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# Postural control and perceptive configuration: Influence of expertise in gymnastics

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## Abstract

The purpose of the present experiment was to investigate how postural adaptations to the perceptive configuration are modified by specific gymnastics experience. Two groups, one expert in gymnastics and the other non-expert, had to maintain the erected posture while optical flow was imposed as follows: 20 s motionless, 30 s approaching motion, and 20 s motionless. The centre of pressure and head displacements were analysed. The postural adaptations were characterised by the variability of movements for the flow conditions and by the postural latencies for the flow transitions. The results showed that the gymnasts tended to minimise their body movements and were more stationary (head) but not more stable (COP) than the non-gymnasts. These results suggest that gymnastics experience develops a specific postural adaptability relative to the perceptive configuration. We conclude that a specific postural experience could be considered as an intrinsic constraint, which leads to modification in the patterns of functional adaptation in the perceptive motor space.


*Keywords:* Balance; Multisensory; Perception/action; Optic flow; Gymnastics

## 1. Introduction

Controlling posture represents a complex task in which perception and action play crucial roles [1–5]. As Gibson observed, movements produced in standing posture by human in a stable environment generate optical flow that allows for the regulation of the posture: ‘‘We perceive in order to move, but we must also move in order to perceive’’ [2] (p. 223). Thus, according to the ecological approach, posture is regulated in a perception/action coupling in which the sensory-motor laws of control are established from the interaction between the optical flow properties and the force parameters [2,5]. Consequently, changes in the perceived flow lead to modifications in postural regulation and, conversely, modifications in postural regulation lead to changes in the perceived flow [1–4,6].

Three general sources of constraint to perception/action have been usually described: the task, the environment and the organism [1,7,8]. The studies that have focused on postural control relative to the organism's properties have shown that sports requiring fine postural control, such as judo [9], dance [9–11], or gymnastics [6,12–14], modify the intrinsic properties of the organism, which implies changes in perception and the motor control of posture. Although most studies have concluded that postural control is improved, others have reported that experience in a specific sport only influences the challenging postures related to that sport [15,16]. However, most of these studies were based on a kinetic analysis of the pressure exerted on a support surface by subjects in isolated conditions with open or closed eyes only. Yet perception and action cannot be separated: perceivables can be understood only in terms of their consequences for action. And actions to control posture depend on information not only about the support surface but also about the organism's motions [8,19].

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Consistent with the idea of direct perception, postural control depends on a perceptive ''global array'' in which each situation is specified in a multimodality emerging from the interaction of the various sensory systems [8,17]. Although each perceptive system is influential, the movement state in the organism/environment interaction is specified only in the multimodality of the perceived energy arrays. Information useful for action emerges from this multimodality [18]. Thus, change in one or more specific perceived flows implies the emergence of new multimodal congruence associated with a new postural control.

Since gymnastics requires the performance of acrobatic elements followed by a stabilising reception, this sport is well known to elicit original perceptive-motor solutions from the athletes. Thus, given that perception is a multimodal process and that intensive sports practice influences postural control, the aim of the present study was to investigate the effect of a specific experience on postural control according to the perceptive configuration. Gymnasts would have less variability of movements and shorter postural latencies. We hypothesised that gymnastics training modifies the integration process, such that specific postural adaptations emerge according to the sensory signals.

## 2. Methods

### 2.1. Participants

Two groups of male athletes gave their informed consent to participate in this experiment. None of the athletes presented postural or vision problems. One group was composed of 12 expert gymnasts, all nationally ranked. The other was a control group composed of 12 non-gymnasts, all experts in other sports (handball, track and field, volleyball, table tennis, and football). This group served to differentiate our findings in a sport requiring fine postural control from those in general sports [6,13,14]. The two groups presented no significant differences (gymnasts: $22.3 \pm 4.1$ years; $69.7 \pm 3.5$ kg; $170.5 \pm 6.7$ cm and non-gymnasts: $21.7 \pm 3.1$ years; $71.2 \pm 4.8$ kg; $173.1 \pm 7.2$ cm).

