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SHORT REPORT

Are there differences in postural regulation according to the level of competition in judoists?

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The aim of this work was to study the posturokinetic capacities and use of visual information by judoists according to their level of competition. Twenty male judoists aged between 16 and 19 took part. They were separated into two groups: those that competed at regional level and those that competed at national and international level. Static balance was measured on a force platform. No difference was seen between the two groups. However, it seems that visual information is more important to the higher level judoists. Perhaps the level of competition influences the sensory canals involved in balance.

Electromyographic activities of experienced sportsmen in conditions of muscular synergy are more precocious than those of the non-initiated.¹ In French boxing, in response to a kick, the muscles of an expert's supporting limb are activated more rapidly than a beginner's, in whom the muscular contractions appear globally and diffusely.² In addition, trained judoists are able to predict variations in fighting conditions and to forestall action³; postural preparation is thought to be optimised to enable experts to react more rapidly. Furthermore, the postural adaptations of experts in combative sports are more efficient than those of beginners during movements specific to the sport⁴; they are able to change their intersegmentary coordination in order to accommodate the specific constraints of the task.²

A pertinent question therefore is whether posturokinetic performance is related to competition level in sports involving a lot of posturokinetic activities. We therefore compared the balancing capacities of judoists at different levels of competition. This was carried out in two different sensory conditions: with eyes open and with eyes closed.

MATERIALS AND METHODS

Subjects

Twenty male judoists aged 16–19 were recruited. They were all at least at regional level (nine regional level, nine national level, and two international level) and performed the same amount of weekly training (10–14 hours). They had all practised judo for at least seven years. None had stopped for more than three weeks during the six months before the study because of injury or any other reason.

The subjects were separated into two groups, one of regional level judoists (RL) ($n = 9$) and the other of national and international level judoists (NIL) ($n = 11$). The mean (SD) age was 17.4 (0.4) and 17.6 (0.3) years, height was 176.1 (4.1) and 177.2 (6.6) cm, and weight was 73.8 (8.4) and 71.5 (5.8) kg respectively.

Experimental protocol

Static balance (maintaining orthostatic posture on stable ground) of each group was measured on a force platform (Satel; 480 × 480 × 65 mm; Satel, Blagnac, France) first with eyes open and then with eyes closed. This device has three

strain gauges, and records the displacement of the subject's foot pressure while standing on the platform. During this test, the subject was asked to stand as still as possible with arms hanging by his side and legs straight. Each test lasted 51.2 seconds (with eyes open and with eyes closed). From information provided by the sensors, a computer records, at 40 Hz frequency, the position of the pressure centre of the feet, and plots a figure called a statokinesigram.

Many variables depict the maintenance of orthostatic posture: surface and length of the statokinesigram, and coordinates of the average position of the pressure centre of the feet on the x axis (lateral displacements) and y axis (anteroposterior displacements). According to Gagey et al.,⁵ the ratio of the statokinesigram length to its surface area gives an evaluation of the energy expended by the subject to maintain his posture, and the variation in speed on the anteroposterior axis gives an assessment of the toughness of muscles of the posterior lodge of the legs. This statokinesigram can be projected on each axis of the platform: in this way, we have the stabilogram in x (lateral oscillations of pressure centre) and y (anteroposterior oscillations). The frequencies of postural sways were analysed from 0 to 20 Hz by applying Fourier's fast transforms to the length variables. This gives (a) the total spectral energy (V^2), which accounts for the average amplitude of sways, and (b) the analysis of energy distribution in three frequency bands: low frequency, 0–0.5 Hz; medium frequency, 0.5–2 Hz; high frequency, >2 Hz. The latter analysis enables assessment of the preferential involvement of short or long neuronal loops in balance regulation. In agreement with other authors,^{6–8} we assumed that low frequencies account for visuovestibular regulation (long loop regulation), medium frequencies for cerebellar participation, and high frequencies for proprioceptive participation (myotatic loop).

Statistical analysis

Statistical analysis of the results was carried out with a two factor analysis of variance (one unrepeated interfactor: the two level (RL and NIL) group factor; and one repeated intrafactor: the two level (eyes open and closed) vision factor). This analysis of variance also gives possible interactions between these two factors. The F value corresponds to Fisher's F.

RESULTS

For none of the variables studied was there a significant difference between the RL group and the NIL group. Some variables were significantly increased in the two judoist groups when they had their eyes closed. However, the presence of significant vision-group interactions for some variables shows that lack of vision produces different alterations in balance performance and different modifications of balance strategies in the two groups (table 1).

