THE LINK BETWEEN SPORT TRAINING AND COGNITION: MOVING BEYOND COGNITIVISM. A PROSPECTIVE RANDOMIZED CONTROLLED PRELIMINARY STUDY

IL LEGAME TRA ALLENAMENTO SPORTIVO E COGNIZIONE: ANDARE OLTRE IL COGNITIVISMO. I RISULTATI PRELIMINARI DI UNO STUDIO PROSPETTICO RANDOMIZZATO CONTROLLATO

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ABSTRACT

New methodological models of sports training and new technological tools with visual stimuli, have been proposed as effective in training cognitive abilities, such as reaction time and selective attention, but the results are still widely debated. The aim of this study was to compare the effectiveness of two training programmes, one using a visual stimuli system and the other using a multiple-stimuli analogue system, and to evaluate their effects on motor and cognitive performance in undergraduate sports science students.

Nuovi modelli metodologici di allenamento sportivo e nuovi strumenti tecnologici di stimolazione visiva sono proposti per l'allenamento delle capacità cognitive, ma la loro efficacia è ancora ampiamente dibattuta. Questo studio ha lo scopo di confrontare l'efficacia di due programmi di allenamento, l'uno che utilizza un sistema di stimoli visivi e l'altro che utilizza un sistema di stimoli multipli, e di valutare i loro effetti sulle prestazioni motorie e cognitive in studenti universitari di scienze dello sport.

KEYWORDS

Sport training, Cognition, Visual stimuli, Reaction time
Allenamento sportivo, Cognitività, Stimoli visivi, Tempo di reazione

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Introduction

In recent years, scientific evidence has supported the circular relationship between exercise and cognition, highlighting the positive effect of exercise on cognitive functions and, at the same time, the importance of high functioning of cognitive processes, such as attention, decision-making and working memory, in the organization of physical and sports performance (Walton et al., 2018). Nevertheless, the physiological changes induced by exercise and the cognitive functions potentially affected by these changes were, and still are, the object of an extended debate so as still few and controversial are the evidence, also in exercise sciences, sport training and conditioning, that explain these effects in relation to learning theories and methods (MacMorris et al., 2009). It's well known that the position of these effects in the cognitive-energetic architecture is directly related to the information processing system. Moreover, cognition is a form of embodied action (Varela et al., 2016) that goes beyond the limits of the computational input-output intersection to be reflected in a relationship of meaning. The subject (athlete) is a living system engaged creating information in an ongoing sensorimotor coupling within its environment (Vörös & Bitbol, 2017). Consistently, the methodology of sports training is moving towards new theoretical approaches that lead not only to the experimentation of new exercise modalities, but also to the use of new technologies in order to stimulate athletes' cognitive functions to react coherently in highly variable and stimulus-rich environments such as playgrounds. In sports training, visual stimuli tools are increasingly used to train and measure the cognitive abilities, particularly Reaction Time and selective attention (RT) (de-Oliveira et al., 2021), but their validity in eliciting the information-processing system is still widely debated (Appelbaum & Erickson, 2018; Čotar et al., 2020; Theofilou et al., 2022).

The speed in detecting and selecting visual information is a function of the information-processing system, an essential feature of cognitive functioning in which the visual system is an element and essential for all other cognitive processes (Koekkoek et al., 2014). Williams et al. (2004) described the ability to pick up relevant visual information as essential for effective performance in several sport domains, but they also highlight that visual search, defined as the ability by which the eyes are used to search relevant information to guide action, is different from reacting to visual stimuli.

RT was defined as the time interval between the appearance of a stimulus, its detection, and the initiation of a response. Processes of motor goal selection

(perception of what is to be achieved) and motor planning (how it is to be achieved) occur during this time (Wong et al., 2015; Delmas et al., 2018). Thus, RT involves the identification and selection of a response to various stimuli (Boisgontier et al., 2014) and it depends to the physical characteristics of the stimulus, its intensity, or duration (Reigal et al., 2019). RT was also described as a good measure to assess the capacity of the cognitive system to process information so as an essential feature of cognitive functioning (Jakobsen et al., 2011). Furthermore, cognitive processes, particularly selective attention, were described as an element that determine the RT (Reigal et al., 2019). Hence, in motor and sport action, RT can be defined as the time it takes for the information-processing system to produce a context-consistent motor response.
The aim of the present preliminary study was to compare the efficacy of two RT training programmes (TPs), one using the technology of a visual stimulus system (BlazePod™) and the other using a system of multiple analogue stimuli, and to evaluate their effects on motor and cognitive RT performance in undergraduate sports science students. To further clarify the effect of the two TPs programmes, a control group (no intervention) was also introduced.

