Postural evaluation in young skaters: Effect of two proprioceptive training

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ABSTRACT

The roller skating involves developing of motor and artistic skills from an early age. The aim was to evaluate the effects that an ocular a podalic proprioceptive training cause to postural control and stability in a sample of young skaters. A total of 25 skaters aged between 9 and 15 (12±2.14) divided into two groups: the eyes group (EG) aimed at exercising visual proprioception, the feet group (FG) aimed at exercising podalic proprioception. The participants were subject to through electronic stabilometry in static mode, open (OE) and closed (CE) eyes, in a time T0 (pre-training) and T1 (post-training), without and with skates. The results through the two paired t-test showed that both variables Wz (TotHz) to CE within the EG (p<.05) and Wx (TotHz) to CE within the FG (p<.05) were statistical significance. The unpaired t-test showed that the FG obtained a greater statistical significance than the EG for the VarVit and Wx (TotHz) variables in CE (p<.05) and Wz (TotHz) in both CE and OE (p<.05). The two-way ANOVA found statistical significance (p<.05) on the Wx (TotHz) variable in open/closed eyes of the FG (T0/T1). We concluded that in roller skating it could be useful to integrate athletic training with a visual proprioceptive training. **Key words**: Proprioceptive training; Postural evaluation; Young skaters.

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INTRODUCTION

Figure roller skating is a complex sport and the athlete must do accurately the technical elements, interpret the musical base, pay attention to the fluidity and elegance of single motor gesture (Merlo, 2009; Kapoula, 2006). The athletes perform technical gestures and movements increasingly difficult, and are subjected to frequent and rigorous training sessions. The most common problems in this sport are musculoskeletal injuries (acute and / or chronic) that mainly involve the foot, the ankle, the knee, the leg, the hip and the back lumbosacral region (Pecina, 1990). The traumas and the training overload are the main causes of injuries involving skaters (Porter et al. 2007). Stress fractures are the most frequent injuries on junior women skaters (Dubravcic-Simunjak et al., 2003).

The Tonic Postural System controls posture. This system uses the information sent by the proprioceptive, vestibular, and visual sensory systems, in order to organize appropriate responses (Berne et al., 2009; Roll et al., 1991). The Tonic Postural System is a complex system, since it is a cybernetic system, the result of a reflex activity that evolves during growth and regresses with aging. Man needs a proprioceptive system that is able to activate the interaction between the system itself and the environment and memory circuits (engram), in order to maintain the posture in erect biped position (Kramer, & Sylvester, 2009). The main receptors (proprioceptors) of the Tonic Postural System that regulate the visuo-podalic axis are the visual receptor and the podalic receptor (Bricot, 1999; Roll et al., 1987). Physical activity training aimed at training the proprioceptive system is necessary to ensure that the neuromotor system continues to function efficiently over the years. It also reduces the risk of injuries through the musculoskeletal system strengthening, the coordination and the body perception (Alessandria, & Pilandieri, 2016; Cordo, 1994; Gagey, & Weber, 2000).

Hypotheses

The aim of this study is to evaluate and compare the acute modification of postural control and stability of an ocular proprioceptive training and a podalic proprioceptive training in a sample of young skaters (Biancalana, & Nart, 2018).

MATERIALS AND METHODS

Participants

The study included 31 female skaters with age between 9 and 15 (12±2.14). The exclusion criteria were the strabismus, monocular blindness, cardiovascular disease or Central Nervous System dysfunctions, foot congenital malformations, an impossibility to stop the wheels on skate. Four girls with health diseases were excluded and two girls because of a defective skate (Tab. I). All participants' parents signed on informed consent form before starting treatment.

