Reading approach to improve strenght: an explorative study

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ABSTRACT

Many studies and common practice use different load and recovery time combinations to obtain improvements in strength performance. The cross education and speech neurons theory could lead to new strategies in motor skills learning and in fitness improvement. Thus, the aim of this study was to verify if a process similar to cross education and visual phenomenon (reading approach) could improve the strength performance. The study consisted of three matched samples that followed three different protocols (strength training, mental and reading approach) and a control group. After 12 training sessions the improvements in maximal voluntary handgrip were assessed. On average, the improvement in handgrip performance was 3.02, 2.97, 2.07, 1.16 kg for strength, mental, reading and control sample respectively. Significant differences among groups were found while no differences were found before and after the protocol, as well as for the interaction. The post hoc analysis revealed significant differences between the strength sample (after training value) and the control group (before the training). Mental or reading training resulted in almost similar improvements that are close to strength training gains. Indeed, at least for the initial training session, the reading training was broadly similar to well-know protocol and could be used to provide complementary stimulus. **Key words:** MENTAL TRAINING, READING TRAINING, STRENGTH, HANDGRIP

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INTRODUCTION

Several studies and the common practice have shown functional improvements during physical training. These cannot be explained only with muscle hypertrophy or cytoskeletal remodeling, but must also involve neural adaptation, i.e. the patterns of muscle activation (Duchateau and Enoka, 2002). Indeed, the first improvements of training program are the changes in the nervous system (Enoka, 1988; Sale, 1988), modification in neuraxis level (amplitude and timing, Ranganathan et al., 2004) and expansion of cortical areas (Duchateau and Enoka, 2002).

Motor improvements are task specific and are restricted to an increase in the activity of the orbitofrontal cortex (medial aspect), in the cerebellum (Gentili et al., 2006) and ventral pre-motor cortex (Olsson, et al., 2008).

Since 1983 a new adaptation in motor command has been described: the cross education (Houston et al., 1983). This phenomenon refers to an increase in strength of the untrained limb during the training of the controlateral. Different studies demonstrated strength improvements of 5-25% in the controlateral homologous muscles (Zhou, 2000), both after voluntary and electrically evoked contractions (Duchateau and Enoka, 2002).

This intriguing possibility opened to a new approach, often poorly followed in training or rehabilitation programs: the use of imagine contraction (You, 1992).

Research has shown that mental practice improve the performance without repetitive muscles contraction or motor neurons activation through descending motor pathways (Feltz and Landers, 1983; Karni et al., 1995; Pascual-Leone, et al., 1994; Decety, 1996 a,b,c). It seems that a similar pattern of adaptation takes in the primary motor cortex even if the action was coverted (Pascual-Leone et al., 1994; Jackson et al., 2003). In particular, this phenomenon is appreciated in 'trained' muscles with small cortical representation (Ranganathan et al., 2004). Studies on little finger abductor, elbow flexor muscles group (Ranganathan et al., 2004) are in favor of quasi-common neurocognitive mechanisms between overt and covert motor action (Gentili et al., 2006). Indeed, during motor or imaginative training neural structures are activated to manage the parameters of performance: parietal and prefrontal cortices, supplementary motor area, premotor and primary motor cortices, basal ganglia and cerebellum (Decety, 1996a,b,c). For practical purposes we can explain that mental action (covert) are in fact real action. Indeed, from a physiological point of view the internal imagery implicates a real activation of the subjects; they have to feel themselves performing actions (Mahoney and Avener, 1987). In particular, it seems that bilateral prefrontal cortex, supplementary motor area and also cerebellum are activated both during motor imagery and real performance. In the first case the programming execution is blocked in the cortico-spinal way.

This impressive mechanism is continually studied using fMRI and blood flow (Olsson et al., 2008) to better define the affected structure; however, to the best of our knowledge none of these studies investigated a similar cross education on the reading action.

Recent studies have suggested that comprehension involves the automatic and unconscious simulation of past experiences, relying on the processing of sensorimotor representations (see for instance Bergen et al., 2007; Marino et al. 2011). According to this "simulation hypothesis", when we understand the meaning of an action-related verb, we unconsciously and automatically simulate the experience of the action described by the verb (Bergen et al., 2007; Barsalou, 1999; Gallese and Lakoff, 2005; Bach et al., 2005; Kemmerer and Gonzalez-Castillo, 2010).

