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IMPACT OF DIFFERENTIAL BIOFEEDBACK INTERVENTIONS ON AUTONOMIC HABITUATION AND FATIGABILITY IN SOCCER PLAYERS

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ABSTRACT

Purpose of this study was to identify and compare the efficacy of skin conductance (Sc) and electromyography (EMG) biofeedback intervention techniques in regulation of sudomotor nerve activity (SNA) and maximal voluntary contraction (MVC) evident in high-performing soccer players having dismal performance. All of the players were assessed with autonomic measures of emotionality (SNA and Sc amplitude); electromyography evaluation of MVC. Fifty-four National-selection group soccer players in Malaysia were randomly categorized into three groups (Gr. A, N = 18, no-intervention control group); Gr. B (who received EMG biofeedback training) and Gr. C (received Sc biofeedback intervention). Players in the intervention groups received their respective trainings for 12 weeks (15 min.s /day for 3 days/ week). Post-intervention analyses revealed marked improvement in the bilateral shooting performance of the soccer players who received Sc and EMG biofeedback intervention training, which were capable of modulating autonomic indices of emotionality as well as the muscle potentiality in the form of enhanced maximal voluntary contraction in the players.

KEYWORDS: **Biofeedback, Skin conductance, EMG, Fatigability; Soccer Shooting**

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INTRODUCTION

Excellence in soccer performance should be considered as optimal level of effective integration between aspects ranging from unique adoption of basic skills, tactical preparations, physiological conditioning and psychological and psychobiological adaptations. While regulation of psychological conditions, with particular reference to cognitive-emotional competence[1, 2] and facilitative influence of psychobiological adaptations [1, 3, 4] were being looked up in recent researches carried out in our experimental set-ups and also by other researchers [5, 6], issues beyond cognitive-emotional and psychobiological competence, such as those pertaining to neuromuscular ability and electrical muscle potentiality and other significant dimensions pertaining to the factors like fatigability and maximal voluntary contraction of relevant muscles could considered as significant determinants of peak soccer shooting performance. Successful shooting performance being one of the most significant aspects of soccer performance, the multi-articular movements involved in soccer kick or shooting is characterised primarily by a proximal-to-distal motion of the segments of lower limb of the kicking leg [7]. Thus, if we need to be concerned with bilateral shooting performance, ability of the players in performing alternative instep shooting or kicking performance within a short span of time and from a shorter distance, requiring faster reactions, would be required. Inherent kinematic aspect of such performance would require controlled movement involving angular velocity, which gets initiated in the thigh, then by the shank and finally the regulated shooting takes place by the foot. Here significance of quadriceps rectus femoris muscle would be mostly emphasized and specific evoke-potentials arising at the rectus femoris and associated inhibitive as well as facilitative factors like relative fatigability and maximal voluntary contraction would be of key importance. Here at this point we intend to pay attention to the methodological concerns, since electromyographic (sEMG) signals obtained by surface electrodes, could be mystifying as those could be accompanied by various prevalent and unavoidable noise components, and hence those may vulnerably contaminate the surface EMG signal and may lead to an erroneous interpretation of the signal [8]. Apart from all these, multiple dynamics of motor coordination and muscle kinematic factors accompanied by psychobiological complications and cognitive-emotional confounding factors are potentially susceptible to create catastrophic impact on natural shooting performance [9, 1, 3, 4, 10]. Thus a need for optimal regulation of cognitive-emotional hindrances as well as those of muscle fatigability etc has emerged as the key concern for optimal soccer shooting performance. With such a background and in search of a valid methodology to obtain further information related to science of optimal soccer performance, the present study was carried out -

1) To know about the differential efficacy of biofeedback interventions on autonomic regulation in the soccer players;
2) To observe the efficacy of the two different biofeedback intervention techniques in regulation of muscular fatigability in the players;
3) To compare the efficacy of the two different biofeedback intervention techniques in regulation of maximal voluntary contraction and fatigability in the players.

METHODOLOGY

2.1. Participants

[1] -- *Monday, September 15, 2014 -- 20:48:48*
F tests - ANOVA: Repeated measures, within-between interaction
Analysis: A priori: Compute required sample size
Input: Effect size f = 0.25
α err prob = 0.05
Power (1-β err prob) = 0.95
Number of groups = 3
Number of measurements = 3
Corr among rep measures = 0.5
Nonsphericity correction ε = 1
Output: Noncentrality parameter λ = 20.2500000
Critical F = 2.4608001
Numerator df = 4.0000000
Denominator df = 102
Total sample size = 54
Actual power = 0.9579391

Based on the sample size calculation, altogether fifty-four highly skilled and consistently high performing Malaysian male soccer players aging between 19.9 and 22.1 years (mean age = 20.8 and SD = 1.13) were selected by the respective selectors, who volunteered as the participants in this study. They were mostly state selection–level athletes and they were selected unanimously by three expert coaches, while they were preparing for their forthcoming soccer season (2014). The sample size was calculated using G power 3.0.17 [11]. The power of the study was set at 95% with 95% confidence interval and the effect size f was set at 0.25.

