [10]. This viewpoint is also held by Young and others, who claim that greater body mass enables people to keep a more balanced body position, which results in fewer body swings [5]. Nevertheless, it is not rare a conviction that too much body mass results in postural instability and, similarly, in a greater inclination to fall, which may consequently lead to injuries and fractures [12].

During measurements taken in conditions of feedback a tendency to achieve the lowest values of ACOP among men and women became evident. The cause may lie in the improvement of precision of the central nervous system's functioning by the activation of visual receptors. In effect, the level of spatial orientation facilitating the ability to maintain static balance may be improved. The subjects, being able to follow the movement of COP on the monitor were in a better position to control and systematically correct its position, or in other words, attempt to keep its image within the central part of the screen. It is an essential ability, whose level may be influenced by a regular implementation of coordination exercises, including balance exercises. These

observations affirm the results of another experiment conducted on males aged 16–19 [2].

In the tested group the change in the engagement of visual receptors brought about the increase in the COP oscillations. The growth was more substantial in the midline than in the frontal plane. The causes might be attributable to the implementation of yet a different strategy to do with the maintenance of the body in the most balanced position, for instance 'the ankle joint strategy' or 'the hip joint strategy'. Nashner and others claimed that the choice of the strategy to do with the maintenance of balance depends on the size of the base area, on the extent of the deflection of the centre of gravity within the bounds of stability as well as on the angular speed of these deflections [13]. In the context of these two strategies, or their combinations, being fallen back on their arises a possibility to implement the third one, referred to as 'the step strategy'. It is assumed in extreme conditions, when the force and the speed of COG's deflection effectively limit the implementation of the former two, for example when COG's deflections are beyond the bounds of stability. The displacement of COG in the midline plane as well as its fluctuations in the frontal plane may be an indication of changes in the way static balance is achieved [3,14]. When it comes to the number of deflections in both planes, the sex of the subjects did not differentiate them in a significant manner. It appears that in sumo, when deflections approach the bounds of stability, the step strategy may be replaced with the shift of the supporting force onto the opponent. Also, one may apply the technique which relies on the opponent's being knocked out of balance and thrown outside the fight area.

The values of the features typical of the ability to maintain static balance in the tested group of sumo sportsmen were lower among men in comparison with analogous research conducted in the non-training group – the male students of physical education and middle-aged men. The tested female sumo competitors obtained higher values of ACOP in comparison with the female students of physical education and classical ballet dancers, both age averages in these groups being 23. These observations may serve as confirmation of the influence of comprehensive and systematic balance training on a faster and more efficient retrieval of balance [10]. Female sumo competitors obtained lower values in comparison with the results obtained by women who turned 50 according to ACOP measurements recorded by identical methodology [14]. It may have resulted from the difference in the amount of exercise taken, from the fitness conditioning of sumo sportsmen, from, among others, training devoted to the development of balance, but also from greater ability to concentrate on the task achievement, which should be typical of young people, particularly professionals.

Balance in martial arts is one of the most crucial coordination abilities both in offense and defence [11]. Lack of balance exercises in the course of trainings as well as the lesser force of muscles responsible for the maintenance of balance may account for the sense of instability and more often than not, lead to a sudden fall. With regard to sumo, the consequence may be that the opponent will be either pushed away from the mat or knocked down, which equates to failure in the fight [15,16].

Conclusions

The elimination of the engagement of visual receptors in the maintenance of static balance among the best Polish sumo sportsmen significantly disturbs the basic COP characteristics. There occurs an increase in ACOP and NDFP, particularly in NDAP.

The introduction of FB while measuring the ability to maintain static balance enables the limitation of ACOP. Its lesser value is achieved owing to a bigger number of COP oscillations, especially in the midline plane. The ability to take advantage of FB to maintain static balance proves its high developmental level.

Sumo sportsmen, in comparison with other sportsmen and non-training individuals, achieved lower ACOP values in the majority of cases. It counted as yet another confirmation of the high level of the ability to maintain static balance.

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