Table 1. Characteristics of the participants in the study. Data are represented using the arithmetic mean (M) and standard deviation (SD)

Participants (n = 25)		
Age (years)	12 ± 2.14	64.2 ± 7.2
Weight (K)	42.57 ± 11.4	32.8 ± 6.2
Height (cm)	151.44 ± 11.93	22.4 ± 4.1

Measures

The socio-demographic variables (age, sex) and the anthropometric data (weight, height) have been detected through a standardized medical history interview and recorded in a special personal card.

A battery of tests was carried out to confirm the inclusion criteria and to verify the sample homogeneity:

- *Dominant eye test*, performed on each eye for three times with a covering cardboard to evaluate the far/near vision (preferential eye) (Alessandria & Piladieri, 2016).
- *Proximal Point Convergence/PPC,* performed using the Lang fixation bar to observe the behaviour of maximum eye muscle activity (Barraud, 1997) and the eyes' convergence.
- *Visual acuity test*, performed using the Snellen chart to measure visual acuity (Snellen, 1873).
- *Astigmatism test,* performed using the image of a star with twelve rays, in each ray there are three parallel lines. It's possible to diagnose an astigmatism if the image appears more or less clear to the subject.
- *Titmus Stereo Test*, stereopsis test performed with polarized glasses using the LEA® symbols (Vision Assessment Corporation, Illinois, USA) This test quickly evaluates the presence of amblyopia, strabismus and binocular acuity problems.
- Stabilometric assessment, performed to evaluate the stabilometric parameters in open and closed eyes condition, in static mode (AFP85 Standards). The recording was performed with Cyber Sabots® instruments (In Tech s.r.l., Marseilles, France). The data were processed using the SabotSoftVib software.

Procedures

A total of 25 subjects divided into two groups randomly: Eyes Group (EG, n=12), Feet Group (FG, n=13). The members of the EG were subjected to a proprioceptive exercise protocol for eye receptors (ocular proprioceptive training) and the members of the FG were subjected to a proprioceptive exercise protocol for podalic receptors (podalic proprioceptive training) (Figure 1).

Participants of both groups underwent 2 stabilometric evaluations with the aim of evaluating the effect of proprioceptive training on the variables considered, namely: a first, at T0 (prior to proprioceptive training), and then at T1 (following proprioceptive training). In both evaluations, the subjects wore skates whose rollers had previously been locked in order to avoid any oscillations that could have possibly compromised the test result.

The EG undergone a training protocol characterized by *Ocular proprioceptive training* and a *Kinesthetic saturation*.

Ocular proprioceptive training session was performed without wearing skates and using instead the Bern's arrow as an aid tool (SprintIT s.r.l., Noale, VE) (Figure 2). The training session, which lasted 25 minutes on the whole, involved the repetition of a cycle of orthopaedic exercises using a Bern's arrow positioned in three different directions (namely: parallel to the floor, with the tip turned forward and the base resting at the halfway point of the nose length; parallel to the floor, with the tip turned forward and the base resting in such a way as to coincide with the eyebrows; perpendicular to the floor, with the base turned forward and the tip resting on the root of the nose). For each position, the subjects were required to fix the central circle with both eyes until succeeding identifying an "X", then to look at the farthest circle, visualizing an upside-down "V", and finally to move the eye from a circle to the another, keeping staring at each of them for 10 seconds' period of time.

The *Kinaesthetic saturation* involved exercises to be performed while wearing skates, aimed at improving the proximal point of convergence as well as maximizing the work of oculomotor muscles, through the evocation of the convergence reflex.

