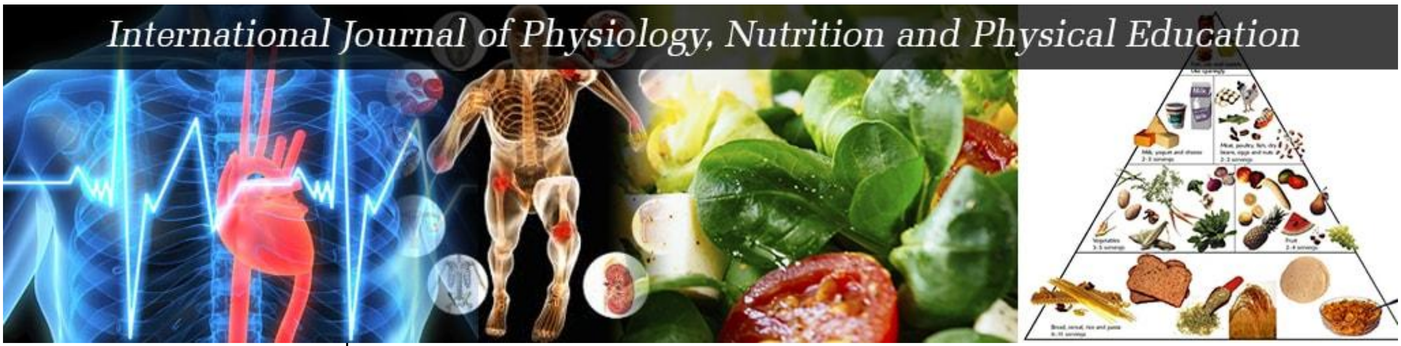

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Comparing efficiency of executive functions between players and non-players of organized sport

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Abstract
The term 'Executive functioning' encompasses a host of higher-order cognitive functioning such as decision-making, problem-solving, planning and goal-oriented behaviour. These functions are regulated by the frontal lobe and are highly significant in the scenario of sports. There is a growing body of research showing the positive correlation between executive functioning and physical activities (Best, 2010). This study aimed to compare the efficiency of executive functions, namely Response Inhibition, Phonemic Fluency and Category Fluency between individuals playing organized sports and individuals who don't. A representative sample of 60 individuals, divided into an experimental group of 30 players of organized sports with a control group of 30 non-players, was sought for the study. The Stroop Test (Response Inhibition), Controlled Oral Word Association Test - COWAT (Phonemic Fluency) and Animal Names test - ANT (Category Fluency) from the NIMHANS Neuropsychology Battery (Rao, Subbakrishna & Kumarpillai, 2005) were administered on the participants. The data was subjected to test of normality and appropriate tests of mean difference were carried out using the Statistical Package for Social Sciences (SPSS-20). The results will be discussed in the full-length paper. The findings will help in understanding the role of sports in regulating the executive functions which imply the need for future experimental studies in this area to explore the isolated causal impact of sport.

Keywords: Organized sports, executive functions, higher cognitive functions

Introduction
Physical exercise has been known as one of the best ways to keep the body and mind healthy. One of the best forms of exercise is involvement in sports. Several bodies of research highlight the effects that playing sports has on cognitive functioning, physical fitness and emotional health. There is sufficient evidence of physical exercise improving general quality of life (Penodo & Dahn, 2005) [22] and psychological well-being (Zubala *et al.*, 2017) [29]. Physical exercise has various proven benefits across all ages - it is correlated with higher levels of perceived competence, goal orientation, self-efficacy (Biddle *et al.*, 2011) [4] and vigilance performance in children (Ballester *et al.*, 2017) [1]; better self-concept and mood in youth and adulthood (Berger & Motl, 2001; Landers & Arent, 2001) [2, 15]; and in the aged population, it helps maintain independence and increases overall survival function (Stessman *et al.*, 2009) [26]. Physical exercise also plays an essential role in counteracting pathological and normal aging (Mandolesi *et al.*, 2018) [20].
Colcombe & Kramer (2003) [6] conducted a meta-analysis of 18 studies exploring the effect of physical exercise on older adults cognitive functioning. The analysis indicated a significant effect of physical activity on overall cognitive performance.
Executive functions (EF) are cognitive processes that are responsible for controlling and organizing behaviors that are goal directed (Banich, 2009) [18] and develop across childhood and adolescence.

