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INCREASE OF ISOMETRIC PERFORMANCE VIA HYPNOTIC SUGGESTION: EXPERIMENTAL STUDY OVER 10 YOUNG HEALTHY VOLUNTEERS

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ABSTRACT

The efficacy of hypnotic suggestion of high performance was evaluated in 10 young healthy volunteers undergoing isometric exercise (hand grip) in basal conditions of usual normal consciousness and in profound hypnosis. To this aim, they were asked to perform dynamometric hand grip at maximal muscular strength and for the longest time compatible with individual tolerance. As a specific suggestion, a hallucination of drinking an 'energizing potion' capable of increasing muscular performance and abolishing the sense of fatigue and pain associated with isometric exercise was induced. Haemodynamic parameters were continuously measured.

In comparison to basal conditions of usual consciousness, the exercise performer under hypnotic suggestion was associated with a 12% increase in maximal muscular strength and a 60% increase in exercise length. A greater increase of heart rate, arterial blood pressure, and double product—accompanied by a lower increase of stroke volume and consequently of cardiac index—was recorded. Nevertheless, exercise-induced vasodilation was comparable in the two conditions, so that the increase in cardiac index observed during hypnotic suggestion was entirely sustained by heart rate increase. Such a condition can only be tolerated for a short time and at the expense of a reduced myocardial (particularly subendocardic) perfusion.

It seems therefore that the hypnotic command 'perform over your natural limits' is followed by an increase in strength but particularly in exercise length. In such conditions, physical performance is actually greater than that achieved in normal conditions, as if the subject was able to draw on energies not usually employed in everyday life. This higher performance is unnatural and is sustained by muscular mechanisms activating unfavourable, and potentially dangerous, haemodynamic reflexes.

Although hypnosis is a formidable tool in the study of human physiology, its use in the physical world (particularly sporting activities) should be limited to specific controlled conditions. In fact, by increasing muscular power and decreasing the sense of fatigue, hypnosis seems to be able to deprive subjects of the natural feedback mechanisms well-synthesized in the sentences 'It's too much for me' or 'I can't take it any more'.

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Section: EXPERIMENTAL HYPNOSIS

Key words: performance, tolerance to effort, hand grip test, muscular strength

INTRODUCTION

Our research group has been dealing for the last 10 years with the physical, measurable, and reproducible effects of hypnosis. To this aim, the physiological effects of hypnotic induction (Casiglia et al., 2012a), neutral hypnosis (Casiglia et al., 2012b), and different hypnotic suggestions (Casiglia et al., 1997a, 2006, 2010; Facco et al., 2009, 2011; Priftis et al., 2011; Giordano et al., 2012) have been taken into account. The effects of the hallucination of heat (Casiglia et al., 2006), situational hallucinations (Casiglia et al., 1997a), hypnotic-focused analgesia (Casiglia et al., 2007; Facco et al., 2009, 2011), hypnotic-induced neglect (Casiglia et al., 2010; Priftis et al., 2011), and hypnotic age regression (Giordano et al., 2012) have been particularly studied using the methods and tools that are typical of human physiology studies (Casiglia et al., 1991, 1998a, 1998b, 1998c, 1999; Tikhonoff et al., 1999). These experiments demonstrated that the effects of hypnosis, always real for the subject (Casiglia, 2008; Spiegel et al., 1985; Szechtman et al., 1998), are also real and measurable in the experimental setting.

Thanks to the capacity of hypnosis to focus attention, modify consciousness, induce subjective experiences of spontaneity when performing a task, and attenuate fatigue, it has sometimes been employed to improve performance in various sporting activities. In this context, it acts at different levels, such as increasing motivation, self-esteem, and positivity, and reducing perception of external stimuli (Spiegel et al., 1985) and increasing the ability to concentrate and reduce distraction (Orlick & Partington, 1988). It can also facilitate some neuromuscular processes normally excluded from voluntary control and help subjects to learn non-voluntary control of certain muscle groups (Unestahl, 1979).

Although many sporting activities are isotonic in nature, isometric exercise is well-suited to an experimental setting, is easy to perform and measure, and is accompanied by haemodynamic variations that are well known and predictable (Palatini et al., 1978). In the study presented herein, we therefore chose the dynamometric hand grip as an isometric dynamometric hand grip.

