LEARNING AND KINEMATICS OF A PARTICULAR TYPE OF THROWING

Marinella Coco[1], Alfio Gangemi[1], Illuminata D'amico[1], Fortunata Inguì[1], Tiziana Ambra[1], Maria Cristina Petralia[1], Valentina Perciavalle[2]
[1]Department of Biomedical and Biotechnological Sciences, University of Catania - [2]Department of Sciences of Formation, University of Catania, Italy

ABSTRACT

Aims*: The purpose of the present study was to analyze, on a sample of children between 9 and 10 years, the learning of a simple but not usual motor task, the launch of a tennis ball to hit a target, by varying the distribution of the practice and the arm (dominant or not dominant) used to execute the gesture.*

Materials and methods*: The aim was to verify whether, after only 3 days of training, there is an improvement of gesture's efficiency (increased number of hit targets) related to specific change in the kinematics of the used arm. For this purpose we used a Wearable Inertial Sensors Device (WISD), capable of measuring movement-related data without any space limitation and with a no bulky set-up.*

Results*: It has been observed that a training session of only 3 days was sufficient to achieve significant improvements in the success probability of a simple but not usual gesture, as the launch of a tennis ball to hit a target. The improvement was observed only when children used their dominant arm. Furthermore, the observed improvement is not associated to significant changes of some kinematic parameters of the gesture, as duration of performance, time to peak and peak acceleration.*

Conclusion*: The probability of success of a gesture does not depend only on the kinematic characteristics of its final phase, the gesture itself, but also includes evidently a change of its 3D approach. Therefore, the effective change is not obtained by acting on the distal muscles of the upper limb, but mainly on the proximal ones, i.e. paravertebral and shoulder muscles, by involving the anticipatory postural adjustments, capable to compensate predictable perturbations before they occur.*

Key words*: Learning, kinematic, children, sport.*

Received *June 18, 2014;* ***Accepted*** *October 02, 2014*

Introduction

Teach a child a principle, a skill or a notion becomes much more effective and useful for its growth if the mechanisms that promote learning are taken into account. Children are able to process a lot of information without problems only if the offered stimuli are age-appropriate.

The effectiveness of the amount of practice, intended as the number of repetitions, is commonly recognized as an important factor for learning and perfecting gestures. Tal Savion-Lemieux and Virginia Penhune[(1)] believe that even a small number of repeats, if well distributed, make learning and consolidation of new gestures more efficient. In other words, both learning and consolidation depend not so much on the amount of practice but mainly on its proper distribution over time[(2)].

Katherine Sullivan and coworkers[(3)], in a study carried out to determine the effect of different relative frequencies of feedback on skill acquisition in children compared with young adults, concluded that, to optimize motor learning, children may require longer periods of practice, with feedback reduced more gradually, compared with young adults[(4-6)]. table

Today is prevailing the idea to prefer the use of a distributed rather than a massed practice for the optimization of learning(7-8), although there are contrary results(9).

The purpose of this research work was to analyze, on a sample of children between 9 and 10 years, the learning of a simple but not usual motor task, the launch of a tennis ball to hit a target, by varying the distribution of the practice and the arm (dominant or not dominant) used to execute the gesture(10-11). The aim was to verify whether, after only 3 days of training, there is an improvement of gesture's efficiency (increased number of hit targets) related to specific change in the kinematics of the used arm. For this purpose we used a Wearable Inertial Sensors Device (WISD), capable of measuring movement-related data without any space limitation and with a no bulky set-up.

Materials and methods

Participants

Twenty children who were healthy and developing typically (10 male, 10 female; mean age: 9.5 years, standard deviation (SD): ± 0.33 years, range: 9-10 years) voluntarily participated in the study. Table 1 summarizes gender and age of the 20 children.

Subject	Dominant		Non Dominant	
	gender	Age (yr)	gender	Age (yr)
1	girl	9	boy	9
2	boy	9,2	girl	9,2
3	girl	9,5	boy	9,3
4	girl	9,6	girl	9,3
5	boy	9,8	girl	9,5
6	boy	9,2	boy	9,5
7	boy	9,8	boy	9,6
8	girl	9,9	girl	9,8
9	boy	9,9	girl	9,8
10	girl	10	boy	10
Mean		**9,59**		**9,5**
S.D.		**0,35**		**0,31**

Table 1: Gender and age of the children which participated to the study.