The FG underwent a *Podalic proprioceptive training* session, performed without wearing skates. The training session, which lasted 25 minutes, involved the execution of 5 different proprioceptive gaits: walking on the forefoot and on the heels, walking on the outer side and inside of the foot, walk with rolling foot.
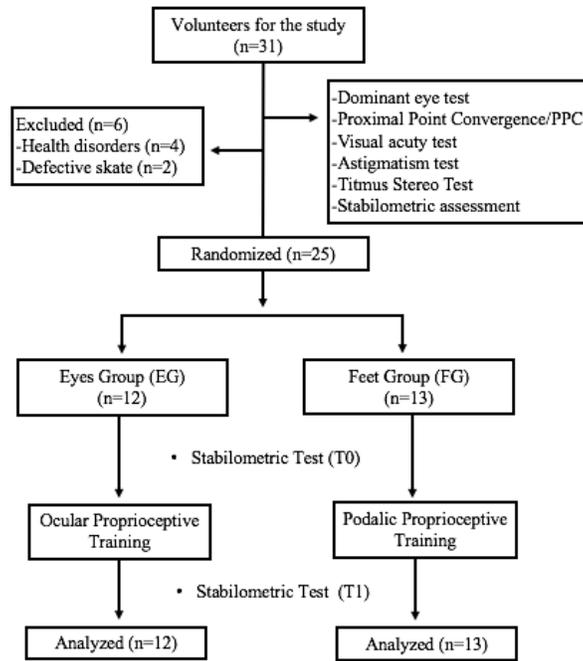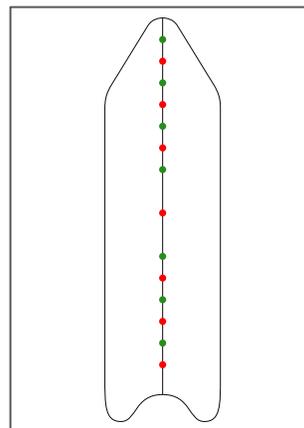

Figure 1. Study design

Figure 2. The Bern's arrow

Analysis

In particular, among the set of parameters acquired with the stabilometric platform, the following ones were considered:

- *Surface*, which represents the ellipse containing 90% of the points recorded during the acquisition time in relation to the displacement of the Centre of Pressure (CoP), i.e. the statokinesigram, and expresses the degree of oscillation of the postural tonic system.

- *VarVit*, which refers to the average of speed variations recorded, and is closely related to the CoP displacements along the entire length of the statokinesigram. The greater the variation in speed, the more unstable the system, thus requiring adjustments to maintain balance.
- *Wx(TotHz)*, which represents the energy of the oscillations throughout the entire frequency band (from 0 to 20.0 Hz), on the X axis (frontal oscillations).

The variables are calculated using the Fourier transform, which allows performing an analysis of the stabilometric signal by expressing both the power and amplitude of the components. For each variable, the mean (M) and the standard deviation (SD) were calculated, as well as comparing the mean values so identified with the standard values derived from the literature and assumed as a condition of normality (Rossato et al., 2013). As for the statistical analysis, the GraphPadPrism 7 program was used instead. Initially, a two-tailed student's unpaired t-test was performed to check if there were any significant differences between T0 and T1 within the EG group and the FG group in open eyes and closed eyes conditions for each of the variables considered. Subsequently, a one-tailed student's unpaired t-test was performed comparing the T1-T0 difference for each variable, both in open eyes and closed eyes condition, in order to verify which of the two groups had benefited most from the proprioceptive training session.

Finally, the ANOVA two-way variance analysis tests were used to check if any changes had occurred within the same group between T0 and T1 and between the open eyes and closed eyes conditions and the post-hoc Bonferroni test, in the event that any statistical significance being so detected.

The significance level was set at $p \leq 0.05$ and the confidence interval was set at 95%.

RESULTS

Paired T-test
The analysis of the data derived on the effect of proprioceptive training between T0 and T1 in each group and for each of the variables considered highlighted the presence in the EG group of a statistically significant difference ($p = 0.0419$) only for the Wz(TotHz) variable in the closed eyes condition, while in the FG group a statistically significant difference was highlighted ($p = 0.0472$) solely for the Wx(TotHz) variable in the closed eyes condition (Figure 3-4).

