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Physiological and Biomechanical Characteristics of the Kick and Goal Techniques of Football Players

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Physiological and biomechanical characteristics of the kick and goal technique in football were studied in athletes of different qualification. The formation of technological skills of football players kicking the ball from the standard position requires coordinated movements and high differentiation of muscular activity.

Key Words: *football; biomechanics; electromyography; stabilography*

Like in other sports, in football the technical methods constitute a system of successive simultaneous movements, providing (due to optimal interactions of inner and outer forces) the maximum efficiency of motor action [1,2]. The development of new and improvement of traditional technologies of athletic training is closely related to studies of the mechanisms regulating the movements of different coordination complexity [3].

We studied the physiological and biomechanical characteristics of the football kick and goal technique in athletes of different qualification.

MATERIALS AND METHODS

Thirty men aged 18-27 years were examined. Two groups were formed, differing by qualification. Athletes with lower qualification (LQA) were students (n=20) engaged in football for more than 3 years, faculty and institute team members having athletic qualification. The group of highly qualified athletes (HQA) were players (n=10) of a professional team (Tom' premier league football club).

Electromyographic studies were carried out on a Neuro-MVP-4 polyfunctional computer complex. Electrical activities of the leg muscles during ball kicking were recorded. Stabilographic studies were carried out on a biological feedback computer stabiloanalyzer Stabilan-01-2. Coordination was evaluated during simulation of ball kicks.

RESULTS

The results of stabilographic analysis of the kick by the external side of the foot in football players of different qualification are presented in Fig. 1 as a curve reflecting the dynamics of common pressure center (CPC) excursion from the beginning of kicking to the end of movement. Highly qualified athletes maintained CPC in the initial position during the preparatory phase, after which CPC drifted forward along the kick trajectory and returned back. In LQA, CPC was shifted backward during the preparatory phase. During the kick, CPC trajectory was bent, which significantly reduced movement efficiency. During the final phase the athlete shifted alternatively to both sides to keep balance.

Mathematical analysis of stabilogram indicated that the "frontal shift" was significantly less in HQA, while

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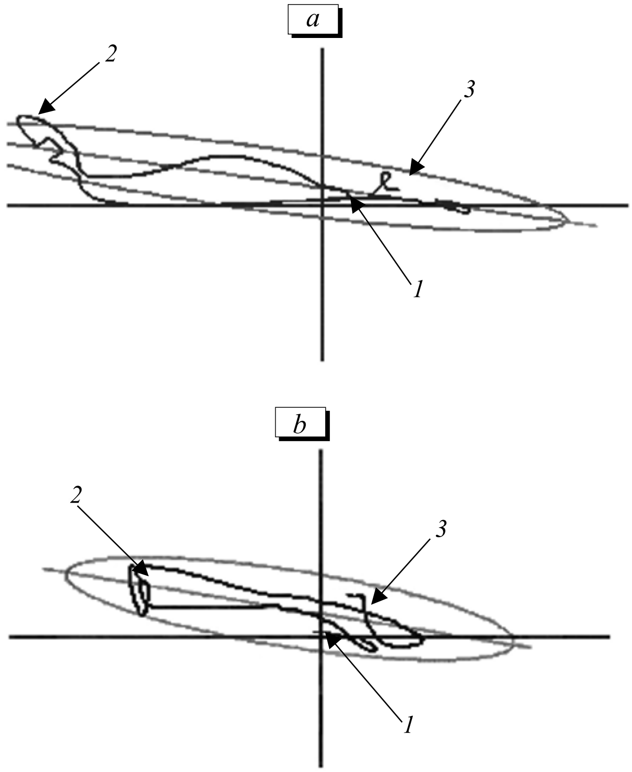

Fig. 1. Statokinesiogram of a kick with the external foot side in LQA (*a*) and HQA (*b*). *1*) beginning of kick; *2*) ball kick moment; *3*) end of movement.

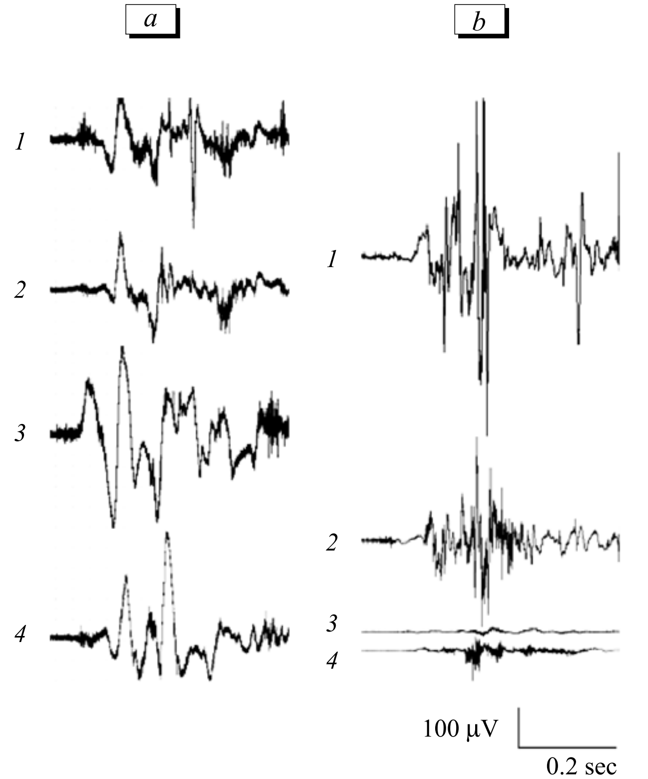

Fig. 2. Electromyogram of foot muscles during kick with external side of the foot, LQA (*a*) and HQA (*b*). *1*) *m. gastrocnemius* (lateral head); *2*) *m. gastrocnemius* (medial head); *3*) *m. vastus lateralis* (lower third); *4*) *m. adductor longum*.

comparison of sagittal shift was virtually the same in the two groups (Table 1). The mean linear velocity was significantly higher in HQA, while the angular velocity of CPC in the two groups did not differ.

