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Effect of BDNF on Skills Improvements in Pole Vault Compared to Hammer throw Athletes.

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Abstract

Physical activity has been reported to improve cognitive function in humans and rodents, possibly via a brain-derived neurotrophic factor (BDNF)-regulated mechanism. In this study of human subjects, we have assessed the effects of acute and chronic exercise on performance

Introduction

Participation in physical activity has been associated with the improvement of a number of physical and mental properties. In addition, physical activity is linked with improvements in brain function and cognition **(Hilman et al., 2008).** Recently, there is growing evidence that exercise promotes brain neuroplasticity. The beneficial effect of exercise on neuroplasticity may be related to exercise-induced increments in neuroplastic factors such as BDNF, but the mechanisms or mode and threshold required for these effects, respectively, are not yet defined (**Vegaa et al., 2006)**.

Research in cell and molecular biology has revealed that brain derived neurotrophic factor (BDNF) have impact on neurogenesis in the brain of all mammalian species including humans **(Jacobs et al., 2000).** These factors directly change the basic structure and morphology of the brain. BDNF was shown to promote and improve neuronal plasticity, retard neuron cell death, induce neural regeneration and stimulate neuronal survival particularly in motor and sensory neurons of the peripheral and central nervous system **(Molteni et al., 2004).**

Since BDNF is readily crossing the blood brain barrier in both directions and taking into account the presence of a high-capacity saturable transport system, it can be assumed that peripheral circulating BDNF is transported into the brain and contributes to neuroplasticity **(Pan et al., 1998).** Apart from the key role as mediator of neuronal plasticity, BDNF is also known for a functional role in the periphery e.g. in repair processes at the site of traumatic injury. Serum BDNF protein is stored in platelets and is released upon agonist stimulation **(Fujimura et al., 2002).** Platelet BDNF is not acquired from the megakaryocyte precursor cells or pituitary gland, but is probably acquired from other sources via the blood circulation.

Taking into account that in the adult nervous system BDNF plays a predominant role in neuronal plasticity **(Egan et al., 2003)**, the potential role of peripheral exercise-induced upregulation of BDNF may help to increase the brain's resistance to damage and neurodegeneration that occurs with age. Moreover, BDNF may play an important role in the skill development and improvement.

Hammer throw and pole vault games are two field games require strength and skill with efficient neuromuscular compatibility. Hence, BDNF may affect these two games. The matter is that to what extent BDNF may improve skills of these games especially pole vault requires more compatibility while hammer throw requires more muscle strength.

Brain-derived neurotrophic factor (BDNF) is a member of the neurotrophic factor family that plays key roles in regulating survival, growth and maintenance of neurons **(Mattson et al., 2004).** Animal and human research has shown that exercise increases neuronal survival and resistance to brain insult (Wichi et al., 2009), promotes brain vascularization, stimulates neurogenesis, enhances learning and contributes to maintenance of cognitive function, all of which are modulated by BDNF.

Exercise for several days enhances BDNF production in the central nervous system in, which suggests that exercise induces neurotrophin release. Recent findings have reported that physical exercise increases circulating BDNF levels in healthy humans (Ferris et al., 2007). The main source of circulating BDNF at rest and in response to exercise has not been defined. Researchers have demonstrated that the brain and/or vascular endothelium may produce BDNF during prolonged endurance exercise (Seifert et al., 2010). An increase in BDNF during heavy exercise bouts to exhaustion has been observed, and the magnitude of its increase is exercise intensity dependent.7 While the effects of moderate (aerobic) and intense exercise on blood BDNF have been demonstrated,6-9 little information about the effect of strength exercise on BDNF has been reported. A few studies on this topic have investigated the effects of strength exercise on blood plasma concentrations of BDNF in humans (Goekint et al., 2010).

It appears that the circulating BDNF level is affected by both acute and chronic physical activity. However, the interaction of acute and chronic physical activity was still unclear. Human research investigating the effect of acute single-bout aerobic exercise has focused on two areas in particular; either characterizing the change in serum BDNF (sBDNF) levels after one exercise session or identifying the effects of exercise intensity on this post-exercise serum BDNF levels (**Correia et al., 2010**).