METHODS

Ten young, healthy, and highly hypnotizable volunteers, whose general characteristics are summarized in Table 1, were studied. They were recruited among the medical and psychological staff of the University of Padua, and were defined as eligible for hypnosis on the basis of a historical questionnaire, confidential interview, and Multiphasic Personality Inventory 2 (Hathaway & McKinley, 1985; Pancheri & Sirigatti, 1995), which aimed to screen out and exclude any participants with a borderline personality or prone to showing unwanted effects during hypnotic dissociation. Hypnotizability was individually ascertained in each participant by means of the Stanford scale of hypnotizability (Kihlstrom, 1962).

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Table 1. General baseline characteristics of 10 participants (mean ± standard deviation). Haemodynamic parameters are measured after 30 minutes of clinostatic rest in a quiet room at an environmental temperature of 25°C. Body mass index was calculated from the weight (in kg)/squared height (in m) ratio. Peripheral resistance was calculated from the mean arterial blood pressure (in mmHg)/cardiac output (in l/min) ratio.

Age (years)	31.8 ± 6.6
Body mass index (kg·m^{-2})	23.2 ± 2.7
Systolic arterial blood pressure (mmHg)	114.0 ± 18.7
Diastolic arterial blood pressure (mmHg)	71.9 ± 9.7
Mean arterial blood pressure (mmHg)	85.8 ± 12.2
Heart rate (b·min^{-1})	68.4 ± 14.7
Stroke volume (ml)	52.6 ± 16.9
Cardiac output (l·min^{-1})	3.7 ± 1.6
Total peripheral resistance(mmHg·min·m^{2}·l^{-1})	44.6 ± 17.8
Peripheral oxyhaemoglobin saturation (%)	97.2 ± 1.2
Skin temperature (°C)	34.9 ± 0.8

The study was divided into a preliminary setting and an experimental setting.

In the preliminary setting, all participants underwent individual hypnotic induction through verbal suggestions. The voice of an expert hypnotist guided each participant towards focusing his/her attention on a single idea, excluding any other external or internal stimuli. Hypnotic induction consisted of a brief enumeration coupled with suggestions of eyelid heaviness and staring at a fixed point. The verification of hypnosis was based on signals such as arm levitation, the easing of facial tension, a dropped lower jaw with a slight opening of the mouth, and slowing of the breathing rate. This phenomenological approach was sufficient to ascertain the presence of deep hypnosis. The analysis of these signals enabled the hypnotist to verify whether the participants were really hypnotized and to maintain or modify this condition by means of continuous appropriate suggestions.

The aim of this preparatory procedure was to establish a valid interpersonal rapport between the operator and the participant, in order to facilitate rapid and valid monoideism during the following experimental setting. To reduce the time needed for further inductions, post-hypnotic conditioning was predisposed in all participants during this first phase. To this aim, the suggestion was given to immediately reach hypnosis when receiving the command, 'Please, relax', accompanied by a snap. The effectiveness of this conditioning was tested before the end of the session. The participant was then de-hypnotized and sent home.

The participants underwent the experimental setting one day after the preliminary setting. They were assigned to either group A (participant numbers 1, 3, 4, 5, and 7) or group B (participant numbers 2, 6, 8, 9, and 10) according to a random-number list. The instrumental devices described below were applied. After resting in bed until haemodynamic stability was reached, each participant received rapid hypnotic induction in 10 seconds through the previously established post-hypnotic command.

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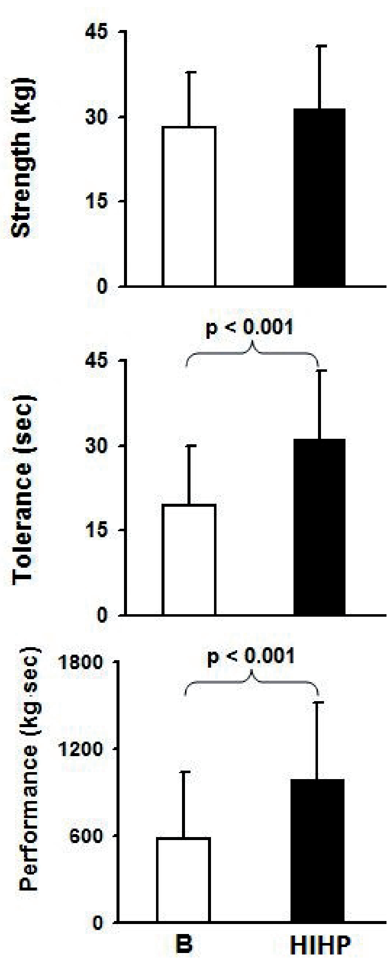
When haemodynamic stability was obtained, basal measurements were performed as described below. The clinostatic posture was maintained throughout the experiment in order to avoid artefacts.