Records of bioelectrical activity of the lower limb muscle during kick with the external side of the food in football players of different qualification showed significant differences in the work organization of

TABLE 1. Stabilographic Parameters of Football Players Kicking the Ball (Me (Q_1-Q_3)

Parameter	Type of kick	LQA (*n*=20)	HQA (*n*=10)
Frontal shift, mm	Internal side of foot	9.60 (5.55-15.10)	1.33* (0.01-3.16)
	Middle instep	2.36 (1.50-5.57)	9.57* (8.23-17.79)
	External side of foot	3.22 (1.31-7.35)	10.67* (9.51-0.13)
Sagittal shift, mm	Internal side of foot	9.17 (0.01-16.02)	12.76 (5.86-15.74)
	Middle instep	9.83 (1.67-18.23)	18.68* (9.99-29.07)
	External side of foot	15.14 (4.04-23.39)	13.65 (0.61-5.05)
Mean linear velocity, mm/sec	Internal side of foot	144.784 (113.26-157.85)	157.202* (136.83-171.38)
	Middle instep	138.48 (114.64-155.05)	193.75* (154.95-55.11)
	External side of foot	153.03 (126.72-189.23)	192.16* (153.16-239.01)
Mean angular velocity, grad/sec	Internal side of foot	20.28 (17.15-22.40)	15.079 (13.00-16.50)
	Middle instep	19.98 (15.90-23.00)	15.16 (13.60-16.50)
	External side of foot	20.41 (17.00-23.00)	16.65 (15.05-18.25)

Note. Here and in Table 2: *p<0.05 in comparison with LQA.

TABLE 2. Bioelectrical Activity of Foot Muscles during Ball Kicking by Football Players of Different Qualification (Me (Q_1-Q_3)

Type of kick	Group (*n*=15)	Parameter	*M. gastrocnemius*		*M. vastus lateralis* (lower third)
			medial head	lateral head	
External side of foot	LQA	Maximal amplitude, μV	919 (482-1231)	917 (512-1628)	1155 (319-2963)
		Mean frequency, sec^{-1}	279 (204-348)	297 (227-464)	222 (63-281)
	HQA	Maximal amplitude, μV	368* (216-595)	1952* (586-2474)	334* (178-2040)
		Mean frequency, sec^{-1}	279 (196-312)	153* (115-258)	210 (122-400)
Internal side of foot	LQA	Maximal amplitude, μV	863 (273-1017)	882 (476-1975)	1246 (368-2446)
		Mean frequency, sec^{-1}	282 (144-382)	262 (182-430)	101 (64-356)
	HQA	Maximal amplitude, μV	1929* (916-2711)	342* (237-678)	503* (294-882)
		Mean frequency, sec^{-1}	207* (98-272)	252 (88-247)	262* (88-497)
Middle instep	LQA	Maximal amplitude, μV	965 (440-1674)	907 (582-2120)	389 (228-1090)
		Mean frequency, sec^{-1}	298 (210-512)	315 (170-389)	282 (66-480)
	HQA	Maximal amplitude, μV	903 (469-1303)	639 (292-1558)	1729* (406-14 278)
		Mean frequency, sec^{-1}	272 (166-589)	197 (109-372)	105* (71-177)

different muscle groups (Fig. 2): in LQA all muscle groups were involved in contraction simultaneously, while in HQA mainly the lateral head of the gastrocnemius muscle worked when performing the kick.

Analysis of bioelectrical activity of the foot muscles during kicking the ball showed significant differences between LQA and HQA groups (Table 2). Electrical activity amplitude in HQA kicking the ball with the external side of the foot was significantly higher than that in LQA, while the oscillation frequency was significantly lower. The amplitude of bioelectric activity in other muscle groups, not directly involved in performance of this kind of kick, was significantly higher in LQA.

Similar differences were detected during performance of other kicks. High amplitude and low frequency of oscillations were recorded in HQA at the medial gastrocnemius head during kick with the internal side of the foot and at the lateral vastus muscle during middle instep kick. The amplitude of bioelectrical activity in other muscle groups was lower in HQA than in LQA.

Hence, the biomechanical regularities of ball kicking were basically different in HQA and LQA. The formation of professional skills of football players during ball kicking from a standard position depends on two groups of factors: 1) movement coordination, *i.e.* decrease in body sway in the frontal plane and increase of linear (but not angular) velocity of pressure center excursion; 2) improvement of muscular activity differentiation, *i.e.* increase in bioelectrical activity amplitude in groups of muscles directly involved in kick performance is paralleled by reduction of the mean frequency of oscillations, while bioelectrical activity of the adjacent muscle groups is suppressed.

The complex of biomechanical and physiological parameters can serve as an indicator for athletic selection, operative testing of technical preparedness of athletes, and as the basis for the development of new approaches to improvement of athletic skills of football players.

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