2.2. Materials Used

1. Skin Conductance Apparatus (ProComp5 Infintiy, USA 2013) was used to assess the extent of autonomic regulation as index of emotionality in the participants.
2. Electromyography Recording Apparatus (MegaTrac ME6000, USA 2008) – was administered to evaluate the muscle potentiality; maximal voluntary control and fatigability of the participants.

2.3. Procedure

In this study participants at first were evaluated on the basis of psychobiological analyses (viz., autonomic regulation and orienting amplitude and spontaneous fluctuation as sudomotor nerve activity) and EMG activity (viz., maximal voluntary contraction or MVC and fatigability or Fatigue AEMG) for the pre-intervention analyses. Special cares were taken to nullify any erroneous influence from any subject-relevant; sequence-relevant and stimulus-relevant interference. Participants were subjected to psychobiological evaluation of emotionality employing the ProComp5 Infinity apparatus, in which spontaneous fluctuation or SF or NS-SCR, i.e., non-specific Sc response as sudomotor nerve activity and stimulus-specific orienting response measures (viz. amplitude) were done [12, 13, 14]. For the EMG evaluation MegaTrac ME 6000 Apparatus was used, and the Raw EMG data were rectified and integrated by RMS (root-mean-square), and thereafter Band Pass filtration of the data, the Waveform data were assessed to derive Maximal voluntary contraction (MVC) and Fatigue score (FatigueAEMG). The flowchart of the detai methodology is shown in Fig 1.

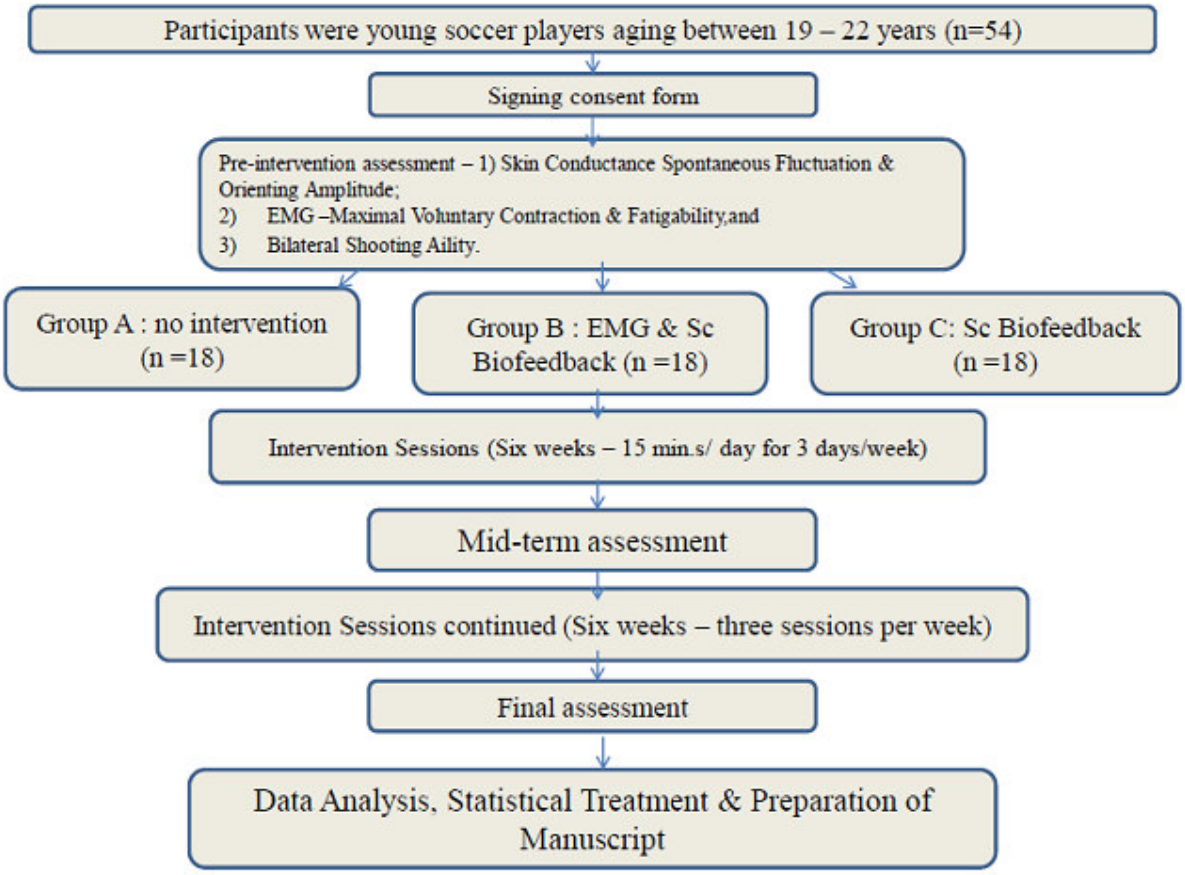

Figure 1
Flow chart of the methodology followed in this study.