Each participant then performed an isometric effort through hand grip until the maximal muscular strength, which was measured by a dynamometric was reached (see Figure 1). The participants were instructed to breathe regularly during the test in order to avoid the haemodynamic variations associated with Valsalva's manoeuvre (Palatini et al., 1978). The dynamometer was provided with an index to record the maximal strength. The amount of physical performance (in kg·sec^{-1}) was calculated as the product of this strength (in kg) and the time (in sec) necessary to observe a 50% reduction of this strength following muscular fatigue.

Figure 1. Variation of maximal strength, maximal subjective tolerance to exercise, and maximal performance at the dynamometric hand grip test in pre-hypnotic basal conditions (B) and in conditions of hypnotically induced high performance (HIHP) in 10 highly hypnotizable normal volunteers.



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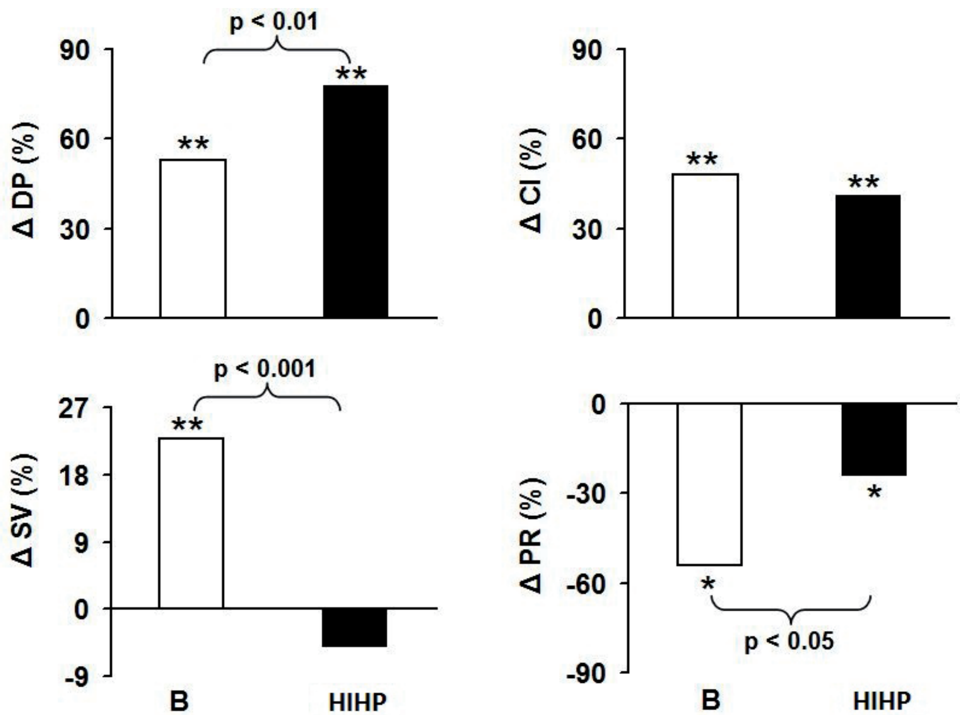
After haemodynamic stability had been reached, with the participant in a clinostatic posture, hypnotic induction was obtained (Casiglia et al., 2012a) and the physiological parameters described above were measured again during neutral hypnosis. The specific hypnotic suggestion was then administered. To this aim, the participant was invited to hallucinate an energy drink able to increase muscular strength and abolish any feelings of pain, distress, or fatigue which notoriously accompany any isometric effort. After this phase was concluded, the participant was de-hypnotized and rested in bed until reaching haemodynamic stability.

Arterial blood pressure was measured (in mmHg) by a Finometer PRO Model-1 (Finapress Medical Systems, Amsterdam, Netherlands), a stand-alone device that provides beat-to-beat blood pressure recording (Schutte et al., 2004). Mean blood pressure was calculated (in mmHg) from the area under the curve of continuous blood pressure recording. The amount of blood ejected from the left ventricle at each systole (stroke volume, in ml) and in one minute (cardiac output, in l·min) were measured with an impedance cardiograph featuring enhanced bio-impedance signal morphology analysis (PhysioFlow Lab1, Manatec Biomedical, Ebersviller, France) (Charloux et al., 2000; Richard et al., 2001). Cardiac index (in l·[min·m^2) was calculated by indexing cardiac output to body surface area (Du Bois & Du Bois, 1916). Total peripheral resistance was calculated (in mmHg·min·[l·m]) from the mean arterial blood pressure/cardiac index ratio. All the devices for haemodynamic monitoring are validated and have previously been employed with success in the same laboratory in many experimental conditions including hypnosis (see Casiglia et al., 1991, 1997a, 1997b, 1998a, 1998b, 1999, 2006, 2010, 2012a, 2012b; Tikhonoff et al., 1999; Facco et al., 2009, 2011; Giordano et al., 2012). Oxyhaemoglobin saturation was measured (in per cent) with a digital pulse oximeter (Fingertip, Rising Medical Equipment, Beijing, China) and hand temperature with a digital thermometric probe (TFA Dostmann GmbH, Wertheim-Reicholzheim, Germany).