Prior to participating in the experiment, parental consent and child assent were obtained for the children who participated. Inclusion criteria were children who were developing typically and performing at grade level in school. Exclusion criteria were any orthopedic or neurological problems that would interfere with the ability to perform a coordinated arm movement. All participants used their dominant as well as non-dominant arm to practice the movement task.

Measurement Settings

During the test, subjects wore an elastic belt with a WISD (FreeSense, Sensorize s.r.l., Rome; sampling frequency = 200 Hz) placed with a band on the wrist of the arm they would use to throw the ball (Figure 1). This device is lightweight (93 g) and contains a triaxial accelerometer to measure accelerations along the three body axes (antero-posterior, AP; latero-lateral, LL; and cranio-caudal, CC) and gyroscopes to measure angular velocities around the above axes (± 6 g and ± 500° s-1 of full range, respectively). Data capture was managed using a Bluetooth protocol and directly loaded into a database. Matlab (The MathWorks Inc., Natick, MA) scripts have been implemented to calculate and analyze the WISD measures.

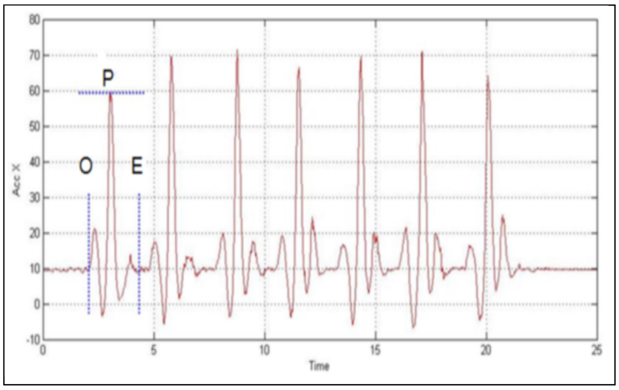

Figure 1: Kinematic characteristics of seven consecutive launches performed by one of the children who participated in the study. The graph shows the change in acceleration of the wrist on the horizontal plane as a function of time. Abbreviations: O, onset of the movement; P, acceleration's peak of the movement; E, end of the movement.

Task

The task for the children was to throw a tennis ball to hit a target (a 1.5 liter green bottle full of water) placed in front of him/her at a distance of 3 m. Ten child had to perform in each session 20 throws with the dominant arm and another group of 10 children with the non-dominant one for 3 consecutive days (Monday to Wednesday). Figure 1 displays the recording of 7 consecutive hits recorded from one child. In a single hit it is possible to identify the onset of movement (O), its end (E) and the perk of acceleration. Evaluated parameters were the number of successes (goals), the duration of gesture (time from O to E), the duration of acceleration from 0 to the maximum value (time to peak, Time from O to P) and the maximum value of acceleration (peak acceleration).

Data analysis

All behavioural measures were averaged across blocks of trials and days of practice. The data were assessed using repeated-measures analysis of variance (ANOVA), with Group as the between-subjects factor and Block or Day as within-subjects factors.

Results

Figure 2 summarizes the results obtained in the present study. As can be seen, children using the dominant arm (D group) had a number of successes (goals) significantly higher ($p>0.05$) than that of the children using the non dominant arm (ND group). During the 3 days of training there is an increase of goals only in D groups of children. No significant differences were observed for the other evaluated parameters, i.e. duration of performance, time to peak and peak acceleration.