This hypothesis was supported by neurophysiological studies where the processing of action verbs involves the activation of the same brain areas, which are activated during the execution or the observation of that same action (Marino et al., 2011; Gallese and Lakoff, 2005; Pulvermüller and Fadiga, 2010; Buccino et al., 2001; Rizzolatti and Fogassi, 2014).

Hauk et al. (2004) used fMRI to show that verbs referring to actions performed with a specific part of the body require the activation of the motor and premotor cortex somatotopically. For instance, the processing of action-related verbs such as "to like", "to pick" or "to kick" requires the activation of brain areas that are adjacent or overlapping to those activated by a real movement of the tongue, of the fingers, or of the feet (Hauk et al., 2004; Pulvermüller et al., 2005).

Tettamanti et al. (2005) observed in a fMRI study the activation during the processing of action-related sentences of the cortical circuit responsible for the planning and execution of the same actions (observation-execution matching system, i.e. mirror-neuron system). Listening and understanding sentences describing actions requires the activation of sensorimotor circuits and "partially overlapping with those active during the execution and observation of the same actions" (Tettamanti et al., 2005).

In studies that used the technique of TMS, in which the representations of the hand and leg in the motor cortex were stimulated, the subjects showed facilitation in the actions corresponding to the types of verbs: responding faster in lexical decision tasks to action verbs relative to the arm (arm action-related words) when the hand area was stimulated (Buccino et al., 2005). Neuropsychological studies have also observed selective deficits for action verbs in patients with disorders involving the brain areas used for the movement, as in the case of Parkinson's or motor neuron disease (Pulvermüller and Fadiga, 2010; Boulenger et al., 2009; Bak et al. 2001; Bak and Hodges, 2004).

These results suggest that during language comprehension, we activate the same motor and premotor areas which are activated during observation, imagination and execution of actions. This have led us to wonder if it was possible to observe strength improvement after reading tasks (as noted in imaging training) which the subjects read sentences and verbs describing an action done with a particular muscle.

Indeed, if "to see" is an action (Rizzolatti and Fogassi, 2014), "to mind an action" is equal to perform it (Decety, 1996 a,b), then we suppose that "to read an action" verb is similar to play it.

MATERIALS AND METHODS

Participants

Forty male academic students with consistent right handedness dominance (Annett, 1970) were freely recruited during the first month of classes (table 1). Once the nature and possible risks associated with the protocol were described, written informed consent was obtained from each participant. All subjects were examined by a clinician and found to be in good general health, free from present or past medical problems to hand, forearm, arm, shoulder girdle and without any neurological problem. The protocol used in the current study was approved by the local Ethics Committee and was in accordance with the Helsinki Declaration of 1975 as revised in 1983.

Table 1. Anthropometric characteristic of all subjects. All of them was consistent right handednes. (Hannet, 1970). S= strenght; M=mental; R=reading; C=control

GROUP	WEIGHT (Kg)	HEIGHT (m)	BMI (kg/m^2)	GROUP	WEIGHT (Kg)	HEIGHT (m)	BMI (kg/m^2)
s1	78	182	23.55	m1	78.5	185	22.94
s2	69.4	176	22.4	m2	66	179	20.6
s3	63.4	176	20.47	m3	67.5	181	20.6
s4	67.5	175	22.04	m4	69.7	179	21.75
s5	60.6	180	18.7	m5	62.1	181	18.96
s6	70.4	177	22.47	m6	64.7	177	20.65
s7	84	184	24.81	m7	89.7	170	31.04
s8	69.1	178	21.81	m8	74.6	182	22.52
s9	66.2	180	20.43	m9	73.3	181	22.37
s10	73.8	186	21.33	m10	76.1	182	22.97
mean	**70.24**	**179.4**	**21.8**	**mean**	**72.22**	**179.7**	**22.44**
SD	**6.89**	**3.69**	**1.71**	**SD**	**8.12**	**4.03**	**3.28**
r1	85	176	27.44	c1	65.2	176	21.05
r2	62.6	171	21.41	c2	58.1	170	20.1
r3	73.1	181	22.31	c3	81.5	188	23.06
r4	60.3	175	19.69	c4	62.3	181	19.02
r5	59.5	183	17.77	c5	65	179	20.29
r6	66	171	22.57	c6	74.3	183	22.19
r7	57.2	169	20.03	c7	71.4	184	21.09
r8	64.8	173	21.65	c8	54.2	176	17.5
r9	59.5	177	18.99	c9	64.1	182	19.35
r10	54.4	177	17.36	c10	53.6	171	18.33
mean	**64.24**	**175.3**	**20.92**	**mean**	**64.97**	**179**	**20.2**
SD	**8.96**	**4.47**	**2.92**	**SD**	**8.83**	**5.75**	**1.72**

Experimental design

Over 120 freshmen were assessed using the 12 items proposed by Annett (1970) to qualify a sample by the handedness criteria. In particular, the first 40 right-consistent students were recruited in this study.