There is no previous investigations – as far as the authors knowledge – studied the relationship between type of gamed and BDNF effects. Also, to what extent BDNF may affect neuromuscular compatibility under effect of chronic training program specific for each game. We hypothesize that the response of BDNF to strength exercise may differ depending on the type of exercise. Thus, the aim of the present study was to investigate BDNF concentration responses to training programs for two different field games (hammer throw and pole vault) and relate them to athletes physical and skill improvement.

Material and Methods

Subjects:

Thirty female students from the faculty of physical education for girls, Helwan University, grade two constituted subjects of this study. They were recruited for the study after completing a medical questionnaire and giving their informed, written consent. All experimental procedures were approved by the Helwan University Human Research Ethics. Participants were divided into two groups. First group was subjected to training program of pole vault game and the second group was subjected to hammer throw training program. All participants were subjected to the first experimental trial exercise before the program.

Exercise protocol design:

This study was proposed to investigate the effect of two different training programs for eight weeks (from 1/10/2011 to 26/11/2011) on the adaptation process for BDNF and its effect on some physical parameters improvement including arm, leg, grip and abdominal muscle strength, hexagon compatibility, elasticity, agility, legs capacity, arms capacity, translocation velocity, ball throwing & receiving compatibility and balance.

Subjects were subjected to specialized program for 8 weeks at 75% of VO2 max for upgraded time started at 1hr/ 3 days/ week and increased be five minutes every two weeks to be 80 min/3days/week at the end of the program. The pole vault or hammer throw exercise session was partitioned into 5 min. for warming up, 50 – 70 min for the game exercise (either pole vault or hammer throw) and 5 min for active cool down.

Blood Analyses

Blood was sampled from an antecubital vein at rest and after the end of the exercise session before and after the training program. Plasma was immediately separated by centrifugation and stored at -20 °C for later analysis. Plasma BDNF was analyzed by using an ELISA kit.

Statistical analysis

All values were reported as the means ± SD. Data are represented with resting samples and compared post-exercise samples. Mean values for the two experimental conditions were compared by using t paired sample by using (SPSS V.17) computer designed statistical program. Specific differences were assigned with a significance level of 0.05.

Results

Table (1) represents the anthropometric results of both groups. There is no any significant differences in all parameters indicating homogeneity of all players participated in this study.

(Table 1)
Anthropometric results (Mean ± SD) for investigated players

	PV group	HT group	t	p	Significance
Height (cm)	**168.73 ± 1.91**	**169 ± 1.46**	**0.19**	**0.85**	**NS**
Weight (kg)	**69.2 ± 2.11**	**69.2 ± 1.26**	**-0.10**	**0.93**	**NS**
Age (years)	**18.33 ± 0.62**	**18.2 ± 0.77**	**-0.47**	**0.64**	**NS**

PV: pole vault group **HT: Hammer throw group**

Results of table (2) revealed results of the two groups in all investigated measurements. They are expressed as Mean ± SD. Strength results showed higher adaptation in the hammer throw group while the other physiological results indicated more profound results in the pole vault players except in the Translocation velocity where both groups gave equally adaptation results.

(Table 2)
Physical and Physiological results of the investigated players
(Mean ± SD) before and after the training program