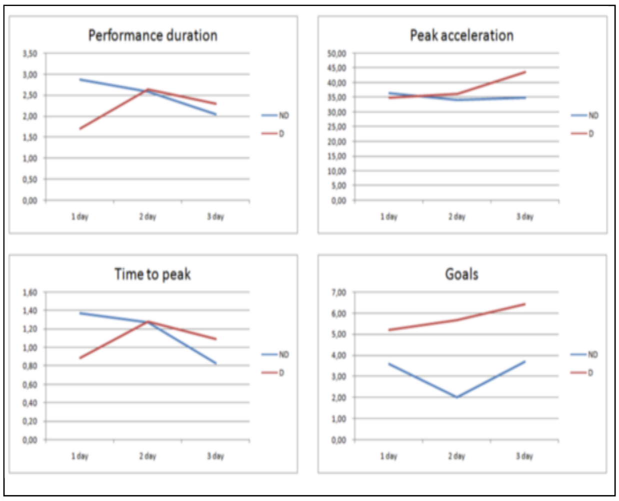

Figure 2: Comparison between the results obtained using the dominant (D) and non-dominant (ND) arm. It can be noted that while there are no significant differences in the parameters relating to the kinematics of the arm, the number of successes (goals) is significantly greater when the dominant limb was used.

Discussion

The present results, although obtained using a small sample of children with an age between 9 and 10 years (10 male and 10 female, with a mean age of 9.5 years), allow us to draw some conclusions.

Firstly, a training session of only 3 days was sufficient to achieve significant improvements in the success probability of a simple but not usual gesture, as the launch of a tennis ball to hit a target. However, the improvement was observed only when children used their dominant arm[12-15].

The observed improvement is not associated to significant changes of some kinematic parameters of the gesture, as duration of performance, time to peak and peak acceleration[16-17]. This observation appears to be very interesting as it raises the question of what could lead to the improvement in the success probability without significantly changing the kinematics of the gesture. The effectiveness of a gesture, that is, a higher probability of success, does not depend only on the kinematic characteristics of its final phase, the gesture itself, but also includes evidently a change of its 3D approach. In fact, the same gesture performed with a different orientation, for example in the horizontal plane, leads to different results. In this case, the effective change is not obtained by acting on the distal muscles of the upper limb, but on the proximal ones, ie paravertebral and shoulder muscles[18]. This implies the involvement of the anticipatory postural adjustments, capable to compensate predictable perturbations before they occur, by changing the body center of pressure before the arm's movement[19].

Finally, the present study underlies the efficiency and reliability of a WISD (FreeSense, Sensorize s.r.l., Rome) for the analysis of the kinematics of an arm movement, which resulted a device easy, economical and feasible in the field. This device, positioned around the participants' waist, has been successfully used for estimating traversed distance in level walking[20] and for assessing locomotor skills development in childhood[21]. To our knowledge, this is the first time it is used for measuring kinematics of arm's movement.

References

1) Savion-Lemieux T, Penhune V. *The effects of practice and delay on motor skill learning and retention*. Exp Brain Res 2005; 161: *423-431*.

2) Perciavalle V, Santangelo F, Sapienza S, Serapide MF, Urbano A. *Motor responses evoked by microstimulation of restiform body in the cat*. Exp Brain Res. 1978; 33(2): *241-55*.

3) Sullivan KJ, Kantak SS, Burtner PA. *Motor learning in children: feedback effects on skill acquisition*. Phys Ther. 2008; 88(6): *720-32*.

4) Gray C, Perciavalle V, Poppele R. *Sensory responses to passive hindlimb joint rotation in the cerebellar cortex of the cat*. Brain Res. 1993; 622(1-2): *280-4*.

5) Perciavalle V. *Substantia nigra influences on the reticulospinal neurons: an electrophysiological and ionophoretic study in cats and rats*. Neuroscience. 1987t; 23(1): *243-51*.

6) Le Pira F, Giuffrida S, Maci T, Reggio E, Zappalà G, Perciavalle V. *Cognitive findings after transient global amnesia: role of prefrontal cortex*. Appl Neuropsychol. 2005; 12(4): *212-7*.

7) Oxendine JB. *Effect of mental and physical practice on the learning of three motor skills*. Res Q. 1969; 40(4): *755-63*.

8) Perciavalle V, Bosco G, Poppele RE. *Spatial organization of proprioception in the cat spinocerebellum. Purkinje cell responses to passive foot rotation*. Eur J Neurosci. 1998; 10(6): *1975-85*.