These subjects were then randomly divided into four groups (10 students each) and performed a 1 Maximum Ripetition (RM) handgrip performance using a digital tools (Jamar Hand Deluxe Digital Hydraulic Dynamometer, Lafayette, USA). In particular, they kept the dominant upper limb along the trunk and hand gripped the tool with their maximal effort for three seconds. These students were instructed to perform three repetitions with 120 sec of interval between trials. The best performance was taken into account (Table 2).

Table 2. Value of 1RM (kg) before and after experimental protocol. Data were collected using Digital Hydraulic Dynamometer.

SUBJECTS	STRENGHT		MENTAL		READING		CONTROL	
	before	after	before	after	before	after	before	after
1	41.30	44.30	58	60.8	52.4	53.7	48.1	49
2	41.80	44.60	48.4	51.6	40	42.4	40.5	42.2
3	42.20	46.70	46	49.2	56.7	60.5	46.2	47.6
4	43.40	45.60	54	54	49.7	50.7	39.5	41.6
5	43.70	46.00	39.3	43	36.6	37.7	38.2	38.5
6	50.00	53.00	41	43.5	53.2	54.1	46.6	46.8
7	56.10	58.40	49.3	53	47.5	55.3	43	46.8
8	56.10	59.50	42.5	45.8	50.2	51.7	38.4	43.5
9	57.00	59.60	49.6	53	29.7	32.7	35.8	41.4
10	59.10	62.20	52.6	55.5	48.3	49.6	41.2	44.7
mean	49.07	51.99	48.07	50.94	46.43	48.84	41.75	44.21
SD	7.34	7.30	5.97	5.62	8.40	8.61	4.10	3.33

Two days later, all subjects performed an exhaustion handgrip performance using a commercial handgrip (Domyos, Villeneuve d'Ascq, France) and the number of repetitions before the self-stoppage were fixed (RE value).

After this step, the four samples followed different protocols as outlined below.

Training group

The first group (called "strength") performed a training based on handgrip action with the commercial tool. The handgrip was performed for four weeks following the instructions reported in Table 3; three sessions per week (Monday, Wednesday and Friday) at the same time (between 6 p.m. and 7 p.m.) were carried out.

Table 3. Parameter of training. The number of repetitions corresponding to 80% of the maximal number of handgrip during exhaution test (RE). After full handgrip 90 sec of rest was observed.

Series	Num of repetition	Level of closure	Recovery
6	80% RE	full	30 sec
6	80% RE	half	30 sec

Mental group

All subjects assigned to the mental group carried out their training following the same schedule and level proposed for strength training group. In particular, they did not perform the action, but imagined it, according with a previous protocol (Yue and Cole, 1992) for mental training.

Reading group

The reading group followed a new approach. They had to read a narrative (139 sentences) created *ad hoc* where more action verbs were present (Kemmerer and Gonzalez-Castillo, 2010). The majority of verbs (117 on 203) described actions performable by hand (i.e. press, hit or grasp) and were arranged in the text from a low level to a high level of requested strength (for example: caress-crawl-rub).

Data collection

These three groups completed the protocols in an environment where noise and disturbance were reduced. A comfortable sitting on a chair station was maintained. The control group did not followed any protocol or new personal training.

All forty individuals avoided any effort with forearm muscles such as gardening, car wash, work inside the house (e.g., electric work). Each individuals did not begin any new sport (i.e. climbing or tennis) during the phases of the study.

Two days after the final session of training all subjects performed a new 1RM handgrip using the digital dynamometer (Table 2).

Statistical analyses

Mean and standard deviation were computed separately for all groups. Before and after protocol, the homogeneity of the sample was verified using the Shapiro-Wilk test for all samples.

Differences in anthropometric characteristic were assessed by Analysis of Variance (ANOVA 1-way) while the differences among groups about performance were computed using ANOVA 2-way (protocol x timing).

A post-hoc analysis (Bonferroni test for independent samples) was applied.

The level of significance was set at 5% for all comparisons.