	Pole Vault (Pv)		Hammaer Throw (Ht)	
	Before	After	Before	After
Arm Strength	12.06 ± 1.70	16.53 ± 1.18	12.66 ± 1.4	21.86 ± 2.45
Legs Strength	37.06 ± 2.89	45.26 ± 1.90	36.53 ± 3.07	60.2 ± 3.45
Grip Strength	21.46 ± 1.95	27 ± 1.73	21.73 ± 1.71	33 ± 1.77
Abdominal Muscles Strength	11.26 ± 1.91	17.06 ± 1.67	11.46 ± 1.85	23.13 ± 1.35
Hexagon Compatibility	19.97 ± 1.21	17.07 ± 0.84	19.89 ± 0.93	13.48 ± 0.99
Elasticity	5.33 ± 0.97	13.33 ± 1.23	5.66 ± 0.98	9.61 ± 1.4
Agility	22.34 ± 0.47	19.60 ± 1.06	22.32 ± 0.47	17.442 ± 0.33
Legs Capacity	152.8 ± 22.83	184.46 ± 17.73	153.46 ± 23.19	162.2 ± 22.67
Arms Capacity	6.59 ± 0.78	8.242 ± .49	6.59 ± 0.71	6.05 ± 0.57
Ball Throwing & Receiving Compatibility	6.317 ± 0.88	13.13 ± .83	6.35 ± 0.89	10.06 ± 0.78
Translocation Velocity	6.94 ± 0.29	5.71 ± .21	6.99 ± 0.29	6.238 ± 0.15
Balance	18.26 ± 2.02	35.86 ± 3.96	18.53 ± 1.81	25.93 ± 1.75
Skills	2.5 ± 0.38	3.76 ± 0.46	2.1 ± 0.51	3.88 ± 0.46
Numerical Record (Cm)	96.0 ± 4.71	106 ± 3.87	9.136 ± 0.47	10.24 ± 0.54
Bdnf Rest (Pg/Ml)	793.73 ± 134.47	867.2 ± 135.2	795.66 ± 127.15	812.33 ± 118.35
Bdnf Effort	930.53 ± 143.4	1144.66 ± 149.23	903.06 ± 128.42	935.13 ± 117.19

These results were compared in table (3) and table (4) using student t test differences. Pole vault players were compared to hammer throw group before and after the training program. All results revealed no significant differences between the two groups before the training program but significant after program. Strength adaptations were higher in hammer throw group including arm, leg, grip and abdominal muscle strength. Physiological parameters require high neuromuscular compatibility are found to be higher in pole vault group. They included Hexagon compatibility, Elasticity, Agility, Legs capacity, Arms capacity, Translocation velocity, Ball throwing & receiving compatibility and Balance.

(Table 3)
Differences between results of players obtained in this study (Pole vault [PV] compared to Hammer throw [HT])

	t	p	significance
	Arm strength		
PV-B - HT-B	-1.03	0.32	NS
PV-A - HT-A	-7.02	< 0.01	S.
	Legs Strength		
PV-B - HT-B	0.43	0.67	NS
PV-A - HT-A	-14.18	< 0.01	S.
	Grip Sterngth		
PV-B - HT-B	-0.47	0.64	NS
PV-A - HT-A	-7.75	< 0.01	S.
	Abdominal muscles strength		
PV-B - HT-B	-0.35	0.73	NS
PV-A - HT-A	-10.75	< 0.01	S.
	Hexagon compatibility		
PV-B - HT-B	0.19	0.85	NS

	t	p	significance
	Arm strength		
PV-A - HT-A	**12.06**	**< 0.01**	**S.**
	Elasticity		
PV-B - HT-B	**-0.82**	**0.42**	**NS**
PV-A - HT-A	**11.33**	**< 0.01**	**S.**
	Agility		
PV-B - HT-B	**0.12**	**0.90**	**NS**
PV-A - HT-A	**6.47**	**< 0.01**	**S.**
	Legs capacity		
PV-B - HT-B	**-0.43**	**0.67**	**NS**
PV-A - HT-A	**3.16**	**< 0.01**	**S.**
	Arms capacity		
PV-B - HT-B	**-0.03**	**0.98**	**NS**
PV-A - HT-A	**9.06**	**< 0.01**	**S.**
	Ball throwing & receiving compatibilty		
PV-B - HT-B	**-0.10**	**0.93**	**NS**
PV-A - HT-A	**10.21**	**< 0.01**	**S.**
	Translocation velocity		
PV-B - HT-B	**-0.43**	**0.67**	**NS**
PV-A - HT-A	**-7.48**	**< 0.01**	**S.**
	Balance		
PV-B - HT-B	**-0.41**	**0.69**	**NS**
PV-A - HT-A	**9.16**	**< 0.01**	**S.**