Here we would like to clarify that, bilateral shooting activity was considered as measure of performance. Players were instructed adequately enough with regard to the task they were supposed to perform, as they were subjected to evaluation of their shooting ability, in which they were supposed to kick a soccer ball to a wall from a distance of 12 feet, and as the ball bounced back they were supposed repeat the kicking activity continuously using the opposite feet for 15 seconds duration. Number of times the ball was kicked bilaterally using both of the feet, was considered as their "Bilateral Shooting Performance Score". Thereafter players were randomly categorized into three groups (Gr. A, N = 18, no-intervention control group); Gr. B (N = 18, who received EMG biofeedback training) and Gr. C (N = 18, received Sc biofeedback intervention). Players of intervention groups received their respective trainings for 12 weeks (15 min.s /day for 3 days/ week). Mid-term analyses on all of the afore-mentioned variables were done after the 6th week and finally the post-intervention analyses were done at the end of the 12th week following similar protocols. The data were treated with SPSS 22.0, descriptive analyses of data were done and reports on correlation analyses, prompted the authors to look into prediction analyses. Thereafter analyses of two-way repeated measure of ANOVA were performed to justify the relative contribution of psychobiological variables in predicting problems of rectus femoris muscle fatigabilty in the high performing players.

RESULTS AND DISCUSSION

Reports on descriptive statistics were summarized in the Tables 1, which represented somewhat consistency in the data obtained from the participants of the three groups (hereafter Gr. A, B & C). Data revealed that there existed mostly moderate and in some cases lower extents of standard deviation indices, which clarified that the data

were considerably free from huge dispersions. Moderate dispersions are considered as somewhat generalised features of psychobiological and electrophysiological analyses outcomes. Table 1 however also represented differences observed amongst the participants of the groups A, B & C on all of the variables assessed, which implied that excepting in EMG fatigue measure, pre-existing differences between the soccer players were not evident in any other parameters assessed, who were categorised into different groups, on one of the psychobiological (i.e., phasic Sc) and one EMG (i.e., fatigability) variable. Further to that, mid-term analyses and post-intervention analyses revealed that participants of different groups had significant differences in between them, implying that those observed differences could be attributed to the differential interventions received by the participants. Finally differential impacts of interventions were observed in the bilateral shooting ability of the players, which however revealed that the players of both of the intervention groups could benefit from the respective intervention trainings they received, which resulted in better shooting performance in them.

Table 1

Descriptive measure and significance of variance amongst the three groups

Groups \ Phases	Orienting Amplitude (Log microsiemens)			Spontaneous Fluctuation (Sudomotor nerve activity-SNA) (No.s)			EMG Maximal Voluntary Contraction (MVC)(µVs)			Fatigue AEMG (µVs)			Bilateral Shooting Scores (No.s)		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD
Gr. A	.47 .11	.49 .19	.41 .21	4 2.8	6 1.5	9 3.9	397.4 144.8	426.9 223.8	401.8 253.5	412.6 39.5	-365.4 42.7	-354.8 84.9	17 6.3	19 4.8	19 5.9
Gr. B	.50 .08	.54 .15	.62 .11	6 2.1	3 2.1	3 1.2	353.1 109.5	647.6 152.4	801.6 203.4	719.1 56.4	714.4 45.8	481.7 95.1	19 7.2	22 8.1	25 6.2
Gr. C	.46 .15	.61 .18	.65 .17	5 1.9	4 1.05	2 .8	374.9 128.6	601.8 214.9	651.8 125.7	684.4 61.5	445.8 58.9	371.8 24.8	16 5.1	22 4.7	27 5.4
KW-values	**1.97**	**5.78***	**8.39****	**1.34**	**4.11***	**14.59****	**3.18**	**22.46****	**24.51****	**5.14***	**19.79****	**21.56****	**2.31**	**4.53***	**12.65****

Table 2

Model a - Summary of multiple linear regression analysis.