### 2.2. Apparatus and procedures

The experimental device and design are illustrated in Fig. 1. Each participant was placed in a dark room and asked to stand barefoot on a forceplate (QFPsystem, 46 cm $\times$ 46 cm) while looking at a flat projection screen (2.1 m $\times$ 2.1 m). The participant's heels were positioned 1.2 m from the screen. The width between feet was the comfortable position for each participant. This position was conserved from trial to trial. A black square with white dots, which were arrayed to create the illusion of an infinite corridor, was projected on the screen. This texture could be motionless or it could appear to be moving towards the participant. The illusion of movement was created by expanding the size of the white dots, which reproduced an approach to the participant. The texture velocity was 1.4 m/s (about 5 km/h), which corresponds approximately to the natural walking speed for adults [20]. It was generated with 3dsmax® software at a frame of 60 Hz and was projected with a SanyoPROxtraX® projector with a 60 Hz refresh rate. The projection subtended a visual angle of approximately 83° horizontal $\times$ 83° vertical. The task consisted in staying in an upright posture and looking at the square centre during three 70 s trials. At the beginning of a trial, the texture was motionless during 20 s. Then, the texture moved in an approaching direction during 30 s followed by a second motionless texture of 20 s (Fig. 1). The participants were not informed when the optical flow motion began or stopped.

A forceplate equipped with three strain gauges linked to a computer was used to record the centre of pressure (COP) position on the anterior–posterior axis throughout the trials (frequency 40 Hz). Moreover, the entire duration of the trial was filmed in profile by a video camera placed 4 m from the participant and 1.5 m from the ground. A marker was attached on the back of the

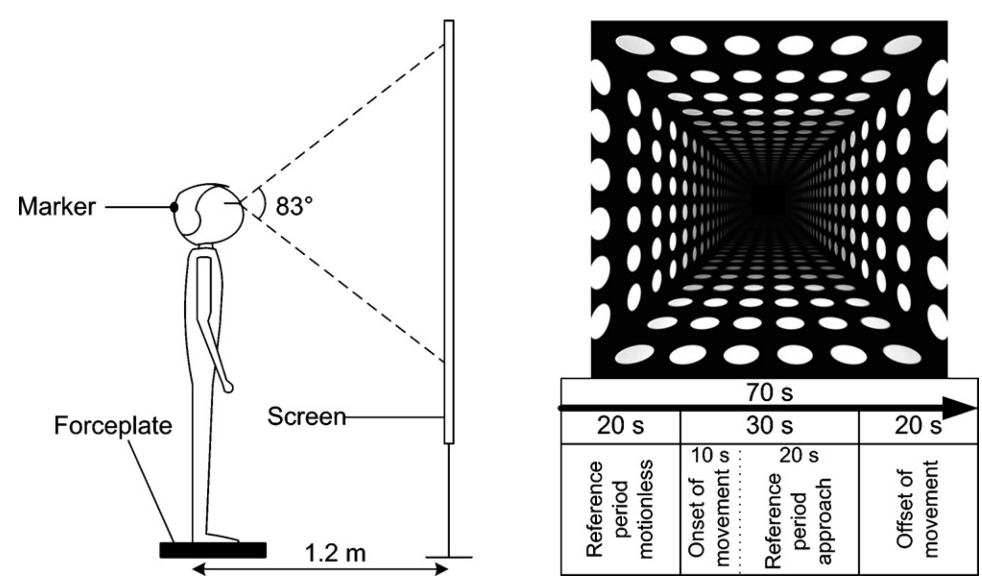


Fig. 1. Illustration of the experimental device (left) and design (right), in which the participant stands on a forceplate and looks at the optical flow texture projected on the screen. The black square with white dots illustrates the optical flow texture. After 20 s of motionlessness, the texture moves in an approaching direction for 30 s, followed by a second motionless period of 20 s.