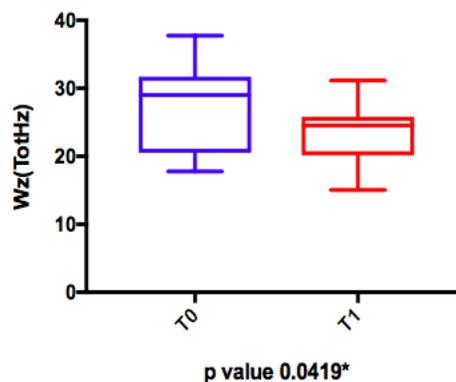Figure 3. The effects of proprioceptive training between T0 and T1 in the EG, for the Wz(TotHz) variable, in the closed eyes condition. Data are represented using the arithmetic mean and standard deviation. (significance level = $p \leq 0.05$)
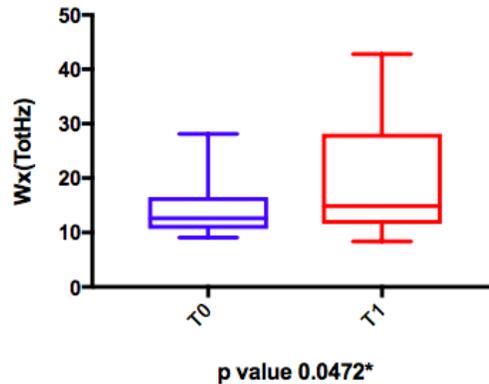
Figure 4. The effects of proprioceptive training between T0 and T1 in the FG, for the Wx(TotHz) variable, in the closed eyes condition. Data are represented using the arithmetic mean and standard deviation. (significance level = $p \leq 0.05$)

Unpaired T-test

Considering the difference (mean value) between T1 and T0 values in the EG group (-2,56 ± 5,04) and in the FG group (1,42 ± 5,31), for the Wz(TotHz) variable, in the open eyes condition, it has been manifested a statistically significant difference (p = 0.0261) (Figure 5).

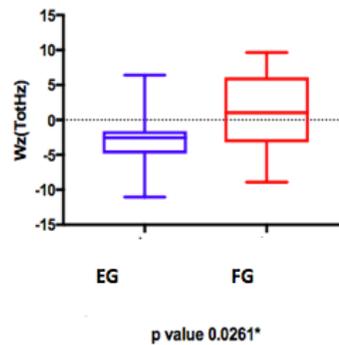| Name	EG	Name	FG	
1	-3,56	1	8,17	Improvement
2	-1,91	2	-3,56	Decrease
3	2,81	3	6,32	
4	-1,49	4	-8,94	
5	-2,47	5	0,24	
6	6,41	6	9,64	
7	-6,01	7	-3,38	
8	-2,23	8	2,34	
9	-5,23	9	0,45	
10	-2,63	10	3,43	
11	-11,04	11	1	
12	-3,43	12	5,79	
		13	-3,08	

Figure 5. The effects of proprioceptive training to T1 in both groups (EG; FG), for the Wz(TotHz) variable, in the open eyes condition. Data are represented using the arithmetic mean and standard deviation. (significance level = $p \leq 0.05$)

Considering the difference (mean value) between T1 and T0 values in the EG group (-33,14 ± 74,43) and in the FG group (30,28 ± 95,35), for the VarVit variable, in the closed eyes condition, it has been manifested a statistically significant difference (p = 0.0392) (Figure 6).

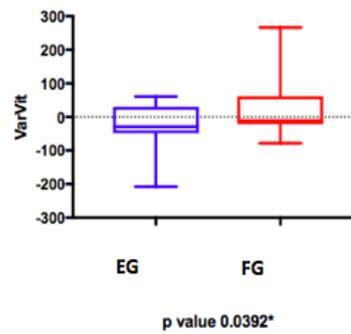| Name	EG	Name	FG	
1	-30,6	1	14,7	Improvement
2	-48,49	2	-11,27	Decrease
3	-27,89	3	-4,81	
4	44,27	4	73,9	
5	-48,51	5	-11,29	
6	51,23	6	182,4	
7	-35,59	7	-78,3	
8	60,5	8	-22,31	
9	-22,8	9	-12,3	
10	-12,11	10	50,05	
11	-120,1	11	-21,11	
12	-207,6	12	-32,5	
		13	266,5	

p value 0.0392*

Figure 6. The effects of proprioceptive training to T1 in both groups (EG; FG), for the VarVit variable, in the closed eyes condition. Data are represented using the arithmetic mean and standard deviation. (significance level = $p \leq 0.05$)