9) Reynolds B, Bilodeau IM. *Acquisition and retention of three psychomotor tests as a function of distribution of practice during acquisition*. J Exp Psychol. 1952; 44(1): *19-26*.

10) Perciavalle V, Coco M, Alagona G, Maci T, Perciavalle V. *Gender differences in changes of motor cortex excitability during elevated blood lactate levels*. Somatosens Mot Res. 2010; 27(3): *106-10*.

11) Coco M, Caggia S, Musumeci G, Perciavalle V, Graziano AC, Pannuzzo G, Cardile V. *Sodium L-lactate differently affects brain-derived neurothrophic factor, inducible nitric oxide synthase, and heat shock protein 70 kDa production in human astrocytes and SH-SY5Y cultures*. J Neurosci Res. 2013; 91(2): *313-20*.

12) Fagone P, Donia M, Mangano K, Quattrocchi C, Mammana S, Coco M, Libra M, McCubrey JA, Nicoletti F. *Comparative study of rapamycin and temsirolimus demonstrates superimposable anti-tumour potency on prostate cancer cells*. Basic Clin Pharmacol Toxicol. 2013; 112(1): *63-9*.

13) Mijatovic S, Maksimovic-Ivanic D, Timotijevic G, Miljkovic D, Donia M, Libra M, Coco M, McCubrey J, Al-Abed Y, Korac A, *Stosic-Grujicic S, Nicoletti F. Induction of caspase-independent apoptotic-like cell death of mouse mammary tumor TA3Ha cells in vitro and reduction of their lethality in vivo by the novel chemotherapeutic agent GIT-27NO*. Free Radic Biol Med. 2010; 48(8): *1090-9*.

14) Perciavalle V., Apps R., Bracha V., Delgado-García J.M., Gibson A.R., Leggio M., Carrel A.J., Cerminara N., Coco M., Gruart A., Sánchez-Campusano R., Consensus Paper: Current *Views on the Role of Cerebellar Interpositus Nucleus in Movement Control and Emotion*. Cerebellum. 2013; 12 (5): *738-57*.

15) Garifoli A, Laureanti F, Coco M, Perciavalle V, Maci T, Perciavalle V. *Neuronal NOS expression in rat's cuneate nuclei following passive forelimb movements and median nerve stimulation*. Arch Ital Biol. 2010; 148(4): *339-50*.

16) Perciavalle V., Di Corrado D., Petralia M.C., Gurrisi L., Massimino S., Coco M. *The second-to-fourth digit ratio correlates with aggressive behavior in professional soccer players*. Mol Med Rep. 2013; 7(6): *1733-8*.

17) Coco M., Alagona G., Perciavalle Va., Perciavalle Vi., Cavallari P., Caronni A. *Changes in cortical excitability and blood lactate after a fatiguing hand-grip exercise*. Somatosens Mot Res. 2014; 31 (1): *35-9*.

18) Talakoub O, Popovic MR, Navaro J, Hamani C, Fonoff ET, Wong W. *Temporal alignment of electrocorticographic recordings for upper limb movement. Front* Neurosci. 2015; 8: 431. doi: 10.3389/fnins.2014.00431

19) Coco M, Fiore AS, Perciavalle V, Maci T, Petralia MC, Perciavalle V. *Stress exposure and postural control in young females*. Mol Med Rep. 2015;11: 2135-2140. doi: 10.3892/mmr.2014.2898

20) Kose A, Cereatti A, Della Croce U. *Estimation of traversed distance in level walking using a single inertial measurement unit attached to the waist*. Conf Proc IEEE Eng Med Biol Soc. 2011; 2011: *1125-8*.

21) Masci I, Vannozzi G, Bergamini E, Pesce C, Getchell N, Cappozzo A. *Assessing locomotor skills development in childhood using wearable inertial sensor devices: the running paradigm*. Gait Posture. 2013; 37(4): *570-4*.

Correspoding author
MARINELLA COCO
Department of Biomedical and Biotechnological Sciences
University of Catania
Catania
(Italy)