1. Participants and methods

Subjects and study design

The present study is a prospective randomized controlled preliminary study involved 66 collegiate students (age 21-26; 50M-16F) at the University of Bergamo (Italy) over the period from February to March 2023. All participants had no ongoing and no history of neurological, orthopaedic, and cardiac or systemic diseases that could interfere with physical performance. None of them had experience in the proposed exercise methodologies. All participants were assessed in anthropometric measurements (Body Mass Index - BMI and 6 skinfolds), in their physical activity level (International Physical Activity Questionnaire - IPAQ) and RT capacity (Reaction Time Ruler Drop Test - RTRDT). At the end of the study, 43 subjects completed the protocols.
After basal evaluation, participants were randomly assigned to Visual Stimuli Group (VSg, 14; 11M-3F), to Multi-Perceptual Group (MPg, 15; 12M-3F) and to No Stimuli group (NSg, 14; 10M-4F). All the participants underwent cognitive and physical evaluation tests on entry to the study (T0) and at 5 weeks (T1, end of TPs), respectively. Participants were asked to not change their habitual physical activity routines over the course of the study. The evaluations and the TPs were always performed in the morning and at the end of a training session. All tests, evaluations

and TPs were administered by qualified professionals and in accordance with standard procedures. Written informed consent was obtained from all subjects.

Cognitive assessment

The six-letter cancellation task (6-LCT) is a validated test used for the assessment of selective attention (Uttl & Pilkenton-Taylor, 2001; Pradhan et al. 2008) also in sports activities (Bastug, 2018). It consists of a so-called paper/pencil test in which, for six specified target letters and in a set time of 90 seconds, the subject must proceed to identify and delete them in a table consisting of letters of the alphabet randomly arranged in 12 rows and 33 columns.

The Letter Digit Substitution Test (LDST) in a validated test for the assessment of the information-processing speed (van der Elst et al., 2006; Pradhan et al., 2009). It requires the athlete, in a set time of 90 seconds, to copy as many letters as possible that match the numbers on top of the paper randomly arranged in 6 rows and 15 columns.

Physical assessment

The physical evaluation of RT was carried out in two modalities, for both with a square setting and in a time of 30 seconds: in the first one (BpTest), the setting was delimited by 4 lights (BlazePod™), the athlete was required to reach and press the lit light, of the same colour, in a sequence given online by the software; in the second one (MPTest), the setting was delimited by 4 cones of 4 different colours, the athlete was required to reach and press the cone of the corresponding colour in a sequence given online by the instructor.

Training programmes

Participation in the activities lasted 5 weeks, in which each group participated in one experimental training activity per week lasting 20 minutes and performed at the end of a collegiate training session. Each session was organized as follows: 10 minutes of warm-up; 60 minutes of routine activities, 20 minutes of experimental activity (VS or MP training programmes), 10 minutes of cooling down.

In detail, the 20 minutes of experimental activities were designed as follow: VSg underwent progressively harder exercises, in terms of visuo-perceptual demand, performed by using BlazePod™; athletes had to react to visual stimuli from lights positioned as a square; MPg underwent progressively harder exercises, in terms of multi- perceptual demand, performed by using cones and verbal instructions for different stimuli; athletes had to react to different mixed verbal instructions based on colours, numbers and letters linked to the cones positioned as a square. NSg (control group) underwent no TP.

Statistical analysis

Statistical analysis was carried out using the Jamovi for Windows statistical package (ver. 2.3.18). For all analyses, a type I error of 0.05 was taken to indicate statistical significance. A one-way ANOVA was performed to evaluate differences in the distribution of demographic, anthropometrical and physical activity level variables between the groups. A mixed ANOVA 3x2 was performed to evaluate changes in the cognitive and physical parameters occurring within the groups *pre* and *post* interventions. *Post-hoc* analyses were carried out by means of Tukey's least significant difference test.

2. Results

At baseline evaluations, the three groups had an overall homogeneous distribution in terms of demographic (Age), anthropometrical (BMI; Skinfolds), physical activity (IPAQ) and RT (RTRDT) levels. In detail, One-way ANOVA analysis results are shown in Tab. 1.

Group	**MPg (mean±SD)**	**VSg (mean±SD)**	**NSg (mean±SD)**	***p***
Age (yrs)	22.0±1.20	22.1±1.49	22.0±1.30	0.988
BMI	22.2±2.28	23.7±3.44	22.6±1.85	0.424
Skinfolds (%)	16.2±3.29	16.71±2.28	15.2±4.24	0.275
IPAQ	3761±1879	3464±1523	3333±1564	0.801
RTRDT	10.7±3.25	11.3±3.73	9.46±2.57	0.310

Tab. 1 – Descriptive One-way ANOVA (Welch)

The mixed ANOVA 3x2 analysis revealed between the groups no significant effect both on cognitive (6-LCT, F=.625, *p*=.541; LDST, F=1.19, *p*=.316) and physical (BpTest, F=.259 *p*=.088; MPTest, F=.930 *p*=.403) outcomes. For the interaction between time and groups, results showed a significant effect both on cognitive (6-LCT, F=28.4, *p*<.001; LDST, F=25, *p*<.001) and physical (BpTest, F=6.29 *p*=.0004; MPTest, F=5.76 *p*=.006) outcomes. In detail, *post-hoc* analysis reveals significant time effect (T0 *Vs* T1) only for MPg in both cognitive (6-LCT, mean difference= -12.267, *p*<.001; LDST, mean difference= -11.067, *p*<.001) and in physical outcomes (BpTest, mean difference=1.302 *p*=.005; MPTest, mean difference= .9927 *p*=.009). A graphical representation is presented in Fig.1.