A priori power analysis indicated that 10 participants included in a Latin-square protocol, where participants were their own controls (see Figure 2), were sufficient to show effects, if any, avoiding β error. Continuous variables were expressed as mean and standard deviation and were compared with analysis of covariance and Bonferroni's post-hoc test. Statistics were adjusted for the covariates of age, gender, body weight, and baseline values. Experiment-wise error rate was taken into account when considering significance levels. The null hypothesis was rejected for $p < 0.05$.

This research adheres to the principles of the Declaration of Helsinki (World Medical Assembly, 1990). All participants gave written informed consent to the procedure. Each one had a preliminary interview and was personally informed about the aims, methods, and possible risks of the procedure, and was given the opportunity to ask any questions that he/she considered necessary. The Ethics Committee of the University Hospital of Padua approved the protocol. All subjects signed an informed consent form. The data collected were subjected to professional confidentiality according to articles 326, 365, and 384 of the Italian Penal Code, to articles 200, 201, 256, 331, and 334 of the Italian Code of Penal Procedure, to article 9 of the Italian Code of Medical Deontology, and to articles 11, 13, 15, and 16 of the Italian Code of Psychological Deontology, and treated according to the Italian Data Protection Act (1996) No. 675.

Figure 2. Per cent variation of double product (DP), stroke volume (SV), cardiac index (CI) and peripheral resistance (PR) performance at the end of the dynamometric hand grip test in pre-hypnotic basal conditions (B) and in conditions of hypnotically induced high performance (HIHP) in 10 highly hypnotizable normal volunteers. * $p < 0.05$, ** $p < 0.01$ vs. rest values.



RESULTS

The general characteristics of the participants are summarized in Table 1.

Muscular strength developed was 28.1±9.7 kg in basal conditions of usual consciousness and increased insignificantly by 12% when the experiment was repeated in conditions of hypnotic suggestion of high performance. Maximal tolerance to exercise was 19.5±10.4 sec in basal conditions and increased significantly by 60% in hypnosis. Maximal performance was 580±463 kg·sec in basal conditions and 993.6±531.5 kg·sec in conditions of hypnotic suggestion ($p < 0.001$) (see Figure 1).

During hand grip in pre-hypnotic conditions, a significant increase of systolic blood pressure (from 113.3±18.5 mmHg to 127.2±19.9 mmHg, $p < 0.05$) and diastolic blood pressure (from 70.9±9.2 to 78.0±9.3 mmHg, $p < 0.05$), heart rate (from 68.1±13.6 to 92.6±13.6 bpm, $p < 0.01$), and stroke volume (from 51.9±17.0 to 58.6±21.3 ml, $p < 0.05$) was observed in comparison to pre-exercise conditions. The double product increased accordingly from 7795±2166 to 11928±3119 mmHg·bpm ($p < 0.01$). Cardiac output increased from 3.4±1.4 to 6.6±4.2 $l \cdot min^{-1}$ ($p < 0.01$) and cardiac index from 2.2±0.7 to 3.8±2.0 $l \cdot min^{-1} \cdot m^2$) ($p < 0.01$) as result

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of the increase of both heart rate and stroke volume. Peripheral resistance decreased from 43.2±13.8 to 31.4±16.6 UR ($p < 0.05$).

When the experiment was repeated in conditions of hypnotic suggestion of high performance, the increase of blood pressure was comparable (from 114.6±19.9 to 131.0±30.2 mmHg, $p < 0.05$, and from 72.9±10.7 to 82.0±11.2 mmHg, $p < 0.05$, respectively). Nevertheless, the increase of heart rate was double (from 68.7±16.3 to 105.9±19.5, $p < 0.01$), so that the increase of double product was greater (from 7971±2545 to 14210±5719, $p < 0.01$). This difference was positively correlated to the greater duration of the exercise ($r = 0.31$, $p < 0.05$). The stroke volume did not increase but instead tended to decrease from 53.3±17.6 to 51.1±24.5 ml. Cardiac output increased from 3.8±1.8 to 5.6±4.0 $l{\cdot}min^{-1}$ ($p < 0.01$) and cardiac index from 2.3±1.0 to 3.3±1.9 $l{\cdot}min^{-1}m^{2}$) ($p < 0.01$) as a consequence of the mere increase of heart rate. Peripheral resistance decreased from 46.0±21.8 to 34.6±11.2 UR ($p < 0.05$) (see Figure 2).