Inhibition, working memory and cognitive flexibility are the three core EFs (Diamond, 2014) [10]. Higher order EFs such as planning, reasoning and problem solving are built from these core EFs (Collins & Koechlin, 2012; Lunt *et al*. 2012) [7, 17, 19]. They have been found to improve in children who were chronically active (Crova, 2014) [8]. Research suggests that physical activity (team games and aerobic activity) has a positive impact on executive functions (Schmidt, 2015) [25]. The current research seeks to perform a comparative study of executive functions between players and non-players of sport.

Review of Related Literature

Studies have shown that performance of working memory has improved in pre-adolescent children alongside cardiorespiratory fitness (Kamijo *et al*., 2012) [12]. Van der Niet *et al*. (2015) [27] found that longer durations of sedentary behavior in children was correlated with worse inhibition and better planning ability with higher volume of physical exercise.

Sedentary children prescribed to several week of exercise exhibited enhanced brain activation and EF (Davis *et al*., 2012) [9]. Highly fit children also showed higher recognition memory performance in relational encoding conditions (Chaddock *et al*., 2011) [5]. Even intermittent intense physical activity increases executive function efficiency (Kvalø *et al*., 2017) [13].

Functions such as response inhibition have been found to be enhanced in regular adolescent sportspersons (Verburgh *et al*., 2014) [28]. Practice of sports is linked to EF in alternative ways from the well-known relationship with physical fitness, including performing cognitive actions that are cognitively challenging as seen in sport game situations (Marchetti *et al*., 2015) [21].

Studies involving college students found that for EFs such as inhibition and problem solving, athletes outperform non-athletes and additionally, the performance in different EF domains varies with the nature of athletic experience (Jacobsen & Matthaeus, 2014) [11].

In a cross-sectional design study of adult elite athletes, Krenn *et al*. (2018) [5] found that EF was found to to be favoured by deliberate practice of strategic sports as opposed to static or interceptive sports. Older adults and preadolescent children have been found to strategically use acute moderate aerobic exercise before performing activities demanding high executive control (Ludyga *et al*., 2016) [16]. In a study of elderly subjects with mean age 86, Scherder *et al*. (2005) [24] found that physical intervention of varying intensities led to some improvement in EF related tasks.

The results found by Colcombe & Kramer (2003) [6] were considered as evidence for a connection between fitness level and brain vitality. Further, the connection was found to be stronger when effects of physical exercise training were assessed tests that tap into EF. The scarcity of research conducted to study the relationship between EF and sports involvement in the Indian context has indicated a need for such comparative study. The current research accounts for implications from existing scholarship on considered and related variables and methodology used to carry out the study.

Method

Objectives

To compare the efficiency of executive functions between players and non-players of organised sports.

Hypothesis

There is no difference between players and non-players of sports in terms of executive functions.

Variables

Quasi-independent Variable: Involvement in sports.
Dependent Variable(s): Executive function of -

- Response Inhibition
- Phonemic Fluency
- Category Fluency

Operational Definitions

Response Inhibition: Response Inhibition measures the ease with which a perceptual set can be shifted both to conjoin demands and by suppressing a habitual response in favour of an unusual one (Rao, Subbakrishna & Kumarpillai, 2005) [23].

Phonemic Fluency: Phonemic Fluency is a measure of Verbal Fluency which indicates the capacity to generate words intrinsically beginning with a given consonant in a regulated manner (Rao, Subbakrishna & Kumarpillai, 2005) [23].

Category Fluency: Category Fluency is a measure of Verbal Fluency which indicates the capacity for intrinsic generation of words belonging to a particular category in a regulated manner (Rao, Subbakrishna & Kumarpillai, 2005) [23].

Players of Organized Sport: Individuals who play some form of organised sports 3-4 times a week and have been doing so regularly for 1+ years as a job or for leisure.

Research Design

A quasi-experimental between-groups research design was employed to compare the efficiency of executive functions in players and non-players of sport.

Sample

The sample consisted of 60 participants belonging to the age range of 17-25 years who took part in the study. The sample was further divided into 30 players of sport and 30 individuals who do not play sports. Convenient sampling technique was used to collect data.