Model ***a*** Dependent Variable – Rectus femoris Fatigability	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations Coefficients			Collinearity Statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
(Intercept)	-18.47	2.54		-7.28	.000					
Orienting Recovery	-9.43	2.03	4.21	4.65	.000**	-.283	-.569	-.613	.842	1.078
Spontaneous Fluctuation	-7.15	.95	-4.83	-7.53	.000**	-.569	-.448	-.716	.949	1.162
Amplitude	3.63	1.09	1.14	3.33	.009**	.348	.603	.471	.908	1.094

[a] (F (6, 51) = 23.79, P < 0.000)) Model Adj.R2 = 49.8%.

Results of multiple linear regression analysis have been presented in the Table 2, which however explained that, independent predictors such as orienting recovery time (p = .000), along with measures of spontaneous fluctuation (p = .000) and amplitude (p = .000) can predict 49.8% of variance in changes in the extent of changes observed in the level of fatigability in the rectus femoris muscles of the players.

Table 3
Mauchly's Test of Sphericity[a]
Measure: MEASURE_1 Obtained from the Soccer Players

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Sc - SF	.026	211.99	2	.000	.501	.504	.500
Amplitude	.028	199.79	2	.000	.509	.509	.500
EMG MVC	.003	751.36	9	.000	.246	.245	.250
Fatigue AEMG	.017	388.14	2	.000	.603	.607	.500
Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.							
a. Design: Intercept Within Subjects Design: Sc - SF + Amplitude + EMG MVC + Fatigue AEMG							
b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.							

Reports from the Table 3 revealed the results of Mauchly's test of sphericity for each of the main effects of the psychobiological and EMG parameters. Tests indicated that all of the main effects violated the assumption of sphericity and therefore the *F-values* for those effects were required to be corrected. Thus all of the outputs (results of ANOVA with corrected *F-values*), are represented in the Table 3 (Table of tests of within-subjects effects), which are reported in the next section one by one.

Table 4
Tests of Within-Subjects Effects
Measure: MEASURE_1 Obtained from the Soccer Players

Source		Type III Sum of Squares		df	Mean Square	F	Sig.
Sc SF	Greenhouse-Geisser	24052.08		1.01	23836.13	313.05	.000
Amplitude	Greenhouse-Geisser	21780.91		1.01	21534.96	272.83	.000
EMG MVC	Greenhouse-Geisser	41741.48		1.02	41387.64	288.03	.000
Fatigue AEMG	Greenhouse-Geisser	46098.19		1.02	32296.65	304.81	.000

We can report the results as for the soccer performers, 'there was a significant main effect of Sc SF, $F(1.01,53.48) = 313.05,\ p < .000$, which implied that, if effects of other variables are ignored, autonomic conditions of the Skin conductance SF were different from each other (table 3). Similarly the output for amplitude could be reported as $F\ (1.01,\ 53.6) = 272.83,\ p < .000$, which were different from each other. For the output of EMG MVC could be reported as $F\ (1.02,\ 53.46) = 288.03,\ p < .000$, which were different from each other. Similarly the output for Fatigue EMG could be reported as $F\ (1.01,\ 53.6) = 304.81,\ p < .000$, which were different from each other. Observed mean difference (Table 1) further revealed that, soccer players who received differential biofeedback interventions, had relatively better psychobiological i.e., autonomic competence, and which is evident in their larger autonomic response amplitude; lesser NS-SCR or SF responses and higher phasic Sc scores and higher electrical muscle potentiality (characterised by higher extent of maximal voluntary contraction and lesser extent of fatigability), compared to their control condition counterparts. Here paying attention to the implications of the observed findings, we can postulate that observed high extent of autonomic competence in the players, especially who received Sc biofeedback training was contributed by higher extents of regulation over sudomotor nerve activity (indexed by lower frequency of SFs). While EMG biofeedback contributed in improvements in peripheral neural activations,

which might have prompted the participants to cope with the muscular potential deficiencies as well as autonomic adaptations too (as indexed by faster autonomic recovery – Table 2). Here we observed differential contributory influences of the interventions on the soccer players, since soccer players are supposed to have higher-order maximal voluntary control of their quadriceps muscles. Further to that, observed role of faster autonomic recovery and regulation over startling response (SFs) in modulating fatigability in rectus femoris fatigability might have helped the soccer players in better adaptation to display better shooting performance [5, 6, 15, 12, 1, 13].

CONCLUSION

- Both of the intervention techniques have been observed to put beneficial impacts in both regulation of emotional turmoil as well as in the control of electrical muscle potentiality.
- Skin Conductance biofeedback was observed to modulate emotional startle response better than the other intervention technique used.
- EMG biofeedback technique was observed as a better intervention technique in regulation of muscle fatigability and maximal voluntary contraction in the soccer players.

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