PV-B: Pole vault before program **PV-A: Pole vault after program**

HT-B: Hammer throw before program **HT-A: Hammer throw after program**

(Table 4)
Differences between results of players obtained in this study (Pole vault and Hammer throw) compared before to after training program

	t	p	significance
	Arm strength		
PV-B - PV-A	**-10.02**	**< 0.01**	**S.**
HT-B - HT-A	**-12.15**	**0.00**	**S.**
	Grip Strength		
PV-B - PV-A	**-10.21**	**< 0.01**	**S.**
HT-B - HT-A	**-16.25**	**< 0.01**	**S.**
	Abdominal muscles strength		
PV-B - PV-A	**-7.36**	**< 0.01**	**S.**
HT-B - HT-A	**-21.95**	**< 0.01**	**S.**
	Hexagon compatibility		
PV-B - PV-A	**9.71**	**< 0.01**	**S.**
HT-B - HT-A	**16.11**	**< 0.01**	**S.**
	Elasticity		
PV-B - PV-A	**-25.90**	**< 0.01**	**S.**

	t	p	significance
	Arm strength		
HT-B - HT-A	**-8.07**	**< 0.01**	**S.**
	Agility		
PV-B - PV-A	**8.28**	**< 0.01**	**S.**
HT-B - HT-A	**31.51**	**< 0.01**	**S.**
	Legs capacity		
PV-B - PV-A	**-4.69**	**< 0.01**	**S.**
HT-B - HT-A	**-6.70**	**< 0.01**	**S.**
	Arms capacity		
PV-B - PV-A	**-10.41**	**< 0.01**	**S.**
HT-B - HT-A	**7.06**	**< 0.01**	**S.**
	Ball throwing & receiving compatibility		
PV-B - PV-A	**-20.37**	**< 0.01**	**S.**
HT-B - HT-A	**-12.46**	**< 0.01**	**S.**
	Translocation velocity		
PV-B - PV-A	**18.07**	**< 0.01**	**S.**
HT-B - HT-A	**8.21**	**< 0.01**	**S.**
	Balance		
PV-B - PV-A	**-13.06**	**< 0.01**	**S.**
HT-B - HT-A	**-9.81**	**< 0.01**	**S.**

Moreover, numerical records and skills degrees were found to be significant in the two groups also. They were represented in tables (2 & 5) indicating high difference between results before compared to after training program.

(Table 5)
Differences between numerical records and skills degree of players obtained in this study
(Pole vault and Hammer throw) compared before to after training program

	t	p	significance
	Numerical record		
PV-B - PV-A	**7.25**	**< 0.01**	**S.**
HT-B - HT-A	**-14.26**	**< 0.01**	**S.**
	Skills degree		
PV-B - PV-A	**8.72**	**< 0.01**	**S.**
HT-B - HT-A	**-11.72**	**< 0.01**	**S.**

Brain derived neurotrophic factor results were highly significant in pole vault group comparing before program to after program either at rest or after effort. The vice versa was found in the hammer throw group where there is no significant differences revealed after training program compared to before program. Of course effort leads to increased BDNF regardless the program but the level of elevation is higher in the pole vault group (Table 6).

(Table 6)
Difference between BDNF results at rest compared to after effort before and after the training program

BDNF			
	t	**p**	**significance**
BDNF Rest PV-B - BDNF Effort PV-B	**-10.19**	**< 0.01**	**S.**
BDNF Rest PV-A - BDNF Effort PV-A	**7.39**	**< 0.01**	**S.**
BDNF Rest PV-B - BDNF Rest PV-A	**-5.73**	**< 0.01**	**S.**
BDNF Effort PV-B - BDNF Effort PV-A	**-9.49**	**< 0.01**	**S.**
BDNF HT-B rest - BDNF Rest HT-A	**-1.77**	**0.10**	**NS**
BDNF HT-B Effort - BDNF Effort HT-A	**-1.82**	**0.09**	**NS**
BDNF HT-B rest - BDNF HT-B Effort	**-14.31**	**< 0.01**	**S.**
BDNF Rest HT-A - BDNF Effort HT-A	**-12.92**	**< 0.01**	**S.**

Discussion

This study was proposed to investigate effect of two different training programs (pole vault & hammer throw) on the adaptation of some physical parameters and correlate them to plasma levels of BDNF. In the present study, the subjects sport activities were pole vault or hammer throw on average for 50 - 70 min with moderate intensity 3 days per week.