Measures

Three tests were administered on the participants

Stroop Test (NIMHANS version) was used to test response inhibition. The colour names “Blue”, “Green”, “Red” and “Yellow” are printed in capital letters on a paper and the colour of the word occasionally corresponds to the colour designated by the word. The words are printed in 16 rows and 11 columns. The time taken for reading the words column wise is first noted, followed by the time taken to read the colour the word is printed in, again column wise. The Stroop Effect is calculated by subtracting the word reading time from the colour reading time (converted to seconds).

Controlled Oral Word Association Test - COWAT (Banton & Hamsher, 1989) [23] measures phonemic fluency. The subject is given one minute to generate as many words as they can starting with letters F, A and S based on the phonetic similarity of words. the number of words per letter is counted and the average of all three forms the score.

Animal Names test - ANT (Lezak, 1995) [23] measures category fluency. The number of words which are generated from the semantic category of Animals in one minute is noted down. This number forms the score.

All tests were obtained from the NIMHANS Neuropsychology Battery (Rao, Subbakrishna & Kumarpillai, 2005) [23].

Procedure

The informed consent of all participants was taken. All relevant demographic details were collected following which the three tests were conducted.

Analysis

The data analysis was done using Statistical Package for Social Sciences (SPSS 25). Descriptive Statistics and tests of Mean Difference were done.

Results & Discussion

The data received from the sample on the three individual tests were analysed using the Statistical Package for Social Sciences (SPSS 25). The following results were obtained:

Table 1: Shows the descriptive statistics for the sample.

Variables	N		Mean		Standard Deviation	
	Sports Players	Non-sports Players	Sports Players	Non-sports Players	Sports Players	Non-Sports Players
Word reading time	30	30	79.96	82.80	9.49	11.45
Word reading errors	30	30	2.50	2.06	1.57	3.11
Colour naming time	30	30	188.23	208.63	32.10	56.73
Colour naming errors	30	30	6.33	5.50	3.35	3.41
Stroop effect	30	30	108.26	125.83	31.75	53.74
COWA-T	30	30	50.77	42.73	13.03	10.85
ANT	30	30	17.33	18.56	4.40	5.92

From Table 1, it can be found that the mean value for the Stroop effect is 108.26 ± 31.75 in players of sport and 125.83 ± 53.74 in non-players of sport. For COWA-T, the mean value is 50.77 ± 13.03 for players of sports and is 42.73 ± 10.85 in non-players of sport. For ANT, the mean value is 17.33 ± 4.40 for sports players and is 18.56 ± 5.92 for non-players of sports.

Table 2: Shows the tests of mean difference for the sample.

Variables	Mean Difference	t	Significance
Word reading time	-2.833	-1.043	0.301
Word reading errors	0.433	0.680	0.499
Colour naming time	-20.40	-1.714*	0.050
Colour naming errors	0.833	0.954	0.344
Stroop effect	-17.56	-1.541	0.129
COWA-T	8.033	2.594	0.120
ANT	-1.233	-0.915*	0.012

*-significany at 0.05 level

From the Table 2, it can be seen that for colour naming time, the t-value is -1.714 which is significant at 0.05 level. This indicates that there is a statistically significant difference between the two groups. Sports players have better response inhibition during colour naming as compared to non-players of sport.

For ANT, the t-value is -0.915 which is significant at a 0.012 level ($p<0.05$) which indicates a statistically significant difference between the two groups. Non-players of sport have better category fluency as compared to sports players.

With respect to the other variables, there was no statistically significant difference found.

The hypothesis is rejected with respect to Category Fluency. For Response Inhibition and Phonemic Fluency, the hypothesis is accepted. This is in line with prior research done by Labelle *et al*. 2014 in which bouts of moderate to high intensity exercise was linked to deleterious performance in the computerised modified-Stroop task in individuals indicating that regardless of age, acute exercise can impair executive control momentarily. Considering limitations of a small sample size, the study if extended might provide insightful results.

Conclusion

This study has found out that there is no significant difference between individuals who play sports and non-players of sport with regards to the executive functions of Phonemic Fluency and Response Inhibition. On the contrary, a significant difference was found between the two groups where Category Fluency is concerned. These findings do not reflect the popular literature. Future directions with larger samples and a profile of executive variables might help us test the hypothesis better and get more concurrent results.

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