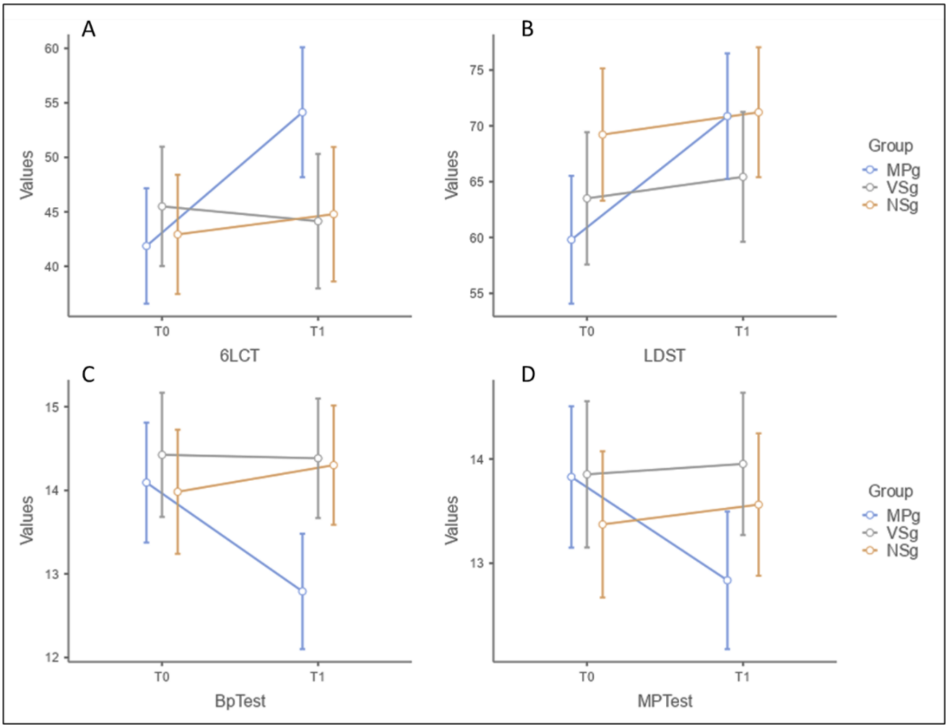

Fig. 1 – Graphical representation showing the marginal means (IC 95%) in groups cognitive (A; B) and physical outcomes (C; D).

3. Discussion and Conclusion

Our study, albeit with preliminary results, aimed to investigate the cognitive potential of two different TPs based on different perceptual stimuli and proposed to undergraduate sports science students randomly assigned to two different study groups and compared to a control group. The results of our study showed a direct link between cognitive and motor performance as an effect of an MP training programme. In line with modern findings about learning and motor learning (Woods et al., 2020), the MP training programme was designed with the idea of thinking about sports training and sport performance in terms of an educational model which mediate the relationship between pedagogical theory and educational practice (Agosti, 2022); the main intention was to combine, in an exercise proposal, the theoretical constructs of two post-cognitivist paradigms, the enactive and the ecological (Avilés et al., 2020), in order that moves beyond cognitivism. This point-of-view on sport training is also in line with the new scientific evidence highlighting RT as a relevant motor skill in sport performance, that directly depends on the speed of the sensorimotor cycle (Reigal et al., 2019), and that placing cognitive processes, in particular selective attention, as a key variable involved in the RT (Avilés et al., 2020). Visual stimuli training by means of specific tools remain a good practice in training visual function in sport performance (Hassan et al., 2022) but in our opinion, and from our results, it is not a useful practice for training cognitive function. In fact, previous studies using visual training tools also expressed the need to better understand and to further investigate the use and specific training usefulness of these tools (Čotar et al., 2020; Appelbaum & Erickson, 2018; Theofilou et al., 2022). Although our study presents new insights, as preliminary it has some limitation in sample size and category. Further validation should be investigated in the context of a randomized controlled trial with a larger population also including athletes from different sports.

Author Contribution:

V.A., conceptualization; data analysis; writing original draft preparation, revision, and editing; *corresponding author.

A.C., data collection; data analysis; revision and editing.

A.E., F.R., training organization and data collection.

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