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## SPORTS MEDICINE

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# Comparative Study of Stabilometric Parameters in Sportsmen of Various Disciplines

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Stabilometric parameters were compared in sportsmen of various disciplines (biathlon, boat racing, judo, and water polo). A decrease in the role of gravitational factor in sport activity was accompanied by the impairment of balance characteristics, which remained within normal limits of the mean population level.

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**Key Words:** *stabilometry; balance; posture; locomotor activity; sport*

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Human activity is determined by the ability to retain a specific statodynamic posture. Previous studies showed that upright standing is an innate reflex [1]. Human balance control in a vertical position depends not only on the state of health, but also on training capacity [3]. Proprioceptive, visual, and vestibular afferentation has a regulatory function, which is realized via variations in the tone of postural muscles. These features provide the maintenance of a fixed body position (*e.g.*, posture) [6]. Professional activity of a human being modifies the strategy to maintain a vertical position, which is particularly pronounced in sportsmen [2,3,5]. Stabilometry allows us to perform the objective evaluation of human stability in a vertical position.

Here we studied the effect of support load on vertical posture maintenance in sportsmen.

### MATERIALS AND METHODS

We examined 100 sportsmen of four kinds of sport (biathlon, boat racing, judo, and water polo). The scheme of this study was approved by the Ethics

Committee of the All-Russian Institute of Physical Training and Sport. The average age of sportsmen was 18-25 years. The maximum oxygen consumption was 48-65 ml/kg/min. The subjects were engaged in sport for at least 3 years. They did not have contraindications, including acute traumas or somatic diseases. All sportsmen were characterized by a similar training period before the competition (1 year).

These kinds of sport were selected due to the specificity of gravitational factor and necessity to maintain a stable vertical position during competitive activity (Table 1).

A stabilometric study of sportsmen was performed on a Stablan diagnostic complex (Ritm). The sportsmen stood barefoot on a platform (European position — heels in, toes out at an angle of 30°) [2,6]. The measurements were performed with open eyes and closed eyes to exclude a correcting effect of the visual analyzer. The speed of center-of-pressure (COP) movements and area of the statokinesiogram were evaluated.

Statistical treatment of data and evaluation of the normal distribution of test parameters were performed by means of univariate statistics ( $\bar{x} \pm \sigma$ ). The differences were determined by Student's *t* test with

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**TABLE 1.** Characteristics of Examined Subjects

Group	Kind of sport	Sample volume, <i>n</i>	High support load	Necessity to maintain a vertical position
Group 1	Biathlon	25	+	+
Group 2	Boat racing	25	+	—
Group 3	Judo	25	—	+
Group 4	Water polo	25	—	—

Bonferroni correction (multiple comparison). The differences were statistically significant at  $p < 0.05$ .

## RESULTS

A comparative study showed that stabilometric parameters depend on the kind of sport.

Significant differences were revealed in the maintenance of an orthograde posture under conditions of visual control. Test parameters were shown to differ between biathletes and water polo players, as well as between water polo players and judoists (Table 2).

Water polo players differed from other sportsmen in the highest speed and area of COP (Figs. 1 and 2). Biathletes and judoists were characterized by the minimum values of test parameters. Oarsmen were intermediate in these parameters.

The absence of visual control was followed by a change in the mechanisms to maintain an orthograde posture (Table 2). The speed of COP in-

creased most significantly, while the area of COP increased least significantly in water polo players. The oarsmen exhibited the greatest increase in the area of COP and smallest increase in the speed of COP. An intermediate increase in the speed of COP and smallest increase in the area of COP were found in biathletes. Judoists were characterized by the smallest increase in the speed of COP and intermediate increase in the area of COP.