Skin temperature and peripheral oxyhaemoglobin saturation were not modified by hypnotic suggestion (see Table 2).

Table 2. Trend of skin temperature and of oxyhaemoglobin peripheral saturation following hand grip isometric exercise in basal pre-hypnotic conditions and in hypnotic suggestion of increased performance. No significant difference.

	Basal conditions (pre-hypnosis)		Hypnotic suggestion of high performance	
	Rest	End of exercise	Rest	End of exercise
Skin temperature (°C)	34.8 ± 1.0	35.0 ± 0.9	35.0 ± 0.6	34.9 ± 0.5
Peripheral oxyhaemoglobin saturation (%)	97.1 ± 1.4	98.0 ± 1.1	97.4 ± 1.2	97.5 ± 1.2

DISCUSSION

Hypnosis and a series of relaxing techniques and have been employed to modify physical performance (e.g. Barber & Calverley, 1964; Albert & Williams, 1975; Unestahl, 1979; Spiegel et al., 1985; Orlick & Partington, 1988; Fernandez Garcia, 2009). A reduction in performance levels has been observed during neutral hypnosis, while an increase has been described when adding motivational instructions (Barber & Calverley, 1964; Albert & Williams, 1975). The experimental study presented herein demonstrates that specific hypnotic commands are followed by higher performance.

The experimental setting was conceived to discriminate between the merely muscular effects of hypnosis and those that are more strictly motivational (Marcorara & Staiano, 2010). The results demonstrate that the hypnotic suggestion of high performance increases the tolerance to exercise rather than enhancing the intensity of effort. In fact, the former increased in a measure that was significantly significant and biologically important, while the second increased insignificantly and inconstantly. It has also been recently demonstrated that the fatigue associated with isometric exercise reduces the efficiency of muscle groups not directly involved in hand grip (Kennedy et al., 2012).

Finally, some words about target organ protection. Isometric exercise exposes target organs to risk (Palatini et al., 1978) and it is only natural to speculate whether the hypnotic suggestion of high performance, leading to increased performance in comparison to basal conditions, also implies increased risk. The hand grip performed in conditions of usual consciousness produced an increase of 12% of systolic blood pressure, 36% of heart rate, and 53% of their double product (an index of myocardial oxygen consumption). Cardiac index, reflecting the haemodynamic load handled by the heart and blood vessels, also increased by 73%. Isometric exercise is confirmed as a potentially dangerous test and therefore should be administered with caution to subjects with coronary artery disease.

In usual conditions, fatigue and pain accompanying the hand grip limit the real haemodynamic importance of this manoeuvre, which is rapidly and spontaneously interrupted. However, in conditions of hypnotically increased performance, and with the neglect of sensations of fatigue and pain caused by hand grip on the dynamometer, we observed that exercise length doubled in comparison to normal conditions. Coupled with more intense muscular effort, this doubled the increase of heart rate and of the double product, reflecting a theoretically higher cardiovascular risk. Furthermore, the stroke volume did not increase, rather it tended to decrease (-5%) during the exercise, probably due to lack of time for activating compensatory reflex mechanisms. The increase of cardiac index observed during the hand grip performed in hypnotically induced high performance (+41% in comparison to rest), which was necessary to compensate for vasodilation, was therefore entirely sustained by heart rate increase, a condition that normally can be maintained only for a brief time and at the expense of myocardial (particularly subendocardial) arterial perfusion.

These results may account for the episodes, often highlighted in the media, when ordinary people perform extraordinary deeds in extreme conditions (usually rescues), sometimes dying immediately afterwards. Self-hypnosis with monoideism of high performance, associated with the neglect of fatigue and pain, probably plays a role in these cases. Although hypnosis is a formidable tool for studying human physiology, its use in physical world (particularly in sporting activities) should be limited to strict experimental conditions. In fact, by increasing muscular power and reducing the feeling of fatigue, hypnosis deprives subjects of their natural feedback mechanisms which can be summarized in the sentences 'It's too much for me' or 'I can't take it any more'.

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