From an analysis of certain variables, NIL subjects seemed to be more stable than RL subjects when their eyes were open (table 1). With eyes closed, the same variables are about the same for the two groups. Therefore, as shown by the vision-group interaction, the differences between eyes open and eyes closed are significantly more important in the NIL group than the RL group. In fact, NIL judoists appear to be more

Table 1 Comparison of postural performance of regional level (RL) and national and international level (NIL) groups of judoists with eyes open or closed

Variables in relation to posture	RL group (n=9)		NIL group (n=11)		Vision-group interaction	
	Eyes open	Eyes closed	Eyes open	Eyes closed	F	P
Statokinesigram area (mm ²)	143.13 (59.85)	170.90 (84.17)	97.78 (54.81)	215.69 (131.30)	3.03	0.03
Statokinesigram length (mm)	529.05 (95.65)	618.62 (133.61)	423.54 (126.33)	655.70 (260.12)	5.62	0.03
Average position in x (mm)	0.52 (7.22)	0.04 (4.69)	-3.33 (5.59)	-3.56 (6.83)	0.01	NS
Average position in y (mm)	-40.28 (13.70)	-41.65 (15.26)	-41.05 (21.84)	-43.61 (17.31)	0.91	NS
LVS	1.28 (0.20)	1.18 (0.17)	1.08 (0.29)	1.18 (0.35)	9.08	0.008
SVY	-4.78 (4.20)	-5.73 (4.33)	-7.12 (4.71)	-5.68 (3.56)	4.28	0.05
Stabilogram length in x (mm)	293.13 (87.97)	331.02 (109.44)	225.11 (86.44)	329.30 (156.52)	3.22	NS
Stabilogram length in y (mm)	350.73 (79.96)	428.25 (94.69)	290.85 (81.11)	477.46 (187.01)	5.57	0.03
Frequency spectrum of anteroposterior oscillations						
Total energy (V ² /Hz)	46.84 (17.61)	66.59 (33.93)	33.05 (18.10)	104.41 (52.89)	11.2	0.003
Low frequencies (V ² /Hz)	41.17 (18.28)	58.21 (30.73)	30.29 (17.80)	92.11 (49.57)	10.5	0.005
Medium frequencies (V ² /Hz)	5.43 (5.00)	7.96 (6.22)	2.53 (1.95)	11.60 (11.22)	3.4	NS
High frequencies (V ² /Hz)	0.26 (0.06)	0.47 (0.27)	0.25 (0.17)	0.75 (0.54)	3.45	NS
Frequency spectrum of lateral oscillations						
Total energy (V ² /Hz)	27.77 (20.81)	44.01 (37.50)	41.06 (30.44)	37.19 (21.22)	0.08	NS
Low frequencies (V ² /Hz)	24.53 (19.31)	37.89 (33.73)	34.94 (28.24)	31.15 (19.67)	0.03	NS
Medium frequencies (V ² /Hz)	3.11 (2.85)	5.78 (4.81)	5.97 (4.25)	5.83 (3.69)	0.85	NS
High frequencies (V ² /Hz)	0.15 (0.10)	0.37 (0.36)	0.19 (0.14)	0.25 (0.16)	0.26	NS

Values are mean (SEM). LVS, ratio of the statokinesigram length to its surface area; SVY, variation in speed on the anteroposterior axis.

dependent on visual information than RL judoists for balance on the anteroposterior axis.

DISCUSSION

This work shows a difference in the visual dependence for the control of static posture between the two groups. As the performance of the NIL group was reduced more by eye closure than that of the RL group, visual information perhaps gains importance as the level of competition increases. This is emphasised by the results of the spectral analysis of anteroposterior oscillations: the interaction vision-group is also significant for the total energy and the energy of the low frequency band. When the eyes were closed, the values increased more for the NIL group than for the RL group. The presence or lack of vision caused different use of the long reflex loops for the regulation of anteroposterior static balance according to the competition level of the group.

This observation that the competition level of judoists influences the performance and strategies of anteroposterior balance more than lateral balance is interesting because judo practice requires anteroposterior more than lateral postural control (judoists make themselves fall either forwards or backwards but seldom sideways).

The closer the experimental conditions matched conditions specific to the activity (eyes open), the more significant the difference between the levels. However, according to Isableu et al.,⁹ there could be no link between the degree of visual dependence and the judoists' level of skill. According to these authors, there is at best a close correspondence between level of competition and motor level as for weighting of spatial references, particularly between perceptive and sensory motor references. Moreover, there is thought to be a close link between acuity of position sense and performance level of the subjects.¹⁰ However, it is quite difficult to determine if improvements in sporting performance increase position sense or if improved position sense involves motor skills.¹⁰

Conclusion

In this study, judoists of the highest level of competition were more dependent on visual information to maintain their posture than lower level judoists. Visual information may be increasingly important in posturokinetic activities as the level of competition increases. However, to complete this study, it will be necessary to analyse the judoists in a situation of

Take home message

Visual information available to trained judoists may be more important in posturokinetic activities as the level of competition increases.

dynamic balance, which increases visual dependence, as vestibular and proprioceptive access is more important than in a static situation.

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