Considering the difference (mean value) between T1 and T0 values in the EG group (-1,64 ± 2,86) and in the FG group (5,32 ± 8,67), for the Wx(TotHz) variable, in the closed eyes condition, it has been manifested a statistically significant difference (p = 0.0072) (Figure 7).

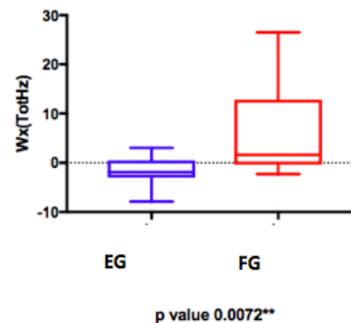| Name	EG	Name	FG	
1	-1,533	1	1,6	Improvement
2	-2,303	2	-2,31	Decrease
3	-1,06	3	2,53	
4	2,033	4	0,36	
5	-2,948	5	-0,969	
6	3	6	26,5	
7	-3,047	7	14,66	
8	0,92	8	-0,036	
9	-3,11	9	-0,69	
10	-0,805	10	14,29	
11	-2,94	11	1,84	
12	-7,899	12	-0,01	
		13	11,36	

p value 0.0072**

Figure 7. The effects of proprioceptive training to T1 in both groups (EG; FG), for the Wx(TotHz) variable, in the closed eyes condition. Data are represented using the arithmetic mean and standard deviation. (significance level = $p \leq 0.05$)

Considering the difference (mean value) between T1 and T0 values in the EG group (-3,35 ± 5,04) and in the FG group (1,92 ± 7,39), for the Wz(TotHz) variable, in the closed eyes condition, it has been manifested a statistically significant difference (p = 0.0252) (Figure 8).
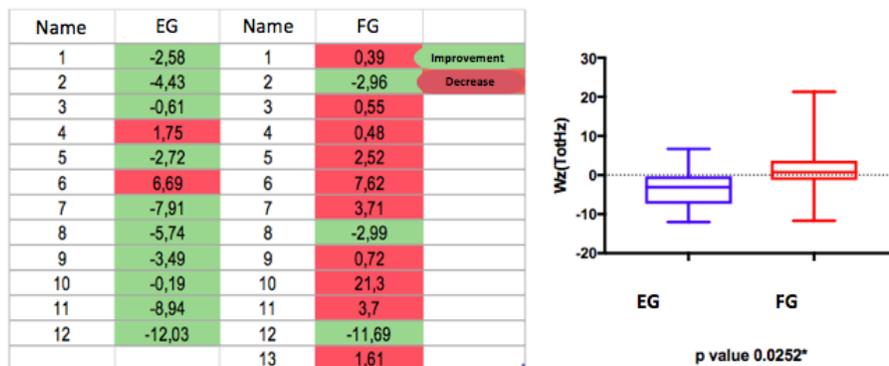
Figure 8. The effects of proprioceptive training to T1 in both groups (EG; FG), for the Wz(TotHz) variable, in the closed eyes condition. Data are represented using the arithmetic mean and standard deviation. (significance level = $p \leq 0.05$)

Considering the differences (mean value) between T1 and T0 values in each group (EG; FG) for the VarVit variable in the open eyes condition, Surface in open and closed eyes condition, Wx(TotHz) in the open eyes condition, Wy(TotHz) in open and closed eyes condition, it hasn't been manifested a statistically significant difference ($p \geq 0.05$).