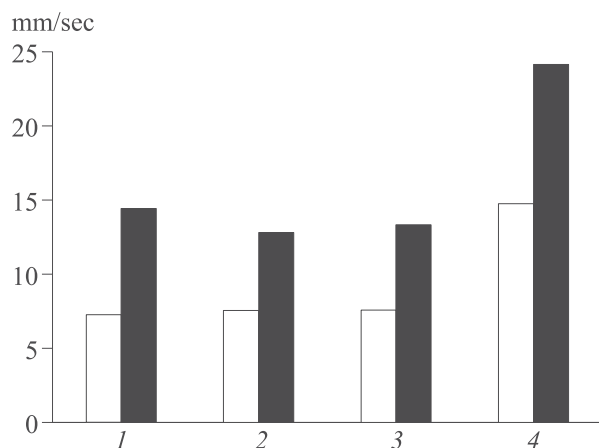
The following results were obtained for an orthograde posture with no visual control (closed eyes): (1) maximum speed of COP in water polo players, no differences in COP between sportsmen of other disciplines; and (2) maximum area of COP in oarsmen and water polo players, minimum area of COP in biathletes.

Our results indicate that a stabilometric study of highly skilled sportsmen is a reliable method to determine the effect of long-term, accented, and intense muscle activity on the mechanisms for vertical posture maintenance. The main distinctive para-

**TABLE 2.** Stabilometric Parameters in Sportsmen of Various Disciplines

Parameter	Boat racing	Biathlon	Water polo	Judo
Standing with open eyes				
speed of COP	7.58±2.05	7.26±5.51	14.75±5.91 * $p=4.32$ * $p=-3.14$	7.56±2.00 * $p=4.75$
area of statokinesiogram	114.96±91.20	74.03±73.94	158.81±83.75 * $p=-2.55$	85.57±59.15 * $p=2.94$
Standing with closed eyes				
speed of COP	13.32±4.09	14.43±6.78	24.14±16.91 * $p=2.33$	12.81±4.00 * $p=2.69$
area of statokinesiogram	264.64±182.29	130.82±67.37 * $p=-2.10$	212.66±153.13	173.11±98.43
Difference between parameters in the absence and presence of visual control				
speed of COP	5.74±2.47	7.18±5.74	9.39±14.35	5.25±3.31
area of statokinesiogram	149.69±127.17	56.79±73.73	53.86±139.13	87.54±103.16

**Note.** As compared to: \*boat racing; \*biathlon; \*water polo.

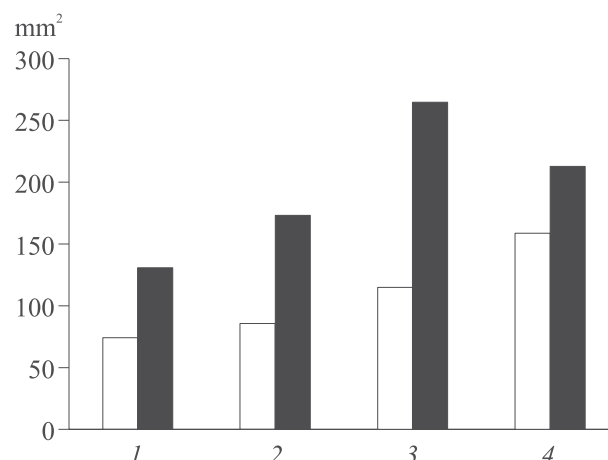


**Fig. 1.** Average speed of COP in biathletes (1), judoists (2), oarsmen (3), and water polo players (4) during testing with open eyes (light bars) and closed eyes (dark bars).

meters are the absolute values and variations in the speed and area of COP in the presence or absence of visual control.

In this study, highly skilled sportsmen were examined after long-term training with various kinds of sport. Our results indicate that the mechanisms to maintain an orthograde posture depend strongly on the kind of accented and intense physical activity. The area and speed of COP movements increased in the following order: biathlon<judo<boat racing<water polo. A progressive decrease in the role of gravitational factor and coordinative complexity of a vertical position in the main competitive practice is observed after long-term training and results in the reduced statokinetic stability, which remains within normal limits of the mean population level [4].

We conclude that stabilometric parameters serve as a reliable criterion for sensorimotor function and realization of human movements under conditions of intense physical activity. This approach allows us to distinguish between the general and peculiar



**Fig. 2.** Average area of the statokinesiogram in biathletes (1), judoists (2), oarsmen (3), and water polo players (4) during testing with open eyes (light bars) and closed eyes (dark bars).

features, which are determined by the intensity and specifics of long-term training.

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