RESULTS

All students were normal weight (mean BMI =21,31 kg/m^2, Table 1). No differences were observed among groups when weight and height (Anova 1-way, p=0.09 and p=0.12 respectively) were considered and normal distributions were found, before and after protocol, in all sub-samples (Table 4).

Table 4. Shapiro-Wilk test for normality. Value close to 1 indicates the normality of distribution.

	Strenght	Mental	Reading	Control
Before training	0.82	0.97	0.91	0.94
After training	0.82	0.95	0.90	0.97

The value of handgrip performance (data pooled together) before the training sessions were about 46 Kg while after protocol 48 Kg.

The maximum improvement was found in S3 (4.5 Kg) while the worst gap was 0.2 Kg (C6). On average, the improvement in handgrip performance was 3.02, 2.97, 2.07, 1.16 Kg for strength, mental, reading and control groups respectively.

The value showed significant differences among groups (Table 5, p= 0.0008) while no differences were found before and after protocol, as well as for the interaction.

Table 5. Anova 2 way (Protocol x Timing). The interaction was also indicated.

	df	F	p
Protocol	3	6.23	0.0008
Timing	1	2.46	0.1214
Protocol x Timing	3	0.09	0.9657

The post hoc analysis (table 6) revealed significant differences between the strength sample (after training value) and the control group (before the training).

Table 6. Bonferroni test for independent sample.

	Control before	Control after	Strenght before	Strenght after	Mental before	Mental after	Reading before	Reading after
Control before			0.424	0.021	0.981	0.065	1	0.690
Control after	1		1	0.072	1	0.202	1	1
Strenght before								
Strenght after			1					
Mental before			1	1			1	1
Mental after			1	1	1		1	1
Reading before			1	1				
Reading after			1	1			1	

DISCUSSION

Several trainers, physical therapists or physical education teachers work to find new protocols and combination of load to improve the performance of individuals: in particular patients or elderly people.

In this study a new approach based on reading action was compared with other well known methods. In particular, a classic training (strength sample) based on handgrip action with commercial tools (the same used in gym environment or in rehabilitation context) was compared to two other protocols: mental and reading training. In particular, the mental one following the indication of Yue and Cole (1992) because already known as valid way to improve muscles activation while the reading was a new definition.

As such, the strength training was setted using low load to trace a real case of training or rehabilitation process during the first session of conditioning. Also the commercial handgrip was chosen to fully comply with a real context of hospital, gym or domestic practice.

As widely demonstrated (Rizzolatti and Fogassi, 2014; Tettamanti et al., 2005) the mirror neurons play a crucial role in motor learning and motor-neuron activation (Pascual-Leone et al., 1994; Decety, 1996a,b,c; Jackson et al., 2003) opening engaging motor learning theories. Thus, following this mechanism/process, our question was "the action of read an action-verbs could have a similar neuronal process that lean to improvements in motor-neurons activation?".

The reading of a specific paper seems to be useful to produce improvement in strength performance (at least for handgrip action and for right hand) very similar to those obtained with mental training (mean difference less of 1 Kg) and close to those found in strength sample. Indeed, these last improvements were about 3 Kg because the protocol was intentionally defined for low load coupling a real situation where people begin their training or rehabilitation process.

The lack of differences among samples (table 6; in particular after the protocol) could lead to interesting considerations. Indeed, we could underlying that for low load the strength, mental or reading trainings are almost similar about the improvement (at least in the first month of practice).

CONCLUSIONS

This pilot study is encouraging to continue studies or protocols and text definition because, at least for the initial training session, the reading training was broadly similar to well-know protocols for early stage of strength training program when the neural adaptation precedes the muscle hypertrophy. Thus, an early activation could be performed without waiting for a physical/ortophaedic/neuronal good condition.

Case of stroke, bone immobilization could be precociously treated also using a reading training to stimulate the motor-neuron and descent nervous way.

On the other hand, the cheapest procedure to realize text made this approach easy to adopt. In advance, the low level of identification that is requested in contrast with mental training made this new approach very interesting even if, obviously, the text must submit verbs well known by the patients. In our opinion, this does not create a bias because these verbs belong to specific cluster (real action) that identifies daily activities very familiar with all people.

Further investigation could verify the improvement in non-dominant hand, in action requiring big muscles mass (i.e. quadriciptes) and in patients with neurological disorder. The use of EMG signal could detect the activation and fRMI could define the cortical pattern.

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