Results revealed general improvement in all physical characteristics in the investigated female students. Students in grade two are still untrained well. To upgrade their physical fitness, it is recommended to practice exercise programs for the development of endurance, mobility and coordination. One of these programs is the recreational pole vault or hammer throw training model, which develops aerobic endurance, strength, mobility and coordination **(Boeva et al.; 2003).**

Findings of this study revealed significant elevation in adaptation physical parameters in the all investigated subjects of the study. BDNF levels were elevated post-exercise either before or after program with highest significant levels after program. The significant increase in plasma BDNF after exercise and after training program suggests that BDNF could possibly be an important tool for monitoring and quantification of neuromuscular compatibility.

This study comprised three main results; the first is the elevation of strength adaptation parameters in hammer throw group more than that of pole vault group. Another manifestation of this study is that the increased skills adaptation parameters in the pole vault group more than that of hammer throw group. The most profound result is that the increase in skill was correlated with BDNF levels.

Exercise can promote brain health and function by protecting neurons and improving neuronal plasticity **(Cotman and Berchtold, 2002).** The novel finding of the present study is that in pole vault training exercise blood BDNF concentration is elevation is found but not in hammer throw group, pointing to exercise-type dependent transient neurotrophic factor induction in humans.

The physiological function of the acute response of serum BDNF concentration may contribute to promote synaptic plasticity and to improve cognitive functions **(Vaynman et al., 2004)** as well as to enhance exercise performance **(Rhojas et al., 2006).** Chronic response may affect neural regeneration and remyelination to be promoted because the activation of the BDNF signal is also required for the priming effect of exercise on axonal regeneration **(Ebadi et al., 1997).**

With regard to exercise protocol, four studies implemented an aerobic training program **(Baker et al., 2010-A; Baker et al., 2010-B; Erickson et al., 2011; Ruscheweyh et al., 2011),** one study investigated the effect of single acute aerobic exercise **(Laske et al., 2010)** and one study included strength exercise (Coelho et al., 2011). Thus, most studies applied an aerobic training to investigate the effects on BDNF peripheral levels. However, the studies reviewed presented distinct sample and different training durations.

An acute bout of exercise induced an enhancement in cognitive function, as shown by the improvement in face-name task performance. This is in agreement with previous studies which suggest that intense acute exercise enhances learning and memory as assessed by a language-learning model **(Yamamoto and Gurney, 1990).**

In agreement with the literature, the serum analysis revealed an acute exercise-induced increase in BDNF concentration in sedentary young men. According to a recent review, 69% of studies in healthy human subjects reported a ‘mostly transient’ increase in peripheral BDNF concentration following acute exercise **(Knaepen et la., 2010).** In the present study, acute exercise induced an increase in BDNF, however given that increases in basal BDNF concentrations were found in the chronic analysis, it may be presumed that the increase in serum BDNF reported here is correlated to chronic adaptation of neuromuscular compatibility.

The source of the BDNF increase remains unclear. Evidence indicates that the brain is a major, but not the sole contributor to circulating BDNF and platelets also represent a likely source of serum BDNF, as has consistently been reported **(Rosenfeld etal., 1995).** In this context, reports of the ability of BDNF to cross the blood-brain barrier may be of relevance, with movement of BDNF from brain to blood said to occur via bulk flow associated with the re-absorption of the cerebrospinal fluid **(Pan et al., 1998).** It has also been suggested that exercise transiently increases the permeability of the blood brain barrier as demonstrated by an increase in the extra-vasation of Evans blue albumin into the brain following 30 min of forced swim exercise in rats **(Sharma et al., 1991)** or post-exercise increases in serum S100B protein concentration in humans **(Watson et al., 2006).**

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