Two-way ANOVA
The analysis of data, only in the FG group, for the Wx(TotHz) variable, in the closed eyes condition, has shown a statistically significant difference ($p = 0.0210$), between T0 mean value ($14,47 \pm 5,24$) and T1 mean value ($19,78 \pm 11,81$) (Figure 9).
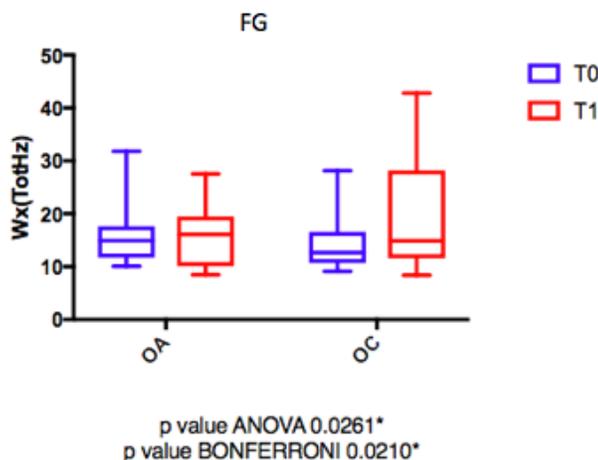

Figure 9. The effects of proprioceptive training between T0 and T1 in the FG, for the Wx(TotHz) variable, in open and closed eyes condition. Data are represented using the arithmetic mean and standard deviation. (significance level = $p \leq 0.05$)

DISCUSSION

The aim of this study was to assess and compare the postural changes and the acute stability during the acute phase of ocular proprioceptive training and podalic proprioceptive training in a sample of young women skaters. From the results on the variables considered, it emerged that at T1, for the *VarVit* variable, the EG

group reduced the average of the recorded speed variations compared to the FG group, thus showing that the former obtained a greater benefit from the proprioceptive training session. As for the *Wx(TotHz)* variable in the FG group, a lower effect of proprioceptive training was highlighted, with a significant increase in the energy of the post-training oscillations compared to the EG group. In the EG group, for the *Wz(TotHz)* variable, at T1 there was a significant reduction in the energy of the oscillations in favour of a better postural control compared to the FG group, whose average increased instead. As for the Surface and Wy(TotHz) variables, no significance was highlighted. This would seem to indicate that, during the acute phase, proprioceptive training did not cause any change - in area in which the CoP moves - to the energy of the oscillations on the Y axis (sagittal oscillations). Compared to the *Wx(TotHz)* and *Wz(TotHz)* variables, the *Wy(TotHz)* variable during the acute phase does not undergo any significant changes at the end of the proprioceptive training session; this could be due to the skate boot, which limits the flexion and extension movements of the ankle, thus preventing any significant improvements and/or worsening of the oscillations on the sagittal plane.

The FG group showed an increase in the oscillations on the X axis and a worse performance in qualitative terms compared to the EG group for the VarVit, Wx(TotHz) and Wz(TotHz) variables. This performance gap could result from a reduced sensitivity of the podalic and articular receptors of the ankle determined by the skate boot, which, by blocking the ankle, does not allow the foot to move inside it (Kavounoudias et al., 1998). The podalic proprioceptive training could actually have destabilized, during the acute phase, the compensations put in place by the postural tonic system. In the EG group, the decreased oscillation energy on the vertical axis and the significantly better performance compared to the FG group, for the VarVit, Wx(TotHz) and Wz(TotHz) variables, could suggest the evocation, during the acute phase, of certain rearrangements of the postural tonic system through ocular proprioceptive training.

CONCLUSION

It can conclude that in roller skating it could be useful to integrate athletic training with a visual proprioceptive training in order to improve postural control and reduce the risk of accidents (Riva et al, 2001).

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